Adapting ourselves from dawn till dusk: On the psychological aspects of Human Enhancement and the possibility of the lost Human

Inaugural-Dissertation

in der Fakultät Humanwissenschaft

der Otto-Friedrich-Universität Bamberg

vorgelegt von

Niklas Alexander Döbler

aus Berlin

Bamberg 2025

Diese Arbeit hat der Fakultät Humanwissenschaft der Otto-Friedrich-Universität Bamberg als Dissertation vorgelegen.

Tag der mündlichen Prüfung: 21.07.2025

Dekan: Universitätsprofessor Dr. Claus H. Carstensen

Gutachter: Universitätsprofessor Dr. Claus-Christian Carbon

Weiterer Gutachter: apl. Prof. Dr. Harald Schaub

URN: urn:nbn:de:bvb:473-irb-109629x
DOI: https://doi.org/10.20378/irb-109629

Per aspera ad astra.

Mein unendlicher Dank gilt Dr. Dorothee Busch, die ich just an dem Tag kennengelernt habe, als mir die Inspiration zur folgenden Einleitung kam. Ein Zeichen?! Ohne ihre Unterstützung, Nachsicht, Liebe, Lachen und Fürsorge hätte ich diese Arbeit nicht fertigstellen können. Ich kann mich allgemein glücklich schätzen, dass mich auf meinem Weg so viele Menschen begleitet und bestärkt haben. Das gilt vor Allem meiner, mit der Zeit gewachsene Familie, insbesondere meiner Schwester Ninotschka und meinen Eltern Anuschka und Wolf. Eine komplette Aufzählung und Würdigung läuft immer Gefahr, jemanden zu vergessen und Missmut hervorzurufen. Da sich die letzten zehn Jahre meines Lebens hauptsächlich in Bamberg abgespielt haben, seien an dieser Stelle und in jüngster Zeit dennoch Constanze, Anna, Thomas, Jonah & Nicolai (in order of appearance) erwähnt. In tiefer Dankbarkeit und Freundschaft verbunden bin ich Hanna und Sabrina, ohne die Bamberg nicht Zuhause geworden wäre. Auch ohne die praktische und emotionale Unterstützung von Sasha, Julia, Marlene, Marius, Folker, Monika, et al. wäre diese Arbeit nicht denkbar. Ich danke den Marken *Red Band*, *Afri Cola* und *Coca-Cola* für das glukosehaltige enhancement und Harald für seine Offenheit und Spontanität. Zuletzt sage ich danke an meinen Mentor CCC für dessen Rat, Humor, Inspiration und Besonnenheit.

Content

Abstract

Being human is stressful and entails confronting various demands. One of the most evident and characterizing strategies for coping with them on an individual and collective level might be environmental manipulations at different scales. However, humans can also use the resources of the material environment to create technologies to adapt themselves instead of the environment and aim at improving their abilities directly. This constitutes what I understand as *Human Enhancement*. It encompasses a variety of contexts and means and can have a profound impact on our being and self-understanding. The latter effects provoke a passionate debate among its adversaries and advocates. But is Human Enhancement really such a disruptive force? Can it – as feared or hoped – really disrupt one of the most self-evident psychological truths we know: identifying as humans? And will the subsequent result really be humanity's evolutionary descendant: the post-Human? Drawing from interdisciplinary insights, I present a psychological theory about the functionality of Human Enhancement and its employment in everyday life. I further elaborate upon the psychological manifestation and malleability of our human identity and argue that technology and science have and can indeed alter it. Key to these theoretical propositions is to acknowledge our human identity as a sense-making, intersubjective psychological structure. Motivated not to confine my discussion about the impact of Human Enhancement to the abstract, core paper #1 (Döbler & Carbon, 2023) empirically explores the controversies concerning the extent of this practice on the matter of vaccination against SARS-CoV-2. Results revealed people's unwillingness to adapt themselves using means they consider unnatural or invasive. These effects were stronger for those who rejected the biotechnological enhancement of their immune capacities, aka the vaccine. Yet, apart from adapting to a physically hazardous environment, Human Enhancement can be used in relation to a given socio-normative context. For further elaboration, I present core paper #2 (Döbler et al., 2024). Here, I highlight how educational or workplace settings may privilege specific enhancements either by direct command or by fostering a demanding environment that urges adaptation in secrecy. Provided historical examples show how social normativity influences how we purposefully and technologically shape our bodies. Elaborating on the premise of adapting to social normativity, core paper #3 (Döbler & Carbon, 2025) presents empirical results indicating that people may use hypothetical genetic engineering for the enforcement of normative gender stereotypes. This would adapt their child to an environment that regularly punishes gender divergence. However, results also indicate that parents may use this power to push for more gender egalitarianism. All results are discussed in the light of how our socio-technological practices and organization influence our understanding of ourselves as humans. Here, the need to adapt ourselves may be so fundamental that adversaries and advocates must find a satisfying way to negotiate the historical and contemporary role of Human Enhancement within their notion of being human. While our human identity has proved to be highly adaptable so that the effects of past enhancements were successfully incorporated into our self-understanding, future Human Enhancement may nonetheless yield the impossibility of integrating its effects. If so, discarding our contingent identity appears as a necessity. Targeting the controversial center of the Human Enhancement debate and the desirability of the post-Human, I discuss psychological mechanisms potentially yielding a disruption in the continuous self-conception of our species. Special emphasis is placed on the empirical psychological phenomena of dehumanization and the adoption of social judgments and material practices into our self-perception. Seen from a collective level, I highlight how we use historical narratives to negotiate changes in this conception and how the reliance on these psychological processes opens the possibility of historizing a radical change in our identity. Interventions like vaccination, productivity enhancements, and genetic engineering may appear controversial, yet not potentially identity-breaking. However, humans do not live isolated from technology. The large-scale adaptation of the environment to meet our needs directly confronts us with the benefits and risks of our contemporary technological lifestyle. The same power applies to Human Enhancement. In that sense, the psychological approach presented here elucidates whether the technological adaptation of ourselves can give rise to the dusk of humanity. Given that our human identity is by no means fixed, the post-Human may be possible, yet not inevitable.

1. Introduction

We begin in paradise. God created the naked but "not ashamed" (*King James Bible*, 1769/2024, Gen 2:25),[1] humans "in his own image" (Gen 1:27). But his creations were aspirational. Capitalizing on this, the duplicitous serpent promised that after eating from the forbidden Tree of Knowledge, humans would emerge "as gods, knowing good and evil" (Gen 3:5). Moral enlightenment came at a price. Furious about breaking his laws, God evicted our ancestors from paradise.

The book of Genesis is no historical document. Still, its themes reflect mythological tropes like human limitations and the futile grasping for divinity. But there is more than the matter of hubris. Note that after their moral awakening but before the eviction, humans realized their nakedness, became ashamed, and quickly "sewed fig leaves together, and made themselves aprons" (Gen 3:7). And even before banning Adam and Eve from paradise, God carried on with these productive efforts and made "coats of skins, and clothed them" (Gen 3:21). By transforming the environment's raw material into something whose '*functionality*' operates with '*intendedness*' and '*purposefulness,*' the clothes made fulfill the three definitory criteria of *technology* proposed by Carroll (2017). The same categorization may apply to the Tree of Knowledge, from which God knew how its fruits would affect humans. In the light of the profound technological world we currently inhabit (Ihde, 1990), the first clothes in Genesis can be read as describing the dawn of what has been called "creative material engagement:" "*a long-term commitment to the discovery of new varieties of material forms, so far as it is possible in a given historical situation, through a saturated, situated engagement of thinking and feeling with things and form-generating materials*" (Malafouris, 2014, pp. 144/147, original italics). If our engagement with the material environment privileges a "synergistic process by which, out of brains, bodies, and things, mind emerges" (Malafouris, 2013, p. 17), then the initial and subsequent technologies of the Fall of Man could be metaphorically considered as the first step toward the contemporary human condition.

This interpretation is not novel. Drawing upon the same association with the Biblical paradise and its unclothed human inhabitants, Don Ihde (1990) argues that human agency is fundamentally constituted and exercised through and by technology. This is so consequential that returning to a mythological "New Eden ... [as] pretechnological New Adam" (Ihde, 1990, p. 42) is "likely neither desirable nor possible. ... We have left the Garden [(Eden)] and inherited the Earth" (Ihde, 1990, p. 20). Our self-definition and way of life are too dependent on our technology;

[1] All Bible references refer to this version of the King James Bible. For readability, following quotes only contain the book, chapter, and verse.

without it, our past and future evolutionary trajectory and self-definition are unthinkable (Ihde, 1990; Ihde & Malafouris, 2019). Yet, contrary to the Bible, complex cognitive abilities and environmental manipulations did not follow a strict sequential order. Instead, manufactured products and cognitive abilities are mutually dependent (Jeffares, 2010; Malafouris, 2013, 2014; Stout & Hecht, 2017). This facilitated the creation and living in ecological niches specifically attuned to our behavioral and cognitive capabilities (Drain, 2022; Iriki & Taoka, 2012) and culminates in the assertion that: "*we are Homo faber not just because we make things but also because we are made by them*. People are both changing and changed by technology" (Ihde & Malafouris, 2019, p. 209, original italics). In other words, our activity within our inheritance defines who we are as humans.

Technology's sustainable effect on *ourselves* also resonates in Genesis. After all, our Biblical foragers left the Garden with novel capacities. Because the material environment was exploited to change the human body's condition (unknowing/naked) to a more "adaptive" one (knowing/clothed), the biblical dawn of humanity[2] as inhabitants of the Earth started with two instances of employing "*embodied technologies to improve the capabilities of the human body or to create new ones. An endeavor primarily conducted to adapt oneself instead of the environment*" (Döbler & Carbon, 2024, p. 598, original italics).[3] In other words, the third chapter of Genesis describes what I and others (e.g., Kourany, 2014) call *Human Enhancement*.

The ability of "knowing good and evil" (Gen 3:5) could be read as successful enhancement in terms of the (bio-)technologically induced adoption of moral principles (see Persson & Savulescu, 2012). Since the ability to employ and enact knowledge is genuinely cognitive (Neisser, 1976) and cognition enables humans to engage with their environment adaptively (Thompson & Stapleton, 2009), the subsequent exercise of crafting skills suggests that humans left the garden not only morally but also cognitively enhanced (see also Kourany, 2014). These capacities arose from *our* engagement with the material environment. Folk-wise, moral capacities and logical reasoning are considered human trademarks (N. Haslam, 2006). So, the qualities that distinguish us from animals were obtained by eating from the Tree of Knowledge and the subsequent Fall of man (see also Žižek, 2014).

But at what cost? Eating from the Tree of Knowledge, or at least crafting clothes, disrupted the heavenly utopia gifted to humans by destroying the phenomenologically "nakedly perceived world" (Ihde, 1990, p. 46). One eviction later, contemporary human technology extends beyond the simple manipulation of "naturally" found

[2] See also the non-biblical but still mythical "Dawn of Man" in Arthur C. Clarke's and Stanley Kubrick's "2001: A Space Odyssey" (Kubrick, 1968), which follows a similar logic (Döbler & Carbon, 2024).

[3] "Adapting ourselves instead of the environment" is a direct quote from Döbler and Carbon (2024, p. 602). During this thesis, the reader will encounter it and the slight reformulation of 'adapt ourselves instead of the environment' several times. For readability, I quoted it only once.

resources but allows for the alteration of molecular processes (e.g., Doudna & Charpentier, 2014). This is not met with unanimous joy. Although Ihde criticizes the romantic desire for the mythological but irretrievably lost Garden, the underlying longing for a 'return to nature' is still an influential trope for contemplating human-technology relations (Midson, 2018). Indeed, some see humanity walking a path toward a being in which the increasingly transformative potential of biotechnology is feared to render "all of our encounters with the world, both natural and interpersonal, ... mediated, filtered, and altered" (Kass, 2003, p. 22). This mirrors specific understandings of "naturalness," where this property is seen as corrupted by human action and/or technology (Siipi, 2008). This accusation is also leveled against Human Enhancement, where the employed radical or novel technologies are suspected of meddling with the inherent value of human activities (President's Council on Bioethics, 2003). Using Human Enhancement to profoundly shift human capabilities beyond what is considered "normal" is highly controversial. Related accusations, e.g., contempt for "the given" (Kass, 2003, p. 20), desiring 'hubristic hyper-agency' (President's Council on Bioethics, 2003), or "playing God" (Schönthaler et al., 2022, p. 363) are — in slight variations — also raised against *transhumanism* (see Hansell & Grassie, 2011; Hauskeller, 2013, 2016; Sharon, 2014; Wilson & Haslam, 2009). This ideology actively promotes the use of science and technology, including Human Enhancement (Bostrom, 2003c) for "the continuation and acceleration of the evolution of intelligent life beyond its currently human form and human limitations ... guided by life-promoting principles and values" (More, 2011, p. 137). Transhumanism affirms that humans should not accept their evolutionary limitations but can and should use emerging technological means to challenge them (Sharon, 2014). This disrespect towards the contemporary *conditio humana* culminates in the highly controversial goal to create "the radically enhanced, virtually omnipotent human of the future," aka the *posthuman* (Hauskeller, 2016, p. 24).[4] Steering humanity toward a primordial but lost utopia by exploiting technology to overcome our limitations is the prepossessing promise of transhumanism (Hauskeller, 2013). Hence, scholars (e.g., Hauskeller, 2013; Ihde, 2011a; Žižek, 2014, 2021) consider aspects of the transhuman project as an attempt to revert the negative consequences of the Fall and return to the Garden.[5]

The debates around transhumanism and Human Enhancement are textured by ancient desires and dogmatic and diverting accounts of an alleged human nature (Hauskeller, 2013, 2016). Moreover, varying definitions of

[4] For me the posthuman is characterized by being *not* human anymore. Hauskeller (2016) mentions that some transhumanists share this understanding and points out that they, in general have, transcending goals regarding the current human state.

[5] The analogy with Eden and the creation of humans in the image of god is discussed many times in the Human Enhancement and transhumanism debate (e.g., Coeckelbergh, 2013; Greely, 2006; Midson, 2018; President's Council on Bioethics, 2003). Hauskeller (2013) argues that the serpent could be considered as propagating transhuman ideals and, therefore, implies that the fruit is an enhancement. See also Greely (2006) and his claim that nobody would prefer a non-enhanced prehistoric lifestyle.

enhancement hinder the identification of technologies of interest (Gyngell & Selgelid, 2016). Still, in the epicenter, we find a human being who is constantly confronted with all sorts of demands (Döbler & Carbon, 2024). In the Garden, this entailed social pressure to eat from a tree or social shame. Post-Eden, humans inhabit an environment that harbors all sorts of risk (Coeckelbergh, 2013) — A perspective inclining us to view technology and science as instruments that redeem us from our existential inadequacies and assist us in overcoming the challenges of everyday life (Coeckelbergh, 2013; Coenen, 2014; Hauskeller, 2016).

But is any enhancement effort to be judged similarly? Anyone interested in an answer must navigate complex issues, ranging from mere tangible concerns about technological and medical safety (e.g., Banjo et al., 2010) up to the question if Human Enhancement may lead to losing whatever makes us human (e.g., Agar, 2010) or can usher the next step in our evolution (e.g., Bostrom, 2013b). This emphasizes what is seen at stake. On the one hand, we have concerns that refer to *ourselves as individuals*. On the other hand, we find hopes and fears about the future of humanity, i.e., *ourselves as humans,* as, for example, defined by a set of selected features and valued continuous history (Pugh et al., 2016; Wilson, 2014).[6] Both aspects are inseparable. If enough individuals get enhanced, humanity as a whole may benefit, suffer, or even be conceptually displaced by a posthuman alternative (Agar, 2014; Bostrom, 2013b; Buchanan, 2011; More, 2011).

From a psychological perspective, we can reduce these most controversial aspects of the debate about Human Enhancement, transhumanism, and the potential posthuman to one question: *Is it possible that human behavior itself has the disruptive potential to dissolve one of our most self-evident experiences: being human?* The following doctoral dissertation will elaborate on this question. I do so by theoretically and empirically inquiring different forms of Human Enhancement from a functional and practical perspective and drawing on evidence on how we operate and understand our humanness. Answering this question may be an ambitious goal for a psychological research program and must remain partially hypothetical. After all, I cannot provide empirical evidence of humans that have turned posthuman. Nonetheless, I attempt to grasp the phenomenon by empirically investigating attitudes and practices revolving around Human Enhancement that is already in use or realistically employed in the near future. Generated insights will then be used to theoretically address whether some ramifications of this behavior can indeed posthumanize ourselves. Suppose we would simply gather attitudes about using pharmacological means to enhance cognitive performance. Such research can generate meaningful insights and

[6] Sample et al. (2020) found two components of Brain-Computer-Interface-related concerns. The "Agent-related" included concerns about individual authenticity but also "redefining humanity" and cyborgization, while "Consequence-related Issues" comprised primarily social, ethical, safety, and security concerns (p. 1252-1254).

reveal contextual variables influencing ethical evaluation (e.g., Dinh et al., 2020), but also confines itself to a local perspective and ignores the far-reaching aspects that may structure attitudes toward this phenomenon. Given the passionate debate about the loss or extension of valuable human-specific assets, aka our human nature, not addressing the potential identity-constituting or -disrupting impact of technology means neglecting what rendered the phenomenon highly controversial in the first place. I am not suggesting that I can quantify the probability of the posthuman. Yet, psychologically scrutinizing these more abstract factors can help to understand why some forms of Human Enhancement spark so much controversy (Wilson & Haslam, 2009) and how reservations or embracement intersect with the adopted notion of humanness (Wilson & Haslam, 2012). The presented psychological approach to Human Enhancement does not answer whether whatever makes us human *should* be changed — but it can approximate *if* and *how* this was, is, and will be possible. Despite all uncertainties, I can provide a psychologically informed view on whether the behavior that has yielded the lost paradise, forced us to take care of ourselves, and led to a widespread adaptation of the environment and ourselves can be pushed so far that it will render our human being irretrievably lost.

2. Outline

I will proceed as follows. Section 3 will provide a comprehensive overview of the ideological frontlines in the Human Enhancement debate. This means situating the following discussions within a framework of ethical relevance and emphasizing the importance of conducting a careful psychological analysis of the matter. Given the far-reaching questions of Human Enhancement, I will argue that any such approach is well advised to incorporate philosophical perspectives to confront the more abstract aspects of the phenomenon. I then conclude by sketching out the fundamental parameters of the here-adopted perspective on human behavior and cognition. In Section 4, I will elaborate upon my definition of Human Enhancement. I then highlight several areas of interest and emphasize how this practice is contemporarily done. This will serve as the theoretical backbone for this thesis and subsequent publications. Conducted through the lens of the Human Enhancement debate, Section 5 features a comprehensive discussion about the production of human self-understanding and the functional purpose of having a concept like 'being human.' This is meant to deepen our understanding of the conditions that adversaries of Human Enhancement want to preserve and advocates want to surpass. Elaborating upon the social and technological influences within this process is the first step in discussing whether losing whatever makes us human is possible. Speaking of controversial Human Enhancement, Section 6 summarizes a publication examining the association

between rejection of a specific enhancement (vaccination) and a more reluctant attitude toward other instances. This empirically exemplifies how biotechnology can be used to adapt ourselves to a physiologically threatening environment and why people may be critical of such conduct. Section 7 then reports on the second publication, in which I discussed how specific factors may influence the adoption of Human Enhancement in organizational settings. The intersection with social variables serves as a starting point to argue how a given ideology can create the demands that foster the impression that enhancing ourselves is necessary and further emphasizes the pervasiveness of Human Enhancement. I proceed in Section 8 by elaborating on how normative expectations not only shape how we enhance but also how we ought to be as human beings. This paves the way for the third publication discussed in Section 9. Here, I present results suggesting that normative gender stereotypes may influence how human genetic engineering is conducted. A clear example of adapting ourselves to a socially pressuring environment, the matter of stereotypes and genetic engineering directly touches upon essentialistic beliefs that are also present in the Human Enhancement debate. Thus, I will seize the opportunity to elaborate further on the intricacies of gender essentialism and Human genetic Enhancement. Section 10 will argue that adversaries and advocates of Human Enhancement and transhumanism may be fundamentally opposed to openly endorsing increasingly potent Human Enhancement. Nonetheless, their motivations may converge in a desire to achieve harmony with human-made technology. This exemplifies how both positions draw on a specific understanding of adaptation to propagate their regulatory approach to adapting ourselves. Generated insights will be used in Section 11 to elaborate on how widespread transformative enhancements may endanger contemporary notions of what makes us human. Here, I will discuss possible psychological mechanisms that may govern such a process and offer a perspective on its potential historicization. I will draw my conclusion in Section 12.

3. The phenomenon

3.1. Conceptualizations of Human Enhancement

What is Human Enhancement? Gyngell and Selgelid (2016) enumerate seven different conceptualizations of "enhancement" (*Table 1*). They apply each approach to the fictional example of administering growth hormones to two eleven-year-old boys, each expected to grow to 1.60 m as an adult. However, while Johnny has a brain tumor-related lack of growth hormones, Billy's parents are simply very short. Each definition is tied to a specific set of concerns and hopes (Gyngell & Selgelid, 2016), with the ethically most suspicious being those that promise significant effects (e.g., Agar, 2014) and/or use biotechnological means (e.g., President's Council on Bioethics,

2003). As seen in *Table 1,* the conceptualizations differ, for example, concerning the factual outcome relative to the norm or the question of whether the initial condition is considered a disease.

Table 1. Different conceptualizations of enhancement — unmodified in content and taken from Gyngell and Selgelid (2016)

Approach:	Enhancements are...	Is giving Johnny or Billy growth hormone an enhancement?
Constructivist Approach	beneficial alterations to functioning that do not treat disease, with diseases understood as states disvalued by society	Johnny but not Billy
Normal Functioning Approach	beneficial alterations to functioning that do not treat disease, with diseases understood as negative deviations from normal functioning	Johnny but not Billy
Beyond-Species-Typical Approach	alterations that take people beyond species-typical values for particular traits	neither are enhancements
Beyond-Species-Maximum Approach	alterations that take people beyond species-maximal values for particular traits	neither are enhancements
Welfarist Conception	alterations that improve well-being	both are enhancements
Modified Welfarist Approach	alterations that give people abnormal biological functioning and improve well-being	neither are enhancements
Functional Approach	alterations that increase some type of functioning	both are enhancements

Note. Reproduced with permission of The Licensor through PLSclear

From a broader perspective, Human Enhancement denotes an attempt to change the human body through external means for good (Döbler & Carbon, 2024). As such, the enhancement effects also concern the *embodied mind* (Clark, 2003), i.e., influence the continuous and intricate relationship between our physical configuration, state, and mental processes (see Kiverstein, 2012). What unifies different approaches is that Human Enhancement forges a direct technological path from the current human condition toward the possibility of realizing a more desired one and its subsequent targeting of ourselves (Döbler & Carbon, 2024).

3.2. Adversaries and advocates of Human Enhancement

But what is the matter with Human Enhancement? Do we not constantly attempt to improve ourselves? With effects that are by no means comparable to getting evicted from paradise? Concurrent with the previous section, empirical results show that the problem seems to lie in the purpose of the intervention, i.e., whether it is said to treat a preexisting medical condition or is meant to boost capacities beyond the "normal" state of health (e.g., Martín et al., 2023; Scheufele et al., 2017). One famous and comprehensive critique of interventions meant to create beneficial effects "beyond therapy" was provided by the eponymous report of George W. Bush's President's Council on Bioethics (2003). According to the council, the scientific breakthroughs at the dawn of the new millennium, e.g., progress in sequencing the human genome (International Human Genome Sequencing Consortium et al., 2001), opened the door for humanity to enter "a golden age for biology, medicine, and biotechnology" (President's Council on Bioethics, 2003, p. 4). This period would be defined by the "myriad ways, the discoveries of biologists and the inventions of biotechnologists are steadily increasing our power ever more precisely to intervene

into the workings of our bodies and minds and to alter them by rational design" (President's Council on Bioethics, 2003, p. 5). While the Council discusses issues concerning coercive forces, enhancement access, and unintended harmful effects, it also explicitly names worries concerning human dignity and hubris. The report eventually states that interests in a "'post-human' future," "'remaking Eden," or "'man playing God'" are not universally shared (President's Council on Bioethics, 2003, p. 7). However, its warnings seemed unheard. In 2010, Allhoff et al. argued that the prevailing wish to extend our capacities and the increasing capacity to "incorporate technology within our very bodies" set us off "near the start of the Human Enhancement Revolution" (p. 1). Four years later, ethicist Nicholas Agar already proclaimed the "age of human enhancement" (2014, p. 1).

In this age, the President´s Council on Bioethics fears that non-therapeutic biotechnological interventions endanger our human identity and "risk making our bodies and minds little different from our tools, in the process also compromising the distinctly human character of our agency and activity" (President's Council on Bioethics, 2003, p. 298). Focusing on means promising to extend human capabilities significantly, Agar claims that the so-called "*radical enhancement* is a way of exiting the human species that threatens many (but not all) of our valuable experiences" (2010, p. 15, italics added). Agar and the council see what makes us human at stake!

Around the same time as the council's report, philosophers like Nick Bostrom (2003c) called for humanity to take its evolution into its own hands. In the early 2000s, Bostrom was one of the loudest proponents of *transhumanism*. This ideology urges humanity to realize its full potential, overcome its evident biological limitations (e.g., Various, 2013), and create a glorious technological and potentially biology-transcending future (Hauskeller, 2016). The means to achieve this are manifold, but particular emphasis is put on enhancement technologies (Bostrom, 2003c, 2005c; Hauskeller, 2016; Sorgner, 2020). Today, transhumanism's most prominent voice, the organization *Humanity+*, endorses "the ethical use of technology and evidence-based science to expand human capabilities. We want people to be better than well" (Humanity+, n.d.). Many people may unite behind transhuman goals like "Getting smarter," "Diversity," "Peace," and personal freedom regarding Human Enhancement (Bostrom, 2003c, p. 13). Yet, public opinion may be more split on supporting the central goal of "having the opportunity to explore the transhuman and posthuman realms" (Bostrom, 2003c, p. 13).[7] Here, the necessary conditions rely on utilizing emerging technologies to purposefully push human evolution in the desired

[7]A transhuman can be understood as an entity whose technologically enhanced capabilities surpass those of contemporary humans but still identifies as human in some sense, while the used conception of the posthuman concerns a being that is specifically not human yet had a (trans-)human past (Sorgner, 2020). This way, the transhuman is a waypoint toward posthumanity (Sharon, 2014).

direction (Sorgner, 2020). Besides this shimmering rhetoric by scholars like Bostrom (Hauskeller, 2016), moderate transhumanists simply argue for the reasonable progression of science and technology to promote human well-being and the solution to global crises (Sorgner, 2020). In summary, transhumanist thinking lures everybody interested in more or less radically challenging the current state of humanity through technology, up to the point where the concept itself may be overdue (Simon, 2019).

Conversely, those more cautious and concerned with preserving this status or an otherwise valued *human nature* (e.g., Fukuyama, 2004; Kass, 2003; President's Council on Bioethics, 2003; Sandel, 2009) are usually called *bioconservative* (T. K. Browne & Clarke, 2020; Sharon, 2014). The most famous clash between these ideologies may be the article by Francis Fukuyama (2004), whose headline suggests that transhumanism belongs to the "World's Most Dangerous Ideas" (p. 42). Here, Fukuyama accuses transhumanism of endangering liberalism's great achievement: the proposition that all humans share the same intrinsically valuable, equality-constituting and untouchable essence. While transhumanists champion and emphasize the naturalness of using novel technological enhancements for transcending human limitations (Hauskeller, 2016), bioconservatism sees the same means as endangering "the values and virtues that humans have developed as a result of the necessity to deal with the imperfection inherent to this [human] nature" (Sharon, 2014, p. 3).

Over the last decades, this enmity fueled a comprehensive debate about ethical, practical, and philosophical implications (e.g., Allenby & Sarewitz, 2011; T. K. Browne & Clarke, 2020; Hansell & Grassie, 2011; Hauskeller, 2013, 2016; Kleine-Gunk & Sorgner, 2023; Pugh et al., 2016; Sharon, 2014). For simplification, I locate bioconservatism at the reluctant and transhumanism at the affirming end of the spectrum of attitudes concerning Human Enhancement (see Sharon, 2014).[8] I call the positions mirroring the transhumanist, enhancement-embracing tradition *advocates* and those closer to enhancement-skeptical bioconservatism *adversaries*.[9] Both poles affirm that it is possible to intervene with the configuration of the human body and mind through Human Enhancement but disagree on this conduct's general desirability and outcomes (Sharon, 2014). However, as Sharon (2014) pointed out, both approaches are fairly human-centered in their conception of the world (cf. Hauskeller, 2016). Hence, I will focus on providing a comprehensive account of the suspiciously transformative practice that

[8] This is a heuristic reduction. For a more comprehensive taxonomy that positions bioconservatism and transhumanism, and the here cited and additional authors along other dimensions, see Sharon (2014). As Sharon mentions, Agar's position changed from rather enhancement affirming to being more rejecting.

[9] "Advocates" (Hauskeller, 2013; Kourany, 2014; Wilson, 2014; Wilson & Haslam, 2009, 2012) and "adversaries" are also used elsewhere (Dijkstra & Schuijff, 2016)

supposedly causes all sorts of desired or feared consequences: *Human* Enhancement and its implications for an alleged human nature.

Advocates and adversaries do not necessarily agree about what human nature means (Coeckelbergh, 2013; Hauskeller, 2013; Sharon, 2014; Wilson & Haslam, 2009). These and other fundamental divergences contribute to the passion and intricacy of the Human Enhancement debate and its manifold discourses (Sharon, 2014). This goes so far that Lewens (2012) denied that human nature can serve any informative purpose in the debate. Empirical research on Human Enhancement generally focuses on general moral or intention to use ratings of pre-defined types of Human Enhancement in pre-defined contexts (e.g., Fitz et al., 2014; Grinschgl et al., 2022, 2023; Hotze et al., 2011; Martín et al., 2023; Mihailov et al., 2021; Sattler et al., 2022; Scheufele et al., 2017; Schönthaler et al., 2022). These studies often rely on non-open response categories and thus limit the extent to which abstract philosophical arguments can be raised. The fear of losing the grounding pillars of one's identity (Riis et al., 2008) or whatever makes us human (Hotze et al., 2011; Sample et al., 2020, 2022) through specific enhancements is partially affirmed when participants are presented with predefined options that explicitly mention these concerns. Nonetheless, if compared side-by-side, reported concerns of laypersons and experts most commonly circle around tangible outcomes like safety, security, or efficacy issues and not the abstract question of diminished humanness or grasping for the divine (Sample et al., 2020, 2022; Schönthaler et al., 2022). In studies that employed open group discussions to evaluate the ethical assessment of Human Enhancement, concerns about losing what makes us human varied in their prevalence (e.g., Franke et al., 2012; Pew Research Center, 2016a; Sattler et al., 2022). Yet, the matter of overcoming or losing human nature is a non-ignorable trope (e.g., Agar, 2010; Buchanan, 2009; President's Council on Bioethics, 2003) that subtly transpires to the public perception of Human Enhancement and thus requires a psychological evaluation (Wilson & Haslam, 2009, 2012).

In summary, psychological research affirms the partial controversiality of Human Enhancement as a practice. Even without referring to the respective intellectual history, public understandings of human nature may approximate a transhuman or bioconservative position (see Wilson & Haslam, 2009, 2012). Using a broad psychological perspective to examine the ways technological interventions influence the notion of ourselves may allow for a glimpse of whether the transhuman project's core is even remotely possible and if bioconservative precaution is advised (see Wilson, 2014; Wilson & Haslam, 2012). If transforming ourselves into the posthuman turns out to be impossible, then the more abstract hopes and fears are misplaced.

3.3. A psychological approach

Further reasons why a comprehensive psychological account of Human Enhancement is needed are:

1. The debate operates with a highly generalized notion of the human condition, for instance, to address the notoriously hard-to-grasp (Hofmann, 2017) distinction between morally affirmed treatment and condemned enhancement (e.g., Martín et al., 2023). Here, some approaches rely on a potentially controversial notion of a "normal/healthy" human as a reference point (Gyngell & Selgelid, 2016; Juengst, 1998 - See Table 1). If one rejects an intervention because it defies this level, one must also argue for the goodness and quality of the "natural" state of comparison (Greely, 2006). Concerned with the fundamental processes of the human mind and their relation to behavior, psychology is predestined to evaluate the success or failure of interventions while also critically assessing the employed "normality" regarding its posed quality and emergence.
2. The goal of improving a capacity is always relational to imposed demands that urge an adaptation (Döbler & Carbon, 2024; Pustovrh et al., 2018). Here, a comprehensive account of Human Enhancement must consider how humans navigate their environment on an everyday basis. The so-expressed agency can be defined as the "functional capacities devoted to governing the interaction ... with the external environment (which of course includes other living beings)" (Virenque & Mossio, 2024, p. 14). While special emphasis on the substantial link between human agency and technology is justified (Ihde, 1990; Malafouris, 2013), we should also reflect upon social and psychological processes that motivate us to engage with Human Enhancement and manifest our agency in a particular way (Döbler & Carbon, 2024; Racine et al., 2021).
3. Physical transformations in a Human Enhancement context, e.g., efforts to slow down natural aging, are often discussed regarding their positive and negative long-term effects on psychological variables such as well-being, happiness, identity, or human relationships (e.g., Agar, 2010; Bostrom, 2013b; Hauskeller, 2013; Savulescu et al., 2011). This emphasizes the need to investigate the relationship between *prima facie* benevolent endeavors and psychological consequences.
4. Psychology can evaluate if and how extreme and abstract philosophical positions of bioconservatism and transhumanism influence individual attitudes regarding specific enhancements (e.g., Wilson & Haslam, 2009). Here, we should be attentive to how specific discursively established understandings and framings of the phenomenon can motivate public policy and collective action (Coveney et al., 2019; see also Jasanoff & Kim, 2009).
5. If concerned about the potential loss of whatever makes us human, advocates and adversaries should evaluate how the relevant concepts are commonly understood (Wilson, 2014; Wilson & Haslam, 2009, 2012). Ascribed humanness is individually affirmed but intersubjectively constituted (Bastian & Crimston, 2014). The latter aspect becomes evident considering the empirical phenomenon of so-called "dehumanization," i.e., evaluating others as possessing fewer characteristics indicative of being human (N. Haslam, 2006). Concerns about dehumanizing Human Enhancement are

common issues in the debate (e.g., Grewal et al., 2020; President's Council on Bioethics, 2003; Wilson, 2014; Wilson & Haslam, 2009, 2012). Addressing the question of whether losing our humanness is possible, I extend previous accounts (e.g., Wilson, 2014; Wilson & Haslam, 2009, 2012) regarding how specific notions come into being and the psychological mechanisms that foster their adoption or dismissal.

In summary, psychology can provide empirical insight into evaluating concrete enhancement examples and relate them to more abstract philosophical approaches. When the enhancement debate disproportionally focuses upon alarmistic or utopian scenarios and enhancements (Jones, 2006), psychology can ground things by pointing out where Human Enhancement may already be in use without yielding assumed disruptive effects. Moreover, psychological insights can be used to make informed statements about the psychological foundations of the identity that is said to be disrupted (Wilson, 2014). Since the interplay of individual variables and historical socio-material conditions influences the evaluation of the enhancement's effectiveness (Menuz et al., 2013), a psychological approach may also be utilized for critical self-reflection. This way, we can examine the emergence and perception of the contemporary human condition, which advocates want to transgress and adversaries seek to conserve, at least partially.

In short, employing a psychological approach contributes to a calmer and more reasonable debate that is aware of its obstacles, intricacies, and pitfalls. At the same time, if we adopt the understanding of Human Enhancement as a ramification of human behavior; as something we do (Döbler & Carbon, 2024), then psychology provides an established methodology to assess motivation and effects.

3.4. The future is now!

Human Enhancement is not an abstract endeavor. Silicon Valley in California is populated by various companies and individuals who, even if not explicitly posing themselves as transhumanists, are motivated to extend human capabilities to never-before-known realms (Bunn, 2022; Kleine-Gunk & Sorgner, 2023). Most notoriously, Elon Musk and his company Neuralink® (2023) promise reliable and secure invasive Brain-Computer-Interfaces to make direct brain-to-brain communication possible — a project directly referred to as enabling "telepathy" (Musk, 2024). Time will tell whether these statements are for marketing only. Nonetheless, they shape the discourse and relevant expectations toward this technology.

Apart from this futuristic outlook, the most classic examples may be the attempt to increase cognitive capacities, often by exploiting pharmacological means (Döbler et al., 2024). Due to the prevalence and different possibilities, this practice poses important psychological questions (Racine et al., 2021). The prevalence of cognitive

enhancement fluctuates depending on the conceptualization of enhancement and is highly dependent on whether one includes caffeine or only focuses on illicit or prescription drugs (Sattler, 2016; Sattler et al., 2024; Schelle et al., 2015).[10] Recent numbers from a representative German sample (N = 22,101) estimate a 3.7% twelve-month and 5.5% lifetime prevalence for using drugs without medical prescription to enhance their cognitive capabilities (Sattler et al., 2024). The same study revealed a 1.6%, twelve-month (4.1% lifetime) prevalence of using illegal substances (excluding cannabis) for the same purpose. Crucially, additional findings showed that 40.5% of participants reported a basic willingness to use substances in this vein. This practice should not be understood as trivial and can harbor ethical controversies. Asked about the administration of drugs to boost the cognitive capacities of their children without medical necessity,˜4% of the responding U.S. parents affirmed to have done so (Sattler et al., 2021). Randomized response technique survey results by Franke et al. (2013) showed that nearly 20% of questioned surgeons used cognitive enhancement at least once, with family or workplace-related performance pressure being significant predictors.

In general, means for Human Enhancement can be used in various contexts (Döbler & Carbon, 2024) and for many purposes (Brand et al., 2016). Anthropological and archeological evidence supports the historicity and variety of Human Enhancement. 8,000 years ago, humans started to chew coca leaves, probably to enhance individual resistance against high altitudes (Dillehay et al., 2010)—the use of psychoactive substances in general dates back to 11,000 BCE (Samorini, 2019). Enhancement for prevention, as in the case of coca leaves, is not uncontroversial. This is notoriously shown in the claim of a Chinese scientist to have used genetic engineering to immunize human twins against the HI-Virus (Almeida & Diogo, 2019; Wang & Yang, 2019). Albeit being a preventive effort, interventions like this improve human capabilities and may qualify as Human Enhancement (Juengst et al., 2018). The same logic applies to the latest example of a globally orchestrated enhancement campaign: vaccination against SARS-CoV-2, the virus that caused the coronavirus pandemic that emerged in early 2020. Carried out with sophisticated biotechnology, many of the academic conceptualizations and authors affirm the status of vaccination as Human Enhancement (Döbler & Carbon, 2021). This may evoke recent memories of a controversial debate about the extent to which humans are willing to let biotechnology interfere with their capabilities. The significant number of German citizens who refrained from getting vaccinated against SARS-CoV-2 (Robert Koch-Institut,

[10] According to Schelle et al. (2015), 41.7% of the questioned Dutch students reported having used caffeine for cognitive enhancement purposes during their enrollment. However, only 1.3/1.7% reported having used illicit or prescription drugs without a prescription for the same goal. Sattler et al. (2024) report a 62.4% twelve-month prevalence for caffeinated drinks but only 2.5/3.7% for caffeine tablets and prescription drugs respectively.

2023) highlights the psychological relevance of attitudes toward Human Enhancement. The vaccination discourse foreshadows what may happen when even more controversial enhancements like genetic engineering are ever put into practice. The latter is already discussed regarding its potential to alter the biological foundation of our personality (Banazadeh et al., 2024). This forces us to contemplate whether we really have the duty to revolt against the psychological characteristics that impair our well-being as suggested by Savulescu (2005).

Individual decisions and urges to enhance are accompanied by various hopes, dreams, and fears, more or less informed by abstract academic positions. Hence, a comprehensive psychological investigation into the past and present ways of conducting Human Enhancement can inform relevant decisions regarding future manifestations (Döbler & Carbon, 2021, 2023, 2024). In short, Human Enhancement has a past, present, and future. The question is now how we as humans have, do, and will relate to the technological interference with ourselves.

3.5. There are too many of them!

The diversity of these examples hints toward a problem: Laypersons' and academics' perceptions about which means count as Human Enhancement differ (Döbler & Carbon, 2021, 2023). In addition, some technologies intended to improve human capabilities are rarely discussed under this term (Döbler & Carbon, 2024). One possibility to address this problem is to focus solely on publications that explicitly use Human Enhancement or closely related terms like cognitive enhancement. However, this risks substantiating the disproportionate focus on means to enhance cognitive abilities in empirical research on Human Enhancement (Döbler et al., 2024). Should we not try to identify the underlying principles by which we can identify and classify different technologies as means for Human Enhancement? In that case, a complete assessment of the literature is impossible. To obtain a comprehensive picture, I attempt to balance the reception of the literature that discusses the more "classical" and sometimes controversial examples of Human Enhancement like cognitive enhancement and genetic engineering (Article 2 - Döbler et al., 2024; Article 3 - Döbler & Carbon, 2025) while also drawing on selected examples, usually not in the center of the debate such as vaccination (Article 1 - Döbler & Carbon, 2023). This is not meant to view all instances of Human Enhancement as equal but to evaluate the disruptive or beneficial potential of single enhancements while maintaining their functional connections (Döbler & Carbon, 2024).

Human Enhancement may also be controversial due to the propagated aim of universally and comprehensively improving the "*as* humans" (Hauskeller, 2013, p. 8, original italics). Respective efforts must be understood relative to a shared understanding of the relevant terms (Beinsteiner, 2019). This requires closely examining the social and material factors determining whether people speak of an "improvement" (Döbler & Carbon, 2024; Hauskeller, 2013;

Menuz et al., 2013; Schmidl, 2022). Hence, *improvement what for? When did I improve?* and whether this is the promised all-encompassing enhancement should also be focused (Hauskeller, 2013). This dodges problems arising from relying on a sketchy notion of normality whose surpassing is the only criterion for enhancement (see Gyngell & Selgelid, 2016).

We also must investigate how the particular technology is thought to intervene with the psychologically valued assets of ourselves. In addition, we should examine how single examples may influence the valuation of the general practice. Thus, it might be beneficial to analyze the general principles governing our interactions with the socio-material environment and how they can be *modulated through and expressed by technology.* However, scrutinizing the underlying rules and commonalities, we should not ignore the practical impacts of specific technologies and enhancements (Döbler & Carbon, 2024; Verbeek, 2005). Psychology has recently been criticized for neglecting how material things impact mental processes (Malafouris, 2020). Dire to solve this issue and link the abstract to the practical, the here discussed psychological approach on the direct influence of technology on our body and mind requires assistance.

3.6. A philosophical companion

Arguing that whatever it means to be human may change through technological intervention is a reflexive problem. Hence, we should investigate how technologies, including means for Human Enhancement, influence the features and relationships that constitute our being. Here, our psychological and empirically informed perspective finds a well-suited companion in the philosophical discipline of *postphenomenology.*[11]

Very basically, this school of thought investigates how technologies *"mediate"* and *"transform"* the *'embodied experience'* of humans (Aagaard, 2016; Rosenberger & Verbeek, 2015; Verbeek, 2005). Doing so builds upon the thesis that the way humans *live*, *relate*, *act*, *perceive*, and *experience* cannot be separated from the ubiquitous and pervasive influence of the technologies that surround us and with which we interact daily (Ihde, 1990). Seminal work by Don Ihde (1990) and further extensions (e.g., Verbeek, 2008) expressed different types of human-technology interactions ("relations" or "relationships") by specific formulas (see Verbeek, 2005, 2011).

[11] See Schmidl (2022) for a sociological application of postphenomenology, including brief comments on transhumanism. I have argued for this companionship elsewhere (Döbler & Bartnik, 2022; Döbler & Carbon, 2024) but will revisit this reasoning here.

Within these relations, the mediating role of technologies stems from their 'betweenness' between human users and the perceived world (Ihde, 1990). Within each relation, humans may be more or less focused on the technology as a material object. Ihde (1990) describes this slipping out of awareness as "'withdrawal'" (p. 32); a process where the devices may become nearly "perceptually transparent" in the sense that it is not consciously experienced, yet still exercises its mediating effect (p. 86). Any technologically induced experiential transformation can be understood as the simultaneous "reduction and amplification" of the world's experienced features (Verbeek, 2005, p. 131). For example, using a telescope to observe the moon dislocates our satellite's position concerning other celestial bodies but simultaneously puts its surface into direct focus (Ihde, 1990). In summary: "technologies transform experience, however subtly, and that is one root of their *non-neutrality*" (Ihde, 1990, p. 49, original italics). Later work explicitly extended these effects to human practices and the notion of how the mediating effect of technology also applies to the "invitation and inhibition" of behavior (Verbeek, 2011, p. 11). One example commonly discussed is how the availability of ultrasound examinations during pregnancy inclines gender revelation and allows for the adjustment of related expectations (T. K. Browne, 2017; Verbeek, 2011).

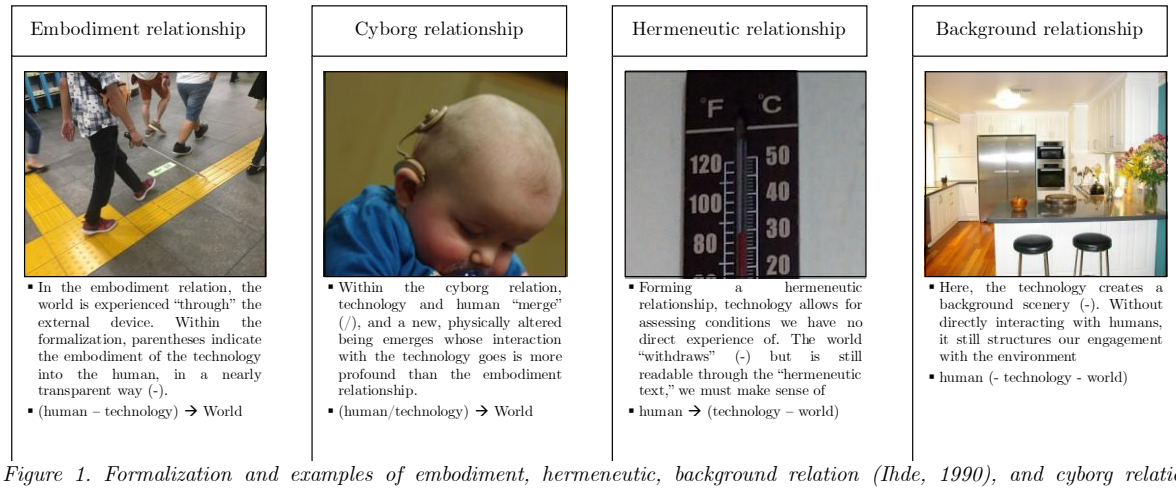


Figure 1. Formalization and examples of embodiment, hermeneutic, background relation (Ihde, 1990), and cyborg relation (Verbeek, 2008). Formulas taken from Verbeek (2008), depicted examples from Ihde (1990) and Verbeek (2011).
From left to right, pictures are licensed under the following creative commons licenses: CCBY 4.0 (Nesnad), CC BY 2.0 Generic (Bjorn Knetsch), CCO 1.0 (Ngostary2k), CC BY-SA 2.0 (Percita)

Seeing Human Enhancement as direct alterations of the human body, as creating an "embodiment relation," i.e., the close interaction of technology and body (Ihde, 1990, p. 32), or a "Cyborg relation," i.e., the physical 'merging' of human and technology (Verbeek, 2008, p. 391) best exemplifies the mechanism of this practice (Döbler & Bartnik, 2022; Döbler & Carbon, 2024; Verbeek, 2011). As seen in *Figure 1*, the so-described immediate attunement of the technology's capabilities with those of the human body renders these relations different from relationships where the technology reveals external information in the form of a "text" that must be "read" ("hermeneutic relation") or constitutes a scenery ("background relation") (Ihde, 1990, p. 105/108; Schmidl, 2022). Still, Ihde

conceptualized hermeneutic and embodiment relationships to reside on the same continuous classification scale (Verbeek, 2005). Embodiment and cyborg relation describe specific ways in which technologies interact with the embodied platform of the human mind and thus create unique transformed experiences (Rosenberger & Verbeek, 2015; Verbeek, 2011). Since Human Enhancement concerns short and long-term technological alteration of the same platform (Döbler & Carbon, 2024), the question of how the used technologies impact our embodied relationship is important (Coeckelbergh, 2013).

Verbeek argued that through their transformative effect, technologies have a *constitutive* effect not only regarding *what* is perceived but also on *who* is perceiving (Rosenberger & Verbeek, 2015; Verbeek, 2005). This extends Ihde's work insofar as the mediating effect is not happening "between" two fixed relata "but rather *coshapes* subjectivity and objectivity" (Verbeek, 2005, p. 130, original italics). The mediational effect of the technologies we encounter every day 'produce' our understanding of the external world and of ourselves as experiencing human subjects (Verbeek, 2005). The meaning of *post*-phenomenology grounds itself in this particular relational and mediated objectivity and subjectivity, and the explicit recognition and validity of these mechanisms in human culture and practices like science (Ihde, 2009; Rosenberger & Verbeek, 2015; Verbeek, 2005). These propositions build on the premise that technologies mediate human intentionality and steer the direction and experienced quality of human perception and action (Ihde & Malafouris, 2019; Rosenberger & Verbeek, 2015; Verbeek, 2005, 2011). Moreover, not only humans are granted intentionality, but also the involved technologies are seen as having a specific way of "sensing" the world (Robert-Demontrond, 2022; Verbeek, 2005). This perspective is strictly confined to technologies being directed to some aspects of the environment and not in the sense that they can behave intentionally, aka purposefully (Robert-Demontrond, 2022). If these capabilities amend the non-mediated human way of relating to the world, the "addition" of sensory capabilities can create a human-technology "composite intentionality" (Verbeek, 2008, p. 387). Maximizing the closeness, a cyborg-like coalescence creates a human transcending mode of experience and thus a "hybrid intentionality" (Verbeek, 2008, p. 390). By being integrated into our functional engagement with the world, the experience- and action-mediating effect of technology influences how we experience ourselves, make sense of it, and act within the same world (Clark, 2003; Döbler & Bartnik, 2022; Robert-Demontrond, 2022; Verbeek, 2005). As pointed out elsewhere (Döbler & Bartnik, 2022; Döbler & Carbon, 2024), these propositions help us to understand the cognitive science perspective on humans as "*profoundly embodied agents*" (Clark, 2007, p. 279, original italics) who use various external means, e.g., Human Enhancement, to form "new agent-world circuits" (Clark, 2007, p. 270).

Moreover, postphenomenology is a well-suited approach to enrich the psychological assessment of Human Enhancement because:

1. Postphenomenology relies on case studies for comprehensive theory building and is one example of the so-called "empirical turn" in the philosophy of technology (Bosschaert & Blok, 2022; Rosenberger & Verbeek, 2015). Doing so, it scrutinizes the employment of technologies in various cultural settings while examining the fundamental role of human embodiment in this practical, daily engagement (Aagaard, 2016; Hasse, 2008; Ihde, 1990, 2009; Verbeek, 2005). Geared towards integrating theory and empirics (Rosenberger & Verbeek, 2015), postphenomenology is conceptually and methodologically open to inform psychology on the effects and underlying mechanisms of specific instances of Human Enhancement (see Döbler & Bartnik, 2022; Döbler & Carbon, 2024).
2. Postphenomenology stresses how historical and modern scientific discoveries were only possible through technological aid (Ihde, 1990, 2009). The knowledge-producing role of the so-called '*techno-science*' extends to non-natural science and is self-reflexive (Ihde, 1979, 2009). This emphasizes how the psychological assessment of Human Enhancement is only possible through the human-technology relations employed in empirical science. Whatever is to be dismantled by the former must be investigated regarding the role technology played in the scientific process of building it.
3. Critics of radical Human Enhancement sometimes argue that the resulting novel experiences and their evaluation yield a subtle and slow '*alienation*' from other humans and the world we all share (e.g., Agar, 2014; Kass, 2003). Moreover, biotechnological enhancements are feared to meddle with our natural agency (President's Council on Bioethics, 2003). Postphenomenology situates experience and agency in a technologically dominated socio-material context while granting the used artifacts a "subtle" experience-transforming effect (Ihde, 1990, p. 112). A postphenomenologically informed perspective improves our understanding if and how expected transformations of experience and agency justify raised concerns (see Sharon, 2014).
4. Postphenomenology addresses existential concerns about the potentially paradisiacal or disastrous future of human-emerging technology relations (Ihde, 1990). Thus, it may be worthwhile to examine how Human Enhancement intervenes with and shapes the existential relationships between humans and their environment (Coeckelbergh, 2013).

Postphenomenology dismantles the traditional understanding of acting subjects and perceptually explored objects by stating that both are not metaphysically given but result from technological mediation (Verbeek, 2011). This position qualifies Verbeek and Ihde as representatives of an approach to technology that rejects the sharp line bioconservatism and transhumanism draw between technologies and the manufacturing, allegedly exceptional humans (Sharon, 2014). Here, I encounter the first challenge. As a psychologist interested in how people think and behave, I must work with the given. This means I must examine how culturally propagated conceptualizations of what it means to be human, theoretically and empirically, relate to how people behave and evaluate encountered

technologies. Such understandings serve as an important motivational function within the Human Enhancement debate (Coeckelbergh, 2013; Hauskeller, 2016; Wilson & Haslam, 2009, 2012). My approach is open to analyzing the mediating influence of emerging technologies and how particular notions of humanity emerge (e.g., Sharon, 2014). Yet, it does not follow that the investigated people share the academic conceptualization of technology or Human Enhancement. Psychology has the responsibility to take its subjects and their beliefs seriously, even if the academic literature "falsifies" them. Yet, it must also be open to approaches that re-situate what is seen at stake (e.g., Sharon, 2014). Still, if attempting to understand why people consider individual and invasive interventions as more controversial than environmental manipulations (M. Haslam et al., 2021; Levy, 2012), the strict human/environment distinction some scholars are skeptical of emerges as psychologically important (For a discussion on the justifiability of this distinction, see Agar, 2014). Luckily, the complete elimination of humans as a category is too far-fetched. Even if postphenomenology sees humans and technology as insoluble dependent (Verbeek, 2011), Ihde refrains from granting objects the same ontological status as human subjects (Sharon, 2014). In other words, the malleability of relata does not necessitate their dissolution (see Rosenberger & Verbeek, 2015).

In summary, postphenomenology does not reject the meaningfulness of the human as a concept but still argues for the impossibility of separating our current understanding of ourselves from the influence of technology. Hence, it can rearrange the relationship between humans and technology in a way that helps psychology to better grasp and focus on its objects and subjects of inquiry.

3.7. Active Humans

The postphenomenological primacy of embodiment and technologically imbued agency (Ihde, 1990) in a socio-material frame (e.g., Aagaard, 2016; Hasse, 2008; Ihde, 2011b) can be informatively linked to psychological and cognitive science theories that champion the role of the *active* body and its *embodied* mind in mutual and inseparable relation to a specifically valued environment (e.g., Clark, 2003, 2007; Rietveld et al., 2018; Thompson & Stapleton, 2009; Varela et al., 1991/1993). Ihde and Malaforious (2019) acknowledge that postphenomenology partially overlaps with these approaches but still point out that the latter are still somewhat negligent of the influence of the specific manifestations and effects of how humans engage with the material environment. This problem is addressed by Malaforious (2013) in his "Material Engagement Theory." According to him, any approach to embodied cognition must not only recognize that the human mind and body are indivisible linked but also acknowledge that human activity in a material environment exerts sustainable influence on all domains of perception and action.

Adopting this notion, I share the expressed sympathy with the central hypotheses of what is called *enactivism* (e.g., Ihde & Malafouris, 2019; Malafouris, 2013). According to this approach to cognition, perception does not create perfect and absolute representations of an objective world (Varela et al., 1991/1993). Instead, each organism, through its bodily activity and emerging sensomotoric feedback loops, engages in so-called "sense-making" which results in the emergence of a value-laden topography of its environment (Thompson & Stapleton, 2009). Thus, *cognition* describes how such "enaction" yields mundane physical features to present themselves with immediate meaning (Varela et al., 1991/1993, p. 206). In short: "Sense-making is behavior or conduct in relation to environmental significance and valence, which the organism itself enacts or brings forth on the basis of its autonomy" (Thompson & Stapleton, 2009, p. 35). This understanding highlights how organisms must use their behavioral repertoire to constantly balance coping with normative socio-material demands and the fulfillment of individual needs (Di Paolo, 2005; Virenque & Mossio, 2024). Enactivism has been applied to social (Butnor & MacKenzie, 2022; De Jaegher & Di Paolo, 2007; García, 2021; Mojica, 2021), material (Malafouris, 2013; Monterroza-Rios & Gutiérrez-Aguilar, 2022; Rolla & Novaes, 2022), and even ethical contexts (Di Paolo & De Jaegher, 2022). Yet, this doctoral dissertation should not be read as primarily enactivistic. When discussing how Human Enhancement relates to our embodiment and can yield changes to ourselves (see Clark, 2003; Coeckelbergh, 2013), I draw from central concepts like active sense-making to examine how technological interventions targeted to modulate our embodied activity may impact our action capacities and experienced reality (see Döbler & Bartnik, 2022). Moreover, I will orient on previous work that highlights how humans navigate normativity at various levels of abstraction (e.g., Di Paolo, 2005; Maiese, 2022) while also highlighting the crucial role of technology in this conduct. Both the enactivist tradition and postphenomenology emphasize how the (technological) activity of embodied agents shapes the meaning of the socio-material encountered world *and* of the former's features (Ihde, 2009; Ihde & Malafouris, 2019; Varela et al., 1991/1993; Verbeek, 2005). Thus, we can link fundamental changes in reality to historical and new technological transformations of ourselves (Ihde, 2011b).

Applied to the Human Enhancement context, this yields the premise that humans are active, embodied beings in a dynamic environment and that their activity to prevail in this environment includes applying things they made to themselves (Döbler & Bartnik, 2022; Döbler & Carbon, 2024). But if our bodily activity is as reality-constituting as suggested, what impact may contemporary and future manifestations of its technological expression have on our self-understanding?

3.8. Summary

A comprehensive and integrative picture of Human Enhancement demands linking practical findings to the abstract debate. Doing so, any psychological approach must address not only future projections but also contemporary and historical manifestations of Human Enhancement. Thus, we cannot operate with a finite set of technologies and must identify general use principles. The following discussion is my attempt to do so while being attentive to any impact these principles may have on *ourselves* as conducting beings.

4. Adapting ourselves instead of the environment

4.1. What is needed?

As seen in Section 3.1. there are many definitions of Human Enhancement. Each may be suitable for a different type of inquiry and problem (Gyngell & Selgelid, 2016). Given the declared goal of finding a shared link between different types of technologies and paying close attention to Human Enhancement as a psychological and everyday phenomenon, a new definition should balance the practical ethical need for identifying useful definitory criteria (Bostrom & Savulescu, 2009) with the proposed practical and transformative influence technology has on ourselves (see Verbeek, 2005). Any so emerging definition should be equally applicable to the abstract ethical and philosophical debate (e.g., Agar, 2014; Hauskeller, 2013), as well as providing additional explanatory power to empirical studies like those on epidemiology (e.g., Sattler et al., 2024) or factors that modulate use intention or moral evaluation (e.g., M. Haslam et al., 2021). Committed to examining the argument that manifestations of our agentic capabilities can infringe their very nature (e.g., President's Council on Bioethics, 2003) while simultaneously being attentive to the historically technological character of these capabilities (Ihde, 1990) and their meaning for the encountered reality (Varela et al., 1991/1993), we need an understanding of Human Enhancement that pays close attention to how we do it and how it affects ourselves.

Moreover, if any estrangement between technologically altered and non-altered humans is supposed to happen not suddenly (Agar, 2014), then we should also be interested in an account of Human Enhancement not confined to those extreme results easily spotted due to their substantially transformed experiences (cf. Agar, 2014). Interested in all the small yet decisive effects of technologies-in-action (Ihde, 1990), a postphenomenologically informed, 'anti-alienation' and "more nuanced view of technology according to which technology [or Human Enhancement] offers a form of engagement with the world" (Sharon, 2014, p. 80) may be useful. These considerations favor orienting toward a "functional approach," which ties enhancements not to their ability to

surpass a specific level of capabilities and are evaluatively reserved whether the intervention *per se* is problematic (Gyngell & Selgelid, 2016, see Table 1). The following is a summary and extension of Döbler and Carbon (2024) and Döbler and Bartnik (2022), in which such an approach was developed. This section addresses and extends the posed questions and formulates the theoretical basis of Human Enhancement that I will use throughout this thesis.

4.2. Mapping the phenomenon

Kirsh (1996) famously showed how, in general, "adapting the environment instead of oneself" (p. 415) can produce highly effective behavioral outcomes. In their analysis of drug-based cognitive enhancement in occupational contexts, Pustovrh et al. (2018), without reference to Kirsh, argued that Human Enhancement can invert this relationship:

> while practically any use of technology influences and changes the way the human mind functions, human enhancement technologies offer an even more radical possibility – that of *adapting human beings directly to specific environments, niches and demands* through the technological restructuring of the body, and especially of the brain. (Pustovrh et al., 2018, p. 302, italics added)

Picking up Kirsh's idea and Pustorvh et al.'s quote, we extended the understanding of discussed enhancements beyond occupational cognitive enhancement toward the general daily struggle of humans for survival, a steady and diverse flow of demands, and, most importantly, the exploitation of various technological means to succeed within this task (Döbler & Carbon, 2024). The discussed employment of technology to adapt humans to demanding surroundings aligns these thoughts and our extension to the intellectual root of the spacefaring "Cyborg," who "deliberately incorporates exogenous components extending the self-regulatory control function of the organism in order to adapt it to new environments" (Clynes & Kline, 1960, p. 27). Drawing from Pustorvh et al. and Clynes and Kline, we regarded the adaptation of ourselves as analytically, practically, and ethically different from the adaptation of the environment (Döbler & Carbon, 2024).

Crucially, the latter is also understood as far more radical than Kirsh (1996) proposed. While Kirsh focused more on local and individual acts, we made the case that one of the most profound adaptations of the environment is the global technological exploitation of the earth's resources (Döbler & Carbon, 2024). Yet, we also pointed out how the survival of the human species is critically endangered by the devastating consequences of technology-driven ecological manipulation (Döbler & Carbon, 2024). Transhumanist Nick Bostrom (2002) saw planetary destruction as what he calls "existential risk" (p. 4), i.e., a condition that endangers humanity's persistence and

technologically induced posthumanization. Bostrom (2002) also discussed those risks as stemming from wrongly implemented emerging technologies, e.g., nanotechnology or genetic engineering. Still, he explicitly argued for the acceleration of developing methods to enhance our cognitive capacities to make these risks less likely (Bostrom, 2013a). As pointed out by us, bioconservative Francis Fukuyama, however, offered a slightly different perspective. In an amended afterword to his famous book "The End of History and the Last Man," Fukuyama (2006) cites several conditions that may hinder the systemic dominance of liberal democratic values and societies. Here, he puts particular emphasis on the destructive role of technology, both on an individual and planetary scale. Fukuyama argues that biotechnology and its "dehumanizing consequences" are an equal yet "more subtle" threat to liberal democracy than the climate crisis (p. 354). From this perspective, we encounter a continuum in which a too profound adaptation of either the environment or ourselves risks devastating consequences (Döbler & Carbon, 2024; see also Allenby & Sarewitz, 2011). It becomes evident that adapting *ourselves* may not only denote the functional mechanism of Human Enhancement but hints toward a source of concern (Döbler & Carbon, 2024). This is reflected in the ethical controversy surrounding the advocates' call for the universal improvement of *ourselves* as humanity (Hauskeller, 2013) and adversaries' worries about a collectively shared human nature (Pugh et al., 2016; Sharon, 2014).

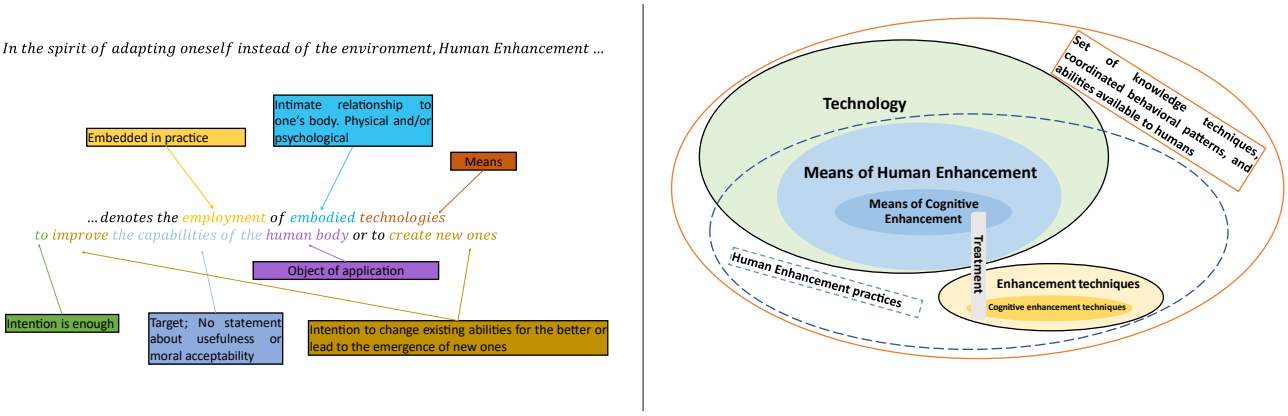


Figure 2. Definition and classification of Human Enhancement. Figures taken from Döbler and Carbon (2024, pp. 599/600)

To link the locus of intervention to the proposed function and to provide a link toward the established literature, we defined "Human Enhancement *as the employment of embodied technologies to improve the capabilities of the human body or to create new ones. An endeavor primarily conducted to adapt oneself instead of the environment*" (Döbler & Carbon, 2024, p. 598, original italics). Human Enhancement was capitalized to underline it as an overarching concept, while the employed technologies are called *enhancements* (Döbler & Carbon, 2024). The proposed definition allows for assessing various means and phenomena under one label while ensuring conceptual connectivity to the philosophical aspects of the debate and the general principle (Döbler & Carbon, 2024). For

example, it does not matter whether described as "non-medical use of prescription drugs for PNE [pharmacological neuroenhancement]" (Bagusat et al., 2018, p. 1) or "instrumental drug use" (Schleim, 2020, p. 2): all these phenomena aim at improving cognitive capabilities through an adaptation of ourselves and can be summarized under *cognitive enhancement*, which then is seen as a facet of Human Enhancement in general (Döbler & Carbon, 2024). At the same time, we can include yet extend beyond conceptions that focus more on external, temporarily embodied means (e.g., Clark, 2003). The following discussion will dissect this definition (*Figure 2*) and foster a better understanding of the phenomenon.

4.3. Practicing Human Enhancement

The identified central function of Human Enhancement highlights the commonness and partial acceptance of this practice (Döbler & Carbon, 2024). With few to no ethical worries, humans brush their teeth to prevent natural decay, drink coffee to boost their biologically rooted sleepiness, or wear clothes to enhance thermoregulation and appearance. This enumeration concurs with examples used by other authors to naturalize and historize enhancement efforts and subsequently focus on the ethically more worrisome biotechnological means (e.g., Buchanan, 2011; Greely, 2006). Conjoining with these authors, we highlighted how many human practices are already structured around means we identify as Human Enhancement (Döbler et al., 2024). Drawn from the literature, given examples vary in moral evaluation and comprise the use of drugs to enhance mood and cognition, vaccination, caffeine, artificial limbs, tools, Brain-Computer-Interfaces, clothes, genetic engineering, and many more (Döbler & Carbon, 2024). If we then submit ourselves to the postphenomenological position that used technologies exert a crucial influence on the encountered reality (Ihde, 2011b; Verbeek, 2005), we have good reasons to believe that the mediational effect of commonly practiced Human Enhancement, in all its different manifestations, exerts the same role (Döbler & Carbon, 2024). In this regard, Döbler and Carbon rejected concerns about the inevitable estranging and posthumanizing effect of specific, experience-mediating enhancements (e.g., Agar, 2014; Kass, 2003) and affirmed that the different existential modes and how we make sense of them are fundamentally channeled through the various technologies and enhancements we employ (see Clark, 2003; Coeckelbergh, 2013; Rosenberger & Verbeek, 2015). What and how we practice influences how we see ourselves (Ihde, 1979; Stetsenko & Arievitch, 2004). Hence, Human Enhancement as a practice is a constituent of our experienced reality, self-understanding, and way of living (Döbler & Carbon, 2024).

4.4. Embodied technologies

But what makes this practice of adapting ourselves possible? Trivially, the human body's biological tissue and physiological processes can be purposefully modified. We can cut open ourselves and install implants, take drugs, or inject vaccines. This denotes what we call "physiologically embodied" enhancements (Döbler & Carbon, 2024, p. 601). As further discussed by us, this leans toward Verbeek's (2008) *cyborg relations* and is linked to potential concerns regarding interventions threatening the integrity of the body (Döbler & Carbon, 2023; M. Haslam et al., 2021; Sattler & Pietralla, 2022; Scheske & Schnall, 2012). Since Human Enhancement may be commonly associated with invasive and visible technologies (Döbler & Carbon, 2021, 2023), related subsets of physiological embodied means may reflect the pop-cultural Cyborg.

However, the reality-shaping influence of technologies also applies to the less invasive *embodiment relations* in the sense of Ihde (1990). Here, Greely (2006) argued that the fact that some external aids are experienced *as if* being part of the user challenges any definitions that understand enhancement only in terms of biological invasiveness (see also Buchanan, 2011). Without mentioning postphenomenology, Greely thereby affirms Ihde's (1990) position that embodiment relations can create the temporal impression that the technology belongs to us. Explicitly concurring with Greely, we found an additional theoretical backbone in Andy Clark's (2003) concept of humans as "Natural-born cyborgs."[12] In his eponymous book, Clark (2003) reinterpreted the original conception of the Cyborg not as some futuristic fantasy but as the status quo: "it is our basic human *nature* to annex, exploit, and incorporate nonbiological stuff deep into our mental profiles" (p. 198, original italics). This concept, in line with cited evidence on the adaptation of the neuronal body representation in attunement to the spatial properties and functionality of the used technological means (e.g., Kieliba et al., 2021; Martel et al., 2016; Vignemont, 2011) are the foundation of what we called "psychological embodiment" (Döbler & Carbon, 2024, p. 595) Together with the physiologically embodied examples, psychologically embodied means define what we understand as "embodied technologies." (Döbler & Carbon, 2024, p. 596) Crucially, this characterization is meant as a broad sketch so that the two types are not mutually exclusive (Döbler & Carbon, 2024).

Building on back then unpublished research by De Preester, it was suggested that external means can only be considered as part of the sense-making cognitive system if 'transparently incorporated' into the pre-existing

[12] Although enactivist authors acknowledge the effort of Clark to highlight the embodied and somewhat enactive character of our cognition, they have criticized him for the primacy he grants to the brain over the body (Gallagher, 2017; Thompson & Stapleton, 2009). I am not about to discuss the underlying debate about the neural architecture of the mind and conceptual subtleties. Instead, references to Clark's theories and those propagated in the enactive tradition are meant to underline the shared emphasis on human activity and our cognitive processes in reciprocal relationship to the socio-material environment.

sensomotoric patterns used for environmental engagement (Thompson & Stapleton, 2009). Any so-achieved link between the dynamics of the biological body and formerly external technological devices then yields a sort of functional 'intimacy' (Thompson & Stapleton, 2009). However, the semantics of this claim counteract the proposition of Ihde (1990) about the impossibility of absolute phenomenological transparency of external tools: even if we wish for such absolute transparency, the embodied technology can never be eliminated from the relationship that brought forward our improved capabilities. In her published research, De Preester (2011) directly discussed what Ihde (1990, p. 75) calls "quasi-transparency" in this context. She argued that not every external tool could be similarly experienced *as if* being a part of ourselves. Her discussion about the distinction between what she understands as superficial bodily "extensions" (p. 121, e.g., cutlery) and deep bodily "incorporation" (p. 123, e.g., prostheses replacing absent limbs or senses) revolves around the normative malleability of the neuronal body representation, phenomenological experience of ownership and subsequently altered experiences (see Schmidl, 2022; Thompson & Stapleton, 2009). Yet, by claiming that only prostheses can be fully incorporated because of their 'completing' effect, De Preester employs a static and conservative human body model that can only be 'filled' but not modified.

Bell and Macuga (2022) have recently challenged the measurement and theoretical assumptions of the idea that external means directly interfere with the neurophysiological representation of the human body. Instead of the traditional view of a single neuronal model that is updated and "extended" by tool use (p. 343), Bell and Macuga (2022) proposed that tool usage does not modify an existing representation but *adds* a model of the tool properties to the standard sensorimotor representation of the body. Bell and Macuga do not mention prostheses and equate "incorporation" and "extension" directly in the title of their paper. Still, their arguments might dissolve the conflict seen by De Preester (2011). Instead of focusing on the malleability of the body representation, Bell and Macuga's arguments emphasize the flexibility of attuning the latter to the properties of external means. Thus, there would be no body model that can be prosthetically "filled up" but only flexibly amended. Hence, no fundamental distinction between extension and incorporation can be made. Vignemenont (2011) claimed that only ontogenetically grown limbs can be 'fully embodied,' so that no external means can completely mimic the "natural" way of sensomotoric coordination. Using this argument, we concluded that an *absolute* integration is not required to qualify means as embodied enhancement (Döbler & Carbon, 2024). Even though the embodied technology remains 'quasi-transparent,' it is still a "partial symbiosis of myself and the technology" (Ihde, 1990, p. 86) so that we fundamentally attribute the tools' capabilities and actions as belonging to ourselves (see also Clark, 2003).

Concerning external adaptations, following Bell and Macuga (2022) and viewing tools and technologies as add-ons may be conceptually more open to incorporating complex means in more diverse settings.

Although Bell and Macuga (2022) do not see them as necessarily supportive of their theory, the results of Miller et al. (2018) may be worth mentioning here. These suggest that tools can function as extending sensory interface because the human hand mechanoreceptors respond to the specific vibrational patterns that emerge when tools interact with the material environment. Moreover, Miller et al. report a temporal correlation between tool vibration onset and receptor activity. Suppose that the qualification of technology as enhancement builds on the agents' bodily capacities to integrate sensory input and the technologies' success in fostering an effective relationship between the agents' mental and physical state with the incoming environmental information (Clark, 2007). In that case, the results of Miller et al. are one additional explanation of how the physiological architecture of our dexterity organs provides the so-required openness to include information 'sensed' by the tool and thus create "new systemic wholes" (Clark, 2007, p. 271). The emerging relationship could be defined as Verbeek's (2008) *composite intentionality*. Even if Verbeek states that this type is especially relevant to the mentioned hermeneutic relation, the material-specific response of the tool relative to the properties of the environment in concert with the capabilities of the human user shows how the distinct world-access of the technology can give rise to an embodiment relation. If so, it is direct evidence of what Ihde (1990) formalized as 'sensing the world *through* technology' instead of hermeneutically "reading" it.

Additional scrutiny should be directed to external technologies designed to influence physiological processes (Döbler & Carbon, 2024). One given example by us in this context was transcranial direct current stimulation (tDCS), a technology that can enhance cognitive functions through cranial application of electric current (Narmashiri & Akbari, 2023). If those interventions are a form of Human Enhancement, how can we properly distinguish their effects from environmental influences?[13] After all, varying properties of our surroundings, including those created by deliberate manipulation, profoundly influence physiological and cognitive processes of the body (Myers & Patz, 2009; Wheeler & Clark, 2008) and are sometimes seen as enhancement as well (Agar,

[13] Agar (2014, p. 50) distinguishes methods for radical self-improvement as either "internalized" (profound physiological integration) or "externalized" enhancement (e.g., infrastructure). Agar accuses Clark's (2003) theory to trivialize this distinction. Indeed, Clark does not only focus on external tools but also on information technology that enables the global distribution and eventual incorporation of knowledge. Clark may be right from an analytic perspective, but not considering the phenomenological experience of integrating external means into what we consider ourselves, of the experience of immediate physical intrusion. For Agar, the latter is also fundamentally different because the internal/external distinction is constituted and maintained by a contingent value process that outweighs any philosophical fidelity. Emphasizing the distinction between adapting ourselves and adapting the environment, I use a physical and psychological experiential criterion for demarking the two kinds. Thus, my definition comprises means that Agar counts as externalized enhancement and denies the enhancement status for some examples Clark would argue for.

2014; Buchanan, 2011).[14] The solution to solely focus on phenomenological aspects, which demarcates mere environmental manipulation from embodiment relations, characterized by the ability to transparently *feel* through the artifact (Ihde, 1990), seems complicated, considering that tDCS may have an effect *after* its external application. Still, we could argue that these particular technologies must be applied very close to the individual body, are targeted at one particular human, and are thus much more specific and "personal" in their application than broad-scale adaptations of the environment (Döbler & Carbon, 2024). Subjective judgments on the extent to which an intervention is experienced to affect oneself in contrast to everybody else and directly influence individual action capabilities could further clarify which interventions qualify as Human Enhancement.

When physiologically embodying external means, adapting *ourselves* may be intuitively evident. Yet, to highlight the significance of psychological embodiment, we again relied on Clark and his claim that a profound alteration of ourselves does not necessitate invasive technologies. Instead, even the tools we use daily "have the power to transform our sense of self, of location, of embodiment, and of our own mental capacities. They impact who, what and where we are" (Clark, 2003, p. 198). Drawing upon this quote to see our capabilities as fundamentally identity-constituting, we concluded that our current understanding of ourselves is not inevitably threatened by what we identify as Human Enhancement but is deeply entangled with the diverse means used for that purpose (Döbler & Carbon, 2024).

Within the here summarized and partially extended notion of embodied technologies, we abandoned enhancement definitions that use the human skin as identificatory boundary (cf. Allhoff et al., 2010). Besides that, we argued that it is sound enough to address the related issue to identify the means that demand ethical scrutiny while avoiding a slippery slope argumentation where any positive alteration of ourselves qualifies as enhancement (Döbler & Carbon, 2024; see Bostrom & Roache, 2008; Bostrom & Savulescu, 2009). Hence, it is more applicable than accounts that only focus on the outcome while neglecting the means used (e.g., Daniels, 2000) or confine themselves to biotechnology (e.g., Buchanan, 2011). While the latter approach may be reasonable given the attributed potential for deep-cutting transformation and the redefinition of established terms (Sharon, 2014), our function-focused analysis of Human Enhancement discards the definitory overemphasis upon technologies that directly act upon molecular processes while also acknowledging that people hold strong opinions to means suspected to be more transformative (Döbler & Carbon, 2024). Moreover, our definition can separate practices

[14] Buchanan refers to these environmental alterations to argue that it is not only enhancement via biotechnology that can be controversial and highly effective. However, under my conceptualization, examples of Buchanan, like agriculture, do not qualify as Human Enhancement (Döbler & Carbon, 2024).

that primarily reside on mental or behavioral strategies (so-called "enhancement techniques" (Brunyé et al., 2020, p. 457) from those that are fundamentally structured around one enhancement, which is attributed as primarily contributing to any adaptation goal (Döbler & Carbon, 2024).[15] In summary, what qualifies embodied technologies as means for Human Enhancement is their operation in maximum proximity, with, on, and inside the human agent, so that they are considered part of our functional engagement with the world. The presence of the technology alongside the related phenomenological effects distinguishes this practice from other forms of adaptation.

4.5. Multistability

Postphenomenology strictly rejects that there is one "essential," i.e., single way to use a technology (Rosenberger & Verbeek, 2015). Instead, technologies are seen as characterized by "multistability" meaning "that they can be used for a variety of purposes (the 'multi'), but not for infinitely many (the 'stability')" (de Boer, 2023, p. 2267). We adopted this definition to highlight how many means humans encounter in their material environment can be used in an enhancement manner (Döbler & Carbon, 2024). Multistability further emphasizes the two-way relationship between use-inclining, normative contextualities, and the action possibilities of the technology (de Boer, 2023). This was exemplified by the variation in ethical evaluation, conditional on used means but in partial interaction with the intervention purpose, i.e., whether the technology is meant to enhance, treat, or prevent (Döbler & Carbon, 2024). Here, we further linked specific, "stable," and effective uses of the technology to individual capacities and prerequisites. Our examples concerned the individually different physiological responsiveness to cognitive enhancement drugs (Husain & Mehta, 2011) but also the general diversity within means possibly applicable for this purpose (Napoletano et al., 2020). In summary, multistability emphasizes how human creativity, material features, individual differences, and socio-material contextuality influence the way we modulate our abilities (Döbler & Carbon, 2024). Furthermore, it abandons the idea that there are "essentially" enhancing technologies and urges us to find a connecting functional principle between different means for Human Enhancement and define the capabilities of their users that make the enhancement purpose and effect possible.

4.6. The imagined enhancement

Our definition explicitly denied that employed means must yield outcomes radically beyond "normal" human expression to count as Human Enhancement. Moreover, we claimed that examining and defining Human Enhancement requires acknowledging its potential non-effectiveness (Döbler & Carbon, 2024). These thoughts

[15] Isolating single technologies and practices for scientific inquiry is possible, but should acknowledge the general context. Moreover, bodily techniques can have an experience-mediating effect (Secomandi, 2015).

were inspired by the noted ambiguity of different definitions about whether Human Enhancement comprises only interventions that "objectively" influence a human capacity for the better or whether the intention to do so is enough to describe the phenomenon (Döbler & Carbon, 2021, 2024).[16] We pointed out that positions that focus on factual, numerable effects alone automatically preclude technologies whose effects cannot be measured due to their non-existence (Döbler & Carbon, 2024). In other words, if I cannot identify a technology as Human Enhancement, I cannot use it as an example to argue against or for the latter. To close this gap, we stated that from an everyday perspective, the technology's "assumed functionality" (Wolff & Brand, 2013, p. 2) to achieve whatever we define as improvement is among the key motivational and identificatory factors for Human Enhancement (Döbler & Carbon, 2024).

Indeed, greater predicted transformations may incline willingness to use an enhancement due to its assumed effectiveness (Looby et al., 2015; Sattler et al., 2014). But if seen as too effective, moral acceptability of potentially unfair enhancement diminishes (Coveney et al., 2019; Fitz et al., 2014; Mihailov et al., 2021; cf. Williams & Steffel, 2014). Even if not considering radical alterations of our capabilities as morally wrong *per se*, empirical results show that *potential* alterations of traits considered integral to people's identity foster moral unease and reduce enhancement willingness (M. Haslam et al., 2021; Riis et al., 2008; K. Wagner et al., 2018). Thus, I recognize the ethical gravity of enhancements that *promise* significant transformations of aspects we currently value (see Agar, 2010, 2014; Wilson & Haslam, 2009). However, we should not fall for an all-too-static view of our capabilities. As a matter of incremental growth, the objective radicality of enhancement is conditional on a yet-to-be-determined and highly flexible population baseline that is also responsive to environmental and socio-material influences (Cassioli & Balconi, 2022). A distinction between "moderate," morally defensible enhancement that merely boosts our "abilities to levels *within or close to* what is currently possible for human beings" and the non-permissible and potentially human-identity-threatening "radical enhancement," i.e., boosting "to levels that *greatly exceed* what is currently possible for human beings." (Agar, 2014, p. 2, original italics) may be drawn for pragmatic reasons. Yet, such positions must always consider the implied statics and difficulties in determining the used level of reference (Bostrom & Roache, 2008; Gyngell & Selgelid, 2016). Moreover, some highly controversial means may only have

[16] E.g., "biomedical enhancement is a deliberate intervention, applying biomedical science, which aims to improve an existing capacity that most or all normal human beings typically have, or to create a new capacity, by acting directly on the body or brain." (Buchanan, 2011, p. 23) versus "Strictly speaking, 'human enhancement' includes any activity by which we improve our bodies, minds, or abilities—things we do to enhance our well-being." (Allhoff et al., 2010, p. 8). Even if Allhoff et al. imply both positions, the semantic difference becomes clear.

neglectable or similar effects than widely used practices (Caviola & Faber, 2015).[17] This supports the suggestion that individual and public discourse about controversial kinds of Human Enhancement does not necessarily orient to empirical facts but operates with "'enhancement imaginaries' – defined as collective sets of beliefs, shared understandings, and expectations about enhancement ... that circulate in policy, research, public discourse, and the media, are drawn on, reproduced, developed and/or dismissed by various publics" (Coveney et al., 2019, p. 321; see also Jasanoff & Kim, 2009). Since controversies about Human Enhancement are often raised before any tangible radical effect can be assessed, e.g., human genetic engineering (Jones, 2006), approaches which refer to the radicality of effects remain heuristic and must acknowledge that the *intention* to provoke radical transformation is enough for a regulatory decision.

Not commenting on this regulatory aspect, Döbler and Carbon (2024) cited evidence showing that people employ enhancement expectations that are not always congruent with actual empirical effects (e.g., Corazza et al., 2014; Maier et al., 2018). Moreover, even though the effects of drugs meant to enhance cognition are minor or non-existent (Roberts et al., 2020), people may experience the effects subjectively stronger than objectively justified (Ilieva et al., 2013) and thus misattribute enhancement effectivity (Döbler & Carbon, 2024). The action-guiding power of subjective beliefs is further exemplified by revealing that assumed enhancement effects and low average college grades can predict the intention to use non-prescribed cognitive enhancement drugs (Looby et al., 2015). Additionally, students who conducted nonmedical cognitive enhancement displayed higher expectations of the stimulants' effects than non-using peers (Holt & Looby, 2018). Similar results were shown among athletes who used supplements to improve athletic performance (Murofushi et al., 2024). Results of this study suggest that although knowing that the use of specific sports supplements may be illicit was negatively associated with their use, this effect was mediated by a positive association between this information, deliberately contemplating the use and the belief in the enhancing power of these substances.[18] Those who knew that the substances may be illicit and subsequently questioned their attitude to them were more prone to using them by being more optimistic regarding the expected performance boost (Murofushi et al., 2024). These results could suggest that people integrate framing information that specific behavior is illicit into their decision-making, as they justify the illicitness by the assumed effect.

[17] Given examples of the former comprise differences between pharmacological, e.g., Modafinil and non-pharmacological enhancement, e.g., Sleep. These examples do not generally meet the proposed definition of Human Enhancement. Still, the point made here concerns the effect of the intervention as a basis for moral judgments.

[18] The respective item was formulated in a way, that people who thought about starting to use supplements had to answer the same way as people who considered stopping the use.

Another study conducted a set of cognitive tests and then administered the same non-active ingredient substance to participants, framing it as either performance-weakening or improving. Results showed that although objective, post-intervention performance was not affected, subjects in the improvement condition predicted significantly higher subjective performance and reported more positive performance improvements than the weakening group (Winkler & Hermann, 2019). Creating a credible justification for believing that the substance will have an effect is not necessarily required. A study administering open-label placebos (explicitly disclosed as possessing no active ingredient) for cognitive enhancement showed no objective or self-assessed performance effects (Hartmann et al., 2023). However, a recent meta-analysis concerning affective outcomes like well-being and anxiety showed an open-label placebo effect on subjectively reported, but not objective physiological measures (Spille et al., 2023). Even when told that they were administered a placebo, people's experiences are still shaped by their engagement with technology. The previously mentioned power of unrealistic individual expectations (Döbler & Carbon, 2024) is best exemplified by the public reception of cognitive enhancement, in which people often employ an overly mechanistic understanding of the mind *as if* easily technologically improvable (Mihailov & Savulescu, 2018). People seem to want to believe that the means they use have magnificent effects. It is "magical thinking" adapted to technology's attributed reliable transforming power (Ihde, 2011a, p. 127).

Fernandez et al. (2022) recently argued for using behavioral economic models to investigate the decisive role of individual expected benefits, attention to risks, capability baseline, and social communication for cognitive enhancement use and evaluation. Highlighting the role of assumed capabilities, Human Enhancement may have an important yet empirically ambiguous influence on individual self-efficacy (Döbler & Carbon, 2024). Self-efficacy regarding academic skills did not vary significantly between real-life users of non-prescribed cognitive enhancement substances and non-users (Holt & Looby, 2018). As partially discussed elsewhere (Döbler et al., 2024), there is evidence for a negative link between educational or general self-efficacy and the intention for cognitive enhancement (Looby et al., 2015; van Veen et al., 2022) or actual pharmacological emotional enhancement (Maier et al., 2015). However, other studies failed to replicate this link (Bagusat et al., 2018). Moreover, no link could be found between objectively tested or subjectively reported intelligence and the willingness to use various methods for cognitive enhancement (Grinschgl et al., 2023), nor self-reported academic abilities and motivation for drug-based cognitive enhancement (Sattler et al., 2014). A combination of high-effect expectations and deficient objective performance measures like grades may outweigh any influence of self-efficacy (Looby et al., 2015). Still, high overcommitment at work, in combination with larger experienced occupational demands than gains, predicted factual

pharmacological cognitive enhancement and, thus, suggests the importance of personal evaluations in relation to a demanding setting (Sattler & Von Dem Knesebeck, 2022). Drawing from a representative sample of the German workforce and the *Job demands-resources* model, Baum et al. (2023) found only weak evidence for a direct positive/negative effect of demands or resources on the motivation to use prescription drugs without medical necessity for enhancing cognition. However, demands (e.g., weekly hours) and resources (e.g., working autonomously, emotional care) were reliably positively and negatively associated with the subjective pressure experienced, which then acted as a partial mediator on the willingness to engage with cognitive enhancement. Although ambiguous and complex, empirical evidence suggests a link between a demanding, stressful organizational environment and a more favorable attitude toward cognitive enhancement (Franke et al., 2013; Maier et al., 2015; cf. Sattler & Pietralla, 2022; cf. Schelle et al., 2015; Wiegel et al., 2016; Wolff et al., 2014; Wolff & Brand, 2013). This supports seeing drug use, e.g., for cognitive enhancement, as partially instrumentally motivated (Müller & Schumann, 2011; Schleim, 2020; Wolff & Brand, 2013). However, according to Mann (2023), focusing on these instrumental reasons alone risks neglecting the contextual conditions that render drug use a "functional response" (p. 71) attractive in the first place. The intricate relationships between factual improvement, expected effects, and disappointed performances with and without the enhancement may lead to evaluation processes whose outcomes must not necessarily match scientific reality (Döbler & Carbon, 2024).[19]

The need to evaluate the appropriateness of chosen behavior before conducting it creates the opening for all sorts of imaginary overcharge and reveals a fundamental ambiguity of Human Enhancement. The technologies' promised reliable transformation of ourselves manifests in awe-inspiring, largely optimistic but also pessimistic "technofantasies" about their impact (Ihde, 1990, 2011a, p. 131). Projected effects are reflected within individual enhancement decisions and influence the discursive role adversaries and advocates assign to this practice (Hauskeller, 2016; Ihde, 2011a; Sharon, 2014). Hence, we should ask what informs individual use and societal regulation: what we know or what we hope or fear to know in the future.

4.7. Effective adaptation of ourselves

Even if emphasizing the intention to enhance, we argued for the presence and importance of normative standards that govern whether the enhancement counts as "effective" and leaves somebody as "*being enhanced*" (Döbler &

[19] Consider the case of a German citizen with 217 self-reported and 130 confirmed vaccination shots against SARS-CoV-2. Although he referred to personal reasons for this enhancement conduct (Kocher et al., 2024), this may be an extreme example of how subjective factors can lead to Human Enhancement beyond the objective reasonable.

Carbon, 2024, p. 606, original italics). This mechanism requires understanding what Ihde (1990, p. 29) calls "microperception" and "macroperception." According to Ihde, the former describes what we commonly understand and directly experience as stemming from sensory input. Macroperception, on the other hand, is a "cultural-hermeneutic" (p. 30) backdrop against which bodily and technologically mediated perceptions are enframed and made sense of. We employed this thought to highlight the distinctiveness of evaluative frames that influence the perception of a supposedly adaptive intervention (Döbler & Carbon, 2024). Suppose we grant the present context a substantial role in determining the individual experienced success of the enhancement (Menuz et al., 2013). In that case, microperception allows us to understand how the *feeling* of the enhancement's effectivity emerges in relation to cultural variables (Döbler & Carbon, 2024). If we claim that external means can only properly enhance human abilities by establishing effective and controllable patterns of sensomotoric coordination (Clark, 2007), macroperception reminds us that enhancement evaluation cannot solely stem from individual experience alone but is embedded into contexts that establish the evaluative criteria of effectivity (Döbler & Carbon, 2024). In short, categories like "effectiveness" always relate to social contexts that, for example, provide quantitative reference frames to affirm individual perceptions at the macro-level of "objectiveness" (Schmidl, 2022). Drawing upon this thought, people's impression of the enhancement effects may diverge from socially established standards but are nonetheless constituted by it (Döbler & Carbon, 2024).

Humans are separated from their techno-social environment yet involved in all sorts of meaningful relations and interactions with it (Coeckelbergh, 2013). Here lies the potential and need to technologically adapt ourselves instead of the environment. Because we experience being distinct from the environment, using external means for adaptation is accompanied by the direct experience of "doing technology to us" (Döbler & Carbon, 2024, p. 621). Advocates and adversaries champion seeing humans and technology as strictly distinct ontological categories while affirming the latter's transformative potential (Sharon, 2014). If we locate this perspective on the macroperceptual sphere, we can understand how any individually, microperceptual experienced *technological intervention* with the body is possibly experienced as either a welcomed embellishment or human-nature threatening technological practice (see Sharon, 2014). Macro- and microperception are mutually dependent (Ihde, 1990). Hence, the meaning of the mediation emerges in relation to a cultural reference frame that desires or despises it (Ihde, 1990; for a rejection of some mediations, see Kass, 2003).

It was argued that the phenomenological experience of being present in the world and the experience of personal agency may be closely linked to the ability to realize behavioral intentions (Triberti & Riva, 2015). Linking this

perspective to the intention-shaping, boundary-dispelling, capacity-enhancing technologies (Clark, 2003; Malafouris, 2013) and the idea that humans consciously and pre-reflectively exploit behavioral possibilities to maximize the effectivity of situational engagement (Rietveld et al., 2018), we argued that technological adaptation of ourselves may be so tempting because it can foster a pathway to realize behavior that fits the individually and culturally adopted qualifications for effectivity (Döbler & Carbon, 2024). If an alignment between our perceived agentic abilities and the surroundings phenomenologically situates us within both (Triberti & Riva, 2015), effective technological adaptation influences not only the physical presence of humans but also how the same presence is experienced (Döbler & Carbon, 2024).

Based on their skills and socio-material background, humans will differ in evaluating which behavior in a given socio-material environment is most effective, but also how straightforwardly it can be realized (Ramstead et al., 2016; Rietveld et al., 2018). At the same time, the established ways to engage with a technology are written into everyday engagement with them and mutually dependent upon individual and social actions (Coeckelbergh, 2018), a principle we can easily extend to Human Enhancement (Döbler & Bartnik, 2022). By effectively realizing the several ways in which we can adapt ourselves instead of the environment, we are not only acting upon dynamic demands imposed by a dynamic environment but are also advancing the individual and cultural stabilization of behavioral patterns (Monterroza-Rios & Gutiérrez-Aguilar, 2022). Hence, the various means we use for adaptive Human Enhancement do not only shape the "rich landscape of affordances," i.e., what skilled humans in a given socio-material context are able to do (Rietveld & Kiverstein, 2014, p. 326) and the agents that navigate it (Döbler & Bartnik, 2022). The perceived current suitability of actions can be influenced by contingent occurrences or by actively changing the state of the environment (Rietveld et al., 2018). Yet, by changing our capabilities, technology can also influence what we are able to do and define the appropriateness of available behavior (Döbler & Bartnik, 2022).

Thus, the effectivity of environmental adaptations (Kirsh, 1996) or adaptations of ourselves are never orthogonal (Döbler & Carbon, 2024). Although Kirsh (1996) employed a different, more Darwinian understanding of organismic adaptation, he pointed out how tool-use, for instance, can bring forth new possibilities to ease adaptation of the environment. The dynamic engagement with the material world may result in creative, mind-shaping, technology-producing activities and practices (Malafouris, 2014) and the sustainable shaping of the environment to ease and improve cognitive and behavioral processes (Clark, 2013; Kirsh, 1996). Being used in engaging with this dynamic world, technologically mediating enhancement impacts the sensory input we rely on

to adjust our conceptualization of our world (Döbler & Carbon, 2024). Yet, as exemplified in the context of climate change or economic systems, novel demands that require technological adaptation of ourselves can also stem from past adaptations of the environment (Döbler & Carbon, 2024). One example of this may be the controversial proposition of Persson and Savulescu (2012) to use moral biotechnological enhancement to foster collaboration against climate change.

To further understand the link between individual action, criteria for effectiveness, valued states, and social organization, a previously undiscussed enactivistic understanding of how we adapt in general may be beneficial. This extends adaptation beyond the experienceable locus of intervention toward a more functional understanding. For organisms fundamentally "concerned" with their existence:

> *adaptivity* is the capability of an autonomous system to respond to tendencies in the trajectories of its states and its relations to the world, such that when these tendencies approach the boundary of its own viability the system modulates its coupling with the world in a way that tends to avert the crossing of this boundary. (Di Paolo, 2015, p. 55, original italics, see also Di Paolo 2005)

The henceforth adopted understanding of *adaptivity* as an *active* process acknowledges that organisms must evaluate action possibilities regarding their suitability for coping with current and projected demands and maintaining a valued state (Di Paolo, 2005, 2015). In the enactive tradition, this evaluation is tied to pre-reflective and conscious *sense-making* (Di Paolo, 2005; Thompson & Stapleton, 2009) and the effective use of the organism's behavioral and cognitive repertoires (Di Paolo, 2015). Perceived behavioral possibilities are informed by the socio-material mediated ways to engage with the environment and are inherently expectational (Ramstead et al., 2016). In a similar vein, human cognition and action can be seen as regulating allostatic metabolic energy use (Barrett et al., 2016; Pezzulo et al., 2024). Under this perspective, Human Enhancement is technologically realized adaptivity in the face of currently present or predicted demands.[20] This projective nature of adaptivity expressed in the statement quoted above also highlights the importance of subjective expectations, as discussed in Section 4.6. Evaluations and validation of success then influence the subsequent adoption of the enhancement as an effective behavioral strategy (Döbler & Carbon, 2024).

[20] Demands are usually understood to be imposed by the environment, i.e., everything external to the agent. However, we can also understand the internal state of the living agent as an environment (Irwin & Schulze-Makuch, 2020). The latter aspect highlights how organismic states can urge motivational demands that must be negotiated on more concrete levels of behavioral execution (Pezzulo et al., 2018).

But what about enhancement due to curiosity (e.g., Shakeel et al., 2021) or the transhumanist desire to radically extend human capabilities? Different reasons for enhancement still converge on using embodied technologies to manipulate *ourselves* in contrast to the possibility of manipulating the environment (Döbler et al., 2024). Such behavior may not be subjectively experienced as adaptation. Yet, integral to Human Enhancement is that the condition of the human body is intended to be altered and transferred into a more beneficial and desired one (Döbler & Carbon, 2024). Moreover, one of the key projects of transhumanism concerns the significant extension of our lifespan (e.g., Bostrom, 2005b, 2013b; de Grey, 2013; Humanity+, n.d.), which closes the circle to adaptivity as preventing crossing thresholds that threaten the existence of the respective organism in the sense of Di Paolo (2005).[21] The transhuman focus on life extension can be seen as a coping attempt to our 'human being-at-risk,' i.e., the fact that our physiological and psychological assets are constantly endangered by our relationships with the dynamic world (Coeckelbergh, 2013). According to Coeckelbergh, especially transhumanists view Human Enhancement as a potent strategy to cope with existence-threatening conditions. However, as further elaborated by him, this strategy does not abolish but only "transforms" (p. 15) the encountered risks and vulnerabilities so that each intervention creates novel multifaceted threats at different scales. Nevertheless, Coeckelbergh also emphasizes how the to-be-prevented states must not necessarily be of direct existential threat. Humans can and must adapt to benchmarks beyond those needed for immediate organismic survival, but are concerned with social relationships, values, or other assets (Maiese, 2022; Mojica, 2021). Thus, the influence of the social sphere is not confined to *how* we use specific technologies (Coeckelbergh, 2018; de Boer, 2023) but also pertains to decision-making *if* one feels the urgency to use them (Döbler & Carbon, 2024). This was briefly discussed for ideological dogmata in neoliberalism and capitalism (Döbler & Carbon, 2024) and will be elaborated in Section 7.4.1.

In summary, adaptivity is about preventing maladaptive, not-necessarily existentially threatening states (Di Paolo, 2005; Maiese, 2022) by operating with the projected effectiveness of actions and realizing an organism's behavioral repertoire (Di Paolo, 2015). Humans must adapt to maintain their state as living organisms (Di Paolo, 2005) and the socio-material systems they organize (Maiese, 2022). Agentic capabilities are inextricably linked to this endeavor (Virenque & Mossio, 2024), so that the entanglement of human agency and technology (Ihde, 1990) manifested into the technological adaptation of ourselves, i.e., Human Enhancement. The partial disentanglement from organismic concerns renders the question of what counts as objectively "effective" adaptation and how we should achieve it partially dependent on subjective judgments (Di Paolo, 2005). Residing in the tension between

[21] Only if not "uploading" human consciousness to a computer (see Hauskeller, 2013),

unconscious organismic processes and conscious planning, the ability for contingent cause-and-effect attribution creates the possibility for technologies to be seen as adaptive, even if the effectiveness of the technology is questioned, but also the potential misattribution of the latter as effective (Döbler & Carbon, 2024). In short, adapting ourselves in the context of Human Enhancement describes not only the location of intervention but also the exercised activity of creating or maintaining a valued state by technologically supported engagement with the normative socio-material environment.

4.8. Molding the self

What necessitates this activity? One simple answer: care. First, we care about the different layers of adopted self-understandings in many ways (Neisser, 1988). Second, adaptivity is required due to the endangered and cared-for future of *the* organism (Di Paolo, 2005). Here, Clark (2003) countered the prevalent view of an essential self by championing what he calls "'soft-self'" (p. 138). He understands our self as an assembled protagonistic psychological structure, informed by cultural, technological, and physiological input, which is constantly reminded of itself by the exercise of bodily action. Clark then elaborates on the malleability and resilience of this concept and its potential to integrate profound technological alterations of related capabilities into our individual and cultural self-understanding. From his perspective, no formerly external, now internal technology can posthumanizingly disrupt our identity (Clark, 2003). Concurring with Clark's soft-self and the importance of our abilities for our self-understanding, we simultaneously acknowledged that evaluation, whether the latter were significantly enhanced, is tied to dynamic and aggregated base levels, influenced by previous enhancements (Cassioli & Balconi, 2022). Hence, we argued that even if conducted widespread and regularly, Human Enhancement is not as automatically identity-threatening as adversaries suggest (Döbler & Carbon, 2024). This conclusion was also built on the postphenomenological premise of technological-experience-mediation, including the ones we have of ourselves (Rosenberger & Verbeek, 2015). Yet, as elaborated in Section 11, this may apply to the past but not necessarily the future. Nonetheless, even if not dissolving our sense of being human, Human Enhancement can deeply impact how we see ourselves and other social agents (Döbler & Carbon, 2024).

Crucially, the enhancement's impact on ourselves manifests partially independent of direct accessibility. A conscious agent is not required to immediately experience the physiological and cognitive processes that give rise to their consciousness (Clark, 2019). Even if individual histories yield differences in the appeal of behavioral options (Dings, 2021), humans can consciously influence the degree to which their behavior is more or less steered by environmental features (Dings, 2018). Elicited bodily responses then inform us about the meaning of our

perceptions and actions (Clark, 2019) and may appear in the form of directly experienced phenomenological states (Dings, 2018). We employed this line of reasoning to showcase how conscious technological alteration of ourselves as an established practice can deeply intersect with our basic cognitive processes while also presenting itself as a viable solution to cope with demands (Döbler & Carbon, 2024). The technological adaptations of ourselves we employ so "mindlessly" can still profoundly impact how we make sense of our existence. Respective results may modulate the appeal of further adaptations. Thus, by becoming deeply integrated into our competent engagement with the world, external technologies substantially influence what constitutes the consciously available social and agentic layer of our self, even without us being aware of this direct influence (Clark, 2003). Experiencing the changed capacities in action, we inform ourselves about what we, as conscious beings, are capable of (Clark, 2003).

Far from being an abstract consideration, close interaction with external means can evoke sustaining structural changes within the brain and body (Thompson & Stapleton, 2009). Apart from the classic examples like tools, as also discussed by Clark (see also Iriki & Taoka, 2012; Quallo et al., 2009; Yoo et al., 2013), this includes neurophysiological changes due to the use of cognitive enhancement drugs (Becker et al., 2022), or, more trivially, potential cellular alterations due to genetic engineering (Xiao et al., 2021). In terms of the conscious self, there are situational and individual parameters that render the appeal of enhancement drugs more tempting so that they appear more (non-)suitable for *me* (e.g., Elliott, 2011; Fernandez et al., 2022; Mann, 2023). If used, the chance for capability improvement has an idiosyncratic component directly related to the drug's features (Husain & Mehta, 2011). But this physiological understanding of myself does not inevitably map to the culturally shared ways we approach ourselves. Hence, in Döbler and Carbon (2024), we pointed out how the transformative effect of the old and new enhancements may be negotiated through available established or emerging narrative strategies, which can constrict the potential of radical changes within one's identity (Iftode et al., 2024). Being the product of a network of producing and distributing socio-material processes, alterations by Human Enhancement should be interpreted in terms of so-called "metaplasticity." Malafouris (2013) uses this term to acknowledge how socio-cultural practices and their specific ways of engagement with the material environment mediate *individual* neuronal changes in our cognitive organization. Metaplasticity showcases how any adaptation, either of the environment or ourselves, indirectly influences the other components that were not the direct target of alteration (Gallagher, 2017) and highlights how a tool-use enabling ecological niche is solidified and iteratively expanded (Iriki & Taoka, 2012). Thus, *my* technologically mediated conduct always relates to what enabled its realization. The extent to which

technological adaptation of ourselves is seen as an appropriate solution depends on our physiological and cognitive condition, relation to the world, and Human Enhancement as an established practice (Döbler & Bartnik, 2022).

In summary, profound technological transformation concerning the capacities I consider to belong to myself is Human Enhancement's key selling point. Here, any technological adaptation can impact ourselves in various ways: *our* level of organismic integrity, neuronal mapping, genotype, and the narratives *we* weave around these features (Döbler & Carbon, 2024). This contributes to the general dynamics of our being but also leads to recognizing the critical role of *ourselves* as valued asset (Coeckelbergh, 2013; Döbler & Carbon, 2024; Neisser, 1988) — A position transcending the individual self, up to the point where advocates or adversaries care about the potential impact of Human Enhancement on *ourselves as humans* (e.g., Agar, 2010; Bostrom, 2013b; cf. Hauskeller, 2013; cf. Pugh et al., 2016). Hence, what is beneficial at one level is not necessarily deemed effective on the other and may even be seen as a serious threat to ourselves in both understandings.

4.9. An ethical leap

Like all functional approaches (see Gyngell & Selgelid, 2016), our conceptualization did not strictly differentiate between treatment and enhancement but stated that therapeutic inventions qualify as either Human Enhancement or closely associated conducts (Döbler & Carbon, 2024). We argued in such a way because therapeutic practices are meant to change the organismic state of the individual for the better and may do so using embodied technologies. In agreement with Gyngell and Selgelid's (2016) understanding, we cited arguments on the evident difficulties to identify an individual and universally applicable "healthy" state of reference whose restoration would constitute a treatment (e.g., Bostrom & Roache, 2008; Menuz et al., 2013). Seen that way, it becomes clear how the thresholds that gear how we exercise our adaptivity can be physiological and social (Di Paolo, 2005). Even though the meaning of therapeutical technological adaptations is linked to social categories like health and disease, they are still an adaptation of ourselves.

To make the thoughts proposed in Döbler and Carbon (2024) eligible for ethical purposes, we oriented ourselves to the work of Verbeek and his claim that moral agency can be understood as constituted within the relationship between artifacts and human users (Verbeek, 2011, 2014). This highlights the need to include contemplation on the action and perception mediating influence of technology within any ethical inquiry concerning the latter (Verbeek, 2011). Crucial to this type of inquiry is a comprehensive picture that captures all types of transformation, whether subtle, radical, or just imagined (Döbler & Carbon, 2024). Seeing Human Enhancement as the adaptation of ourselves underlines Verbeek's (2011, 2014) arguments that even though moral agency is a shared quality that

softens traditional lines between material things and humans, taking over and acting *morally responsibly* requires us to understand how technologies mediate our agency in the most profound ways (Döbler & Carbon, 2024). Following Verbeek, we can assess how enhancements impacted the relevant conduct of the agent whose social situatedness allows direct praise and punishment by others. This is the consequential application of the idea "that one's moral actions and decisions are technologically mediated without giving up the possibility to take responsibility for these actions and decisions" (Verbeek, 2014, p. 85). If the existence of humans as morally relevant and capable subjects also results from technological mediation (Verbeek, 2011), then adaptation of ourselves highlights how *we* must bear the consequences for *our* behavior because their cause is attributed to us as enhanced and acting beings. Either the effects of the enhancement are mixed with our abilities so that *we* are seen as responsible for an outcome, or moral reservations shift evaluation so that *we* are held responsible for using illicit means that fundamentally affect *our* abilities (Mihailov et al., 2021).

4.10. Conclusion

The omnipresence and relative size of environmental manipulations like roads or dams should not distract us from the fact that adapting ourselves instead of the environment is an integral and historical part of our species' contingent cultural and technological development (Döbler & Carbon, 2024). If we then affirm that technological interventions and tools of all kinds can exert a significant and lasting influence upon ourselves as individuals and humanity in general (Clark, 2003; Coeckelbergh, 2013; Sharon, 2014), Human Enhancement identifies us as *Homo faber* (Döbler & Carbon, 2024) — an understanding that emphasizes the reciprocal transformative relationship between material objects and their producing humans (Ihde & Malafouris, 2019).

Nonetheless, specific enhancements can be controversial. Here, the availability of the technology alone forces us to make critical choices about which role we want to concede to embodied technologies (Ihde, 1990; Verbeek, 2005). Interested in addressing this issue, we should be attentive to the convincing role of individual beliefs, imagined effects, and valued states of ourselves — variables that heavily invest in the technological manifestation of our general adaptivity. Yet, we should not forget that adaptation of ourselves may also be an existential question whose conditions for success transcend subjective evolution and reservations. Having proven its contextual effectiveness, Human Enhancement is something we have done, do, and are very likely to keep doing. In that sense, Human Enhancement denotes the strategic exploitation of the material environment in a way that not only aims to improve a specific condition but also entails the possibility of changing the relationships that have brought forward the behavior in the first place (Döbler & Carbon, 2024). By fostering effective engagement with a

demanding world while also mediating our experience, Human Enhancement can subtly or openly shape what it means to be ourselves as individuals and ourselves as humans (Döbler & Carbon, 2024). The question, relentlessly discussed by advocates and adversaries, is now whether this may ever bring the seemingly self-evident experience of being human – a particular relationship to ourselves – to an end.

4.11. Intermezzo

The preceding discussion is my theoretical inquiry into Human Enhancement. While I gave and will give concrete examples, my discussion of this phenomenon is often abstract. Different enhancements vary in ethical and practical impact (Döbler & Carbon, 2024). Yet, within the ethical assessment of technology, we should not create redundant and overly specific frameworks but situate a technological phenomenon as precisely as possible within existing approaches (Sætra & Danaher, 2022). If linking ethical and functional aspects, the endeavor spans multiple technologies and becomes increasingly abstract, but still relates to the general concept of Human Enhancement.

Although work upon my definition partially overlapped with the publications that build the corpus of this publication-based dissertation (Sections 6, 7, and 9), the following thoughts and propositions should be read as directly building upon the discussed core of Human Enhancement as using embodied technologies to adapt ourselves instead of the environment to achieve tangible improvement. The three publications will examine controversial examples of this practice from different perspectives. The first highlights adapting to an environment entailing a biological threat to our physical health (Döbler & Carbon, 2023), while the second and third emphasize how the environmental aspects to which we seek to adapt can also reside in the social realm (Döbler et al., 2024; Döbler & Carbon, 2025). The third paper will also examine adapting the environment by adapting ourselves.

These publications directly result from external contingencies that created research opportunities to apply my theory within concrete scenarios. Due to their empirical and more practical nature, elaborating on my theoretical thoughts on the possibility of the posthuman was partially neglected. Still committed to what is considered one of the most important aspects of the Human Enhancement debate, the following sections will not only consist of a reflection on my published work but will also apply these thoughts to those questions that have fallen short.

5. What is the purpose of the Human?

The fact that it concerns a *human* is inherent to *Human* Enhancement and contributes to its controversies (Döbler & Carbon, 2024). This is also because the overall debate may question traditional understandings of the term (Sharon, 2014), but also due to the declared goal of positively and universally impacting our *conditio humana* by

single interventions (Hauskeller, 2013). But what is the purpose of using a concept like *human* or *human nature*? Of giving it so much leverage, not only in the Human Enhancement debate but also in our everyday interactions? One answer might be that conceptualizations of ourselves as a species and our alleged nature are needed "not in order to learn what we are, but in order to make sense of it" (Hauskeller, 2009, p. 109).[22] This sense-making purpose is accompanied by a constant conceptual adaptation of the term's meaning in different contexts (Hauskeller, 2016). Examining how different understandings of ourselves are produced, disseminated, enacted, and changed by our technological activity can elucidate whether Human Enhancement can yield the irretrievable loss of whatever makes us human.

5.1. Making sense of who we are

Humans are segregated from their environment, yet in perpetual engagement with its features (Coeckelbergh, 2013). As living beings vulnerable to various conditions and demands, we must exercise our agentic capacities to adaptively negotiate our relationship with the other agents and the environment (Virenque & Mossio, 2024). Key to doing so is the aforementioned organismic sense-making, i.e., the "automatic" labeling and valuing of incoming sensomotoric information created by interacting with the external environment (Thompson & Stapleton, 2009). For humans, this rather biological approach is enriched by what Coeckelbergh (2013) calls "existential vulnerability" (p. 2): the fact that various environmental contingencies potentially endanger all sorts of valued physiological, psychological, and socio-material assets. According to Coeckelbergh, this emerges from the fundamental relatedness of our conscious sense-making so that the respective vulnerabilities stem from a particular relationship we have formed with the world. Since we are required to make distinctions and arrange information hierarchically, this condition seems inevitable: "we are condemned to relate to others and to the world, and we are condemned to value" (Coeckelbergh, 2013, p. 130). This manifests in reflexively making sense of the world so that we choose the adequate actions and means for achieving projected goals (Bandura, 2006). However, apart from tasks like finding appropriate food sources, sense-making requires a conception of us as acting beings. Without a regulatory, autonomous point of reference, making sense of the world and engaging with the material environment in a way that maintains *our* structural integrity and allows for effective coordination of *our* behavior is impossible (Thompson & Stapleton, 2009). Moreover, the world we need to make sense of is populated by other agents and

[22] Hauskeller used his 2009 essay nearly unchanged as chapter 3 of his 2016 book, which deals with transhumanism's mythological aspects and Human Enhancement. This section underscores his basic premise and revisits its central arguments using a wide range of empirical evidence. See also Fahrenberg (2003/2011).

their contingent behavior (Virenque & Mossio, 2024). Here, a repertoire of general, group- or species-related knowledge may be beneficial for understanding (Epley et al., 2007). We need to make sense of ourselves and the world to evaluate how actions impact what we value. This also pertains to an identity that transcends the individual and concerns the species concept with which we commonly identify (Hauskeller, 2009). In other words, we need to make sense of ourselves as individuals and as humans.

5.2. Ecce homo!

There are myriads of approaches to understanding the human condition (for overviews, see Fahrenberg, 2003/2011; Fernández-Armesto, 2004/2005). All these variations converge on the attempt to grasp the meta concept, *to which* we as individual agents relate, the properties that transcend the individual. The sheer number of approaches suggests an agreement on the existence and need for a comprehensive conceptualization of ourselves, but also a failure to reach a consensus about its precise content. Hauskeller (2013) emphasized that the meaning of "human" is contingent upon the contemporary understanding of those who adopt, share, and enact this label in the spirit of self-definition. In the sense proposed by Hauskeller, a specific conception is aimed at capturing central aspects of our existence and demark those not human and those who are "*truly* human" (Hauskeller, 2009, p. 103 original italics; see also Nolan & Branscombe, 2008).[23] The symbolic separating function is similar to social identification strategies exploited by various species (Moffett, 2013). However, drawing such sharp and definitive lines is hard, if not impossible (Fernández-Armesto, 2004/2005; Hauskeller, 2009). Furthermore, while Fernández-Armesto (2004/2005) highlights the historical revisions of human identity, Praet (2014) argued that even now, identifying our peers as other humans may not be as common as it might seem. We shall not fall into the trap of viewing our self-understanding as sacrosanct because *we* appear so self-evident or well-known to *us* (Ihde, 1979; Praet, 2014). But could it really be that our species membership is "a temporary condition subject to revision, not an eternal and inevitable fate" (Fernández-Armesto, 2004/2005, p. 4)? Could it really be that our the blueprint we use to make sense of this fundamental part of our identity is changed by Human Enhancement (Buchanan, 2011)? Given the apparent controversies, a close examination of the Human may be appropriate.

When I speak about *the Human,* it is meant to capture one particular self-understanding meant to convey what it *means* to be a "true" member of a group identified as human (see Fahrenberg, 2003/2011; Hauskeller, 2009; Praet, 2014). In German, this may be best described as having one specific "Menschenbild*"* ("image of the human")

[23] Hauskeller discusses these terms as related to our human nature. However, his thoughts are equally applicable to understandings of ourselves that employ a less naturalness-clinging term.

(Fahrenberg, 2003/2011). However, this term does not sufficiently emphasize the immediate identification and phenomenological affirmation of *being* human. Approaches to the Human differ regarding the selection and value of the referenced identity-constituting features (Fahrenberg, 2003/2011; Hauskeller, 2009; Wilson, 2014; Wilson & Haslam, 2009). I call this a selection of *semantics*. The Human is seen as constituted by evaluating information obtained by conscious reflection about our being and the reflexive attempt to integrate semantic information from various sources, including everyday perception and pre-reflective engagement with the environment. These constructive mechanisms create explicit and implicit semantics, which differ regarding conscious accessibility (Fahrenberg, 2003/2011). Generally, these semantics denote any information about ourselves, but only a few are integrated into one conception of the Human. Those employed within one version of Human are intended to be exhaustive for the meaning and demarcation of our "true" being and, thus, not necessarily meant to capture every possible phenotypical variation (see Hauskeller, 2009). This gives approaches a structure in which semantics are arranged concerning their importance (Fahrenberg, 2003/2011). Since the sense-making process operates with the valuation of information (Thompson & Stapleton, 2009), the selectivity and hermeneutic function of related definitions are emphasized (Hauskeller, 2009). Valuation of semantics reflects the general valuation of ourselves as individual Human or ourselves as Humanity. From a developmental perspective, the Human also entails information about the process and potential to acquire or be attributed relevant semantics (see Praet, 2014; Wilson, 2014). Moreover, used semantics can also inform about conditions that entail losing one's humanness (see N. Haslam, 2006; Praet, 2014).

Understood as part of our self-concept, or statement about ourselves, the Human is identificatory (Fahrenberg, 2003/2011; Hauskeller, 2009, 2013). Here, the Human occupies a foundational role within the self (Nolan & Branscombe, 2008). If I identify with the former, my self, informed by all sorts of group memberships and identity-relevant information, is always a "human self" (Nolan & Branscombe, 2008, p. 201). However, not identifying as Human does not inevitably dissolve my structural self (Hauskeller, 2013).[24] Moreover, there are two inseparably connected levels of identification: one is the general identification with the concept itself ('I am a human'), and the second is the more finetuned affirmation of a specific descriptive or explanatory approach, for instance, 'this means that I have an immutable essence' or 'this is because I have DNA that is labeled human' (see Fahrenberg, 2003/2011; Hauskeller, 2009; Wilson & Haslam, 2012). Any self-identification as being human presupposes self-

[24] Hauskeller seems to understand this as identification in principle or identification with narrative content. The self as a psychological structure is not tied to being human, yet if considering myself as not human anymore, I have undergone a narrative change (see Wilson, 2014)

recognition, an ability that for children of our species is reliably present at around 24 months of age (Rochat et al., 2012). Indicating a basic understanding of being human, children aged 6 to 9 largely denied the possibility of overtaking the identity of pet animals (Guardo & Bohan, 1971). In the same study, older children were more likely to justify their statements with direct reference to features of a generalized human identity, e.g., being able to speak. Any individual that is identified and identifies under one of these conceptualizations can be considered a human (see Hauskeller, 2013). The former aspects highlight how applying Human semantics to other individuals is possible, even if they do not share them. If concluding that being human is constituted by having specific DNA, this approach extends to other beings, even if they do not know about the existence of DNA.

The Human is a special case of identifying with what Sani et al. (2008) called "perceived collective continuity" (p. 160). Usually applied along the boundaries of religion, ethnicity, or nationality, Sani et al. (2008) use this term to describe that people view particular social groups with changing members as time-persisting. Here, the label "human" maximizes the magnitude of individuals eligible for group membership (Nolan & Branscombe, 2008).[25] According to Sani et al., any perceived group-continuity is twofold and consists of what they call "perceived *historical* continuity" (p. 161, original italics), whose aspects are conserved in a meaningful narrative that causally and coherently stitches the group's past and future together. The other aspect is the so-called "perceived *cultural* continuity" (p. 160, original italics), i.e., the perception that one's in-group is characterized by "deep, essential contents (traits, inclinations, beliefs, values, and so forth) that are relatively unchanging" (Sani et al., 2008, p. 165). The individual "self-continuity" (personal integrity as the same being over time) is characterized by similar dimensions (Sani et al., 2008). This personal level refers to what is commonly called "narrative identity," i.e., a coherently and meaningfully crafted structure that links personally made and socially conveyed valued experiences, norms, and beliefs (McAdams, 2001; McAdams & McLean, 2013; Wilson, 2014). Since this psychological structure ensures the individual continuity of chosen aspects as part of ourselves, its processes are critical for assessing whether enhancements can yield a continuity-breaking loss of identity (Wilson, 2014). Noteworthy, affirming, and conjoining individual and collective continuities are associated with favorable mental and physical health measures (Fivush et al., 2008; Sani et al., 2008; Sedikides et al., 2023). This emphasizes the double connotation of ourselves *as individuals* and ourselves *as humans* (see Pugh et al., 2016) and the benefits that stem from adopting this identity.

[25] Nolan and Branscombe discuss to which extent member-restricted social identities can influence the adoption of the "human self" (p. 201). Doing so, they seem to imply, but not explicitly make the case for the human self as form of a perceived collective continuity. Instead, they seem to take identification with the human self as given, yet possibly modulated in importance.

Individual self-continuity requires a reliable autobiographical memory that links past information as belonging or experienced by the same agent (Agar, 2014; Sedikides et al., 2023). Concerning collective continuity, the same information-preserving function can manifest in family-related transgenerational narratives, which allow for the effective integration and sense-making of one's own experiences (Fivush et al., 2008). This effect inspired a recent investigation into the impact of having migrant parents. Participants made sense of their individual and family stories by linking them to general narratives of collectively shared historical immigration experiences (Haraldsson & McLean, 2022). Similar strategies were also observed in the American LGBTQ+ community (Weststrate, 2021). Identifying with the previously mentioned historical continuity is vital for propagating that contemporary actions will benefit future group members (Reicher, 2008). Research on self-continuity and constituting mechanisms was pointed out to be important for the Human Enhancement debate, where adversaries and advocates deem the continuity of individuals (Agar, 2014; DeGrazia, 2005; Wilson, 2014) or humanity as a whole (Agar, 2014; cf. Buchanan, 2011; cf. Pugh et al., 2016) is seen at stake.

Linked to the sense-making function, different conceptualizations of the Human function as *prescriptions*, or "miniature utopias," meant to fixate "what it means to be a *good* human" and therefore enact a "mythological" function to steer our lives into a desired direction (Hauskeller, 2009, pp. 105/106, original italics).[26] Employed in the Human Enhancement debate, this entails the open call to enhance ourselves to ensure 'true humanness' (Hauskeller, 2013, 2016). The normative functionality of the Human also becomes evident in the anthropological studies of Praet (2014). Praet introduces the notion of a "restricted" yet conceptually "open" understanding of what he calls "Humanity" (2014, p. 21).[27] Contrary to the classical Western idea of humanity (lowercase h), where someone 'effortlessly' becomes a member at birth, Praet argues that being a member of Humanity requires individuals to "*keep in shape*" (2014, p. 24, original italics). According to Praet, Humanity means that individuals only identify the members of their cultural group as Human. Praet shows that many indigenous cultures conflate community membership with being a "true" human. In some of these communities, even newborns are subjected to the normative expectations of Humanity and are not considered fully human until able to meet them. Hence, membership in Humanity is not tied to visual similarity or biological kinship but to following a particular way of living. Praet focuses on the *Chachi* people, residents of modern Ecuador. Within this community, members of the

[26] E.g., the definition of national identity as a historically enduring (Reicher, 2008). See also Fernández-Armesto (2004/2005)
[27] For terminological consistency and to highlight the individual human as the target for Human Enhancement, I use Human and capitalize it similarly to Praet (2014) to underline the conceptual nature of this term. He also uses Human for members of Humanity.

species *Homo sapiens* are only considered to be *Chachi* (literally translated as "true humans") if they speak their language, adhere to the local ways of living, moral norms, and show skillful behavior. Individuals who fail to meet these demands are seen as non-Humans and are sometimes described with appalling qualities that are the opposite of how *Chachi* live (e.g., *Chachi* are peace-minded, non-*Chachi* are belligerent, *Chachi* do not eat human flesh, non-*Chachi* do). Although *prima facie* highly exclusive, Praet shows that across communities, outsiders following the respective ways of living can be integrated and qualify as proper human beings (cf. Gil-White, 2001). Praet summarizes: "Humanity is never guaranteed but has to be achieved perpetually; it is forever in the making" (2014, p. 27).

We should not ridicule Praet's ethnographic evidence as local phenomena of "primitive" tribes. Historically, European cultures have also employed a semi-permeable practice-based understanding of humanness (Fernández-Armesto, 2004/2005). Moreover, recent empirical evidence within a Western context has shown that the ascription of being a "true" human is contingent on whether the evaluated being enacts values and behaviors indicative of this group (Phillips, 2022, 2023). Phillips (2022) showed that although explicitly framed as *Homo sapiens,* people who drastically violate social norms are seen as less "true" human compared to those displaying morally benevolent behavior. Additional findings suggest that it is not only moral conduct but also emotional abilities that qualify the ascription of this category. The same study also found that participants' understanding of "true" humanness extends to biologically non-human beings. Hypothetical extraterrestrials who exercise morally desired behavior were seen as being "truer" humans than *Homo sapiens* who violated moral norms. Phillips (2023) also revealed that morally flawed individuals were rated as "truer" humans than "ideal" humans who were "morally infallible" (p. 2). However, instead of excusing bad conduct, moral imperfection had to be qualified. In the same publication, participants rated individuals presented as having an "evil" character as less "true" human and less favorable than those beings described as morally flawless or morally flawed but dedicated to acting as right as possible. In the same study, people were more prone to hypothetically harm social groups whose members count neither as "ideal" nor "true" humans. The effects on favorable fallibility are mirrored by the finding that if confronted with alleged personality shortcomings of their in-group compared to their out-group, participants were more likely to rate flaws as indicative of human nature and thus justified as 'just being human' (Koval et al., 2012). These results support the idea of Hauskeller (2009) that aspects of the Human can transcend biology and are linked to specific normative conduct and the identification of the veracity of human identity.

Apart from the guiding aspects of specific conceptualizations, the *fundamental* normativity of the Human is strikingly evident, considering that the rare self-identification of persons as animals (often wolves) is treated as a clinical phenomenon called "Lycanthropy" (Connors et al., 2014).[28] While there is some accepted disagreement about which semantics identify the Human, not accepting the basic premise of being human may justify the involuntary commitment to a mental health facility. However, suppose that those beings that the *Chachi* do not consider part of their group affirm this categorization. In this case, mental pathology may be ascribed from a psychiatric point of view, but not from the perspective of the *Chachi*. This highlights how humanness is an individual and intersubjective culturally influenced identity (Bastian & Crimston, 2014; Fahrenberg, 2003/2011).

For other authors or laypersons, the Human may appear synonymous with the term *human nature,* potentially understood as a collection of commonly shared "natural" or biological traits that draw a line between us and animals (Buchanan, 2011; Fernández-Armesto, 2004/2005; for a conceptual introduction, see Lewens, 2012). Yet, by emphasizing the "natural" aspect, proponents of this concept not only introduce a steady element but also imply a boundary between what is considered natural and cultural (Coeckelbergh, 2013). Hence, in his analysis of human vulnerability, Coeckelbergh (2013) favored *human being* instead. According to him, the latter is more open to include the perpetual existential sociocultural influences exercised by technology, including Human Enhancement. He further argues that analyzing our human being is less concerned with a particular essence ('What are we?') but focuses on the mode of being ('How are we?'). Like other authors (e.g., Clark, 2003; Fernández-Armesto, 2004/2005; Hauskeller, 2009, 2016), Coeckelbergh therefore underscores the dynamicity of our being. I have used and will use my notion of the Humans in a way meant to include any other account of human nature, regardless of its specific content. When authors speak about human nature in whatever way, they simply evoke a specific version of the Human under the logic employed here. My point is not to detach humans from nature or resolve any boundaries. One can still understand the Human in purely nature-based categories. Yet, concurring with Hauskeller (2009), I emphasize that understanding ourselves does not occur within a mythical garden where every relation is fixed but is constantly negotiated and re-interpreted. By understanding the Human as being interwoven with our activity rather than an immovable essentialistic starting point that determines our activity, the *how* links to the *what* (see Ihde, 1979; Stetsenko & Arievitch, 2004).

In general, the Human is open in the sense that we can form a notion about it. Closed as it functions as an excluding concept, but also incomplete and malleable because we can always attempt to discover novel aspects,

[28] I owe this argument to Thomas Kollmann.

which may necessitate a revision of previous positions and re-drawing of demarcation lines. Openness can also be understood in terms of *becoming human*, i.e., that individuals can earn access to this group by correctly exercising the qualifying behavior (Praet, 2014). This suggests a performative understanding of the Human, which may vary across conceptualizations. Historically, this manifests in the assertion that those deemed "uncivilized" could become human, but those who reject the necessary rules of society are more akin to wild animals (Fernández-Armesto, 2004/2005). This contingency highlights the idea of Hauskeller (2009) that when contemplating what we are, we should not search for a definitive answer but highlight how related notions of the Human are produced and eventually used. Here, the strategic re-evaluation of the Human-constituting semantics may be attractive because behavior and moral expectations are easily influenced by the affective appeal of this label (Hauskeller, 2009). This function requires flexibility but is potentially concealed by the rigidness semantics posited as "natural."[29]

5.3. The essentialistic Human

In the Human Enhancement debate, the notion that humans possess some invaluable, "natural" essence (e.g., Fukuyama, 2004) threatened by technology is one pertinent version of the Human (Buchanan, 2009; Lewens, 2012; Sharon, 2014; Wilson & Haslam, 2009, 2012). Postulating such essence is a manifestation of so-called "psychological essentialism" (for reviews, see N. Haslam & Whelan, 2008; Neufeld, 2022; Rothbart & Taylor, 1992). This means that being human is linked to an assumed presence of an '*immutable,*' '*persisting,*' '*inherent*,' '*natural*,' and '*behavior and personality-determining*' essence that clearly defines (non-)belonging to this category (N. Haslam, 2006; N. Haslam et al., 2005; Smith, 2016).[30] Besides being applied to the Human, such essentialism shapes our understanding of gender, race, and personality (N. Haslam & Whelan, 2008; Neufeld, 2022). Such framing of biological entities harbors moral prescriptions (Lewens, 2012), even if the exact characteristics of the assumed essence are secondary compared to its proposed existence (Neufeld, 2022; Smith, 2016).

Nonetheless, psychological research examined which characteristics humans see as indicative of their alleged essence. Results by Haslam et al. (2005) investigated perceptions of humanness and found a two-dimensional understanding. Haslam summarizes these and other findings as follows: One dimension is referred to as "human nature (HN)" and the other "Uniquely Human (UH)" (2006, p. 256). The human nature dimension is meant to reflect essentialistic traits rooted in our biological history (Wilson, 2014). Human nature consists of communal

[29] For a somewhat similar diagnosis of gender display, see Butler (1988)

[30] According to Neufeld (2022, p. 3), the following features describe any assumed essence: "Natural kinds," "Causal power and large inductive potential," "Sharp category boundaries," "Homogeneity," "Immutability," "Intrinsicality," "Innate potential," "Hidden and unobservable," "Distinctness and sameness."

traits like "Emotional responsiveness," "Interpersonal warmth," but also "Individuality" or "Cognitive openness," while the less essentialized, uniquely human traits are those who allegedly separate us from animals, e.g., "Civility," "Moral sensibility," or "Rationality" (N. Haslam, 2006, p. 257). Note how translating our sense of morality into proper conduct is also linked to qualifying as "true" human (Phillips, 2022, 2023). Coherent with the proposed sense-making and norm-conveying functions (Hauskeller, 2009), the perception of whether personality traits and values are part of human nature correlated positively with their desirability (N. Haslam et al., 2005). Moreover, behaviors deemed indicative of the same concept were considered generally positive (Wilson & Haslam, 2013). Seeing personality traits as pivotal to an essentialistic human nature was positively associated with the belief that these traits influence a person's behavior in various contexts and are thus deemed important for making inductive conclusions (N. Haslam et al., 2005). As argued before (Wilson, 2014; Wilson & Haslam, 2009, 2012), Haslam's two dimensions, including the cited empirical foundation and related psychological mechanisms, are highly relevant to the employed notions of humanness in the Human Enhancement debate. Here, Wilson and Haslam (2009, 2012) and Wilson (2014) suggested that advocates of Human Enhancement operate with an anti-essentialistic, UH-feature-based understanding of the Human. Wilson and Haslam argue that from this perspective, manipulation of related traits would have no identity-disrupting consequences. Adversaries (e.g., Fukuyama, 2004; Kass, 2003) tend to employ a more essentialist understanding that should not be reduced to an additive collection of traits but resembles what laypersons understand as being indicative of human nature (Wilson & Haslam, 2012). For them, interfering with these essential traits endangers our prolonged existence as human beings by inflicting significant harm to the constituting continuity (Wilson, 2014). I will repeatedly cycle back to Wilson's and Haslam's contextualization of this model and empirical findings, especially on the traits allegedly associated with human nature. I call approaches that employ this version in particular and those who generally propose a valuable human essence the *essentialistic Human*.

I do not propose to uncritically adopt this understanding of human nature (for a critical discussion of Haslam's approach, see Over, 2021; Smith, 2014), nor suggest that everybody who draws upon essentialistic arguments proposes similar implications or assumes the same associated traits. Moreover, it is also possible to consider the traits described by Haslam as indicative of humanness without adhering to an essentialistic argumentation. However, the empirical foundation and humanness as an everyday, intersubjective phenomenon render the proposed 'folk-based' perspective important because respective understandings can discursively shape the evaluation of Human Enhancement (Wilson, 2014; Wilson & Haslam, 2009, 2012). If framing novel enhancements

as targeted, scientific, and value-based informed interference with the biological platform of our experiences (Buchanan, 2011), the HN-traits and their assumed biological roots gain additional importance for understanding the position of the adversaries and advocates (Wilson, 2014; Wilson & Haslam, 2009, 2012). Haslam's approach is not perfect. Yet, it allows us to link the Human Enhancement debate to a tradition of psychological research on the ascription of humanness (Wilson, 2014; Wilson & Haslam, 2009, 2012).

It was argued that social norm sensitivity evolutionarily inclined humans to view other cultural groups as essentialistic different, e.g., different biological species (Gil-White, 2001).[31] This static, kinship-focused view counteracts Praet (2014) and his observation that for some groups, like the *Chachi*, concepts like an essentialistic biological human nature or hereditary humaneness do not exist. Nonetheless, the communities described by Praet may operate not with a biologically grounded essentialism but use what has been called "value-based essentialism" (see Bailey et al., 2021, p. 1997). This proposition assumes that group membership is issued by following a specific set of values (Bailey et al., 2021) and may explain his observations that external agents may become part of the community and thus become "true humans," even though they were not born into it (cf. Gil-White, 2001). Thus, the evidence by Praet (2014) supports the proposed cultural dependencies in essentialistic thinking (Machery et al., 2023; Olivola & Machery, 2014; cf. Neufeld, 2022), and impressively shows the transcultural contingency of ascribed "true" human identity. Phillips's (2022, 2023) results suggest that this also applies to non-Indigenous communities, while the two-dimensional model of Haslam (2006) offers a basic understanding of how people understand and evaluate an alleged human essence. Even if understandings have been changing (Fernández-Armesto, 2004/2005), psychologically affirming the essentialistic Human has proven its pertinence to ourselves. But if our identity as humans really reflects more of a convenient simplification than empirical reality (Fernández-Armesto, 2004/2005), can the defining aspect of ourselves be stripped away from us?

5.4. Denying and valuing the essentialistic Human

Approaches to the Human are also meant to bring forward a normative and metaphysical perspective that satisfies the affective bycatch of how we use the label "human" (Hauskeller, 2009). Indeed, appeals to universalism grounded in a valuable essence (e.g., Fukuyama, 2004) invoke the notion that there is something more to humans than neurons, limbs, and cells. In variation, these essentialistic arguments are often evoked by adversaries (Sharon,

[31] As pointed out by Tim Ingold in a comment in the same article, Gil-White's (2001) arguments draw upon the same biological essentialism that it identifies as fundamentally flawed yet pragmatically used. Despite all justified criticism, I still think that we can pragmatically state that people draw upon essentialistic understandings of groups while postponing the question of whether this is evolutionarily necessitated.

2014) but are also sometimes employed by advocates (Hauskeller, 2016). Here, Buchanan (2009) criticized essentialistic reasoning, like the one by the President's Council on Bioethics (2003), due to the conflation of normativity and description and dehumanizing implications. Indeed, Haslam pointed out that those who lack traits associated with human nature could be considered not identifiable as human (N. Haslam, 2006). Yet, Smith (2014) criticized Haslam's reasoning for falsely treating the traits as constituting the essence instead of being caused by it. Smith further argues that by posing human nature traits as potentially overlapping with other lifeforms, Haslam describes anything but a distinctly human essence. Regardless of the logical flaws, Haslam pointed out how his conceptualization helps to understand how the arguments of laypeople and scholars in the Human Enhancement debate are informed under an explicit *folk psychological* understanding of what constitutes our human identity (Wilson & Haslam, 2009, 2012). Important is not the question of whether a human essence exists but the observation that people affirm that traits are indicative of the latter and use them as justification for their judgments (e.g., Bain et al., 2006; N. Haslam et al., 2005; Wilson & Haslam, 2013). Following this thought, revisiting the content of human identity can be informed or triggered by academic inquiry (Fernández-Armesto, 2004/2005) but ultimately depends upon the adoption of those individuals who operate with this identity (Hauskeller, 2009). By behaving *as if* this concept was genuine and *as if* modification of the essence meddles with the derived humanness, associated beliefs guide public attitudes in the Human Enhancement debate (Wilson & Haslam, 2009, 2012). Moreover, as I will argue later, this *as if* is relevant not only to the discourse but also to our adopted identity as humans. The fact that people value the essentialistic Human is reason enough to pay close attention to its influence. As partially noted by Smith (2016) himself, ascribing and identifying entities as (non-)human is a phenomenon that, like so many others, operates not on principles of strict logic and perfect rationality.

This is also shown within a small, yet decisive logical inconsistency that characterizes essentialistic humanness in the debate about Human Enhancement. According to Wilson and Haslam (2009, p. 256), adversaries of Human Enhancement justify their opposition by arguing that it endangers a "fixed" and "immutable" essence universally shared by all humans. Nonetheless, the obtruding question is how an *immutable* entity is to be changed in the first place (Buchanan, 2009). Even if theoretical accounts on psychological essentialism install "immutability" as a key aspect (e.g., N. Haslam & Whelan, 2008; Neufeld, 2022; Prentice & Miller, 2007), empirical results showed that rating personality traits and values as indicative of an essential human nature did not correlate with the perceived immutability of the same traits (N. Haslam et al., 2005). Moreover, although people think that characteristics of a person's assumed "true" self are temporally immutable, i.e., prolonged in the distant future, viewing distinct

personality traits as immutable in the literal sense was only weakly associated with rating them indicative of a true self (Christy et al., 2019). The same study showed that "true" self-ratings were best predicted by the extent the trait was seen as intrinsic and behavior-influencing. Although laypersons showcase flexibility within their essentialistic thinking, this does not render this line of reasoning irrelevant.

Smith (2016) acknowledges confusion also within a different phenomenon: when people are seen as having less pronounced qualities associated with being human, aka experience *dehumanization*. Haslam (2006) proposed two different kinds of this phenomenon, each based on one of his already-mentioned dimensions of humanness. First, the so-called "mechanistic dehumanization" (p. 259) denotes attributing less traits deemed indicative of an essentialistic human nature. This yields "robotic" beings characterized by "inertness" and "coldness" rather than "emotional responsiveness" and "interpersonal warmth" (p. 257). Secondly, humans evaluated as possessing fewer qualities linked to human uniqueness are seen as lacking reasoning abilities, culturally deprived, without a moral compass and are victims of what Haslam calls "animalistic dehumanization" (p. 259). Directly referencing this model and its empirical basis, it was argued that these processes can provide valuable insights for understanding how we talk about Human Enhancement and a potential posthuman (Grewal et al., 2020; Wilson, 2014; Wilson & Haslam, 2009, 2012).

In an experimental investigation by Landry et al. (2022), participants were presented articles claiming the scientific discovery of a biological essence across ethnic groups or the rejection of the same claim. The study found that participants who read about the alleged scientific revelation of a genetic essence displayed more essentialistic thinking than those who read the counterclaim. The latter was positively associated with higher dehumanization and fully mediated the experimental manipulation's effect. Mechanistic dehumanization can be linked to favoring aggression toward groups whose members are perceived to be hostile (Kteily et al., 2015) and can be triggered by information about others' behavior and attitudes (Felig et al., 2024; Izydorczak & Dolinski, 2024) or descriptive framing of the target (Utych & Fowler, 2021). This renders the essentialistic Human contingent on behavior or external factors and undermines the notion of a universal and time-persisting human essence. The overall reluctance to use the essentialistic Human according to its inert logic reconciles this version with those non-essentialistic understandings that link being human to showing proper conduct (see Praet, 2014). Accounts that propagate a more essentialistic Human still imply the performative and intersubjective approach described by Praet (2014). If tied to essentialized qualities like communality (N. Haslam, 2006), one cannot be a "good" human (Hauskeller, 2009) if not performing this semantic with other persons. Failing to meet the expectations of the

humanness ascribing person, attribution of traits linked to the respective essence can be withheld. This may be seen *as if* the person partially or absolutely lacks the valued essence *as if* they were not 'sub-' but "nonhuman" (N. Haslam, 2006, p. 259; cf. Over, 2021).

Understanding the Human as group-demarking and normative (Hauskeller, 2009) explains why the essentialistic Human may be especially compelling. The dominant view of essences, including the human one, as biologically and evolutionary rooted (Neufeld, 2022; Wilson, 2014; Wilson & Haslam, 2009) may explain why adversaries are sometimes accused of equating the natural with the "good" (see Hauskeller, 2013). This reflects the moral and normative flavor of human nature, which — although exploited by both sides — is more dominant within arguments of the adversaries (Buchanan, 2011; Hauskeller, 2013, 2016; Pugh et al., 2016; Sharon, 2014). In addition, psychological essentialism leads to the emergence of decisive and clear bounds between categories (Neufeld, 2022; Rothbart & Taylor, 1992; Smith, 2014). Hence, an essentialistic understanding of the Human establishes the boundary between the 'artificial non-human' and "natural" human (Sharon, 2014).[32] Committing to the subsequent ontological framework of biotechnology as an external threat (Sharon, 2014), Human Enhancement and an alleged human essence are dialectically interwoven. If Human Enhancement is posited as threatening the essentialistic Human, it is only through the ascribed dehumanizing potency that the alleged human essence is endangered, ought to be protected, and thus affirmed in its preciousness. Appeals to human dignity or a human essence become amplified if employed as counterarguments against possible technological interferences (Caulfield & Brownsword, 2006). The ascribed awe-inspiring capability and the prospect of changing human nature mystify its alleged power and reassure the value of the essentialistic Human.

5.5. Making the Human

I have argued that the semantics of the Human are contingent—that people across the globe, laypersons and scholars, employ different understandings of what it means to be human and what qualifies that label. In the following section, I will examine socio-material processes of how different semantics can be produced by and eventually socially affirmed.

5.5.1. A sedimented making Human

Engagement with the world directly informs our self-understanding. This is because organisms continuously *enact* a world whose valued properties relate to a history of forgone interactions with the environment (Di Paolo, 2005;

[32] Some transhumanists aim to dismantle this kind of anthropocentric division (Sorgner, 2020). Yet, the logic of technologically mastering an external nature draws upon the mentioned differentiation (Sharon, 2014)

Gerard & Maublanc, 2023; Thompson & Stapleton, 2009; Varela et al., 1991/1993). From everyday behavior to the level of conscious reflection, this historical engagement leads to what phenomenology understands as *sedimentation*: "those past experiences settled in one's mind which actively contextualize present experience. ... [I]t actively informs our ongoing experience. Sedimentation provides the pre-perceptive context that enables our current perceptions to occur with immediate meaningfulness" (Rosenberger & Verbeek, 2015, p. 25). Consciously making sense in this context can be understood as drawing from a "figure/ground" relationship (García, 2021, p. 5). Ihde (1990) draws on the same figure/ground metaphor to elucidate the relationship between his micro- and macroperception. Apart from this, sedimentation in postphenomenology means the culturally embedded "internalization of practical skills, of technical and cognitive competences linked to the repeated use of the object and its inscription in the daily life of the subject" (Robert-Demontrond, 2022, p. 105). In other words, past experiences with and without technology shape and enable future engagements with the world they took place in.

If sense-making depends on organismic sensorimotor activity (Thompson & Stapleton, 2009), then the Human's sense-making function depends on the activity of those who consider themselves to belong to this group and the particular sediment it has produced. Sociomaterially mediated individual engagement with the world realizes novel states that our cognitive apparatus must make sense of and subsequently interwinds culture, mind, and body (Malafouris, 2015). Since our activity is fundamentally embodied in self-produced technology (Ihde, 1990), any symbolic content and meaning of material culture is inextricably linked to the sensorimotor information flow that is circularly generated by our embodied and material activity and subsequent environmental manipulations (Malafouris, 2013; Monterroza-Rios & Gutiérrez-Aguilar, 2022). This highlights how conscious thought can also emerge from "*thinging,*" a term meant "to articulate and draw attention into the specific varieties of cognitive life instantiated in 'actual occasions' of thinking and feeling *with, through*, and *about* things" (Malafouris, 2019, p. 7, original italics). Prehistoric tool crafting, for instance, enabled agents to consciously reflect on their agentic capabilities so that the manufacturer's phenomenological impression of such emerged from interacting with the stone (Malafouris, 2013). This echoes the position that the feed of somatosensory information caused by the agents' activity can bring forth the conscious experience of the agent as the object for subjective self-inquiry (Newen, 2018), and that becoming iteratively proficient in one's action and linking it to an understanding of ourselves hinges upon experiencing and processing the effects we have on the socio-material world (Bandura, 2006). Malafouris (2013) suggests that different prehistoric material manipulation techniques can provide valuable hermeneutic insights into the human condition. Hence, he and Don Ihde strongly advocate understanding *Homo*

sapiens as *Homo faber*: "we make things which in turn make us" (Ihde & Malafouris, 2019, p. 196). This should not be understood as indicating any human exceptionality regarding tool-making, but to highlight the sustainable and persistent impact our activity in the material environment has on human minds, bodies, and culture (Ihde & Malafouris, 2019; Malafouris, 2013). Moreover, it is meant to emphasize the self-reflective and -identificatory aspect of technology: "No other species has been or can be defined *as a species* on the basis of its relationship with tools and material culture" (Malafouris, 2013, p. 153, original italics). In other words, it is not about whether other species also use tools, but the meaning of this tool for us and the subsequent production of other semantics.

Ihde and Malaforious (2019) emphasize the deep, mutual, indivisible relationship between organism and environment, so the process of classical Darwinian adaptation never flows in one direction. I agree, but I want to highlight how conscious reflection about targeting ourselves with technology shapes any related practice (Döbler & Carbon, 2024). From an enactive perspective, any activity is '*asymmetric*' in the sense that someone acts on something (Di Paolo, 2005). As further argued by Di Paolo, this aspect is homologous to having '*perspectivity*' on the world and necessary for understanding adaptivity as an active process. In this sense, adapting ourselves instead of the environment is not meant to be a passive and generational evolutionary process but situated in individual, culturally enframed activity (Döbler & Carbon, 2024; Pustovrh et al., 2018). Suppose we analytically dissolute the strict human-technology boundary that plagues the Human Enhancement debate (Sharon, 2014). Yet, this does not eliminate the experience of reflecting upon our conduct with what we consciously experience as not belonging to us. Hence, it is not about whether other species use material resources to adapt themselves instead of the environment, but our experience when doing so — the way this practice brings forth a particular understanding of ourselves and the world, and any reservations we might have against this conduct. All these components are informed by the historical sediment of past actions and practices.

These interconnections of culturally available practices, the agentic self, and individual embodied activity are well acknowledged (e.g., Monterroza-Rios & Gutiérrez-Aguilar, 2022; Pyysiäinen, 2021; Ransom & Gallagher, 2023; Rietveld & Kiverstein, 2014). Psychological socio-developmental theories, for example, claim that our self fundamentally serves the purpose of tangibly "*changing something in and about the world* (including in oneself as part of the world)" (Stetsenko & Arievitch, 2004, p. 494, original italics).[33] This process includes external tools to

[33] Stetsenko and Arievitch's account builds upon the tradition of Lev Vygotsky, who emphasized the role of socio-material practices in the emergence of cognitive abilities that characterize the human mind (Drain, 2022). In this section, I am not primarily interested in how the relevant abilities emerge, but rather how the species category these abilities belong to relate to

extend our capabilities (Stetsenko & Arievitch, 2004). In that sense, any so-emerging "bundle of 'taken-for-granted' skills, knowledge, and abilities that structures and informs our sense of who we are and what we know" is up to constant re-evaluation (Clark, 2003, p. 134). Hence, our technologically influenced way of embodiment has a pronounced hermeneutic quality (Ihde, 2011b). Here, the *Homo faber* provides a similar hermeneutic account of our contemporary and future being (Ihde & Malafouris, 2019). Highlighting the role of the material environment, it is conceptually open to include Human Enhancement as "thinging" means for self-production.[34] Yet, the emergence and presence of mental capabilities should not be reduced to the sole influence of external tools but contextualized, acknowledging the social processes and practices revolving around using and transferring them (Drain, 2022; Jeffares, 2010). Once again, the evidence presented by Praet (2014) offers a fascinating perspective on the role of technology for qualifying as Human in a social community. Across different cultures and continents, different communities ascribe "true" humanness only if individuals exercise skillful engagement with the environment. For the *Chachi*, this includes the ability to build proper canoes, while for the North American *Navajo,* being one of their kind (they sometimes call themselves "*the* people"), depends on corn cultivation and the creation of beautiful artifacts. Praet also cites anthropological literature about the *Ongee,* a community on the Andaman Islands near Myanmar. For these people, controlling their spiritualized body smell is highly important. Subsequently, the *Ongee* light fires or, more importantly for us, modify their body with paint to prevent smell transmission. According to Praet (2014), failure to do so would endanger their status within their community. Human-qualifying skillful engagement with the material environment may hinge upon adapting the environment properly (e.g., *Chachi* and *Navajo*). However, as demonstrated by the Ongee, being a "true" human means using external means to prevent bodily smell and thus improve a respective capability and adapt oneself.[35]

In summary, the sedimentation of socio-material practices like Human Enhancement informs the semantics of the Human. Members of this group then engage in social or individual activities that further shape the background

---

them. Nevertheless, Vygotsky's stated that using external means and embedding them into a meaning-providing structure of social processes radically shifted the evolutionary and cognitive trajectory of *Homo sapiens* (Drain, 2022). The general observation of Vygotsky aligns with the role I and others (e.g., Döbler & Carbon, 2024; Greely, 2006; Malafouris, 2013), assigned to pre-historical tool use. Examining the overlap with my postphenomenological approach must be postponed to future research (but see Hasse, 2008).

[34] Malafouris (e.g., 2008, 2013, 2014) strongly emphasizes the direct interaction with material things, e.g., in practices like pottery. His study on the phenomenological experience within this craft is not precisely applicable to technologies interaction with our bare hands (e.g., vaccines outside a syringe). Still, the *Homo faber* is more about the various and manifold interactions between material components of our environment rather than being confined to those we can directly touch. In terms of the size of manipulatable objects, the capacities to manipulate the environment have extended upwards and downwards. Malafouris (2020) acknowledges this when stating that humans can influence the trajectory of their evolution through material culture.

[35] Preventive efforts carried out by embodied technology, e.g., vaccination, are Human Enhancement (Döbler & Carbon, 2021; Juengst et al., 2018). This is not confined to protection against a disease.

they use to make sense of themselves. This functions also by reflexively contrasting our unenhanced capabilities against what might be possible through technological aid or the mediated experience against those who lack the technology in question (Ihde, 1990, 2011b). Although the *Homo faber* is only one approach to the Human, its anti-essentialism — shared by postphenomenology — and emphasis on socio-material self-production (Ihde & Malafouris, 2019) can elucidate how other contingent notions of the Human emerge. This may even be true for the essentialistic Human. If our valued but static human nature is endangered by an external threat (technology) (Sharon, 2014), any assumed antagonism hinges upon the identified discordance between these poles. In other words, if one can change anything but still claims that one was unchanged, the latter assertion only emerges in reaction to one's socio-material activity. Thus, I employ the *Homo faber* to highlight the socio-material-self-authoring capability of humans. I do not argue that one particular way of engaging with the environment like building sandcastles qualifies us as human, but that the diversity of engaging with the material environment provides all sorts of semantics, which then can be integrated into specific approaches to the Human.

5.5.2. Techno-scientifically making the Human

Because of the human-environment dynamics, the Human can only serve the proposed sensemaking function if it is sufficiently malleable to incorporate novel semantics (see Hauskeller, 2009). Still, this dynamicity and relative flexibility have not discouraged us from pursuing the goal of fixating the Human within an objective system of meaning or fantasizing about how Human Enhancement could enable reliable authority over every aspect of ourselves (Hauskeller, 2013). In modern times, one dominant socio-technological practice aims to produce a fixed and somewhat disrobed Human, open to common knowledge, ready for inspection, and eventual manipulation: Science.

Overall, human self-understanding is heavily influenced by contemporary practices and institutions (Ihde, 1979; Rose, 2018; Stetsenko & Arievitch, 2004), which happen to be dominated by technologies and science (Ihde, 1979; Nizzi, 2015; Verbeek, 2005). This is visible in the specific approaches to the Human, for example, in terms of evolutionary theory or the computational mind (Fahrenberg, 2003/2011), and shows how modern scientific and philosophical inquiry spearheaded the dismantling of taken-for-granted beliefs about our extraordinary capabilities or identity (Fernández-Armesto, 2004/2005). If combined with its (bio-)technological enactment (Ihde, 1990), adversaries disapprove, and advocates admire the transformational power of technologically enforced scientific progress (Hauskeller, 2013, 2016). Science and technology are certainly not the only sources of self-understanding. Still, following Ihde's ideas, modern techno-scientific progress has been proven to be a highly influential source of

self-evaluation; it is a socio-material practice in which we — relative to the components of this practice — actively negotiate our relationship with the world and ourselves (Verbeek, 2005). In concurrence with the role given to technology (Rosenberger & Verbeek, 2015), scientific advancements may influence the adopted understanding of our subjectivity and self as humans (Sharon, 2014). For instance, the detection of DNA provided a scientifically "objective" way to identify fellow humans (Fernández-Armesto, 2004/2005). Here, breakthroughs, like the Human Genome Project, were press-covered or announced by drawing upon essentialistic metaphors about disclosing the "book of life" (Nerlich et al., 2002; Sharon, 2014). Invoking such language showcases how biomedical advancements contribute to "geneticization" (Lippman, 1993, p. 178), i.e., the cultural framing of human life, diversity, and abnormalities to be grounded in fully readable and manageable genetic processes (Lippman, 1993; Sharon, 2014).

Ihde (1990, 2009) emphasizes the precedent of technology over modern science. Reflected in the very term, this *techno*-science means that, "*only through being technologically mediated is the newly produced knowledge possible*" (Ihde, 2009, p. 55, original italics). Used instruments are seen to reveal "objective" information that human sensory capabilities cannot directly perceive. This and the status commonly given to the retrieved information have been called "*instrumental realism*" (Ihde, 2011b, pp. 112–113, original italics). In short, "scientific instruments constitute what scientists observe; they 'interpret' reality before humans can observe it." (Verbeek, 2005, p. 141). Ihde's contribution to the philosophy of science stems from highlighting the culturally embedded reality-constituting role of the used instruments (Verbeek, 2005).

Psychology is no exception to these socio-material dependencies. Inspecting the early psychophysical laboratories at the dawn of the 20th century, we see machines, clocks, and all sorts of technological instruments (Lück & Miller, 2005). Fast forwarding to the 21st century, psychology's goal of semantically filling the Human still employs various technological means. This entails questionnaires that rely on writing and, therefore, a "technologically embedded form of language" (Ihde, 1990, p. 81), experimental settings, but also the deployment of increasingly sophisticated statistical models that require digital calculations and interpretational expertise (Schmidl, 2022). Whenever an aspect of the world is scientifically measured, humans engage in a hermeneutic relationship with the used technologies and media and, therefore, interpret their "subjective" percept of the technologically produced insight relative to cultivated knowledge, which provides "objective" criteria for this process (Schmidl, 2022). Subsequently, the technological instrumentation is not a neutral collector of objectively "true" information but mediates the researcher's perception of the object while also influencing any cultural interpretation of the same (de Boer et al., 2022). Consider, for instance, that psychological insight heavily builds on quantification,

enabled but also constrained by the material properties of the used media and inner logic (Tafreshi et al., 2016). This may eventually lead to the misconception that individuals *are* what is measured — that they can be reduced to an "objective" product of linear algebra (Tafreshi et al., 2016).[36] This also applies to questionnaires in diagnostic practices like clinical psychology. Rothbart and Taylor (1992) discuss how socially constructive yet essentialized diagnostic labels can emerge from contingent category limits within continuous measures (see also N. Haslam, 2000; N. Haslam et al., 2000). In that sense, psychology's role as a technological attempt to fixate the Human encircles what ought to be read and provides an empirical and materially rooted methodology of how to do it (for a methodological overview, see Fahrenberg, 2003/2011).

One example of how a specific version of the Human is produced and maintained by questionnaires can be seen in empirical research on dehumanization. These studies (e.g., Cassese, 2021; Kteily et al., 2015; Nguyen et al., 2022; Z. Zhang & Chen, 2024) often employ questionnaires that distinctively map or aggregate the human nature/uniqueness framework by Haslam (2006). Any questionnaire aims to map a subjective experience into a measurement whose "objective" meaning can be understood by various capable interpreters (Uher, 2018). Within planning, conducting, and receipting these studies, scientists and laypersons produce and adopt a specific notion about humanness and *what it is like* to dehumanize and be dehumanized (e.g., Golossenko et al., 2023). This fulfills the postphenomenological premise that technological mediation can shape our understanding of subjectivity and objectivity (see Rosenberger & Verbeek, 2015). Related meanings are subjected to methodological preselection and thus mediated by the researcher's intentions, the questionnaire's medium, and the understanding of the answering person (Uher, 2018). Since Haslam's framework means operationalizing folk perceptions of humanness, scientific research and adopted semantics can inform each other in the Human Enhancement debate (Wilson & Haslam, 2012). By stabilizing and affirming that (not) being human can be captured by a set of questions and their mathematical expression, empirical research that commits itself to a written account of the semantics of the Human contributes to the veracity of the same semantics within a paradigm.

The retrieved technologically mediated information about the object of inquiry is tailored to human epistemic abilities and thus has a self-reflective effect (Ihde, 2011b). Such information is not passively received by scientists. Instead, the latter are actively involved in producing and making sense of the produced 'hermeneutic text' (Ihde, 1990). Great examples of this are brain-imaging technologies like positron emission tomography (PET) or

[36] Scored values at a personality scale provide a specific set of potentially reified categories to make sense of my behavior and being: 'I have scored 5, that is because I *am* highly neurotic.' (see Uher, 2018)

functional magnetic resonance imaging (fMRI) (Ihde, 2009) or the materialization of thoughts and relations in forms of scientific models, which ease embodied cognitive understanding and sense-making of the modeled phenomenon (Hasse, 2008; Rolla & Novaes, 2022). In his examination of PET scans' scientific and clinical practice, Dumit (2004) shows how public reception of findings may bring forward a specific, measurable "objective" notion about ourselves. This leads to the impression that there are distinct "*kinds* of brains" reliably linked to different "kinds of persons" (Dumit, 2004, p. 6, original italics). The respective line is often drawn between 'healthy/normal' and 'unhealthy' brains (Dumit, 2004), which then reflects the technologically mediated emergence of potentially essentialized categories (de Boer et al., 2022; see also N. Haslam, 2000; N. Haslam et al., 2000; Rothbart & Taylor, 1992). However, Dumit also highlights the variation of results depending on the methodology used, experimental settings, and even labs. The impression of an "objective" glimpse into our neuronal architecture is watered down by the concert of the instrument's technological mediation, the researchers' subjective choices, and the investigated participant's characteristics (de Boer et al., 2022). Nonetheless, technoscientific image practices foster the increased reduction of human identity to a specific genotype, imaged brain activity, or biochemical processes (Sharon, 2014). Image technologies like PET exemplify how observable behavior and traits are linked to brain-related categories whose alleged face validity can result in an inadmissible reduction and collapse of the former into the latter (Dumit, 2004). This reductionism heightens the assumed transformational benefits of biotechnology targeting the individual brain instead of social conditions (Álvarez, 2011). The most extreme manifestation of the so-propagated machine-like understandings of the Human (Thomas, 2022) would be the transhumanist idea of separating the human mind from its body and "uploading" it to another medium (see Hauskeller, 2013; Koene, 2013). Assumed feasibility implies an essentialistic human identity, characterized by the equation of brain, mind, and person and the partial independence of brain processes from their biological tissue (Sharon, 2014).

Nevertheless, the appealing visuals of technologies like PET tempt us to equate a person with their brain and foster the idea that human nature can be objectively revealed within a brain scanner (Dumit, 2004). The visual aspect cannot be overstated here. Often relying on an engaging red-orange palette to indicate statistically significant measurements, imaged brain processes, and used metaphors may foster the false impression of a positive and absolute increase when there is often only a relative but also a potential decrease in measurements (Lilienfeld et al., 2015). Thus, what characterizes the technoscientific way of displaying the world to us is not only the extended information processing capabilities of the mediating instrument (Ihde, 2011b) but also the "objective"

visual information presentation, whose aesthetic features are never neutral (Ihde, 1990) but situated in the individually acquired but culturally shared network of semantic and affective associations (Ortlieb et al., 2020).

The entanglement within affective variables further highlights the many intricacies of how science produces the Human. Take, for example, two dominant contemporary semantics of the Human: possessing a unique dignity or human DNA (Caulfield & Brownsword, 2006; Hauskeller, 2009). Only after being technoscientifically able to identify human DNA can the latter become a relevant semantic of the Human (Fernández-Armesto, 2004/2005). Human dignity as a defining aspect of a to-be-protected human identity gained argumentative momentum as a counterargument to inventions like cloning and stem cell research (Caulfield & Brownsword, 2006) and is also evoked in the Human Enhancement debate (e.g., Bostrom, 2005a; President's Council on Bioethics, 2003).[37] This shows how being able to manipulate the biochemical marker of our species' membership elevated the meaning of other concepts, which then served as a justification for preventing the former. This was only possible by concatenating the two concepts and claiming that interventions targeting human DNA endanger human dignity (Caulfield & Brownsword, 2006). However, the same knowledge can be used oppositely. Especially in the early 20th century, scientists propagated racist ideas about the alleged "objective," genetically based deficiency of ethnic groups (Fernández-Armesto, 2004/2005). "Objectively neutral," scientifically produced Human semantics gained relevance by being linked to more affective and harder-to-grasp ones.

This again highlights the close association between individual perception and encultured technological mediation (see Ihde, 1990). The continuous embodied and skillful activity of individuals in a field of research enables them to "internalize" meaning and access encultured knowledge that they were not involved in producing (Hasse, 2008, p. 48). Individual bodily perception is seen in the context of the cultural-scientific framework (Hasse, 2008; Ihde, 1990). Scientific knowledge, mediated through its material production and communication, constantly shapes the background of our experiences (Nagataki, 2015). Not confined to experts, sedimentation into "common knowledge" enables laypersons to make sense of information, even without procedural knowledge about its scientific production (Schmidl, 2022).

The power of technoscientific practice for producing the essentialistic Human should not be neglected. When confronted with experimentally manipulated claims that sociology and psychology have determined specific values

[37] The author does not know whether he has human DNA, although he considers it likely. Note also the argument by Ludwig Wittgenstein that doubting to possess a human brain is unwarranted because my entire daily life tells that I do (Wittgenstein, 1970). At the same time, the author's dignity seems to be far less certain than the scientifically retrieved fact of this molecular composition.

as not belonging to human nature, participants rated the values as less important than if reading the counterclaim (Bain et al., 2006). Moreover, experimental manipulations that refer to scientific authority for disputing or supporting the existence of alleged group essences can reduce or increase the affirmation of essentialistic beliefs, respectively (Bailey et al., 2021; Landry et al., 2022).[38] People orient heavily on scientific expertise for assessing essential "natural" category membership and may support this argumentation by evoking how future advancement may enlighten a currently indescribable essence (Rothbart & Taylor, 1992). Yet, we can decide to what extent we affirm that our being is completely determinable by contemporary scientific insights and models (Žižek, 2017). Confrontation with belief-disputing evidence, for instance, can lead to questioning the epistemic power of science to investigate particular issues (Munro, 2010). Technoscientifically produced insights thus lead either to affirming its revealing powers or asserting that it misses relevant aspects of the (essentialistic) Human. If science is so keen to disrobe the human condition from its exceptionality (Fernández-Armesto, 2004/2005), is metaphysical resistance not understandable? A similar argument is often used by adversaries:

> the inability to articulate clearly what human nature is becomes evidence that nature and human nature are categories that cannot be reduced to the sphere of ethics governed by human reason. In other words, if it cannot be articulated, than [sic] we should not be meddling with it, and the attempt to rationalize this is precisely a symptom of the hubris that leads human beings to believe that they can master and manipulate nature for their own purposes. (Sharon, 2014, p. 70)

Thus, the essentialistic Human is something beyond the reach of science and thus requires protection against technoscience. Opposed by transhumanism as the "ideology for technoscience" (Coenen, 2014, p. 52), both positions show how our technoscientific products' assumed capabilities in relation to ourselves fuel paradisal and calamitous fantasies (Hauskeller, 2016; Ihde, 1990, 2011a) and shape the individual narratives we adopt (Coeckelbergh, 2017). This may happen in a positive, amending way. Clark (2003), for instance, linked our narrative identity to the historically practiced cognitive and physiological entanglement with external means and artifacts so that the current state of our enhanced capabilities constitutes parts of our self. We can extend this descriptive account to a prospective one. If any active adaptive endeavor builds on perceived or expected inadequacy (Di Paolo, 2005), we can also contrast our "naked capacities" against the projected level of technologically enhanced ones (Ihde,

[38] Science is also needed to produce evidence for or against what falls under the second dimension of Haslam's (2006) model of humanness: human uniqueness (Fernández-Armesto, 2004/2005). Intra-genus research, for instance, on tool use (e.g., Bruner et al., 2023) or general cognitive abilities (e.g., Breyl, 2020), produces similarities and differences.

1990, p. 75). Here, the mediating effect of our technological products confronts us with the limitations of our capabilities (Ihde, 2011b) and may motivate the attempt to technologically transgress them (Ihde, 2011a). Qua its technological mediation and assumed transformative power, Human Enhancement and the technoscientific possibility of creating a new level of *our* capabilities make us aware of the latter's current or, in hindsight, noticed insufficiency (Döbler & Carbon, 2024). The so-assumed power of technology promises to align our capabilities with normative expectations and thus emphasizes our bodies as targets for adaptation (Beinsteiner, 2019). Since this is a projection and does not require execution, the semantics of us as improvable, even "disabled," beings are produced by the potential of the enhancement and not necessarily by its tangible effect (Hauskeller, 2016, p. 121). To eventually succeed, we must identify the state that requires alteration. Here, technoscientific products can make our condition accessible to us while also identifying us as authorities to evoke change (Bergen & Verbeek, 2021; Döbler & Carbon, 2024). Technoscience elucidates the extent of adaptation needed by precisely determining *what* needs to be improved by *how much* and *which* intervention may be suitable. Doing so systematizes and sediments our inadequacies and can provide insights about whether the enhancement was "objectively" successful (see Döbler & Carbon, 2024; Schmidl, 2022). Viewing Human Enhancement as a technoscientific practice allows us to attribute the semantic production processes of the latter to the former.

Technoscience and Human Enhancement bring forth a simultaneously capable and incapable being. Incapable in the sense of needing adaptation, but capable of producing the necessary means to overcome shortcomings. Sparrow (2015, 2019, p. 10) argued that adopting and continuously advancing radical enhancement practices like genetic engineering will render those modified by earlier and less-potent generations of enhancement "outdated" and "obsolete." Without tuning into this dystopia, widespread Human Enhancement can elevate the improved condition to the status of normality (Nizzi, 2015). By projecting what we *could* be, the byproduct of Human Enhancement might be someone who, at the moment of his technoscientifically production, is already partially outdated: the contemporary Human.[39]

5.5.3. Making the Human together

The Human is not only a scientifically gathered set of features but an intersubjective, interactive phenomenon. Similar to the self in general (Stetsenko & Arievitch, 2004), it cannot be reduced to a collection of narratives. Instead, it is *performative* and resides in socio-material interaction (Bastian & Crimston, 2014; Praet, 2014). When

[39] See Simon (2019) for a similar argumentation on the matter of posthumanism and the current historical conception of humanity. Contrary to him, I argue that the here described process even takes place in the enhancement efforts we conduct on an everyday basis.

addressing someone as human, I presuppose or acknowledge the chosen semantics (see Wilson, 2014). This interaction-enabling function of ascriptions is a relevant aspect of symbols to indicate group (species) membership (Moffett, 2013). Yet, as argued used ascriptions are flexible. This is best shown within empirical phenomena like attributing human characteristics to non-human entities. So-called "anthropomorphism" builds on using information about ourselves to enhance making sense of the world and was conceptualized as the 'inversion' of dehumanization (Epley et al., 2007). Besides the cultural manifestation of this phenomenon (Fernández-Armesto, 2004/2005), empirical studies show that anthropomorphism positively influences judgments about moral status (H. M. Gray et al., 2007; Nijssen et al., 2019) and trustworthiness (Roesler et al., 2021). It includes deliberate, spontaneous and fast cognitive processes (Urquiza-Haas & Kotrschal, 2015) and enables interactional engagement with the non-human socio-material world (Airenti, 2018). One aspect of social interactions is that the occurring movements, facial expressions, and utterances contribute to maintaining the self-organizing dynamic of the situation (De Jaegher & Di Paolo, 2007). This effect of anthropomorphism was shown in a study by Straub (2016). Straub manipulated the interactional behavior of an android in a public café. Other visitors adjusted their behavior according to the android's displayed and assumed social capacities. In the condition with the highest level of interactivity, visitors even asked the android whether they could touch the android — a direct affirmation of moral status. However, failing to meet assumed capabilities led to interaction breakdown and the android being objecti- instead of subjectivized. Perceived and observed interactional capacities and behaviors create a path for mutual understanding and behavioral attunement to each other (De Jaegher & Di Paolo, 2007). In short, interactional behavioral convergence with what we understand as humans affirms the same concept and stabilizes constituting patterns of sociality.

This creates novel possibilities for understanding ourselves. Interacting with other agents allows for so-called "participatory sense-making" (De Jaegher & Di Paolo, 2007, p. 500). Accordingly, meaning is not isolated in the physical or mental form of something but is sometimes generated or enacted by interrelated social interaction between different agents (De Jaegher & Di Paolo, 2007). The general mechanism in face-to-face social sense-making resides in the power of joint social interaction to make hitherto not-reflected states available for reflective evaluation (García, 2021). Usually exemplified by coordinated activities like dancing or dialogical practices like psychotherapy (De Jaegher & Di Paolo, 2007; García, 2021), we can extend this to participation in scientific research contexts as well (e.g., de Boer et al., 2022; Hasse, 2008; Rolla & Novaes, 2022). Although consciously reflecting upon being a human may seldom happen, the sense-making and interactional function of the Human is

perpetuated and steered by agents who adopt and enact the relevant semantics. For instance, if we claim that humans possess a particular essence or treat something differently because of ascribed humanness, we *performatively* and *participatory* enact the (moral) meaning of this category (Coeckelbergh, 2023; Hauskeller, 2009).

A more radical reading emerges from "dehumanizing" intentionality and ascribing to technologies as well. This postphenomenological proposition assumes that the latter have a material-dependent mode of gathering, processing, and mediating information that is attuned to human capabilities (Ihde, 2011b; Verbeek, 2008). Thus, human interaction with them, aka "thinging" resembles participatory sense-making activities (Malafouris, 2014). The prime examples are wearables that track physiological processes like heart rate or calorie consumption (e.g., Robert-Demontrond, 2022; Van Den Eede, 2015). As Van Den Eede (2015) pointed out, these devices are one of the most straightforward examples of the postphenomenological hermeneutic relationship of reflexively 'reading ourselves through technology' (Ihde, 1990). Doing so fulfills the more general function of "bring[ing] into presence and awareness the human body as something that is supposed to be adapted to the possibilities of this technology" (Beinsteiner, 2019, p. 125). Wearables, technoscientifically, constitute an 'embodied-hermeneutic relationship' and improve the human capability of reading one's bodily functions (Van Den Eede, 2015). In their function as Human Enhancement, they can accentuate bodily shortcomings (e.g., high heart frequency) and urge adaptation while also positing themselves as effective means to do so (Döbler & Carbon, 2024; Kristensen & Ruckenstein, 2018; Robert-Demontrond, 2022; Van Den Eede, 2015). Using them brings forward an "objectively" quantified and encultured notion of myself that is charged with all sorts of normative expectations and transformational possibilities (Kristensen & Ruckenstein, 2018; Van Den Eede, 2015). Since the revealed data is hardly available for conscious reflection and the technology is designed to specifically measure *human* physiological states and convey them in a form comprehensible to humans, this relationship fits the mechanisms of participatory sense-making (see García, 2021). The produced meaning was only producible by the joint activity of technology (measuring + conveying) and embodied user (wearing + reading + understanding), as well as the mutual attunement of properties that allow using the technology (wearable + able to wear). We can extend this to technologies that do not blatantly reveal some measured aspects of ourselves, yet imply a specific inadequacy that must be met by using the technology (see Coeckelbergh, 2013; Hauskeller, 2016). By more or less subtly shifting our attention to aspects about ourselves hitherto not recognized or by becoming so deeply incorporated into our functional engagement with the world, the capabilities of the technology are "owned" by us (Ihde, 1990). Thus, Human Enhancement modulates the sense-making function and outcomes of the Human in a participatory way.

From a postphenomenological and enactive perspective, self-expression and understandings are deeply rooted in our social institutions and the reciprocal dependent collective and individual material activity (Ransom & Gallagher, 2023; see also Rose, 2018). When we conduct the manifold practices constituted by technoscience, we constantly produce, inform, and evaluate different notions of the Human. It is at this point where we can see how the individual human self partially embodies a contingent history of socio-material activities and how the self is informed by commonplace actions, even if not intended to produce meaningful insights about the self (Stetsenko & Arievitch, 2004). From the enactive perspective, *to do*, *be,* and *know* are reciprocal processes constituted and informed by individual and socially coordinated activity in an enacted world, where the distinction between ourselves and the other should not be considered as given, but are linked to a constant engagement with the surrounding socio-materiality we have constructed (Di Paolo & De Jaegher, 2022). Acknowledging the participatory role of technology in this conduct highlights ourselves as Homo faber (Ihde & Malafouris, 2019): We are what we do, and we do together with things.

5.6. Summary of the Human

I have discussed how the Human is a concept that helps us to correctly and effectively value information about the environment and ourselves as living beings. Cited evidence on the manifoldness of understandings suggests that the latter are contingent but functionally treated as indicative of historical group identity. Positive or negative affirmation of so-produced semantics always happens in relation to the history of past engagements that inform our sense-making activity. Here, semantic production seems to be privileged by socio-material practices like science and Human Enhancement. However, we should also not forget that due to its extension to multiple individuals, the Human depends on the social adoption of the general concept or particular semantics.

These considerations about ourselves as individuals and humans may appear abstract, but can suddenly burst into practical relevance. In 2020, an event of global extension radically confronted us with the inadequacy of our physiological capabilities. Our 'human being-at-risk' (Coeckelbergh, 2013) was brought into awareness. Quickly, the environment was modified to protect us. At the same time, scientists employed technoscience to identify the malicious agent, learn about why we were so unprepared, and subsequently started working on preventive measures to adapt ourselves instead of the environment. The related discourse recycled general tropes about which future technological interventions with our being are desirable or must be endured (see Coeckelbergh, 2013). In short, the abstract Human Enhancement debate concretely manifested in the question of vaccination against SARS-CoV-2 during the COVID-19 pandemic.

6. Core paper #1: Boosting human capacities

Döbler, N. A., & Carbon, C.-C. (2023). Boosting human capacities: Attitudes toward Human Enhancement and vaccination in the context of perceived naturalness and invasiveness. *Discover Psychology*, *3*, 24. https://doi.org/10.1007/s44202-023-00085-3

The published paper and its Supplementary can be found as Appendix 1 and 1.1. in Section 17.

6.1. Motivation

Vaccination, often relying on advanced biotechnology and capable of shifting the immune capacities of individuals above "normal" levels, is recognized by many academic conceptualizations as Human Enhancement (Döbler & Carbon, 2021). Contrasted against disease contagion measures like shutting down public spaces or building physical barriers, it is a perfect example of adapting ourselves instead of the environment with technological aid (Döbler & Carbon, 2024). The connection between Human Enhancement and vaccination is not only conceptual but also ethical. The general controversy around vaccination (e.g., M. Browne, 2018; Kata, 2012) was unignorably present during the COVID-19 pandemic (e.g., Ginossar et al., 2022). Here, an attentive observer could identify homology between vaccination-relating arguments and issues (e.g., bodily autonomy and distributional justice) and those evoked against Human Enhancement in general (Döbler & Carbon, 2021). Intrigued by those adamant about not getting vaccinated, I suspected this particular segment (~15% of the adult German population in January 2022 - Robert Koch-Institut, 2022) had strong beliefs that may influence their evaluation of other enhancements.

Despite the tremendous tragedy of a deadly pandemic, COVID-19 led to the unique opportunity to witness the global distribution of Human Enhancement and investigate related attitudes. Not aware of any other studies examining these topics side-by-side, I was motivated to find out if academic research could establish an empirical connection where previously there was only a theoretical one.

6.2. Theory and method

Rejecting vaccination may be grounded in "core beliefs about personal agency, and a spiritual, natural, life-affirming approach to health" (M. Browne, 2018, p. 2541). Since vaccination is seen as a concrete manifestation of Human Enhancement, the motives that drove the behavior of those not vaccinated against SARS-CoV-2 (*unvaccinated* henceforth) were suspected to influence their evaluation of Human Enhancement in general. Owed to the postulated diversity of Human Enhancement (Döbler & Carbon, 2024), attitudes toward specific enhancements differ (Grinschgl et al., 2023; Schönthaler et al., 2022). This effect should not be present when the act of enhancement alone is a controversial issue. One reason may be a feature-based evaluation of the employed

means.[40] With this in mind and like other studies (e.g., Grinschgl et al., 2023; Sattler et al., 2014; Schönthaler et al., 2022; K. Wagner et al., 2018), I employed a hypothetical cognitive enhancement scenario to assess the evaluation of other enhancements. I was interested in evaluating the willingness to use these means based on their perceived naturalness and invasiveness. These variables were chosen because associated beliefs play an important role within the anti-vaccination discourse (e.g., M. Browne, 2018; Ebrahimi et al., 2021; L. R. Martin & Petrie, 2017; McLenon & Rogers, 2019; Meier et al., 2022) and for accepting specific enhancements (e.g., Conrad et al., 2019; M. Haslam et al., 2021; Mihailov et al., 2021; Sattler & Pietralla, 2022; Scheske & Schnall, 2012). Furthermore, naturalness can be linked to the conception of technology as opposed to nature (Siipi, 2008). As the Human Enhancement discourse often entertains the opposition between "natural" and "unnatural" enhancements and states (e.g., Allhoff et al., 2010; Buchanan, 2011), I suspected that a generally affirmative attitude toward nature negatively affected the acceptance of Human Enhancement. Linking enhancement evaluation to self-reported vaccination behavior and intention allowed for robustly situating the findings in the pandemical context and concrete behavior. The context of a virus-bearing environment and a potential risk-mitigating technology emphasizes Human Enhancement as a 'risk-transformation' strategy, as suggested by Coeckelbergh (2013). Hence, I also evaluated whether Human Enhancement technologies could modulate the experience of risk and clarified the specific psychological effects of this enhancement.

Employed measurements were self-developed and aimed to reflect attitudes toward Human Enhancement and vaccination. To better access the network of beliefs, I also asked for the attitude toward a wide range of potentially controversial phenomena. For further clarification on perceptions of Human Enhancement, participants indicated the extent to which different technologies were seen as respective means. These measures were used in the first online questionnaire study with $N = 314$ (18.5% unvaccinated). Participants were targeted through Facebook groups and other online communities. Data sampling for the first study occurred in January 2022, a time when every German citizen had free access to vaccination against SARS-CoV-2. I then conducted a second online study in May 2023. I recruited $N = 300$ (14.33% unvaccinated) participants to evaluate differences in the naturalness/invasiveness perception of vaccination against SARS-CoV-2 and re-evaluated the findings of the willingness to engage with cognitive enhancement. This was done to identify to which extent naturalness and invasiveness perceptions generalize to the vaccine.

[40] In Schönthaler et al. (2022) one psychometric factor explained over 50% of acceptance variance across "classical" enhancements, e.g. genetic engineering or pharmacological means, but did not explore feature perception.

6.3. Results

Study 1 showed that perceived invasiveness and an affirmative attitude toward naturalness had a negative effect on the willingness to use means for cognitive improvement. Perceived naturalness of means increased this willingness. Results suggest that these effects were more pronounced and, thus, more important for unvaccinated participants. Effect certainty and strength varied depending on which means were evaluated (*Table 2*).

Table 2. Predicting the willingness to use interventions for memory enhancement

	Model							
	All interventions				Interventions with parallel frequencies			
	β (Median)	CI95% Low.	CI95% Up.	pd	β	CI95% Low.	CI95% Up.	pd
Perceived invasiveness	-0.53	-0.65	-0.40	100.0%	-0.61	-0.85	-0.37	100.0%
Perceived naturalness	0.81	0.69	0.92	100.0%	1.15	0.93	1.37	100.0%
Attitude Human Enhancement	0.34	0.04	0.63	98.6%	0.36	-0.14	0.86	92.2%
Naturalness attitude	-0.04	-0.10	0.01	92.3%	-0.12	-0.21	-0.04	99.7%
Vaccinated	0.57	-2.03	3.19	66.2%	-0.16	-3.48	3.15	53.7%
Application: Frequent	-0.22	-2.57	2.21	57.2%				
Application: Once	1.81	1.62	2.00	100.0%	2.54	2.28	2.80	100.0%
Vaccinated x Perceived invasiveness	0.31	0.18	0.44	100.0%	0.18	-0.08	0.44	91.1%
Vaccinated x Attitude Human Enhancement	0.06	-0.27	0.39	63.4%	0.33	-0.21	0.89	88.7%
Vaccinated x Perceived naturalness	-0.41	-0.54	-0.29	100.0%	-0.67	-0.90	-0.45	100.0%
Vaccinated x Naturalness attitude	0.01	-0.05	0.07	59.5%	0.07	-0.02	0.16	93.0%

Note: pd = probability of direction, i.e., the probability that the effect has the same numerical sign as the median. CI95%: Low./Up. Lower/Upper 95% credible interval boundaries. Tables refer to Döbler & Carbon (2023): Table 4; Models 5 and 10. Estimates are non-converted and differ from exp-converted values in the original. Interventions with parallel frequencies: comparing only those interventions assessed as one-time or daily use and qualify as Human Enhancement under my definition. All interventions: includes ratings for interventions that do not fall under my definition of Human Enhancement and were not assessed with the same application frequency. Non-vaccinated and Application: daily use = reference levels.

Unvaccinated differed in the perception of how invasive and naturally assessed cognitive enhancement means were perceived. For instance, unvaccinated rated the singular injection of drugs as less natural (Cohen's $d = $ -0.68) but more invasive ($d = 0.97$) than vaccinated counterparts. Results also confirmed that an affirmative attitude toward naturalness had a negative effect on both the attitude toward vaccination and Human Enhancement. Interaction effects revealed more pronounced negative effects for the unvaccinated participants (*Table 3*).

Table 3. Predicting the attitude toward Vaccination and Human Enhancement

	Outcome							
	Positive attitude vaccination				Positive attitude Human Enhancement			
Predictor	β (Median)	CI95% Low.	CI95% Up.	pd	β	CI95% Low.	CI95% Up.	pd
Enhancement rating vaccinations	0.16	0.02	0.30	98.7%	-0.22	-0.45	0.01	97.1%
Vaccinated	1.32	1.10	1.54	100.0%	0.38	0.04	0.72	98.5%
Naturalness attitude	-0.44	-0.61	-0.27	100.0%	-0.49	-0.74	-0.24	100.0%
Attitude Human Enhancement	0.28	0.15	0.42	100.0%				
Vaccinated x ER-rating vaccinations	-0.14	-0.30	0.02	95.8%	0.47	0.23	0.73	100.0%
Vaccinated x Naturalness attitude	0.20	0.02	0.38	98.4%	0.22	-0.05	0.50	94.4%
Vaccinated x Attitude Human Enhancement	-0.26	-0.42	-0.10	100.0%				

Note: pd = probability of direction, i.e., the probability that the effect has the same numerical sign as the median. CI95%: Low./Up. Lower/Upper 95% credible interval boundaries. Tables are adopted from Döbler & Carbon (2023): Table 5; Model 5, and Table 6; Model 4 in the original.

Groups differed significantly regarding their attitude toward different phenomena, touching on the relationship between humans and nature. For instance, unvaccinated rated space colonization (d = -0.48) and genetic engineering of humans (d = -0.76) more negatively and homeopathy (d = 1.36) more positively than vaccinated counterparts. Mirroring results from another study (Döbler & Carbon, 2021), participants did not consider

vaccination an evident example of Human Enhancement. Showcasing the risk-transforming effect of Human Enhancement (Coeckelbergh, 2013), vaccinated participants increased feelings of safety right after vaccination. Further models showed that supporting disease control measures, most likely as a reference to the perceived virus hazard, could predict vaccination intention.

Results from Study 2 indicated that unvaccinated participants rated vaccination against SARS-CoV-2 as less effective, less natural, and less safe than vaccinated counterparts. Perceived unnaturalness and invasiveness were reported to have played a comparable role in deciding not to get vaccinated as perceptions of ineffectiveness and lack of safety. Evaluating the final model on willingness to use cognitive enhancement from Study 1 with the data from Study 2 supported the model's prediction quality.

6.4. Discussion and one step further

My results align with previous findings on the positive role of naturalness (Conrad et al., 2019; Marteau et al., 1995; Scheske & Schnall, 2012; Williams & Steffel, 2014; H. Zhang et al., 2024) and negative influence of invasiveness (M. Haslam et al., 2021; Sattler & Pietralla, 2022; Scheske & Schnall, 2012; H. Zhang et al., 2024) in evaluating more "classical" means for Human Enhancement — effects mirrored in vaccination evaluation (Chen et al., 2023; Meier et al., 2022; Rossen et al., 2019). It seems that the President's Council on Bioethics (2003) was correct when stressing the gravity of the means' perceived naturalness. Yet, we must be cautious. According to the council, this objection does not build on the artificiality of the technologies but on their interfering effect with a meaningful connection to one's activity and the desire for authentic merit. For the council and its chairman, Leon Kass (2003, p. 23), modern and novel biotechnologies[41] corrupt our natural agency and condemn humans to defenseless 'passivity.' However, what about the mediated and historical technological expression of human agency (Ihde, 1990; Verbeek, 2005)? Applying this perspective to biotechnology (Sharon, 2014) and linking it to the functional principle of Human Enhancement (Döbler & Carbon, 2024): Is using embodied technological means to adapt ourselves not an expression of human agency par excellence?

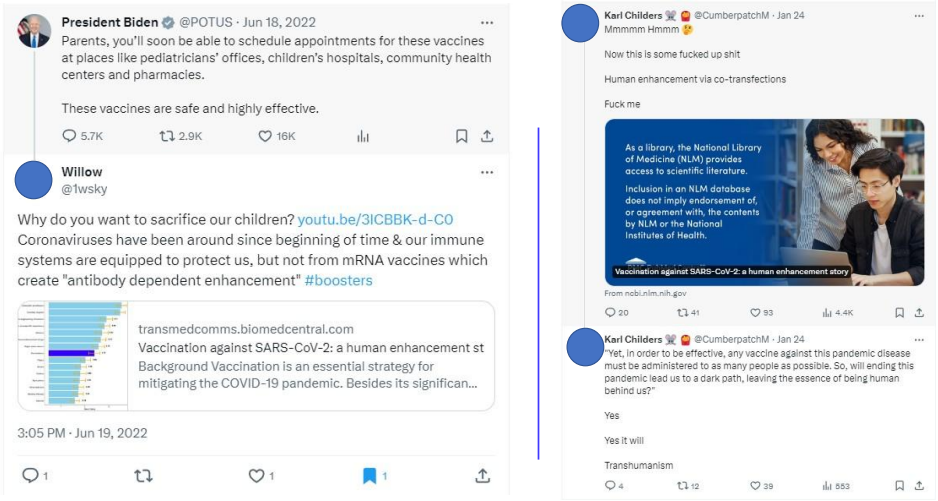
Ambiguity of the involved terms may contribute to one's general reluctance. The following discussion will elaborate on possible understandings and the values that may be seen at stake in the vaccination debate.

[41] The council's report mentions vaccines as examples of such on the second page. The respective section enumerates what the council understands as biotechnology and is not an anti-vaccination statement. The council concedes that biotechnology, like vaccination, can also create significant goods. Yet, its insistence that protective vaccines' narrow application focus renders them "good" biotechnologies is not coherent, given that the effects may yield the criticized enhancement (see Döbler & Carbon, 2021; Juengst, 1998).

Furthermore, I will argue that the technological capabilities of the vaccine qua their mere presence already impact our engagement with the world.

6.4.1. Ambiguous concepts

The emergence of modern biotechnology can make it increasingly more complex to distinguish between the artificial and natural (Ihde, 1990). Different understandings of the latter term across laypersons and experts, for example, when discussing livestock vaccines (Ditlevsen et al., 2020), show that "naturalness" can be equivocal (Buchanan, 2011; Siipi, 2008). Still, as shown, the individual conception of naturalness seems to be a converging point for the attitude toward vaccination, a general notion of Human Enhancement, and particularly cognitive enhancement. Besides the ambiguous understanding of naturalness, Human Enhancement is also subjected to potential disagreement. While the academic perspective affirms that vaccination is Human Enhancement (e.g., Allhoff et al., 2010; Buchanan, 2011; Juengst, 1998), laypersons do not necessarily share this classification (Döbler & Carbon, 2021, 2023). However, they seem critical of any technological intervention deemed unnatural and invasive, which would encompass vaccination and a large proportion of the enhancement examples discussed in the literature. Instead of getting heated up about a potential lack of definitory precision amongst laypersons and academics, a thorough evaluation of specific enhancement concerns and psychological communication strategies is needed (see Döbler & Carbon, 2021, 2024). To effectively address concerns, findings on how framing technology's purpose and additional information concerning its prevalence can shift moral evaluation of controversial enhancements (Martín et al., 2023), and re-framing vaccinations as less naturalness-impinging may foster intention to use them (Chen et al., 2023), may be fruitful.



The tweet by @1wsky appears to be deleted.
Screenshot taken at February 6th, 2024, at 3:19 PM GMT+2

Screenshot taken at February 6th, 2024, at 3:23 PM GMT+2

Figure 3. Tweets sharing Döbler and Carbon (2021). The CC-BY license applying to this text does not apply to the screenshots.

As seen in *Figure 3*, a prior, rather theoretical article that elaborated the conceptual link of vaccination as Human Enhancement (Döbler & Carbon, 2021) was shared by several "X" (formerly known as "Twitter") users who used it to highlight the danger of vaccinations and transhumanism (@1wsky, 2022; @CumberpatchM, 2024a, 2024b; @POTUS, 2022). This reception in the discourse produces anecdotal evidence for the hypothesis (Döbler & Carbon, 2021, 2023) that critical attitudes against vaccination and Human Enhancement are closely related. Inquiring the subjective yet decisive meaning of controversial terms is key to understanding what is seen at stake and why people are willing to protect it.

6.4.2. Endangered purity of ourselves

As briefly discussed in the present article, Chen et al. (2023) highlighted the importance of vaccination rejection and concerns about *purity*. This refers to the "Moral foundation theory," which postulates that concerning moral judgments, "*Intuitions come first, strategic reasoning second*" (Haidt, 2013, p. 106 original italics). After the formation of these intuitions, individual differences yield different ways to explain and justify them by drawing upon different so-called "moral foundations," like "fairness/cheating," "care/harm," or "loyalty/betrayal," but also what was originally called "sanctity/degradation" (Haidt, 2013, p. 351). In short, people have different preferences for which arguments they evoke to make sense of their fast-paced judgments. Appealing to the "sanctity/degradation foundation" can effectively posit something as valuable and sacrosanct and thus impact the persuasiveness of respective arguments in bioethical debates (Haidt, 2013). The renamed "purity" foundation was found to influence the evaluation of various enhancements negatively (Grinschgl et al., 2023; M. Haslam et al., 2021; Mihailov et al., 2021; cf. Sandbrink et al., 2024). The moral gravity of human nature in the Human Enhancement debate stems from the disputes about its not-to-be-touched value (Wilson & Haslam, 2009) and the

prospect of purposefully redrawing valued "natural" boundaries (Sharon, 2014). Moreover, dominant ideologies consider external technologies as endangering the 'purity' of the human body (Coeckelbergh, 2013).

However, across different empirical studies, definitions of purity are inconsistent and sometimes formulated without reference to "naturalness" (K. Gray et al., 2023). Gray et al.'s review of definitions reveals that purity is often understood to encompass acts that are not directly personally harmful (e.g., incest). However, they also point out that people can view actions deemed impure, such as eating certain foods, as linked to individual harm and subsequently suggest seeing concerns about impurity as "higher-order harms" (p. 299) that are seen as endangering norms and abstract values. This proposal highlights the double meaning of *ourselves* in the Human Enhancement debate. Seeing vaccination against SARS-CoV-2 as an "impure" technological agent was linked to affirming statements like "*My* body is sacred" and the reluctance to let "foreign substances polluting *my* blood," or "contaminate the sacredness of *my* body," which then were statistically aggregated into what the authors denote as "*the* Human Body Is Sacred" (Chen et al., 2023, p. 6, italics added). In this sense, concerns by the unvaccinated about the state of *themselves as individuals* and the functioning of *their body*, endangered by the invasive and unnatural technology, were translated into identifying *themselves as endangered Human*. If linked to the proposed higher-order harms, people skeptical of the vaccination may generalize the danger for themselves to an abstract danger for humanity. Apart from physical harm, an analysis of COVID-19-related conspiracy theories that circulated on YouTube and Twitter ("X") revealed that the dominant topic was the concern of how vaccination endangers individual freedom (Ginossar et al., 2022). Freedom is a value laypersons consider linked to human nature and are keen to protect (Bain et al., 2006). Adopting this version of the Human, people may oppose what is considered a threat to *their* bodies, linking this threat to the defining semantics of the species *they* identify with.

Further evidence for this double meaning is provided, considering that the prospect of technological interventions with our bodies may be accompanied by concerns about physical integrity (Coeckelbergh, 2013). Devaluation of invasive enhancement means compared to non-invasive ones (Döbler & Carbon, 2023; Grinschgl et al., 2023; Sattler & Pietralla, 2022; Scheske & Schnall, 2012) showcases the value of the integrity of ourselves as individuals. The link toward ourselves as humans becomes visible when discussing the implications of a prevailing view that attempts to define humans *ex negativo* as opposed to technology (Coeckelbergh, 2013). According to Coeckelbergh, this approach conceives the technologically altered cyborg as the utmost threat to the otherwise non-corrupted human body. These so-evoked images of the modified human body resonate with the declared concerns against enhancement-related practices and metaphors that pose *ourselves* as "mere raw material to be

molded according to human will" (President's Council on Bioethics, 2003, p. 287). Crucial to these notions is focusing on technologies that are seen as invasive and the link between the individual and the Human. Interestingly, the unvaccinated saw cognitive enhancement interventions as more invasive than their vaccinated counterparts. Even if perceptions of vaccine invasiveness did not differ between vaccinated and unvaccinated, my results showed that perceived invasiveness was reported to be a substantial factor for not getting vaccinated. This may exemplify how, in specific contexts that require vaccination, the used biotechnology is not seen as a simple sting but as "power inscribed not only on the body, *but in it*, down to the molecular level" (Bickford, 2019, p. 43, italics added).

Further evidence for the role of self-related integrity was provided in a recent study. Participants rated invasive implants to enhance appearance or mental capacities as less natural and more morally condemnable than physical exercise (H. Zhang et al., 2024). When comparing the implant with plastic surgery, participants rated the former as less morally acceptable but equally natural. Moral evaluation was positively linked to and partially mediated the positive influence of naturalness judgments and willingness to use interventions. Additionally, the implant was conceived as evoking stronger changes in identity than non-invasive methods (but not surgery). This and other research on vaccination rejection (Reich, 2016) suggest a link between perceived naturalness and invasiveness that was neither modeled in my publication nor found in previous research (Scheske & Schnall, 2012). This requires further inquiry and highlights an understanding of ourselves that stretches beyond physical integrity. Putting psychological integrity into the heart of concerns, people were shown to be reluctant to enhance psychological capacities deemed pivotal to their identity (Riis et al., 2008; K. Wagner et al., 2018). These concerns about individual identity can extend and overlap with concerns and features of the nature we claim for ourselves as humans (Pugh et al., 2016; Wilson & Haslam, 2009), which constitutes our distinct identification as the latter (Wilson, 2014; Wilson & Haslam, 2012). My research did not assess whether people reject vaccination because it is considered threatening human nature. Still, with all necessary caveats, vaccination as a proxy for Human Enhancement could be seen as a threat to human nature, not because of directly targeting a tangible essence but because of the suspected technological interference with values and other features people view as indicative elements of this posed essence (Wilson, 2014; Wilson & Haslam, 2009). Even though being a logically invalid position (Smith, 2014) and rejecting vaccination can have various reasons (Betsch et al., 2018), the valuation of ourselves could indicate the following: similar to other biotechnologies, vaccination is rejected not because it is feared to destroy our humanness *directly* but due to the potential to *corrupt the assembly* of inferred aspects so that we cannot identify with this humanness anymore.

6.4.3. Practical effects on ourselves

Adopting the postphenomenological premise of technology as experience-altering: How can drugs, vaccination, or other substances that are quickly metabolized have the same effect as implants or more tangible tools? After all, there is nothing the world can be 'felt through,' nothing integrated into my immediate experience, and thus no evident embodiment relation (Ihde, 1990; Verbeek, 2008 - Section 3.6.). Verbeek (2008) meant to solve this problem by introducing his cyborg relation. Ihde (1990), utilizing the example of birth control pills, however, suggested that respective effects appear to be more like a background relation, so that practices like sexual intercourse are contrasted and are experienced differently. Understanding Human Enhancement in general as risk-managing strategy (Coeckelbergh, 2013) enlightens results suggesting how different contraception methods, including oral ones, modulate concerns about unplanned pregnancies and experienced sexual satisfaction (Oddens, 1999). At the same time, women may feel primarily responsible for contraception (Alspaugh et al., 2020; Brown, 2015), which can render this technological adaptation into a normative gender stereotype. My findings also support the proposition of Ihde in the sense that vaccinated participants largely reported an improvement in subjective safety following their first vaccine shot. They also cited beliefs in its effectivity as decisive for the vaccination decision. Hence, for those willing to receive it, vaccination against SARS-CoV-2 is a subjective and objective adaptation (see Döbler & Carbon, 2024). Affirmation of this double effect rendered several conducts, like in-person live events, less dangerous and legally possible again, and very likely stemmed from an altered experience of personal risk at the micro- and macroperceptual sphere (see Ihde, 1990).

However, those who reject this embodied intervention may doubt that the promised effect is possible. If persons reject the vaccination because they deem it ineffective but fear negative side effects, they, nevertheless, affirm the possibility of (maladaptive) transformation through biotechnology. The availability of a technology normatively shapes revolving practices also due to the *possibility* of not using it (Ihde, 1990). Even if it is not applied, humans relate to these means as something *they* do not need because it is threatening something valuable to *them* or is considered an ineffective adaptation of *themselves* in relation to the environment. If we link this to positions that argue that the practice of vaccination is inferior compared to the "natural" immune capacities of the human body (e.g., L. R. Martin & Petrie, 2017), we see how the production or affirmation of the Human can also happen by opposing the products and practices of technoscience. Conversely, the need for vaccination results from identifying *ourselves* as insufficiently protected against environmental hazards — *we* are threatened by something *external*, feared to intrude on our bodies. Although *prima facie* reproducing the separatist ontology of adversaries, this

demonstrates how the mediational effect of modern biotechnology (Sharon, 2014) can also frame ourselves as an endangered concept. Hence, vaccination fulfills two central premises of postphenomenology (see Nizzi, 2015; Rosenberger & Verbeek, 2015; Verbeek, 2005): the production of a specific notion of an (endangered) subject and (menacing) object through technological mediation and a more or less direct influence on our practices.

6.5. Critical appraisal

Apart from the limitations enumerated in the paper, I acknowledge the following criticism: Even if not equivalent to an affirmative attitude to naturalness and rejection of invasiveness in general, the purity concerns subscale of the moral foundation questionnaire (Moralfoundations.org, 2023) could have been a promising choice for connecting findings to the established literature. The number of findings may overwhelm the reader. Focusing on a handful of key findings might have been advantageous.

Due to reasons like occupational vaccine mandates, vaccination status is not tantamount to naturalness attitude and other variables. This could be addressed by using the identificatory significance of vaccination status as an additional source of information. Other research has shown that this variable can explain outgroup discrimination (Henkel et al., 2022) and memory bias regarding support of disease control measures and risk evaluation (Sprengholz et al., 2023). This could further elucidate how beliefs and values gatekeep enhancement decisions.

Because the baseline of capabilities may influence the enhancement effort one is willing to endure, assessing individually perceived cognitive abilities before measuring willingness for cognitive enhancement may be beneficial (Fernandez et al., 2022). Yet, other studies found little evidence for an effect of self-assessed cognitive capabilities on the willingness to use different means of enhancement (Grinschgl et al., 2023; Sattler & Pietralla, 2022).

Asking about how the participants evaluated the naturalness of the intervention did not propagate a specific notion of this concept. The scale on the general affirmative attitude toward naturalness asked for agreement on a wide range of statements (e.g., “Humans and nature have separated too much,” “Humans should stop trying to control nature”) that also had a strong normative component (e.g., “What is natural is also good” – See Appendix 1.1). Before replication, a careful analysis of which of the many understandings of naturalness (see Siipi, 2008) was operationalized is needed.

The study was planned while simultaneously working on my definition of Human Enhancement (Döbler & Carbon, 2024). The proposed definition still applies to vaccination, but some examples presented to participants in this study (e.g., meditation) do not qualify as Human Enhancement under my definition. Thus, for theoretical

consistency, I focused more on the second set of models (Models 6 – 10 of Table 4 in Appendix 2 and Table 2 in this manuscript), where all evaluated interventions are Human Enhancement under my definition.

In the second study, evaluating not only the willingness to use model but also the ones predicting attitudes toward Human Enhancement and vaccination could have been beneficial. Unfortunately, one required measure (rating vaccination as an example of Human Enhancement) was missing.

6.6. Conclusion

We are obliged to relate, value, and subsequently care (Coeckelbergh, 2013; Di Paolo, 2015). Care about ourselves, our future, our society, our species. My results show that preference for the ways we shape the relations from which this care and the associated vulnerabilities emerge (see Coeckelbergh, 2013) are subjected to individual differences and manifest in individual enhancement decisions. Whether to engage with specific technological interventions seems to build upon a set of beliefs and attitudes that comprise the fundamental relation between humans and the environment, as well as differing perceptions of the technology and Human in question. Widespread Human Enhancement, as exemplified in the mass distribution of vaccination against SARS-CoV-2, emphasizes how the enhanced (immune) self sets a new normative standard (Nizzi, 2015). However, for some, the prospect of using a technology deemed invasive and unnatural renders adhering to this new norm unbearable.

7. Core paper #2: Enhancement WOK or BOO

Döbler, N. A., Carbon, C.-C., & Schaub, H. (2024). Human Enhancement Without Organizational Knowledge and by Organizational Order. *Journal of Cognitive Enhancement*, *8*(1–2), 170–183. https://doi.org/10.1007/s41465-023-00278-7

The published paper can be found as Appendix 2 in Section 17.

7.1. Motivation

While adaptation towards a physically dangerous environment runs deep through the conceptual history of Human Enhancement (see Clynes & Kline, 1960), people nowadays populate a wide range of socio-material environments. Especially at the workplace, they encounter a wide range of risks, influences, and tasks that require adaptation (Pustovrh et al., 2018). Here, the intuitive solution may be an adaptation of the work environment, for example, to increase safety, security, and performance-related variables. However, as Pusthorv et al. (2018) pointed out, workers can also be inclined to use technological means against themselves. Given the often-referenced goal of *improving* human capacities, investigating Human Enhancement in highly competitive and thus evaluative settings seems close at hand. Previous researchers have conducted investigations into the hypothetical and factual use of

Human Enhancement in educational (e.g., Dietz et al., 2013; Dinh et al., 2020; Fuermaier et al., 2021; Maier et al., 2015; Mann, 2023; Wolff et al., 2014; Wolff & Brand, 2013) and workplace settings (e.g., Baum et al., 2023; Dinh et al., 2020; Franke et al., 2013; Raspe et al., 2020; Sattler et al., 2022, 2023; Sattler & Von Dem Knesebeck, 2022; Wiegel et al., 2016; Williams & Steffel, 2014). The present article contextualizes these findings within a framework of organizational power and knowledge while also providing a general overview for practitioners.

7.2. Theory and Method

Building on the premise that Human Enhancement is contemporarily done, I reviewed empirical evidence for such engagement and its effects in organizational settings. I then summarized them in a new framework that shines light on the two poles of organizational involvement within individual Human Enhancement efforts.

7.3. Results

I defined two kinds of organizational entanglement with Human Enhancement. Either this conduct happens "*without organizational knowledge* (*WOK*)," like in doping or performance-boosting drugs, or "*by organizational order* (BOO)," e.g., vaccination mandates or state-ordered doping (Döbler et al., 2024, p. 171, original italics). Placed on a continuum, each pole refers to what an organization, like an education facility or employer, knows about the behavior of its members. Emphasizing the directive power of organizations, BOO explicitly addresses motivational aspects. Still, WOK can also entail subtle behavioral inclinations. Even if conducted in secrecy, Human Enhancement can "be motivated *by organizational virtue*" (Döbler et al., 2024, p. 174, original italics): individuals may feel obliged to enhance due to the organizational climate that champions a specific level of capabilities or promotes unethical behavior.

These aspects highlight intra-organizational processes that may create an environment people feel the need to adapt to. The application of Human Enhancement in organizational settings may be accompanied by safety and security-related issues. Still, as shown for vaccination and often argued for cognitive enhancement as well, the prospect of improving safety and security may render ordering enhancement a universal organizational policy for some tasks. With this in mind, I highlighted difficulties in regulating Human Enhancement in organizational settings and argued for a case-by-case examination.

7.4. Discussion and one step further

The proposed framework shines an important light on the practical side of adapting ourselves instead of the organizational environment. This highlights the relationship between individual conduct and higher levels of

societal organization. Yes, Human Enhancement is done to a single individual. But, we can neither neglect contextual factors (Döbler & Carbon, 2024) nor how social and ideological factors convey the need to adapt our behavior (Maiese, 2022). Favorable peer attitudes and enhancement use by others render individual enhancement endorsement more likely (Dinh et al., 2020; Mann, 2023; Martín et al., 2023; Sattler et al., 2013, 2014, 2021; van Veen et al., 2022; K. Wagner et al., 2018). Direct peer demand had a negligible influence on the willingness to conduct cognitive enhancement (Sattler et al., 2014). Still, reflecting the widespread concern about socially coercive enhancement practices (Schelle et al., 2014), Adam giving in to Eve's demands and eating from the forbidden tree was expectable.

How we employ technologies and do Human Enhancement is influenced by our practices, activities, and conscious and unconsciously shared norms and expectations (Coeckelbergh, 2018; Döbler & Bartnik, 2022). These components create a regiment of factors that govern *how* and *what* we adapt, but also which conditions are seen as worth conducting this effort (Pustovrh et al., 2018)—time to pay closer attention.

7.4.1. A neoliberal case report

Why do I put so much emphasis on the matter of adaptation? Is not *improvement* the kernel of Human Enhancement? Although I consider adaptation the more fundamental mechanism, elaborating on the relationship between improvement and adaptation may be required. Crucially, human adaptation is not always a life-or-death matter but also manifests in the subtle and continuous pre-reflective behavioral attunement and enactment of established practices (Maiese, 2022). From an enactive perspective, humans, on a fundamental sensory-motoric level, "*internalize*" observed norms and adopt behavioral responses to cope with these socially uttered demands (Maiese, 2022, p. 342, original italics). Contextual variables influence the evaluation of Human Enhancement and allow for framing individual efforts as improvement (Menuz et al., 2013). Hence, when we inquire about the functional kernel of Human Enhancement, this practice and the used means must be seen in the context of:

> the unfolding of the horizons of meaning which precede all aspirations to effect and provide them with guidance and direction. The question whether our practices of technological self-production can be detached from the teleology of optimization cannot even be asked, before the meaning is taken into account that establishes this teleology. (Beinsteiner, 2019, p. 128)

Even if a reference to improvement is unignorable in the Human *Enhancement* debate, we should aim to understand the related terms before positing it as a universal, positive, and seemingly self-evident telos (Chadwick, 2009;

Hauskeller, 2013). Hence, I join Beinsteiner in the call that we must understand the contextual meaning of improvement (see also Hauskeller, 2013; Hofmann, 2017). As Agar (2014) pointed out, viewing objective improvement as necessarily good renders a related conception of Human Enhancement inevitably morally acceptable. In a similar vein, Hauskeller (2013) rejected the existence of any Human *Enhancement* in this literal sense. According to him, this is because pre-defined contexts that determine what counts as "better" are too narrow, so there are no interventions that yield all-encompassing improvement and are always morally permissible. Hauskeller's analysis is more concerned with the moral value of specific enhancements in relation to their potential side effects. Nonetheless, his insistence on defining criteria that render someone "better" sense is important. Extending on these points, we can ask what constitutes the dominant reference frame or horizon of meaning to speak with Beinsteiner that labels outcomes as an improvement? One answer is *ideology*.

Basically, an ideology describes a desired vision and organization for society (Piketty, 2020). Yet, this macro-scale definition neglects the perspective of the individuals whose beliefs and actions constitute what we call society and who are meant to be improved by Human Enhancement. Hence, I will employ a more fundamental understanding, drawing upon the theories of Slavoj Žižek. Accordingly, an ideology is not some dwelling utopia that seeks to overcome the present conditions. Instead, the ideology is already at work in defining the status quo; it structures social relations, their enactment, and meaning on the most fundamental level (Žižek, 1989/2008). People may be aware of distortions, contradictions, and irrational beliefs commonly framed as "ideological," but for Žižek (1989/2008), the crucial point is that people are nevertheless actively participating and maintaining the conditions that gave rise to a particular social organization. According to Žižek, ideology is not "before" the truth but within it (cf. Maiese, 2022). Thus, an ideology impregnates our understanding of what it means to be an individual, how societies "naturally" organize, and which aspects of *ourselves* are subjected to the critical inspection of others, as well as the appropriateness of our actions to meet these social demands (Žižek, 1989/2008). From an enactive perspective, a given ideology can be seen as cultivating behavioral patterns so that individual agents can attune easily and "mindlessly" adapt to the socio-material environment (Maiese, 2022). Understood this way, an ideology governs how we should adapt.

In the following discussion of how an ideology may influence Human Enhancement, I will focus on *neoliberalism* and its emphasis on individual self-improvement (see Döbler & Carbon, 2024). At its core, neoliberalism champions minimizing state interference with capitalistic business activity and the free market (Connell, 2010). However, this ideology is not confined to economic policies but also imbues social institutions and individual actions (Adams et

al., 2019; Gershon, 2011). Analyzing the influence of neoliberalism on work and organizational psychology (WOP), Bal and Dóci (2018) show how this discipline enacts and reproduces the ideologies' premises, e.g., "meritocracy," "individualism," "social Darwinism," and the constant aim for necessary progress (p. 539). According to them, by specifying a particular outcome as desired intervention effects and discussing respective strategies, WOP shapes our understanding of what it means to improve. Doing so justifies not only the adaptation of the organizational environment but also of the organization's members (Bal & Dóci, 2018). Overall, neoliberalism's dogmas substantially impacted psychological theory and practice (Adams et al., 2019).

In her analysis of the intellectual roots of this ideology, Stiegler (2022) shows how neoliberalism was built on an identified "*defectiveness of human material*" (p. 131, original italics). Interested in societal social progress, neoliberalism's intellectual pioneers argued that:

> the intelligence inherited from its long evolutionary history has adapted the human species to stable and closed environments. In light of the final destination of evolution, the principal organ of adaptation for the human species has brutally become that of its maladaptation, maladjustment, and structural lag. (Stiegler, 2022, p. 150)

Stiegler reveals how neoliberal dogmas of governmental restraint, free commerce, and individual self-interest were posited as the final stage of human organization, necessitating a socio- and bio-political agenda, where:

> readapting the human species to the demands of the globalized economy involves not only continually improving its defective genetic patrimony through the elimination of anomalies and the enhancement of performance, but also assuming ambitious social policies in the matters of prevention, care, and health—which promote at the same time the equality of opportunities and adaptability. (Stiegler, 2022, p. 154)

These are plans for a political and large-scale evolutionary program. But what about the acting individuals? Those who have bodies 'equally adaptable'? Here, one classical reference used by many, including Stiegler, is that neoliberalism conceives the Human as the *entrepreneurial*, *self-responsible*, and *self-exploiting* "homo œconomicus" (Foucault, 2008, p. 226; Scharff, 2016). In the contemporary socio-economic system, available techniques and technologies constantly urge this subject to improve itself (Scharff, 2016). Answers to this call include exploiting specific enhancements (Mann, 2023). Other than the plans described by Stiegler (2022), we encounter *individualized* adaptation efforts to cope with the demands of an already neoliberalized workplace, education system, or social

environment (Döbler & Carbon, 2024; Mann, 2023; Pustovrh et al., 2018). For instance, Pusthurov et al. (2018) argue that increasing reliance on cognitive work in concert with capitalist demands incentivizes pharmacological cognitive enhancement so that the quality as an employee is conflated with the quality as human.

Human Enhancement seems like an uncanny ally for how agency is understood in neoliberalism. Accordingly, humans must posit themselves as possessing an improvable set of skills that must be efficiently and business-like managed (Döbler & Carbon, 2024; Gershon, 2011). Moreover, neoliberalism's dogma of the free market entails a strong appeal to self-responsibility and individualism (Gershon, 2011). Hence, if people live in and work in precarious economic systems, they may not be angry but display self-criticalness and negligence of the responsible structural conditions (Scharff, 2016). Besides calling for general self-improvement, neoliberalism urges individuals to reliably facilitate intense positive emotions (Adams et al., 2019), which could incline using Human Enhancement for mood modulation (Döbler & Carbon, 2024). Interviews within the LGBTQ+ community elucidate how drugs are used to enhance sexual experiences, facilitate intimate social connections, and make specific practices possible in the first place (Pienaar et al., 2020). This shows how Human Enhancement can influence social relationships to the most intimate level and could exemplify how neoliberal ideology has advanced into a significant proportion of everyday life.

Yet, a direct investigation into the impact of self-reported neoliberal attitudes on the willingness to use brain stimulation for enhancement purposes yielded non-significant results (Medaglia et al., 2019). Moreover, if exposed to an online advertisement that frames cognitive enhancement as beneficial for career progress or related to prosocial goals, users were likelier to click on the latter (Castelo et al., 2019). However, one must not consciously endorse what is happening to maintain an ideology (Žižek, 1989/2008). By facilitating, naturalizing, and maintaining social relations and actions, the ideology precedes the individual but is nevertheless maintained by individual action and social participation (Bal & Dóci, 2018; Maiese, 2022; Žižek, 1989/2008). Focus group interviews showed that people assume the need to display one's best performance or the desire to outperform peers as motivations for cognitive enhancement (Coveney et al., 2019). Interviews with students suggested that their use of cognitive enhancement was a self-necessitated behavioral answer to the perceived conditions in neoliberalized education facilities (Mann, 2023). A survey among Dutch students showed that 68% considered ADHD medication uptake without medical necessity to be effective, and 51.7% saw the possible simulation of symptoms to obtain the drugs as beneficial (Fuermaier et al., 2021). Wiegel et al. (2016) showed that German university teachers were more likely to use cognitive enhancement drugs when reporting higher stress. These results show how Human

Enhancement is embedded within social-material spheres, which not only issue motivating, enhancement endorsing demands but also regiments which adaptations qualify as adequate (Döbler et al., 2024; Döbler & Carbon, 2024). From an enactive perspective, individuals attune their behavior and sensemaking to pre-given and subsequently integrated ideological norms (Maiese, 2022). This is the ideological perspective of Human Enhancement *by organizational virtue*, where reducing adaptations of ourselves solely to personal reasons falls for the self-immunizing logic of neoliberal individualism.

Neoliberal subjects compete not only against others but also against themselves (Bal & Dóci, 2018; Scharff, 2016). Due to this two-fold competitive entanglement, a purely subjective understanding of improvement is insufficient. Only "objective" enhancement, which others can acknowledge, constitutes the necessary improvement. Given the neoliberal focus on the self-responsible individual, the origin of outcomes is reattributed to stem from individual success/failure instead of structural conditions (Scharff, 2016). Hence, in a neoliberal context, individuals may justify their behavior by referring to unshakable social normativity and implicit expectations (see Bal & Dóci, 2018; Mann, 2023) that are naturalized by applying evolutionary principles to society (Stiegler, 2022). This shows how technologies and their capabilities bring forth a specific notion of (entrepreneurial) subjectivity and objectivity (Rosenberger & Verbeek, 2015; Sharon, 2014). This happens, for instance, by championing the scientifically proven plasticity of the brain as justification and naturalization for continuous but individual adaptation to the equally plastic market (Álvarez, 2011). Since the individual may have limited influence on environmental conditions, such reductionist arguments may convey that adapting ourselves is the most appropriate strategy to achieve socially valued outcomes (Álvarez, 2011). That way, the given conditions, including the framing and motivations of individual actions, are evaluated in terms of the alleged *inevitability* and *necessity* for the persistence of the societal organization (Bal & Dóci, 2018). On the political level, decreasing cognitive performance in light of increasing work demands may be re-framed as treatment-requiring maladaptation (Pustovrh et al., 2018). This may individualize structural problems while maintaining the positive feedback loop between successful adaptation and increasing demands (Agar, 2014; Elliott, 2011; Pustovrh et al., 2018). When the structural conditions that have given rise to the urge for enhancement are neglected (Elliott, 2011) and the employee consciously affirms that he must improve his abilities to meet the demands of his workplace (Gershon, 2011), the optimization teleology and constituting meaning horizon (Beinsteiner, 2019) are taken for granted. Although factually adapting to the socio-material environment, the focus on neoliberal improvement puts individualized merit into focus, *as if* the shared understanding of improvement is derived from a self-explanatory, "natural" drive

(see Stiegler, 2022). However, by acting *as if* the emerging behavior is inevitable and necessary, these justifications are ideologically validated by the contingent behavior they are supposed to proactively rationalize (Žižek, 1989/2008). If seen as merely responding to external, allegedly inviolable conditions (Mann, 2023), Human Enhancement can also be understood as a coping attempt conducted from the position of an alleged "objective" yet a factually contingent necessity. Take cognitive enhancement drugs. Even if the effects are minor (Roberts et al., 2020) and are thus unlikely to compensate for skill inequality, their availability and *individual, active* and *self-responsible* use attunes with the neoliberal agent, as equally characterized and risk-affirming striver for skill optimization (Gershon, 2011; Mann, 2023).[42] From the perspective of the individual, it is the *ménage-à-trois* of subject-required and technologically-enabled-to-adapt appeals to self-responsibility and performance and individually embodied technologies that render adaptation of ourselves over adaptation of the environment as being perceived necessary (Döbler & Carbon, 2024; Mann, 2023; Pustovrh et al., 2018).

All technological aid aside, people still want to believe in the power of individual merit. For instance, people, in principle, support pharmacological cognitive enhancement as an expression of bodily autonomy but reject it in competitive settings (Coveney et al., 2019). Upkeeping the importance of invested effort may be especially important for people who value fairness (Mihailov et al., 2021) or want to conserve the character of specific activities (Greely, 2006). However, people rated successful performance achieved with the help of cognitive enhancements as less authentic but as similarly/more promotion-worthy than a similar or worse outcome where no enhancement was involved (Fitz et al., 2014). Hence, by enacting an ideology that values not only the process but the outcome, people are willing to take the risk of improper conduct to claim relevant, otherwise unreachable achievements. This conclusion is supported by empirical evidence on the predictive power of values associated with neoliberalism on the prevalence of cheating in assigned tasks (Pulfrey & Butera, 2013). "Self-enhancement," the value in question, was also associated with being more favorable to using a wide range of enhancements (Schönthaler et al., 2022).

In this context, transhumanism and its ideological dogma of technological, self-responsible improvement seem like the perfect ally for the neoliberal project and *vice versa* (Spreen, 2018). The technological capabilities are seen as the final building block for the necessary reliable performance augmentation (Flessner, 2018) and suggest a profound self-instrumentalization (Thomas, 2022). The historical neoliberal diagnosis of humanity as

[42] Given its vulnerability-reducing intent — which, in fact, only has a transforming effect (Coeckelbergh, 2013) — the attempt to gain a competitive advantage through pharmacological means substitutes socio-economic risk against biological and health-related ones (e.g., addiction, Mann, 2023).

fundamentally flawed and in need of a political "readaptation" concerning the increasingly complex economic environment (Stiegler, 2022, p. 23) echoes the limitation-focused transhumanist view that necessitates individual enhancement (Hauskeller, 2016; Sharon, 2014). More intersections are visible when considering that transhumanism prioritizes the individual self over the social aspects of the human condition (Steinhoff, 2014). Besides this clear affirmation of individualism, authors have called for the adoption of a "Proactionary Imperative" as transhumanism's "intellectual basis" (Fuller & Lipiska, 2014, p. 1). This approach builds on the "'proactionary principle,'" which was formulated in opposition to the more risk-averse and tempered "'precautionary principle'" (Fuller & Lipiska, 2014, p. 3). According to its inventor, transhumanist Max More, the proactionary principle is meant to overcome precautionary hesitation in developing and adopting emerging technologies to ensure the best possible results of technological progress (More, 2013c). Fuller and Lipiska use More's conception as a starting point to draft a political and legal framework meant to realize the proactionary dogma for calculated and responsible risk and the advancement of science to progress the "control over the most fundamental features of human existence" (Fuller & Lipiska, 2014, p. 131).[43] The most apparent manifestation of neoliberalism in this institutionalized transhumanism is the postulation that "proactionaries accept a quite literal understanding of genes as 'bio-capital': namely, as currency through which one sort of thing is exchanged for another, resulting in the mutual enhancement of the traders" (Fuller & Lipiska, 2014, p. 135). The evident capitalistic language of Fuller and Lipiska affirms the neoliberal dogma of treating yourself as an absolutely privatized business (Thomas, 2022) under the dogma of private revenue maximization (Pustovrh et al., 2018). This highlights how the neoliberal subject is expected even to stretch its self-responsibility and risk-managing toward its biological and genetic condition (Sharon, 2014) and once again resonates with the evolutionary undertone of neoliberalism's intellectual history (Stiegler, 2022). The concert of modern biotechnology and neoliberal dogmata already brings forth a mediated reading of ourselves and the world (Sharon, 2014). In summary, the specific meaning of improvement is the product of what it means to adapt to projected and current demands posed by a socio-material context (ideology). Only through the network of practices, virtues, values, demands, and knowledge improving in a specific way is emphasized as the imperative manifestation of adaptation.

[43] Compare this to the neoliberal subject as a rational risk-manager (Gershon, 2011; Scharff, 2016) and Human Enhancement as a risk-transforming practice (Coeckelbergh, 2013). Given the vehemence and projected utopian outcomes in Fuller and Lipiskas's argumentation, we could even go so far as to claim that this imperative is meant to convince us to take a long-overdue shot at achieving divinity (Hauskeller, 2016)

Yet, other research has already rejected that individual enhancement outcomes can be equally translated to higher levels of social organization on a theoretical (Allenby & Sarewitz, 2011; Faber et al., 2017) and empirical basis (Sattler et al., 2023). Hence, what is adaptive for groups, organizations, and society is not necessarily good for the individual and *vice versa* (Döbler et al., 2024). Moreover, my previous work on people adamantly rejecting Human Enhancement, e.g., vaccination (Döbler & Carbon, 2023) and cases where healthcare professionals defied vaccination mandates and were laid off (Okpani et al., 2024) show the limitations of organizational and ideological power and virtue.

Admittedly, my definition of Human Enhancement partially conflates improvement with adaptation. Nonetheless, acknowledging the mechanism of adaptation side-by-side with the matter of improvement may assist in circumventing a specific notion of the latter. We may be required to adapt, but not necessarily in a way that entangles the adaptation with striving for constant self-improvement in the face of market and work demands (Pustovrh et al., 2018). Still, neoliberalism effectively has molded evolutionary principles like adaptation and feelings of 'lagging behind' into a clear political agenda enriched by all sorts of biological metaphors, which convey an alleged necessity for sociopolitical evolutionary mastery and progress (Stiegler, 2022). If we then consider how neoliberalism champions individual self-responsibility and malleability (Gershon, 2011), the appeal towards specific kinds of Human Enhancement may stem from the implicit and explicit preclusion of widespread adaptations of the environment. In that case, the only option to ensure systemic participation seems to be a technological adaptation of oneself (Döbler & Carbon, 2024). The practical incorporation of Human Enhancement into this ideology gives a different undertone to the statement that "through Human Enhancement, we become the things we made" (Döbler & Carbon, 2024, p. 602). Radical neoliberalism may incentivize increasingly more radical enhancement, so that we ought to become the thing to perform.

7.5. Critical appraisal

My understanding of "organizational knowledge" refers to whether the organization, represented by individual superiors or other powerful members, knows about the potentially illicit enhancement conduct of other members. However, the same term was and is used to describe the intra-organizational ability of organization members to use and compare relevant information to exercise allocated tasks successfully (Tsoukas & Vladimirou, 2001). Hence, the chosen terminology may appear confusing. By relating the knowledge aspect to the level of the organization, I may have insufficiently personified societal structures. Overall, the proposed theoretical approach would have

benefited from empirical data that — by committing to one example — investigates the extent and character of enhancement WOK or BOO.

7.6. Conclusion

Organizational and ideological contexts may appear deceivingly natural, like Adam Smith's infamous invisible hand, which arranges all components according to their allegedly best interest or sorts out those who fail to adapt. Still, even in the case of enhancement without organizational knowledge, adapting ourselves is never purely individual conduct. Humans and their shared ways of living are always socially demanding (Maiese, 2022) and thus contribute to the prevalence of Human Enhancement either by directly ordering it or subtly influencing motivational processes. Here, organizations are not equipped with the biblical Eye of Providence. So, as long as it happens without organizational knowledge, Human Enhancement may yield negative consequences, but not necessarily eviction from the organizational context. Yet, if one single demand can easily trigger enhancement aspirations, the environment-creating authorities must question themselves as to what extent they are responsible for the outcome.

8. The normative Human

Examples discussed so far highlight how specific enhancements can be normatively expected in a given environment or assist in engaging with the same in an effective way (see Döbler & Carbon, 2024). Overall, organismic activity must facilitate functional valuation of the environment and the subsequent effective identification and prevention of "wrong" and potentially lethal states (Di Paolo, 2005; Thompson & Stapleton, 2009). Thus, even within our "mindless" everyday behavior, there is always a "right" or most "appropriate" way of doing things or interacting with other agents (De Jaegher & Di Paolo, 2007; Maiese, 2022; Mojica, 2021; Rietveld, 2008). Moreover, artifacts stand in reciprocal influence to human practices that produce and use them (Coeckelbergh, 2018; de Boer, 2023; Ihde, 1990). In short, normativity lives in practice and is practiced in living. Even in the biblical Garden, humans encountered (and defied!) divine proscriptive normativity. But what is the relationship between the normativity of organismic processes and those we encounter in the social realm? We heard so much about the biologically grounded essentialistic Human. Can the normativity of the Human manifest in biological variables? Is there really a way to interfere with organismic processes and simultaneously shatter our "right" identity as Humans?

Recall how the Human is entangled with normative and idealized semantics (Hauskeller, 2009). Linking it to possessing human DNA may have weaker implications than knotting "true" humanness to proper moral conduct

(Phillips, 2023). But as reasonably argued by Hauskeller (2009) on the case of genetic chimeras (organisms in which human and animal DNA is combined), any understanding of the Human, including a genetic one, yields an elevated moral status for the qualifying entities. Indeed, the ethical debate about producing these organisms discusses questions like softened distinctions between species or endangered human dignity, or moral norms (Kwisda et al., 2020). The meaning we assign to our genome entangles "objective" biochemistry with normative questions about how to treat entities possessing this feature. Thus, the Human seems inseparably tied to proper engagement with the social-material world (Phillips, 2022, 2023; Praet, 2014). This performativity requires us to individually act and treat others according to the adopted semantics and their meaning. If failing to do so, severe consequences may follow. The impression that somebody did not display relevant characteristics of the Human and, thus, treated other humans '*inhumanely*' may lead to dehumanization and serve as justification for aggression against individuals (Bastian et al., 2013; Phillips, 2023) and their groups (Kteily et al., 2015). Yet, apart from denying somebody relevant aspects of the Human, the mentioned evidence shows how proper conduct can lead to the ascription of humanness. For instance, Butler (1988) suggested a direct link between humanization and the enactment of traditional gender roles. Picking up on this proposal, Martin and Mason (2022) empirically showed that gender and stereotypically associated traits are indeed one of the most central features for perceived humanness and pivotal for making sense of others' actions. Normative expectations regarding gender are often essentialized (Saguy et al., 2021) but can actually physically manifest in the individual. For instance, the special emphasis on female attractiveness may frame cosmetic interventions as means of achieving proper womanhood (Little, 1998). This observation exemplifies how the beauty industry may create a gendered version of the "good" enhanced, universally "better" human (Hauskeller, 2013). In a less invasive manner, eating certain dishes and maintaining a certain weight are gender-specific norms (Cavazza et al., 2015; Koenig, 2018). In that sense, following a specific diet can inscribe social normativity into the physical body. At the same time, physical features can bleed into the social realm. For example, when women experience stigmatization due to infertility (Xie et al., 2023) and potentially feel dehumanized by the procedures meant to overcome this condition (Redshaw et al., 2007).

From an enactivistic perspective, gender normativity structures our behavior so we bring forward and maintain the historized and naturalized meaning of gendered categories and their link to humanness (Butnor & MacKenzie, 2022). Attempts to understand why people's action and appearance expresses this naturalized normativity can manifest in the assumption of a gene-based gender essence that inevitably had to produce observed behavioral differences (Dar-Nimrod & Heine, 2011). Such understanding imbues "objective" genetic information with

normative demands about the proper conduct of males and females (Hendl, 2017). But similar to the mentioned chimeras, this link may be disrupted by emerging biotechnology. New biotechnologies allow for the precise manipulation of the human genome (Doudna & Charpentier, 2014). Hence, the controversial capability to intentionally and sustainably change human biology according to our values and gusto (e.g., Buchanan, 2011; President's Council on Bioethics, 2003) seems on the edge of the possibility. The normativity of humanness, its gender-related facets mixed with biotechnological agency — one does not have to be bioconservative to acknowledge the disruptive potential.

9. Core paper #3: A perfect child

Döbler, N. A., & Carbon, C.-C. (2025). Does creating the perfect child mean enforcing or dismantling normative gender stereotypes? Evidence from an interactive virtual genetic engineering exhibit. *Acta Psychologica*, *254*. https://doi.org/10.1016/j.actpsy.2025.104748

The published paper and its Supplementary can be found as Appendix 3 and 3.1 in Section 17.

9.1. Motivation

In the periphery of the Human Enhancement debate, scholars discussed whether we must use available technology and knowledge to: "select the child, of the possible children ... who is expected to have the best life, or at least as good a life as the others, based on the relevant, available information" (Savulescu, 2001, p. 415). *Prima facie,* there seems to be nothing wrong with caring for one's child's well-being. However, this may not only concern aspects of predispositions for genetic diseases but may also pertain to features whose presence renders socially induced harm more likely (e.g., skin color or sex, Sparrow, 2007). Another factor causally linked to experiencing negative, potentially quality-of-life diminishing consequences is the violation of normative gender stereotypes (Rudman, Moss-Racusin, Glick, et al., 2012).

Nowadays, biotechnological interventions of embryos can target a wide range of psychologically relevant features (Banazadeh et al., 2024). Given the functional principle of Human Enhancement and the increasing potential of biotechnology beyond mere embryo selection, people may create children "perfectly" adapted to the abundant social normativity of gender (see Butler, 1988; Butnor & MacKenzie, 2022; Fitzgerald, 1997; Rudman, Moss-Racusin, Glick, et al., 2012; Saguy et al., 2021). However, transhumanism sees genetic engineering as a risk-mitigating strategy (Coeckelbergh, 2013). Radically applied to the role of gender, Hughes and Dvorsky (2008) theorized that these biotechnologies could dismantle solidified gender norms. In the best transhuman sense, the proposed technological adaptation of ourselves would deliberately eliminate any chance of being oppressed by cruel biology (Thweatt-Bates, 2012/2016). Following this logic, people could use this technology to design children whose

features explicitly do not match stereotype content and contribute to their re-negotiation: An adaptation of the environment qua the adaptation of ourselves in the broadest sense.

Similar to vaccination, we once again encounter the possibility of using controversial biotechnology to adapt ourselves in relation to a normative environment. But this time, personal health or organizational membership is not the focus. Instead, the biotechnological adaptation is suspected to interfere with one of the fundamental qualities of our identity as men and women and eventually humans.

9.2. Theory and Method

I suspected that parents are generally invested in their child's well-being. This motivation extends to affirming the potential use of genetic engineering for the prevention and eventual cure of genetic diseases (Jedwab et al., 2020; Snure Beckman et al., 2019). Additionally, according to Butler (1988), individuals are heavily pressured to behave according to traditionalized expectations, aka stereotypes, to ensure their participation in a gender-dominated world. Hence, these convictions can be seen as signposts for successful adaptation to an environment which, according to Saguy et al. (2021), is structured by the traditional binary of male and female signifiers and maintained through the fulfillment of derived gender-specific expectations. Parents are important for conveying gender norms to their children (Davis & Greenstein, 2009; Saguy et al., 2021). Given the harsh consequences of violating gender stereotypes (e.g., Blondeel et al., 2018), parents are suspected of evaluating choices regarding interfering with what is assumed to be the genetic "natural" basis for behavior and personality in relation to this consequential gender normativity (see Dar-Nimrod & Heine, 2011; Fitzgerald, 1997). Here, they encounter two kinds of stereotypes: The *prescriptive dos* and the *proscriptive don'ts* (Prentice & Carranza, 2002). Examples of the former are that females shall display more emotionality, while for males, athleticism is seen as desirable (Prentice & Carranza, 2002). On the proscriptive side, females should not be "dominant," males not "weak," and both gender should maintain a concurring "feminine" or "masculine appearance" (Koenig, 2018, p. 7). Cross-culturally, the most evident prescriptions are that males are expected to be agentic, while females shall enact more traits linked to communality (Bosson et al., 2022 - as measured by the "Big Two": "agency" and "communion"). Given the importance of gender as structuring component of our social relations (Butler, 1988; A. E. Martin & Mason, 2022), negative consequences due to norm-violating behavior (Blondeel et al., 2018; Rudman, Moss-Racusin, Glick, et al., 2012), and transgression into socio-material spheres (Saguy et al., 2021), people can choose to personally show stereotype-confirming behavior or enforce it within others (Rudman, Moss-Racusin, Glick, et al., 2012). Since gender can also be enacted pre-birth (T. K. Browne, 2017; Jack, 2020; Verbeek, 2011), hypothetical

use of genetic engineering may be steered by the goal to enable children to display their gender in the "right" way.[44] This motivation may lead to enforcing normative gender stereotypes so that the children's altered genome is expected to manifest in ways that minimize expected risk and maximize expected benefit. This is the *Good-Gender Hypothesis — Good-GH.*

However, people sometimes express the hope that genetic engineering can mitigate societal issues (Sadler & Zeidler, 2004; Van Dijke et al., 2018). The gender-related manifestation of this is the transhumanist projection of a "Postgender Future" (Hughes & Dvorsky, 2008, p. 13), in which biotechnologies dismantle biology-based gender-related oppression (Thweatt-Bates, 2012/2016). Less phantasmatic, gender stereotypes have been proven to regularly adapt to changed social conditions (Diekman & Eagly, 2000; Eagly et al., 2020). Change in stereotype content can be facilitated by so-called "vanguards," i.e., persons who counteract stereotypes (Rudman, Moss-Racusin, Glick, et al., 2012, p. 168). Deeming stereotypes oppressive and bad, why not use powerful genetic engineering to purposefully create these vanguards and effectively dismantle normative convictions about gender? This is the *Emancipating-Gender Hypothesis — Eman-GH.*

Both hypotheses build upon the idea that interfering with the human genome will create tangible phenotypical differences. One can certainly question this stark influence of the genome (Resnik & Vorhaus, 2006). Nonetheless, the act of purposefully intervening with the embryo may force children and their social environment to contemplate the wider implications and associated goals of this process (Habermas, 2002/2005; Hendl, 2017). In this context, I presented different arguments highlighting why parents may be inclined to use genetic engineering even though the success of their intervention may be uncertain. Moreover, I examined the literature to determine the content and type of contemporary normative gender stereotypes. While the Good-GH predicts the enactment of these stereotypes, the Eman-GH suggests dismantling stereotypes by leveling out any gender differences. *Table 4* provides an overview.

Table 4. Hypotheses of Döbler & Carbon (2025)

	Good-Gender Hypothesis	Emancipating-Gender Hypothesis
Idea	People want "well-adjusted" children whose characteristics do not result in unnecessary friction with stereotypes.	People design individuals who deliberately counteract stereotypes and eventually shift the feature distribution that informs these stereotypes into a more egalitarian direction.
Why?	Women and men are punished economically, socially, and physically if they do not exhibit gender-conforming behavior. Stereotypes are seen as veridically related to a gendered essence.	Gender equity is an important issue, and advocates of Human Enhancement emphasize its potential to create a better world for everybody.

[44] The same may apply to any procedure that prenatally reveals the child's gender to the parents (T. K. Browne, 2017) or selects an embryo based on its sex (Hendl, 2017). Yet, I pointed out that in these cases, manipulation opportunities are not as widespread as under human genetic engineering.

Investigating these hypotheses was possible by cooperating with the "Deutsches Museum Nürnberg - Das Zukunftsmuseum." Within this museum, which is about the future and its emerging technologies, one exhibit enabled visitors to genetically engineer their virtual "perfect child." I analyzed the anonymized dataset extracted from this exhibit. Within the exhibit, people could first select the child's gender, followed by appearance and disease disposition-related choices. Hereafter, people could manipulate personality and talents like intelligence and creativity. Each change costs the same amount of virtual money regardless of the magnitude of change. The final dataset to test these hypotheses contained N = 13,641 virtual children. I have no information about the sociodemographics of the creating visitors, including their number. Bayesian regression models were constructed to test which of these strategies is dominant. Multinomial logistic regressions were calculated to determine if children's values were increased (Prescription), decreased (Proscription), or maintained. Hereafter, Zero-One-Inflated Beta regressions modeled the outcome distribution of children whose values were manipulated. I then calculated expected posterior values for group comparison.

9.3. Results

People could choose to maintain the gender the exhibit randomly assigned to their child (random Female = rF or random Male = rM) or deliberately pick the gender (Female = F or Male = M). Children were largely relieved from disease dispositions and designed with high expressions of valued traits like intelligence. This supports the hypothesis that these children are generally designed to live a good life.

Table 5. Comparisons of chosen gender and designed features

	Sensibility			Good-GH: Females > Males
Comparison	Δ (Median)	CI95% Low.	CI95% Up.	% Good-GH
Female - Male	0.04	0.00	0.07	98.04
Female - random Male	0.05	0.02	0.09	99.94
random Female - Male	0.02	-0.02	0.06	86.02
random Female - random Male	0.04	0.00	0.07	97.78

	Sociality			Good-GH: Females < Males
	Δ	CI95% Low.	CI95% Up.	% Good-GH
Female - Male	0.00	-0.03	0.03	57.49
Female - random Male	0.00	-0.03	0.03	51.52
random Female - Male	-0.02	-0.05	0.02	83.27
random Female - random Male	-0.01	-0.04	0.02	80.18

	Openness			Good-GH: None
	Δ	CI95% Low.	CI95% Up.	% Direction
Female - Male	0.02	-0.01	0.05	90.79
Female - random Male	0.00	-0.02	0.03	59.57
random Female - Male	0.00	-0.03	0.03	54.01
random Female - random Male	-0.02	-0.04	0.01	84.23

	Agreeableness			Good-GH: Females > Males
	Δ	CI95% Low.	CI95% Up.	% Good-GH
Female - Male	0.02	-0.01	0.05	87.82
Female - random Male	0.01	-0.02	0.04	63.32
random Female - Male	-0.01	-0.04	0.03	35.62
random Female - random Male	-0.02	-0.05	0.01	11.15

	Conscientiousness			Good-GH: Females < Males
	Δ	CI95% Low.	CI95% Up.	% Good-GH
Female - Male	0.00	-0.03	0.03	42.18
Female - random Male	-0.03	-0.06	0.00	96.26
random Female - Male	-0.02	-0.05	0.01	89.08
random Female - random Male	-0.05	-0.08	-0.02	99.94

	Intelligence			Good-GH: Females < Males
	Δ	CI95% Low.	CI95% Up.	% Good-GH
Female - Male	0.01	-0.02	0.04	27.18
Female - random Male	0.02	-0.01	0.04	9.21
random Female - Male	-0.03	-0.06	0.00	98.19
random Female - random Male	-0.02	-0.05	0.00	95.48

	Sportiness			Good-GH: Females < Males
	Δ	CI95% Low.	CI95% Up.	% Good-GH
Female - Male	-0.08	-0.11	-0.05	100
Female - random Male	-0.02	-0.05	0.01	94.07
random Female - Male	-0.05	-0.08	-0.02	99.97
random Female - random Male	0.00	-0.03	0.03	45.85

	Musicality			Good-GH: None
	Δ	CI95% Low.	CI95% Up.	% Direction
Female - Male	0.11	0.08	0.15	100
Female - random Male	0.00	-0.03	0.04	59.1
random Female - Male	0.08	0.04	0.12	100
random Female - random Male	-0.03	-0.07	0.00	96.79

	Creativity			Good-GH: Females ≠ Males
	Δ	CI95% Low.	CI95% Up.	% Good-GH
Female - Male	0.05	0.02	0.07	99.89
Female - random Male	-0.01	-0.03	0.02	67.68
random Female - Male	0.04	0.00	0.07	98.52
random Female - random Male	-0.02	-0.05	0.01	88.6

Note. Comparison denotes which groups were compared. CI95% Low. and Up. are the lower and upper bounds for the 95% credible interval. Maximum value of difference 2 to -2. The Good-GH column denotes the respective prediction that should apply to all gender differences, regardless of being random or non-random children. Here, red denotes the prediction of higher female, blue a prediction of higher male values, and yellow a predicted unspecified difference. % values are the probability of the effect being on the side as predicted by the Good-GH. Colored bars refer to the proportion that corresponds with the prediction. It is the probability of direction, i.e., the proportion of the posterior difference with the same numeric sign as the median. Values were attuned to the predicted direction. If the median is 0.00, the value distribution can indicate one over the other direction because of the rounding procedure. Where no direction was submitted, values indicate general probability of effect and color direction.

Table 5 shows an overview of found differences across gender. They did not provide conclusive evidence that one of the proposed strategies dominates. Yet, comparisons for sensibility, for instance, provided clear evidence for enacting contemporary stereotypes concerning expected lower emotionality for males but higher values for females (e.g., Koenig, 2018; Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). A similar pattern

was found for sportiness. Yet, enforcing the stereotype that males ought to display more athleticism (Prentice & Carranza, 2002) was conditional on whether the gender was picked deliberately. Conclusions were supported, given that the probability of changing these features partially mirrored the respective gender-specific pro-/prescriptions. Conditional on available resources and initial feature expression, children purposefully designed to be male were more likely to get their sportiness values increased than their female counterparts. In the case of sensibility, the same male children were more likely to get a value decrease. However, the prescription that females shall be more emotional than males was not enacted as there was little to no evidence for a likelier increase in sensibility for the former group. Absent differences in conscientiousness and intelligence in children with deliberately chosen gender pointed more toward nullifying gender differences and counteracting contemporary stereotypes. In general, I found evidence that a "perfect" child is designed in partial accordance and discordance with well-defined convictions that comprise general and gender-specific evaluations of the to-be-manipulated features.

9.4. Discussion and one step further

My findings support the theoretical proposition that "perfecting" one's child can manifest in small yet decisive attunement to social norms and expectations (see Little, 1998; Sparrow, 2007). The fact that normative gender stereotypes are a mixture of pro- and prescriptions is reflected in findings on the probability of decreasing certain features. Proposed strategies operate with a specific understanding of 'adapting to improve.' Instead of being designed to achieve meritocratic performance measures, the child is adapted to a gender-specific reference frame so that the improvement refers to the goal of living a good life or contributing to a more egalitarian society. This dispels the notion that Human Enhancement must always be linked to the quantitative growth of biological characteristics (see Döbler & Carbon, 2024; Menuz et al., 2013). Instead, Human *Enhancement* can also refer to an improved fit between the individual and the environment (Döbler & Carbon, 2024; Menuz et al., 2013). The following discussion will elaborate on the role of essentialism, potentially significant individual and societal side-effects, and questions of technological feasibility within this hypothetical scenario.

9.4.1. Essentially less human females

Thinking about gender is characterized by a profound essentialism (Butler, 1988; N. Haslam & Whelan, 2008). Related expectations constantly bleed into our understanding of biological sex (T. K. Browne, 2017). Thus, I have argued that essentialistic beliefs may be a powerful motivator in influencing people's decisions to manipulate the targeted traits (Döbler & Carbon, 2025). Overall, the meaning of gendered traits and behaviors, as well as their presumed biological associations, are obtained and stabilized through social interactions and participatory sense-

making regimented by historized conventions (Butnor & MacKenzie, 2022). These conventions are then justified by their alleged essentialistic cause (Butler, 1988; West & Zimmerman, 1987). Given the essentialistic flavor of genetic information, collapsing gender differences to an allegedly immutable biological basis is a powerful method for complexity regulation (Dar-Nimrod & Heine, 2011). Such reduction to genes alone enacts a hermeneutic approach that explains individual variation in phenotype, personality, or the self in terms of related molecular, unifactorial cause-and-effect reasoning (Lippman, 1993; Sharon, 2014). This may yield the idea that a pair of chromosomes is and always has been suitable to capture the whole gendered identity of a human (Hendl, 2017).

Indeed, the enhancement-criticizing President's Council on Bioethics (2003) stated that our male- or femaleness is the most defining aspect of our biological condition. However, transhumanists who call for using technology to free ourselves from gender oppression also fall for the logic of a biology-based essentialism (Thweatt-Bates, 2012/2016). I have also briefly discussed the potential fallacy of these assumptions (Döbler & Carbon, 2025): Essentialistic thinking is a *psychological* phenomenon (N. Haslam & Whelan, 2008; Neufeld, 2022; Prentice & Miller, 2007; Rothbart & Taylor, 1992). It is a reductionist mode of explaining the extent of similarities across groups of entities (Neufeld, 2022; Prentice & Miller, 2007) and must not necessarily conform with what we consider the undeniable truth or metaphysical fidelity (Rothbart & Taylor, 1992). The hermeneutic power of available information about gender even proves true if the target is non-human (A. E. Martin & Mason, 2022). Considering its positive correlation with stereotypes in many domains, including gender (N. Haslam & Whelan, 2008; Saguy et al., 2021), psychological essentialism may function as additional justification for the employment of genetic engineering to manifest the genetic foundation for adherence or defiance of normative expectations. Even if partially undermining the prospect of immutability, this pseudo-essence is still considered rooted in biology and deemed pivotal for shown behavior (Döbler & Carbon, 2025). This aligns with the observation that classical psychological essentialism is not sufficiently described by referring to an inner feature but must entail the *subjective beliefs* that affirm the causal responsibility, naturalness and inner roots of the assumed essence (N. Haslam & Whelan, 2008). Linking the Human and gender qua their sense-making function, an *essentialistic gendered Human* emerges. Yet, if genetic engineering can either be an affirmative or disruptive force for any conceptualization of gender essentialism (Döbler & Carbon, 2025), this may also apply to the Human.

In his seminal article on dehumanization, Haslam (2006) briefly reviewed gender-specific effects, suggesting that females are often seen as less human. Novel results support this view. Describing women in animalistic and predator-like terms(denying uniquely human characteristics) can facilitate endorsing oppressive, sexist statements

(Tipler & Ruscher, 2019). Implicit measures revealed that male participants who associated women with being more animalistic were more likely to endorse sexual abuse and were less empathetic to victims (Rudman & Mescher, 2012). Denying characteristics linked to human nature (mechanistic dehumanization) and animalistic dehumanization were linked to misogynistic and violence-affirming attitudes against women (Bevens & Loughnan, 2019). Mechanistic dehumanization can be triggered by presenting women in sexualized poses and diminishes empathy in a hypothetical domestic violence context (Felig et al., 2024). Among young females, dissatisfaction with their appearance was positively associated with feelings of autonomy-related dehumanization (Holland et al., 2021). Moreover, recalling past feelings of appearance-based objectification was linked to experiencing mechanistic dehumanization in women (Chevallereau et al., 2021). It seems that to be ascribed or completely identify with the essentialistic Human, women must fulfill a range of normative expectations.

Other studies support this perspective. Martin and Mason (2022) asked participants to rate whether categories like race, gender, or disability could be meaningfully applied to moving geometric shapes. When primed to anthropomorphize, only applicability ratings of gender were able to predict the ascription of human nature/uniqueness associated traits, emotional capabilities, and unspecified humanness. The same publication revealed that men are generally less humanized than women and that the humanization of groups was mediated by attributing stereotyped gendered traits. The authors explained the former effect through the crucial role of communality-related interpersonal traits in evaluating humanness (Chu & Martin, 2021), which are stereotypically desired for women (e.g., Bosson et al., 2022; Koenig, 2018). The humanization measure employed by Martin and Mason (2022) in this context was adopted from Kteily et al. (2015) and asked for general humanness on a 0-100 scale. Given the increased humanization of women, this measure seems to reflect essentialistic human nature traits that comprise emotional capabilities and "Interpersonal warmth" (N. Haslam, 2006, p. 257). Correlations reported by Kteily et al. (2015) support this view. However, other facets of Haslam's (2006) conception of human nature, e.g., "Agency, individuality" (p. 257) can be linked to male prescriptions (e.g., Koenig, 2018; Prentice & Carranza, 2002). In this context, findings by Formanowicz et al. (2018) suggest that agentic behavior is most important for humanness ascriptions. Directly elaborating on these findings, Chu and Martin (2021) showed that communal attributes are the main driver behind humanization. While the former study largely depended on non-human stimuli, the latter results were present concerning non-human entities like objects, extraterrestrials, and human social groups. Other results indicated that communality and agency variables are equally associated with affirming or denying humanness of social groups (Kuljian & Hohman, 2023). In the broader Human Enhancement debate,

especially adversaries highlight the importance of human nature traits to preserve our humanness (Wilson, 2014; Wilson & Haslam, 2012). Given the crucial role of gender and its associated characteristics in determining what even counts as human (Butler, 1988; A. E. Martin & Mason, 2022), genetic engineering along the established lines of normative gender stereotypes may directly impact the extent to which others acknowledge individual humanness.

These mechanisms extend to the level of features visitors could manipulate in the exhibit. Because human nature, in the sense of Haslam (2006), builds upon communality, emotionality, and open-mindedness, depriving the virtual children of sensibility, agreeableness, openness, and creativity endangers them to be mechanistically dehumanized. Since lacking communal and emotional traits constitutes an unfulfilled female stereotype, gender differences in dehumanization are expected. *Prima facie,* this concerns Eman-GH females because following the adjunct strategy could mean designing female children who, relatively speaking, are neither highly agreeable nor sensitive (Döbler & Carbon, 2025). Yet, it is unclear if low and "nonhuman" communality would be based on absolute or relative values. In the latter's case, females are only expected to experience mechanistic dehumanization when their communal traits are equal to or lower than the male expressions. In absolute terms, deviating from a predefined "human" norm would yield dehumanization effects for both gender, but with a gender-specific effect due to the defiance of the female prescription. Minimizing features like intelligence and conscientiousness may manifest animalistic dehumanization in the sense of Haslam (2006). However, most participants opted for maximizing features, which, theoretically speaking, would not constitute the classical *de*-humanization (see N. Haslam, 2006). Still, Haslam et al. (2008) suggest that elevating persons to a super-powerful status may be a unique form of dehumanization. Indeed, people described by favorable yet mechanistic attributes were seen as possessing fewer traits associated with a biologically constituted human nature (Utych & Fowler, 2021; see also Phillips, 2023; Solanki & Cesario, 2023; Waytz et al., 2015).[45] Still, the link between traits that privilege dehumanization and their gender stereotypical relation to the essentialistic Human suggests that females may lose this version of the Human more easily. Yet, if created as "good," stereotype-conforming individuals, females may also be increasingly humanized.[46]

Overall, the link between the essentialistic Human and its gendered derivation seems important. Fierce critics interpret the vision of a biotechnologically enacted "postgenderism" (Hughes & Dvorsky, 2008, p. 2) as indicative

[45] Someone equipped with "superhuman" rationality but sub-average emotional capacities may evoke a different perception than somebody with an average level of both traits (Grewal et al., 2020).

[46] Little (1998) suggested that the stereotype of female beauty is so strong that it renders conforming individuals universally "good." Hauskeller (2013) discusses this argument regarding enhanced, aka universally "better" humans.

of a despicable transhumanism that loathes biological sex and desires to overcome the traditional family values and physical sexual reproduction (Hartfiel, 2023).[47] In a more modest approach, adversaries of genetic engineering may find that interventions with our DNA threaten our essentialistic human nature (Wilson, 2014). If the expression of this inherent quality semantically overlaps with a historically assumed gender essence, losing gender may be tantamount to losing a valued version of the essentialistic Human. This could explain additional resistance against these interventions but also suggest a potential endorsement as long as valued gender lines are not transgressed.

9.4.2. Gender as necessity

The previous thoughts on psychological essentialism elucidate Butler's (1988) claims that gender has no essence but "regularly conceals its genesis" (p. 522). This means that one is inclined to mistake coherent, normatively aligned behavior and observed differences *as if* being caused by an actual inviolable gender essence (Butler, 1988; West & Zimmerman, 1987). This is a powerful social force that renders "the authors of gender [to] become entranced by their own fictions whereby the construction compels one's belief in its necessity and naturalness" (Butler, 1988, p. 522). If we follow Butler's assertions that there is *no* essential necessity in the occurrence of gender-specific behavior, we encounter a phenomenon in which the effect or manifestations of contingencies are, nonetheless, seen *as if* being inevitable necessities (for a deep dive into this thought, see Žižek, 2014). The effectiveness and pervasiveness of the gendered ascriptions suggest that a boy's behavior is mistaken to be determined by his essential "boyness" and not by the social and individual forces that charge contingent behaviors with gendered meaning (Butler, 1988).

This exemplifies how gender, in general, and stereotypes, in particular, solidify historical contingencies and turn around cause and effect (Butler, 1988; Žižek, 1989/2008). The biotechnological enactment of contemporary gender stereotypes may operate with a similar mechanism. If employed for creating Good-GH children, an alleged primordial, "natural" truth is realized. Although gender identity is linked and retrieved from a series of historical and contingent facts, the alleged essence appears necessary and inevitable in determining the occurrence of these facts. The child must align with the stereotypes because these stereotypes necessitate their own cause: their enactment (see Žižek, 1989/2008). In this sense, people who opt for the biotechnological enactment of gender can

[47] Hartfiel's arguments must be considered with care. She does not only viciously attack transhumanism but also sees contemporary movements for the acceptance of LGTBQ+ rights as a manifestation of this ideology. Even if marginalized in the academic sphere, her positions have the power to influence the public discourse. After all, her book can be found in the "Ethics" section of the seminary library of the Archdiocese of Bamberg

immunize themselves from any accusation of committing an unnatural act by simply arguing that they were giving nature a jump-start. They have simply realized what "'will have been' necessary" (Žižek, 2014, p. 146).

Even if hypothetical parents did not act upon essentialistic beliefs or were simply interested in minimizing friction for their offspring, biotechnologically creating children in accordance with normative gender stereotypes and leaving a tangible genetic trace serves as further justification for the alleged essentialistic foundation of the latter (Döbler & Carbon, 2025). We may even go as far as to state that the same mechanism may underlie potential Eman-GH children. Following the transhuman logic of dismantling gender's "ontological necessity" (Thweatt-Bates, 2012/2016, p. 86), we do not encounter a transfer from contingent to necessary but an "undoing" in the sense of Žižek (2014, p. 161): the necessary is reverted to the contingent and treated *as if* always have been that way.[48] Genetic engineering can potentially extinguish features that we experience as profoundly gendered. But it can also reinforce and embrace them, rendering boys and girls into what they allegedly always have been.

9.4.3. Parental expectations

My results show that visitors largely designed children free of disease predispositions. Although such conduct still evokes criticism, the general value of good health seems to foster increased moral admissibility of genetic engineering for intuitively health-related outcomes (Jedwab et al., 2020; Scheufele et al., 2017). Given the potential benefits, Caplan (2009) asked why the majority of parents should be barred from using certain enhancements for their children just because some misguided parents would abuse these means to overboard their children with their expectations (for a discussion of this argument, see Resnik & Vorhaus, 2006). Caplan may have fallen for what Ihde calls "*illusion* of neutrality" (Ihde, 1990, p. 164, original italics), the idea that a technology itself is neutral and that there are only "bad" or "good" use cases (Selinger, 2015).[49] It is illusionary because it is impossible to separate the technology from its application: the functional employment and resulting mediational effect automatically valorize the technology (Ihde, 1990). Technologies are reciprocally embedded into the dynamic socio-material contexts of preexisting normative conventions, rules, and customs (Coeckelbergh, 2018; de Boer, 2023; Döbler & Bartnik, 2022). One heuristic to assess a technology's moral valence builds on predicting the most apparent actions in a given context and the subsequent evaluation of desirability (Klenk, 2021). Caplan (2009) acknowledges this by calling for a case-by-case evaluation.

---

[48] See also the transhumanist project to enhance our life span, i.e., the urgency to negate or at least delay the only necessity humans as living organisms inevitably face: dying (Hauskeller, 2016).

[49] E.g., "'Guns don't kill people. People kill people'" (Selinger, 2015, p. 205).

However, once employed, the technologically created possibilities, e.g., in prenatal diagnostics, *demand* a series of decisions from everybody involved (Schmidl, 2022; Verbeek, 2005, 2011). Transhumanism champions individuals to make autonomous decisions about Human Enhancement (Bostrom, 2003b). But we must not forget that in social contexts, choices are often already made *for* us but required to be affirmed *by* us (Žižek, 1989/2008). This elucidates how displaying gender "right" is conceived as '*historically necessitated*' (Butler, 1988) and subjected to power-related social processes (Butnor & MacKenzie, 2022). Any deviation from the historical pathway may be perceived as threatening the constitutive pillars of contemporary gender relations (Rudman, Moss-Racusin, Glick, et al., 2012). You may explore some aspects of gender atypical behavior; it may be sometimes even beneficial (C. L. Martin et al., 2017). But if you want to exploit the whole range of gender's "performative fluidity" (Butler, 1988, p. 528), physical, social, and economic punishments are likely (Judge et al., 2012; Kochel et al., 2012; Rudman, Moss-Racusin, Glick, et al., 2012; Stotzer, 2009). In other words, "if you make the wrong choice, you lose freedom of choice itself" (Žižek, 1989/2008, p. 186). The choice of which gender one enacts in which way is made for you, but must still be freely affirmed by constraining deflections to a sufficient minimum. Respective decisions, including those about the use of pregnancy-related technology, are not only inescapable (Ihde, 1990) but also reflect and result from contemporary and bygone sense-making activity in attunement to experienced gender normativity that manifests at all levels of conscious access (Butnor & MacKenzie, 2022). Once possible, the question of how to integrate biotechnology into gendered expectations must be addressed.

Thus, I rebut Caplan's (2009) claim that the responsibility for bad results rests solely on the parents and not the technology. Technologies are never neutral but actively and constantly involved in how people make morally relevant decisions relative to a specific structure of cultural values (Verbeek, 2011). In a context in which essentialistic notions about genes and gender dominate and prevail, and non-conforming to gender stereotypes is associated with physical and social harm, parental expectations are likely to be not confined to gender-unspecific qualities like health but could be motivated to create a gendered version of their perfect child (see T. K. Browne, 2017). Hence, the potential ban hinges upon whether the potential *biotechnological enforcement* or *dismantling* of gender is desirable.

9.4.4. A straw man?

It is nowadays trivially true that nature cannot account for any human variation but must always be seen in the context of nurture. This limits the extent to which genetic information manifests in phenotypical differences (Dar-Nimrod & Heine, 2011). Our ability to foresee whether a specific genetic engineering intervention will lead to the

intended outcomes or change dispositions caused by multiple genes is extremely limited (Salvi, 2002). For instance, the complex temporal relationship between genetic, environmental, and individual factors on personality (Kandler et al., 2021) renders reliable genetic manipulation of these features highly improbable.[50] This puts significant question marks behind the technological and biological feasibility of precise human genetic engineering (Sparrow, 2019). Is this study investigating a straw man?

Note how parents' current efforts to align their children with their values and expectations already aim at genetic factors. When picking a sperm donor, for instance, women favor a high educational degree (Whyte et al., 2016). The attained level of education is heritable but depends on the complex interplay of other variables, with varying degrees of genetic influence (Krapohl et al., 2014) and environmental influences (Branigan et al., 2013). *Assumed* causal responsibility of genes and related essentialism can be powerful yet delusive motivators (Dar-Nimrod & Heine, 2011). Selecting for education is an uncertain bet on the effect of nature over nurture. Using genetic engineering similarly is a bet on the dominance of technology over nature.

In line with my arguments on enhancement motivating subjective beliefs (Döbler & Carbon, 2024; Section 4.6), the success of the intervention is only one side of the medal; the question of what parents contemplate doing is the other. Answers can discursively establish an imagined practice whose assumed manifestations are used to justify regulation or project a favorable vision that political action tries to realize (Coveney et al., 2019; Jasanoff & Kim, 2009). Examining how people would use this technology allows us to capture how shared norms and laypeople's ideas of technological potency and biological causality guide parental decision-making.

9.5. Critical appraisal

Besides the limitations mentioned in the manuscript, the following criticism must be acknowledged. The use of "adaptation" in the context of the Eman-GH is not necessarily in line with the naturalistic and organismic understanding of adaptivity (see Di Paolo, 2005) or its social manifestation (see Maiese, 2022) but more akin to the meaning that emphasizing the location of the intervention in contrast to the manipulations of the environment (Döbler & Carbon, 2024). Still, if adapting the environment is the goal of following the Eman-GH strategy, adapting the child to meet designer-imposed demands is the mechanism to achieve this. Moreover, applying technology prenatally makes it impossible for the organism to conduct the intervention. Adaptation conducted by

[50] Drawing from various arguments, including the influences between genotype and environment, Agar concludes that adapting the former is morally comparable to adapting the latter (Agar, 2014). See Sorgner (2015) for a similar conclusion concerning education and genetic engineering.

external authorities is inherent to any intervention that involves an embryo. Hence, both strategies adapt the latter to the demands of the parents.

The political agenda that resonates within the Eman-GH is highly controversial and, in principle, even opposed by Savulescu (2001). Nonetheless, as the cited thoughts on abortion practices show (e.g., Hendl, 2017), childbirth is hard to isolate from any political gender-related circumstances. Still, future research should investigate political considerations within individual reproductive decisions and genetic engineering.

People disagree on whether the moral and ontological status of the embryo is the same as a post-birth human (Pardo & Calvo, 2008). The functionality of Human Enhancement can also be applied to embryonic genetic engineering (Döbler & Carbon, 2024). Still, if we want to maintain the emphasis on *the Human,* this study investigated *potential-future-Human Enhancement*. Yet, due to the length of the manuscript and the exhibit's focus, the term Human Enhancement does not appear in the manuscript. A more substantiated link to my previous research might have been helpful.

Considering the absence of any information about the visitors, I discussed several motivational foundations for adhering to one of the hypotheses. Future research must address to which extent the shown behavior is grounded in prevention reasons or more associated with pronounced essentialism.

9.6. Conclusion

It does not require strong genetic determinism to acknowledge the nimbose character of genetic engineering. Like no other means, it reveals how Human Enhancement relies on using technologically constituted agency to enact a specific normativity of adaptation into the individual. Apart from significantly shaping the personality-based pillars of individual identity, these effects can transpire into the alleged essence of the Human. Even if deemed overhyped, discussions about genetic engineering can reveal dominant and overly confident naiveties about reliably determining our biological condition (see Ihde, 2011a). For now, the idea alone has the potential to inspire visions about whether the enforcement or dismantling of the essentialistic gendered Human is deemed necessary. If so, one might not only discard a profound pillar of our social organization (see Saguy et al., 2021) but also a constitutive element of our identity as humans.

10. A return to the Garden

Wilson and Haslam (2009) argue that advocates champion a Human primarily characterized by allegedly unique human features such as rational and intelligent behavior. According to them, this reflects an Enlightenment-

inspired approach to ourselves, while adversaries, in their emphasis on a valuable human essence and emotional capabilities, orient toward a Romanticism-leaning reading.[51] However, the advocates' desire to transgress the Human may be similarly linked to romantic ideals like self-transformation as to enlightenment views of privileging rationality and self-determination (Coeckelbergh, 2017). This highlights how transhumanist virtues of rationality are just a proxy for conveying utopian visions of a harmonious and self-transcending being (Hauskeller, 2016). Romantic dwellings are often characterized by the effort to reinstate a shattered primordial harmony (Coeckelbergh, 2017). Especially advocates frame Human Enhancement as potentially eliminating the unfavorable circumstances of our existence (Hauskeller, 2013, 2016). Adversaries, however, sometimes fear that specific enhancements may infringe on existing harmonious relationships (Buchanan, 2011). Yet, in both cases, arguments dwell upon creating or maintaining a particular harmonious relation with the environment and its technological components (Coeckelbergh, 2017).

Due to the general "precarious" existence as a living organism (Di Paolo, 2005, p. 439), awareness of our "being-at-risk" (Coeckelbergh, 2013, p. 44), or "lagging behind" socio-technological and political developments (Stiegler, 2022, p. 27), humans seem always required to make use of their agentic adaptivity. If we suspect that human agency is inseparably linked to human technology (Ihde, 1990), what role do we assign to the effort to technologically adapt ourselves within our longing for harmony? Here, Ihde (1990) is probably correct that by contemporary standards, returning to an actual life with no technology, aka the Garden, is highly uncomfortable. Nonetheless, the unfulfillable goal to fully incorporate the technologies' capacities without being reminded of their origin, the attempt to eat the technological cake and have it, may still inspire paradisical or catastrophic visions about embodied technology's negative or positive effects (Ihde, 1990). Calling out the technological reenactment of the well-known dwelling upon harmony and limitation-transgression, Ihde states that: "The technofantasy is to have this enhancement be so totally transparent that it *becomes us* .... to have and to *be* the power embodied" (2011a, p. 127, original italics). Broadly culturally speaking, this manifests along the poles of building culture around nature or heavily relying on technology to shape nature according to the demands of culture (Ihde, 1990). These ideas may work similarly to so-called "sociotechnical imaginaries," which are meant to politically propagate a projected techno-societal organization and a normative path for related developments (Jasanoff & Kim, 2009, p. 120). Suppose our engagement with technology is characterized by an inherently impossible phantasmatic element

[51] See Allenby and Sarewitz (2011) for a similar diagnosis, and transhumanist Max More (2013b) for affirming that transhumanism is rooted in the movement of Enlightenment. A critical analysis is provided by Simon (2019).

(Ihde, 2011a), fueled by the constant strain we experience in relation to the socio-material environment (e.g., Coeckelbergh, 2013). Assume further that we can re-conceptualize the idealized (pre-technological) Garden, which was lost in the Fall as a state of "*primordial unity and harmony*" (Žižek, 2014, p. 49, original italics). If now adaptivity concerns actively creating a trajectory into a desirable future by achieving or maintaining a valued state in relation to environmental demands (Di Paolo, 2005), adversaries and advocates must attune their vision of human-technology relations to the constant change that is the side effect living in a technologized environment. This leads to two questions. First, if adaptation seems necessary, how do adversaries and advocates want us to adapt? And second: If the tempting, lost Garden is stable and pre-determined, is adapting ourselves the only way to attain it and restore the lost harmony?

10.1. Adversaries

Critics of Human Enhancement are not automatically anti-technology in general. Still, seeing the rapid advancement in biotechnology and Human Enhancement unfolding on the horizon, skeptical voices (e.g., Agar, 2014; President's Council on Bioethics, 2003) deemed us at the edge of critical regulatory decisions.[52] Potentially losing a valued human nature through intrusive technology would be so catastrophic that the adversaries' positions may be summarized as "dystopic" (Sharon, 2014, p. 7). By projecting a dystopian future, adversaries implicitly or explicitly draw upon a more favorable state, one that comprises some "natural" (e.g., President's Council on Bioethics, 2003) or simply the not-so-bad current state (Davies, 2017).[53] The valued state can be primordial concerning today. Yet, the present in relation to the feared future can also be described this way.

If worried about the potential loss of the Human, no strict return happens because the undesirable point from which we ought to return has not been reached yet. However, one could also understand return as *initiating* a turn because the chosen path is anticipated to lead to a disastrous state. A more radical reading would be that the precious state has already been lost. Pessimistically speaking, one could argue that the rapid advancement and adoption of biotechnology rendered the grim prediction Kass (2003) issued over 20 years ago ("Human experience under biological intervention becomes increasingly mediated by unintelligible forces and vehicles, separated from the human significance of the activities so altered" p. 22) factual or at least much closer to realization (cf. Sharon, 2014). Because we are free to define the valued state from which biotechnology has allegedly dissuaded us, any

[52] Transhumanists propose a comparable urgency to *accelerate* Human Enhancement (e.g., Bostrom, 2005b) up to the point where we reach out for divinity (Hauskeller, 2016).
[53] This argument does not require a profound dystopia yet may gain persuasive power when evoking it.

technology can be relatively disruptive compared to the pre-defined state.[54] Since radicality and the associated magnitude of enhancement are always relational to a historical baseline (Cassioli & Balconi, 2022), even an established vaccine can be seen as radical compared to when this enhancement was unavailable (Döbler & Carbon, 2024). Very broadly, adversaries value a specific state because it lacks the allegedly corrupting technological means or practices and is subsequently primordial to them. The emerging picture then justifies adaptive reactions for return. This is visible in the repugnance against invasive embodied means whose adoption would annihilate a valued bodily 'purity' (Coeckelbergh, 2013). Moreover, bioconservatism sometimes argues that Human Enhancement may interfere with the contemporary carefully tared and worth conserving harmony between a presumed human nature and valued aspects of our social organization (Buchanan, 2011).

Wilson and Haslam (2009, 2012) and Wilson (2014) proposed that the effect of Human Enhancement on attributed humanness may depend on the to-be-enhanced feature. They cited the findings of Riis et al. (2008), showing that people oppose the enhancement of traits they deem pivotal to their personal identity, and argued that the overlap between these traits and those deemed highly indicative of human nature explains the adversaries' aversion to alter them. Recently, the finding that the perceived fundamentality of target traits moderates enhancement evaluation received additional support (M. Haslam et al., 2021; Medaglia et al., 2019; K. Wagner et al., 2018).[55] Nevertheless, the moral gravity of what we consider central to ourselves may not be purely repulsive. Riis et al. (2008) also found weak evidence that framing an enhancement as uncovering a "true" self rather than extending it can ameliorate enhancement reluctance. Appealing to essentialistic beliefs, this effect shows the motivating but also discouraging role of authenticity in the Human Enhancement debate (see Elliott, 2011; Hauskeller, 2013). Using cognitive enhancement drugs can yield lower ratings of authenticity by observers (Fitz et al., 2014). Yet, people may see their own enhanced performances as reflecting their morally justifiable "true" and authentic level of capabilities, while the performance of peers is considered as technologically altered and thus more reprehensible (Williams & Steffel, 2014). These results suggest that criticism implicitly favors not the return to the pre-technological but the specific *pre-enhancement Garden*. However, if the enhancement does not transgress but helps to establish or maintain valued boundaries, it may actually contribute to a harmonious co-existence between humans and their technological products.

[54] E.g., "in the eyes of a hunter-gatherer, we might already appear 'posthuman'." (Bostrom, 2005a, p. 213)

[55] Results of Medaglia et al. (2019) dependent on distinguishing between enhancement and treatment and whether the imagined target of the intervention was oneself rather than somebody else. Wagner et al.'s (2018) scenario asked imagine the intervention being done to one's own children.

Indeed, Buchanan (2011) argued that the bioconservative dogma of harmony conservation does not necessarily discard enhancement efforts but may actually endorse them. One example: Arguments against Human Enhancement often seek to protect and maintain a valued state (Buchanan, 2011). For many people, being in good health is such a state (Lau et al., 1986). Individual conceptions of this state's constitution vary so fundamentally that they are associated with affirming or rejecting all kinds of contemporary and future health-promoting Human Enhancement (M. Browne, 2018; Döbler & Carbon, 2023). However, desiring to maintain the current state of health or human nature may necessitate using controversial enhancements like genetic engineering (Powell, 2015). Moreover, the success of past technological efforts to increase life expectancy may at least require additional argumentation of why future interventions may disrupt human identity (Pugh et al., 2016).[56] Similarly, the contemporary valued state may have emerged through enhancement in the first place. Individual critical attitudes toward vaccination cannot prevent the widespread distribution of this enhancement, creating societal effects that benefit the hesitant individual (Bärnighausen et al., 2014; Buchanan, 2011; Döbler & Carbon, 2021). If one justifies vaccine rejection due to a feared disruption of valued assets like personal identity or the Human, both concepts may refer to a state that is so beneficial because of widespread Human Enhancement.[57] We must reject the idea that there is a "natural" state of health untouched by technology and Human Enhancement.[58]

This hints at a larger predicament for passionate adversaries. In their study, Bain et al. (2006) report that, compared to categories like "middle-class," rules (e.g., "cheating"), or activities (e.g., "hunting"), affirming or being able to comprehend human values like being "humble," "enjoying life," living an "exciting life" or "freedom" (p. 356) were rated as being the most indicative of human nature. Moreover, values linked to human nature were considered more important than these other concepts, but were seen as somewhat constructed and not "natural." The expression of these values concerning their relationship to technology demands closer attention. Is not partying, including the instrumental use of psychotropic substances and human-enhancing alcohol, one possible way to enact the value of living in excitement? What about the freedom to choose the ways we adapt our bodies (see Sandberg, 2013)? I am not claiming that values and technology are tantamount. Yet, technologies are valued because of their fundamental and constituting role in our activities (Klenk, 2021; Verbeek, 2011), so their influence on our valued

[56] Infamously, this may comprise the biotechnological enhancement of moral capabilities for climate protection (see Persson & Savulescu, 2012; Pugh et al., 2016). See Buchanan (2011) for a similar argument on vaccination.
[57] See Cassioli and Balconi (2022) and Menuz et al. (2013) for Human Enhancement definitions that take into account dynamic baselines based on historical enhancements and other developments.
[58] Such "natural" state probably never existed within the human civilization (Ihde, 1990). See Sharon (2014) for a critique of how adversaries inconstantly argue with "nature" to reject Human Enhancement.

being is pervasive (Coeckelbergh, 2013). Even if this means valuing something because of the absence of technology (Ihde, 1990). Supposing that the composition of some of these technologically mediated and constituted values yields what people understand as indicative of an essentialistic human nature, we might ask to what extent adversaries of Human Enhancement seek to protect an immutable Human produced by the means they want to banish. This perspective extends common arguments that naturalize Human Enhancement (see Hauskeller, 2013, 2016) in the way that before claiming that some enhancements will disrupt our "natural" ways of doing things (e.g., President's Council on Bioethics, 2003), we should examine how the abstract notion of "natural" human agency in everyday settings is constituted by technologies and the systems they are integrated in (Allenby & Sarewitz, 2011; Verbeek, 2014).

Another example from the biblical Garden may be enlightened here: "male and female created he them" (Gen 1:27). Adam and Eve's gender identity was not a result of self-reflection and deliberate authorship, but due to divine positing, as some Christian critics of gender theory point out (e.g., Favale, 2022). Even if being Christian is associated with more skepticism towards some types of Human Enhancement (Pew Research Center, 2016b), previous thoughts on the biotechnological enactment of normative gender stereotypes (Döbler & Carbon, 2025) suggest that seeing certain traits as essentially gendered but also bemoaning that a secular counter-revolution neglects this primordial truth, the return to what was pre-given may need biotechnological aid. We can extend this ambiguous relationship to all sorts of gendered phenomena. Take, for example, the prescriptive stereotype for females to maintain a gender-congruent appearance, expressed through having a specific body shape and wardrobe (Koenig, 2018) or being generally concerned with their looks (Prentice & Carranza, 2002). Females also face more negative social consequences due to obesity (Tang-Péronard & Heitmann, 2008). Note how historical and modern technological weight-loss commercials specifically target women (Blaine & McElroy, 2002; Rasmussen, 2012). Assessing the motivations to use prescription drugs without medical necessity among college students showed only one significant gender difference: female participants were more likely to have used these means for weight-loss (Cruz et al., 2017). Additionally, wearing make-up is a historically solidified embodied technology for enacting gendered ideals (Clarke & Bundon, 2009). Make-up can increase physical attractiveness (Kellie et al., 2021) but undermine the female prescription of warmth and even reduce ascribed humanness (Bernard et al., 2020). In all of these cases, the goal may be the naturally beautiful stereotype-conforming "true" woman (Hauskeller, 2013; Little, 1998). Here, the desired "natural beauty" is sometimes inconsistently framed as exclusively achievable by artificial cosmetic procedures and means (Hauskeller, 2013). In this vein, Hauskeller also suggested that the same

logic of equating female "trueness" to "goodness" applies to humans in general. Given the extensively discussed role of gender and humanization, we can affirm this proposition and claim that Human Enhancement can be crucial for the "correct" female gender display, which may result in complying with the essentialistic gendered Human. Still, the evidence on make-up-related dehumanization indicates that the "true" sometimes results from contrasting the "natural" and non-technological against the technologically aided enactment of gender. Nonetheless, the idea of a "good" woman as something meant to be achieved or preserved occurs in relation to available enhancements.

These arguments highlight how technology's pervasive and historical influence on our being yields the discursive obligation to formulate criteria to morally distinguish future from past enhancements (Coeckelbergh, 2013). Indeed, with sufficient habituation, the effects of specific enhancements may be taken as self-evident so that we do not ascribe any disruptive effects to these established means (Döbler & Carbon, 2024). However, contemporary integration does not mean that past effects were undisruptive. This is metaphorically captured in the loss of the valued Garden. If the current state really resulted from successfully integrating the profound experience-altering power of enhancements that some adversaries criticize (e.g., Agar, 2014), we must question on which grounds we condemn emerging enhancements for similar effects (Döbler & Carbon, 2024). This may support the conclusion drawn by Buchanan (2011) that conservative positions for harmony and preservation, if taken seriously, actually endorse instead of reject Human Enhancement. Instead of seeing the era of Human Enhancement currently unfolding (Agar, 2014), such a perspective acknowledges the historical and civilizational role of Human Enhancement in a way that nobody could seriously endorse to return to a non-enhancement time (Greely, 2006). Since past enhancements, e.g., vaccination, can influence our normative conception of ourselves (Nizzi, 2015), viewing diseases as harmless and men and women as essentialistically different may neglect the technological conditions that enabled this judgment. In this sense, what adversaries may seek to preserve or return to may be a Human partially constituted by historical enhancement.

10.2. Advocates

The transhuman claim of seeing technology as generally beneficial (e.g., Bostrom, 2003a; Kurzweil, 2005) and arguing that human evolution is far from done (Various, 2013) was called out to be a "romantic" (Coeckelbergh, 2017, p. 187) or "utopian" narrative that serves as justification to push for trans- and posthumanity (Hauskeller, 2016, p. 9). These arguments are often enriched by the naturalization of Human Enhancement and the rejection that human nature exists or consists of revolting against the same nature (Hauskeller, 2013, 2016). Especially the first proposition intuitively counters any desire to return to the *pre-technological* Garden in the sense of Ihde.

However, if the metaphorical and conceptual Garden refers to some harmonious and desirable state (Žižek, 2014), the Fall of Man was the initial moment in which the inevitability of death and risk befell our lives; conditions that now require amelioration via technological means (Coeckelbergh, 2013). Eager to return to such a state, transhumanists promise that "Paradise *is* attainable [and] [s]cience and technology make it so" (Hauskeller, 2016, p. 8, original italics). This may be best visible within the transhumanist vision of the "Singularity." The infamous term denotes the point in time where we — enabled by the exponential growth of human technological capacities — finally "transcend these limitations of our biological bodies and brains. We will gain power over our fates. Our mortality will be in our own hands" (Kurzweil, 2005, p. 9). A development that "will ultimately infuse the universe with spirit" (Kurzweil, 2005, p. 389). As noted by Coeckelbergh (2017), the former quote and the overall flavor of eschatology of Kurzweil's arguments demonstrate a profound propagation of spiritual dissolution. Kurzweil's vision aims to create a perfect condition where we face no existential threats (Coeckelbergh, 2013) and, as also shown in his quotes, return to a harmonious relationship with our planet (Peters, 2011). The underlying idea of the singularity was framed as a new-age flavored attempt to 'undo the Fall' — as the desire to return to a state of divine mutual experience, i.e., the Garden (Žižek, 2014, 2021). Desiring unification qua technological singularity is not a *sine qua non* for being a transhumanist (Thweatt-Bates, 2012/2016).[59] However, it may still resonate in our attitudes toward contemporary technologies. By enabling global connections and transcending one's identity, the internet, for instance, fuels the romantic fantasy of merging into a harmonious digital community, where preserving our personal data can be seen as a twisted realization of immortality (Coeckelbergh, 2017; see also Hauskeller, 2016).

The transhumanist dream of technological harmony also manifests within the moderate but still unfulfillable desire to create novel absolutely phenomenological transparent devices, i.e., achieving a state in which we have access to technologically enhanced capabilities without being constantly reminded that they stem from technological origin (Ihde, 1990, 2011a): "the desire for pure transparency is the wish to escape the limitations of the material technology ... the desire to escape the newly extended body" (Ihde, 1990, p. 75). This is not about simply eliminating the physical prevalence of technology but creating an integration so deep that the positive effects are absorbed by humans in a quasi-magical way (Ihde, 2011a). In direct reply to Ihde (2011a), transhumanist Max More (2011) argues that vaccination is a successful example of such profound integration. One must not be

[59] E.g., Sorgner (2023): "visions of immortality belong in the realms of fiction, religion, or psychiatry. ... Neither singularity nor immortality is near" (p. 28).

a fully-fledged transhumanist to desire this close entanglement between emerging technology and humans. Empirically reflecting the desire to "own" enhanced capabilities, technological wearables can modulate self-efficacy of their users (Rieder et al., 2021). Indicating the preference for a certain unawareness of the technology-in-use in the sense of Ihde, customers may especially favor the discrete application of some wearables (Chong et al., 2020). Conjoining both aspects, users report viewing these devices as more supportive of their health-related behavior if they are experienced as more embodied (Nelson et al., 2024).

We can extend Ihde's observation to all sorts of technology. Can we not understand the ethical line that is drawn between established practices for cognitive improvement (working out, getting enough sleep) and more controversial pharmacological enhancements (Caviola & Faber, 2015) as indicative of lacking pure practical transparency because the uncommon material agent evokes doubts whether a good performance was really ours (see Mihailov et al., 2021; President's Council on Bioethics, 2003) and thus may impoverish perceived authenticity (Fitz et al., 2014; cf. Williams & Steffel, 2014)? Are not the hopes that vaccination against SARS-CoV-2 was charged with one example of using technology to return to a primordial, i.e., pre-COVID state? A goal that unified those vaccine critics and proponents, although the former did not want to employ powerful biotechnology to eliminate all restrictions. What about the sexual revolution, enabled through hormonal birth-control technology, which made the visible and feelable technological boundary of condoms less necessary (see Ihde, 1990)?[60] Consider also the lingering neoliberal vision of significantly (techno-socially) adapting the working environment and the employee to foster mutual harmony between employees and employers (Bal & Dóci, 2018). What about the dialectical relationship to nuclear energy, where we simultaneously affirm its destructiveness only to rejoice about our untroubled mastery to almost magically solve our energy problems (Ihde, 2011a; Jasanoff & Kim, 2009)? Is not the concept of "Technologieoffenheit" [openness to technology], infamously evoked as a strategy to prevent climate change, and building on futuristic technologies like efficient synthetic fuels and nuclear fusion primarily a longing that seeks the benefits of pre-industrial times in which humans and nature were not captured in a disastrous dance of reciprocal mutilation *without* sacrificing any of our industrial living standard?[61] If advocates pose humans as different from technology and nature yet see the former as in charge of both (Sharon, 2014): What better way to re-affirm this human exceptionalism than by enforcing harmony upon the powerful things we created?[62]

[60] Note how the aversion against hormonal "unnatural" contraception suggest a desire to return to more "natural" methods (Alspaugh et al., 2020).
[61] For a respective call written by the Senior Principal Scientist of Shell(!), see Wilbrand (2022)
[62] The desire to fully master technology may be impossible (Ihde, 1990).

However, even if seeing the current technologically enabled state as desirable, transhumanists are not satisfied yet. For instance, progress within transhumanism's central project of prolonging the human lifespan still has room for improvement (Hauskeller, 2016). Although pre-Covid life expectancy was constantly increasing (Dattani et al., 2023), transhumanists still struggle with the unavoidability of death (Coeckelbergh, 2013; Hauskeller, 2016). Since Human Enhancement merely transforms risk, the transhuman project of creating a perfectly balanced and safe state will most likely fail (Coeckelbergh, 2013). This is a self-created entrapment grounded in the underlying premise according to which the moral value of a successful enhancement follows a continuous positive 'more-is-always-better' function (Agar, 2014). As argued by Agar, this forces transhumanism to constantly reach beyond the current state, propose novel "amendments to the human constitution" (More, 2013a, p. 450), and push for increasingly more technological development (e.g., Bostrom, 2003a). Transhumanists' aim for "perpetual progress" (More, 2011, p. 140) may be melioristically motivated (More, 2013b), but Agar's analysis highlights the instant outdatedness of any technological improvement. As Sparrow (2015, p. 232, 2019) put it, following the advocates' vision of rapidly producing increasingly powerful enhancements may render those humans enhanced by previous, less powerful means "obsolete."

Even if transhumanists are eager to deny that progress is certain (More, 2013b)[63] and acknowledge potential negative consequences (More, 2011), they do shy back from evoking normative urgency to pursue and accelerate the development of increasingly potent Human Enhancement (Agar, 2014; Hauskeller, 2016). This way, transhumanism installs technoscience and its manifestation in Human Enhancement as welcome redemption (Coenen, 2014) to control a naturally impaired Human (Hauskeller, 2016). Here, the reliable and comprehensive control of (our) nature can be seen as the final fantasy of a civilization built on the promises of technological potency (Ihde, 1979). Achieving this means "we would be 'one' with our 'world.'" (Ihde, 1979, p. 34). The return would be complete.

10.3. Same, same, but different

The arguments discussed here may be stereotypical and not exhaustive. Yet weaker forms may still shape our thinking about Human Enhancement and manifest in psychologically relevant decisions and cultivated behavior.

[63] Here, More acknowledges that people use illustrative figures to demonstrate that technological progress is actually happening but rejects the notion that this is happening with "genuine inevitability" (p. 10). Yet, as pointed out by Agar (2014), Kurzweil draws upon the described figures to convey the inevitability of objective and good growth. His quotes about the proliferation of intelligence in the cosmos further highlight the ideal of perpetual enhancement (Agar, 2014).

Eye to eye with the transformational and awe-inspiring power of technology and Human Enhancement, our capacities appear critically limited (Hauskeller, 2016; Ihde, 2011b). As argued before (Döbler & Carbon, 2024), the expected transformational effect of Human Enhancement exemplifies the two-fold attitude to the used technologies as something whose capacities are desired but embodied material presence is deprecated (see Ihde, 1990, 2011b). This characterizes risk-focused accounts that seek to eliminate the technologies' negative effects without sacrificing the obtained benefits, as well as technology-affirmative approaches that seek to enlarge the latter but are nonetheless displeased by the technological dependency (Ihde, 1990). Here, the lesson learned from postphenomenology is the constant individual, cultural, and practical negotiation of our relationship with technology based on the encountered capabilities (Ihde, 1979, 1990). Adversaries and advocates share the fundamental humanistic ontology of separating humans from technology and merely dispute whether technology threatens the Human or can be reliably mastered by us (Sharon, 2014). In doing so, they must find a way to harmonize the relata of this relationship in one way or another.

Ihde (1990) sees human attitudes toward self-created technological power constantly oscillating. A quote from Wagner's *Parsifal* (1882)[64] may elucidate his position further: "*Die Wunde schließt der Speer nur, der sie schlug* [The wound is only closed by the spear that struck it]." Technology causes adverse conditions, e.g., climate change. The often proposed solution (e.g., Persson & Savulescu, 2012) to the soaring threat to our existence is *more* technology and *more* Human Enhancement (Coeckelbergh, 2013). Any ideology builds upon creating a harmonious totalization of social relationships that is effectively undermined but also perpetuated by its limiting conditions (Žižek, 1989/2008). Being no exception, it becomes visible how especially transhumanism propagates an "identification with the [technological] aggressor" (Spreen, 2018, p. 53, my translation) to realize related techno-salvational fantasies, which promise a return to the lost Garden (Hauskeller, 2013). This concurs with the observation that desiring the technology's capacities "is simultaneously a desire for a change in situation — to inhabit the earth, or even to go beyond the earth — while sometimes inconsistently and secretly wishing that this movement could be without the mediation of the technology" (Ihde, 1990, p. 75). In part, this also applies to the adversaries. Even if committed to retaining the concept of human nature, adversaries must realize the profound dependency of our current condition on the technologies and enhancements we created and use (Coeckelbergh, 2013; Döbler & Carbon, 2024; Ihde & Malafouris, 2019). In this sense, the projected transformational power of Human Enhancement inflicts a blatant and unbearable wound upon what has been created by the same means.

[64] Žižek frequently uses this quote. I will borrow elements of his 1989 interpretation at the end of this section.

Striving for novel ways of integration and transformation at a much deeper level, others view the wounding means as the spear meant to accomplish the healing. Still, both positions need the open wound to justify their ideological approach to structuring the relationship between humans, nature, and technology (see Žižek, 1989/2008). They need to see technology as something external and separated from the Human (Sharon, 2014). Only then can the spear be discarded or cunningly wielded.

This implies the need to negotiate our relationship to what we posit as external to us. Human adaptivity is one way to autonomously and agentically regulate ourselves in relation to the socio-material environment (Virenque & Mossio, 2024). If a breakdown in adaptivity implies a "disharmonious activation of conflicting adaptive mechanisms" (Di Paolo, 2005, p. 440), then successfully exercised adaptivity implies harmony. For the adversaries, an all-too-extreme technological manifestation of technologically aided adaptivity risks losing what they consider worth preserving. This valued state is partially created and maintained by a history of Human Enhancement. Thus, if propagated at all, adapting ourselves should be constrained to *preserve a desired contemporary state* and subsequently detain a trajectory that endangers this state (i.e., initiate a return).[65] This reflects Di Paolo's (2005) classical understanding of adaptivity to prevent crossing a significant boundary. It is adaptivity in the spirit of preservation. On the other side, we find the advocates for whom the adaptation of ourselves means to pursue a deeper integration of technology into humans, i.e., paving the way *toward a desired future state*.[66] Similar to the adversaries, adaptivity is seen as the capability to prevent a specific state, but this state is not a contemporary valued one, but one of cessation. Evading it requires a much more creative and radical approach. This is similar but not confined to adapting humanity to reach the desirable end of its evolutionary process, i.e., a neoliberal society (Stiegler, 2022). It is adaptivity for advancement.

Operating with abstract hopes and fears alongside practical examples, both extreme attitudes toward Human Enhancement converge toward an all-too-familiar motive of returning to a mythological primordial state of maximized socio-material harmony. This is why one could link *both* positions to the intellectual history of Romanticism (Coeckelbergh, 2017). However, the uncomfortable truth for adversaries and advocates may be that the Garden is some "*primordial unity and harmony which never existed, which is just a retroactive illusion*" (Žižek, 2014, pp. 49–50, original italics). Even the most classical "natural state" of social harmony, described by 18th-

[65] Strictly speaking, enhancement efforts to ensure the existence of humanity (e.g., Persson & Savulescu, 2012) or maintain a specific state of health (e.g., Powell, 2015) fall under this categorization.

[66] One could link the positions of the adversaries to the Good-GH, as well as the goal of the advocates to the Eman-GH (see Döbler & Carbon, 2025). Yet, motivations for following these strategies can be manifold, so that resemblance may be confined to predicted behavioral outcomes and not the employed line of reasoning.

century Enlightenment thinker Jean-Jacques Rousseau, was always meant to be conceived as a hypothetical scenario (Graeber & Wengrow, 2022). The fantastic location we want to return to emerges only in hindsight (Žižek, 2014). The classic psychological example is the famous Spring break study that showed how memories of a pleasant event were more positive and a better predictor for the wish to repeat it than the immediate *in situ* experience (Wirtz et al., 2003).

For the adversaries, this seems alarming. The technological dependency in whatever we do (Ihde, 1990) and pervasive influence of Human Enhancement (Coeckelbergh, 2013; Döbler & Carbon, 2024) emphasize the impossibility of returning to this phantasmatic destination. Moreover, the employment of emerging technologies in the constant effort to redefine ourselves suggests that stopping the potentially post-humanizing activity, polemically speaking, seems senseless (Fernández-Armesto, 2004/2005).[67] Even if the results will probably not match what advocates hope for, humanity seems to already be walking down a path that inevitably leads to losing the Human. However, there may be hope. In the following section, I will argue that by taking specific psychological processes seriously, they suggest the possibility but not the inevitability of the lost Human.

11. The possibility of the lost Human

I have reviewed how humans must constantly adapt in one way or another and how different stances on how to do so involve actual, imagined, and projected states whose character is influenced by technoscientific practice. Historically speaking, constant engagement with the socio-material world and acquisition of knowledge contributed to an ever-changing understanding of ourselves as humans (Fernández-Armesto, 2004/2005). Even recently, it was pointed out that the dimensions in which we understand and evaluate humanness may be unstable (Wilson & Haslam, 2009). But is there a possible change so disruptive that it heralds the end of the Human?

I will now attempt to answer this question. To ensure conceptual coherence with the Human Enhancement debate, I will employ the more transhumanistic conceptualization where the posthuman is understood as a stage succeeding the Human (Midson, 2018).[68] Since there is disagreement about the meaning of trans- and posthuman, even in the transhumanist community (Sorgner, 2020), I will use the following terminology: a *trans-Human* is a specific conceptualization of the Human. The *post-Human* entails an identificatory rejection of the Human and

[67] Operating with a different conception of the posthuman, Hayles (1999) implies the same point by the ironically meant title of her book: "How we became posthuman." See also Clark (2003).

[68] Cf. Hauskeller (2016) who claims that for some transhumanists, a posthuman is a human with significant enhancements but still points out that others want to enhance themselves to the point of non-identifiability.

thus its loss. In this sense, the trans-Human preserves categorical identification as human and may be seen as a necessary step for completing the path from being human to being post-Human (Sorgner, 2020).[69]

This approach differs from what is sometimes called "critical post/humanism," which focuses on dissolving and relocating the established pre-defined boundaries between humans and technology and calls for an intellectual movement beyond these categories (Hauskeller, 2016; Midson, 2018, p. 218; Sharon, 2014). As Hauskeller (2016) argues, using the following quote, critical posthumanists champion radical self-authorship: "People become posthuman because they think they are posthuman" (Hayles, 1999, p. 6). Sharon (2014) classified Hayles and other authors like Donna Haraway as proponents of a posthumanism, which is characterized by the proposition that our understanding of being human is radically open, in constant movement, and influenced by advances in science and technology. Posthumanists like Hayles claim that human and posthuman identities are comparable constructions (Hauskeller, 2016). Thus, Hauskeller (2016) uses the second quote of Hayles (1999) to demonstrate that the key point of her conception is to see the post-human as "a point of view" (p. 2), that entails "new models of subjectivity" (p. 4). Because the posthuman in posthumanism should be understood metaphorically (Hauskeller, 2016), Hayles' (1999) posthuman does "not really mean the end of humanity" (p. 286) but, as expressed in this quote, enunciates the overcoming of a humanist version of our self-understanding (Midson, 2018). This is linked to propagating a politically emancipating understanding of our identity, which captures our lived experience as humans more veridically (Sharon, 2014). Thus, this version of posthumanism is concerned with purposefully losing *one* Human but not *the* Human (Sharon, 2014).

My account, however, takes the possibility of categorically ending our psychological species self-concept seriously. I do not seek to argue for an intellectual shift but to describe the psychological processes that lead to (non-)identification with the Human. Hence, I am not entertaining a specific conception of the post-Human, for instance, as "an amalgam, a collection of heterogeneous components, a material-informational entity whose boundaries undergo continuous construction and reconstruction" (Hayles, 1999, p. 3; for this and other definitions, see Sharon, 2014). Yet, I acknowledge that postphenomenological ideas theoretically incline to dissolute any strict boundary between humans and technology and propagate the posthumanist idea that humans are not masters over nature (Ihde & Malafouris, 2019; Sharon, 2014; Verbeek, 2011). This also pertains to the idea that technoscience can significantly influence our subjectivity (e.g., Hayles, 1999). However, any conceptual overlap

[69] The prefix "trans-" denotes not only the goal ('*trans*-cendence') but also the status of being a '*trans*-itional' step (Sharon, 2014).

with my approach concerns the starting point of my analysis and not the end. Like critical posthumanism, I touch upon collectively shared understandings of the Human. Although I exemplify this by focusing on the essentialistic Human, my analysis should suit any other conceptualization of our species self-concept. Because I focus on how individuals relate to and affirm/reject this psychological sense-making structure, I elaborate on *the* post-Human and not posthuman*ism.*

However, there is a problem. In Döbler & Carbon (2024), I have expressed my support for the position that technology in the broadest sense and, therefore, Human Enhancement is indivisibly linked to our individual self-experience and human being (see Clark, 2003; Coeckelbergh, 2013; Ihde & Malafouris, 2019; Rosenberger & Verbeek, 2015). Respective positions argue that "technology cannot be de-humanizing ... because it is at work in the very humanization process of the human" (Sharon, 2014, p. 108). Or that: "Technologies, to be short, are not opposed to human existence; they are its very medium." (Rosenberger & Verbeek, 2015, p. 13). In reference to the latter quote, I rejected the idea that Human Enhancement, *in general,* endangers our being as humans (Döbler & Carbon, 2024). While I still support the idea that the loss of the Human is not an inevitable result of accelerated enhancement efforts, my initial argument demands further qualification and fine-tuning to answer whether something that constitutes our being can also disrupt it. I elucidate this alleged contradiction by recalling the Human's contingency and flexibility (Hauskeller, 2013) as well as the described mechanism of perceived collective continuity (see Sani et al., 2008). As argued, semantics of the Human are produced and embedded in technological activity and enacted by individuals who have adopted them. In that sense, arguments highlighting the historical, Human-constituting influence of Human Enhancement operate with one version of the Human, where integrating the semantics produced by our (technoscientific) activity is and was successful. Yet, just because we have made sense of us today and created the conceptual basis for humanity's perceived collective continuity does not mean that the category or its content itself is immutable (see Hauskeller, 2013). Even if some argue that humans are able to adapt their identity to enhancement-induced change (Buchanan, 2011), the whole point of the Human is that "the predicate 'human' is itself a human classification, ... so that my continuing humanity depends on the elasticity of the currently prevalent image (or images) of the human" (Hauskeller, 2013, p. 126). Thus, the humanization argument describes a historical process leading to the current time in which we still identify ourselves (enhancement-using) humans. It is a snapshot of our current sense-making in relation to the preceding sediment. But previous integration does not necessarily ensure future persistence (cf. Buchanan, 2011; Pugh et al., 2016). If it meets its sense-making limitations, updating or discarding the Human may be required. The contingent flexibility

of the Human provides conceptual resilience to ensure continuity. But it is also the foundational mechanism for its possible loss.

11.1. What comes after the Human?

It should be clear now that the adversaries' opposition to Human Enhancement partially builds upon the fear of losing relevant semantics of the Human (Wilson, 2014). In that case, adopting the human identity constituted by these semantics seems impossible and the underlying continuity is broken (Buchanan, 2011). Such radical change in being human — possibly creating a post-Human progeny, but also the feared loss of humanness — contains a reflexive process that results in denying one's humanness (see Rose, 2018). Hence, any post-Human must be able to identify as non-human. Otherwise, any discussion about the prospect of noticing the emergence of post-Humanity ends in an epistemological deadlock. Thus, the post-Human self-concept may operate similarly to the sense-making function of the Human, as proposed here and by Hauskeller (2009). It is a flexible psychological structure arising from the organismic separation from the world and meant to integrate semantics about one's being to effectively engage with a normative socio-material world and manifest in conscious self-identification.

The emergence of the non-Human-self may result from the slow and aggregating production of new, not integrable semantics or the re-evaluation of old ones (Agar, 2014; Buchanan, 2011). As Human Enhancement must be considered partially unreliable with respect to the factual outcome (Döbler & Carbon, 2024), it may accidentally produce yet to defined semantics that are impossible to integrate into a given conception of the Human. The result is "a future populated by [post-Human] beings with whom we [as humans] can identify only nonveridically" (Agar, 2014, p. 200). From the perspective of the changed being: "only after what I have become can no longer be aligned with the vague and changing ideas that people have about themselves as humans, I am human no longer" (Hauskeller, 2013, p. 126). In a similar vein, Buchanan (2011) argued that biotechnologically induced generational alterations of widely shared characteristics (his understanding of human nature) may hinder the continuous identification with past generations and thus yield the emergence of a new species, aka the post-Human. If we abstract these thoughts from the alteration of "objective" features, to subjective endorsement of Human semantics, the resulting "new conceptual-explanatory scheme in which the concept of a human being was replaced by that of a posthuman" (Buchanan, 2011, p. 120) is then subjected to interpersonal evaluation and collective sense-making. Results of this process will determine whether the identification as non-human is legitimate or a case for a psychiatric facility as in the case of Lycanthropy (Section 5.1.1). If the group of people becomes large enough and identifies a common link between them, the new concept becomes the basis for a new, individually adopted and

enacted post-Human perceived collective continuity. To speak with Ihde (1990), making sense of the individual embodied microperception of myself happens in relation to the culturally and collectively shared sphere of cultivated macroperception, which is populated by the different semantics concerning the Human. This topography of meaning resulted from past sense-making activity with and without technology. It is from this relation that identification as human or post-Human emerges. Losing the Human is not about re-filling it with semantics while maintaining the general identification but about the emergence or loss of semantics that necessitate a categorical and comprehensive break in identifying with what we consider "truly" human.

On a cultural level, the post-Human refers to a present understanding of the Human insofar as it entails the impossibility of seamlessly integrating it into its own historical continuity (Simon, 2019).[70] The "normal," everyday manifestation of this would be the psychological phenomenon of what is commonly called "self-discontinuity." This denotes feeling detached from an earlier state of self, e.g., due to significant life events (Sedikides et al., 2023). Emerging conflicts between established and novel identities can encourage embracing or re-negotiating past and novel group membership (Iyer et al., 2008). Similar processes can occur on the level of national collective identity, where discontinuities to a positively perceived past and continuities to a negative one may threaten integrated valued aspects of the individual (Roth et al., 2017). Although comparable, the discontinuity is more than a detachment; it is an identificatory rejection of being human. It is thus more fundamental than "normal" breaks humans experience in their lifetime.

Given the capacities of Human Enhancement to shape our bodies and mediate our experiences, my approach (Döbler & Carbon, 2024) points in a similar direction as the argument of Agar (2014) that contemporary humans cannot identify with the experiences of beings whose capacities are largely different from ours. However, unlike him, I do not derive any statements about moral desirability from this observation. Nonetheless, his idea that significant enhancements yield "transformative changes" (p. 8) is useful here. These changes mean that those:

> evaluative frameworks we apply to our lives—and to the rest of the world—are significantly altered. We place different values on characteristically human experiences, beliefs or achievements prior to the change than we do after it. This change seems warranted by changes to the state of our minds and bodies. (Agar, 2014, p. 8)

[70] Bostrom (2013b) draws upon the childhood analogy to discuss the implications and character of such a potential break in continuity (cf. Agar, 2014).

Let us evaluate Agar's subsequent conclusion that these enhancements may risk "to end the existence of its human subjects" (2014, p. 56). This is an issue of what is commonly called "numerical identity," i.e., the endurance of something as a persisting entity, and is opposed to the aforementioned narrative identity, which also denotes how we socially and consciously narrate this process of endurance (Wilson, 2014). According to Wilson (2014), the quote above and Agar's overall position draw upon an understanding of numerical identity that grounds the human persistence *as the same person* (Wilson calls this "personhood," p. 249) within psychological aspects like autobiographical memory. Yet, Wilson postulates that psychological numerical identity and narrative self-continuity are geared by the same psychological mechanisms. He also affirms Agars' (2014) proposal that tampering with autobiographical memory may endanger our individual personhood. Wilson (2014) also reviewed the already mentioned findings on the two notions of humanness and their implication for dehumanization (e.g., N. Haslam, 2006; N. Haslam et al., 2005) and claims that merely being a *Homo sapiens* does not necessitate being ascribed with personhood and thus 'full humanness.' To emphasize this distinction, he contrasts the psychological personhood-understanding of numerical identity with a biological one (see DeGrazia, 2005; Wilson & Haslam, 2012). Wilson then links the latter to organismic persistence and calls it "humanhood" (2014, p. 249). I largely concur with Wilson's observation about the psychological link between numerical and narrative identity. Still, I want to formulate terminological criticism. By calling the persistence as the same biological entity "humanhood" and claiming that being a *Homo sapiens* and alive satisfies this ascription, Wilson elevates biological statements to semantics of our self-concept. Humanhood in the sense of affirming our identity as belonging to the group *Homo sapiens* thus, has the same functional status as any other contingent approach to the Human (see Hauskeller, 2009) and is already part of our narrative identity. Even if Wilson eventually acknowledges the mutual relationship between human- and personhood, he does not explicitly address the meaning of "human" as part of our narrative identity. Nonetheless, he implicitly does so by briefly mentioning that the ascription of humanhood entails beliefs about the possible development of uniquely human or human nature traits. Wilson then claims that being attributed personhood means acknowledging the complete presence of these traits. Yet, humanhood is not as neutral as Wilson seemed to have in mind but reflects a biological, evolutionary reading of the Human.

Overall, Wilson (2014) confines his discussion to a more descriptive account of which psychological concepts resonate within the Human Enhancement debate and is rather skeptical if a radical identity break is *really* possible. Nonetheless, his account allows for a more nuanced understanding of how different conceptualizations of the Human are seen at stake. Drawing from the mentioned insights on (de-)humanization and self-continuity, I will extend

Wilson's theoretical propositions. Yet, instead of only focusing on the aspect *that* people dehumanize each other, I will elaborate on the mechanisms *how* these processes may influence individual identity, how Human Enhancement may evoke them, and how related results influence not only our individual self-continuity but also the collective one. The latter aspect seems especially important in light of the argument that Human Enhancement may be objectionable if irreparably discontinuing our meaningful and historical connections to other people (Pugh et al., 2016). But how does such a disconnection occur?

In his book, whose title calls to "Reject Radical Enhancement," Agar (2010) distinguishes between humans and non-humans based on differing capacities. This, however, is only half of his argument. The final step of posthumanization occurs because these differences are the reason that those significantly enhanced have little to no interest in procreating with humans. According to Agar, such attitudes constitute psychologically grounded "reproductive barriers" (2010, p. 21), whose presence indicates the separation of species. This biological approach to the Human as a species resonates with the romantic practices of the already mentioned *Chachi* people. *Chachi* are expected to follow rigorous and heavily enforced monogamy and confine their choice of spouse to *Chachi*, i.e., "true humans" (Praet, 2014). In short, Agar's post-Humans are the results of a psychologically mediated and highly selective mating behavior causally linked to the radical enhancement of beings who used to be members of the human species.

The advocates' position on humanness suggests that quantitative growth in uniquely human characteristics (e.g., intelligence) poses no threat to our sense of humanness (Wilson & Haslam, 2009). Yet, Bostrom (2013b) suggested that the post-Human was solely based on significantly having longer and healthier lives or greatly improved cognitive/emotional capacities. He also noted that a mere change in our self-understanding cannot give rise to the post-Human (cf. Hayles, 1999) and claims that the post-Human must emerge from "radical technological modifications" (Bostrom, 2003b, p. 6). In direct response to this quote, Agar (2010) agrees on the matter of self-authorship but emphasizes the importance of (intelligence-related) self-views for mating decisions and any so resulting species separation. I partially agree. Even if Buchanan (2011) argues that post-Humans are characterized by the collective and qualitative modification of our skill set, it is not enough to have these capacities; we must relate them to our individual and collective identity — we must "own" them. If a technological change in the body leads to a radical break in our conception of what it means to be human, this is the result of an interwoven hermeneutic process that is composed of the mutual influence of embodied existence, to-be-integrated enhanced capabilities and social affirmation (see Clark, 2003). The "owning" refers to the individual identification with the

produced semantics (see also Agar, 2014). Bostrom (2013b) partially acknowledges this in his attempt to sell the benefits of Human Enhancement by drawing a rich picture of how it may benefit the reader's experiences as a post-Human and his statement that these altered capabilities may not put an end to our being human because the meaning of this concept could be successfully adapted.

The evidence that people are not solely relying on species membership in their ascription of humanness (Phillips, 2022, 2023) and its performative accessibility (Praet, 2014) may support Agar's (2010) idea of psychological reproductive boundaries. Yet, I am also reluctant to adopt his strict biological, sexuality-based understanding of the post-Human. His thoughts may be relevant to the solidification of intergroup boundaries. Still, there must be some semantics integrated into my self-conception that yields an irreconcilable reproductive barrier. Agar acknowledges this so that the post-Human starts with a relational non-identification with the Human as a sexual partner, which then sets in motion the subsequent demarcation process.[71] Nonetheless, these processes critically *presuppose* a change in self-conception.

Agar and Bostrom both argue that a post-Human self-conception may entail semantics in the form of novel or enhanced capabilities, which then lead to the re-valuation of our experiences. Concurring with Hauskeller (2013), I locate the possibility of the post-Human within the outcome of the underlying adaptation process. Hence, I agree with Bostrom and Agar but emphasize the *sine qua non* role of a subsequently changed self-conception as the initial moment of the post-Human. Thus, my successfully enhanced post-Human emerges *after* obtaining the capacities and relating them to ourselves (cf. Bostrom, 2013b) but *before* the intervention may lead to a specific evolutionary trajectory based on reproductive behavior (cf. Agar, 2010). Similar to Hauskeller (2013), I locate its emergence at the contingent moment where an identification with the similarly contingent version of the human is impossible.

The preceding discussion yields a straightforward hypothesis: The post-Human comes after the Human insofar as novel, technoscientifically produced semantics necessitate that individuals cannot identify with its perceived collective continuity anymore. The post-Human is the embodied affirmation of the disjunction. The moment an individual or group of humans identifies with the post-Human, the Human was lost for them, and the perceived collective continuity was broken. But how does it get lost?

[71] This process requires that the respective radical enhancement is applied extensively. If below the critical mass, individual families that reject procreation with ordinary humans will simply cease to exist.

11.2. Dehumanizing till the post-Human

One way to conceptualize the loss of the Human is by linking Human Enhancement to being dehumanizing. This means that examples of this practice are believed to undermine whatever makes us human (Wilson & Haslam, 2009). Adversaries fear that identification with the essentialistic Human becomes impossible once those traits they deem indicative of it are seen as irretrievably corrupted by technological intervention (Wilson, 2014; Wilson & Haslam, 2009, 2012). Deprived of critical aspects of human nature, evaluated beings appear not identifiable as humans anymore (N. Haslam, 2006). However, strictly speaking, orthodox essentialism is unidirectional. Thus, the essence is meaningfully linked to observable features, but an intervention with the latter does not touch the former (Neufeld, 2022). Nonetheless, interventions that target traits associated with human nature are considered ethically suspicious and potentially dehumanizing (Wilson & Haslam, 2009), up to the point of yielding a continuity- and identity-breaking catastrophe (Wilson, 2014).

Seeking to preserve traits associated with human nature, adversaries may be especially concerned with preventing mechanistic dehumanization (Wilson, 2014; Wilson & Haslam, 2009, 2012). If, for instance, the President's Council on Bioethics (2003) argues that Human Enhancement will impale the character of human activity, the subsequent deprivation of autonomy characterizes a loss in what is seen as constitutive of the essentialistic Human (Wilson & Haslam, 2009). Approaching this issue from the empirical angle, recent hypotheses have suggested that visible cybernetic enhancement, mood, or cognitive enhancement drugs can trigger social dehumanization effects in the sense of Haslam (2006) and thus negatively impact social interaction (Castelo et al., 2019; Grewal et al., 2020).

Transhumanism partially considers Human Enhancement as means for achieving "true" humanness (Hauskeller, 2013). This implies that any prior state is less-than-true and manifests by asserting that the current human condition is critically impaired (Hauskeller, 2016). Here, prominent transhumanists were accused of relying on "dehumanising [sic], mechanistic language (perceiving humanity as something akin to a bug-ridden computer system)" (Thomas, 2022, p. 156). The fact that transhumanists use this rhetoric supports the idea that they conceive the Human as more related to those traits that render it allegedly unique, so that interfering with these traits will not result in de- but 'superhumanization' (Wilson, 2014; Wilson & Haslam, 2009, 2012).

As argued before me, the potential for dehumanization, either in a humanness-depriving or transcending way, is a common trope in the Human Enhancement debate. Since my research program is less interested in metaphysics and more concerned with the subjective factors that steer Human Enhancement and its effect on our identity, the

discursive role people assign to their conception of humanness and identity must be scrutinized. Selection of to-be-enhanced features in concert with the adopted perspective on humanness may determine the character of expected dehumanization and thus explain the adversaries' and advocates' positions (Wilson, 2014; Wilson & Haslam, 2009, 2012). My conceptualization of the Human as individually adopted yet intersubjectively affirmed (Section 5) emphasizes the role of social interaction for its potential loss. Indeed, social processes can influence the semantics of the self (Stetsenko & Arievitch, 2004) and the Human (Bastian & Crimston, 2014). Building on previous propositions by Wilson and Haslam, I re-examine the empirical evidence on dehumanization and examine to what extent related phenomena can really contribute to a break within our identity.

11.2.1. Empirical results on dehumanizing enhancement

Putting the hypothesis of dehumanization-triggering implants (Grewal et al., 2020) to the test, Jost (2024) found that visible modifications of the face can indeed diminish humanness ratings.[72] This effect was strongest for modifications of the eyes and was not dependent on disclosing any implant functionality. Yet, Human Enhancement consists of more than implants, inciting a cyborg association. Castelo et al. (2019) directly assessed dehumanization due to cognitive enhancement. Results suggest that people were less inclined to enhance their cognitive abilities due to an assumed deterioration of emotional capabilities, increased perception as robot-like, and subsequent social stigmatization. However, the authors examined respective effects by aggregating ratings on different technological means like genetic engineering, pharmacological enhancement, brain implants, and smartphone apps. Although they include used technology in their statistical models, their reports of post-hoc tests are limited. In one of the exceptions, they report that using the brain implant yielded higher dehumanization effects than the smartphone app. Noteworthy, an app is unlikely to qualify as Human Enhancement under my definition (see Döbler & Carbon, 2024), and genetic engineering evokes different concerns than a pill (Schönthaler et al., 2022). Examining the Supplementary information of Castelo et al. (2019) reveals that across all technologies, using them in an enhancement rather than therapeutic manner was associated with more dehumanization, i.e., less ascribed emotional abilities and more ratings as robot-like.[73] Moreover, people using the enhancing Brain chip were seen as robot-like as those using a pill or genetic engineering. Hence, these effects are not solely caused by the association between robots and electric devices like cybernetic implants. Additionally, framing the intention of the enhancement effort as being prosocially motivated nullified the dehumanization effect, thus questioning the extent

[72] Jost's work was conducted as a Bachelor thesis. He is currently preparing a manuscript publication. Participants explicitly rated perceived humanness.

[73] The latter effect was not found regarding the smartphone app.

of the latter beyond perceived non-communality (Castelo et al., 2019). These results inspired the hypothesis that dehumanization via visible enhancements occurs due to diminished perceived interpersonal warmth (Grewal et al., 2020). Sattler et al. (2023) found that people indeed evaluated a hypothetical co-worker who used pharmacological cognitive enhancement as less interpersonally warm and discussed whether this could yield the mechanistic dehumanization effects as hypothesized by Grewal et al.

As mentioned in Section 9.4.1, dehumanization processes may bear significant consequences for the social evaluation of children whose features were genetically adjusted. This may be primarily because of the crucial role of gender associations for humanization in general (Butler, 1988; A. E. Martin & Mason, 2022), especially the female-prescribed (Bosson et al., 2022; Koenig, 2018) dimension of communality (Chu & Martin, 2021; cf. Formanowicz et al., 2018). As mentioned, Haslam (2006) links being interpersonally warm to his human nature dimension. Hence, the cited results provide evidence of how Human Enhancement may threaten the essentialistic Human, while also targeting factors we may use to inform our individual identity.

Apart from directly assessing the link between dehumanization and classical means of Human Enhancement, effects of the former were observed along the lines of different attitudes toward vaccination against SARS-CoV-2 (Ballone et al., 2023). However, in this study, dehumanization was modeled to be based on whether people saw their in-group as morally different from their out-group, and did not investigate the hypothesis that vaccinated persons are perceived as less human *because* the technological modification was suspected of having altered features associated with a human essence. Moreover, it only revealed animalistic dehumanization effects and thus merely the denial of allegedly uniquely human characteristics. Closing this gap, Izydorczak and Dolinski (2024) showed that those favorable of vaccination animalistically and mechanistically dehumanized non-favorable peers. The latter dehumanized the former only if considering favorable human nature traits. These positive features were more likely to be ascribed to the vaccine skeptic in-group than to the affirmative out-group.

If ascribed humanness is not a sole matter of species membership (Phillips, 2022, 2023), transhumanism shall lead us to the next step of evolution (Hauskeller, 2016; More, 2013a), and the post-Human can be considered a different species (e.g., Agar, 2010), is there evidence that for humans who evaluate other humans, species membership itself is up for debate? Not operationalizing dehumanization as denial of associated features, Kteily et al. (2015) confronted participants with the famous "Ascent of Man" scale. This is a graphical and ordinal representation of *Homo sapiens*' ancestors as morphological and evolutionary predecessors to the Cro-Magnon. Kteily et al. asked participants to locate different groups of people according to their perceived evolutionary status.

Across several studies, the authors found that participants dehumanized humans not only subtly but also by explicitly denying out-groups the same evolutionary degree they assigned to their in-group. This so-called "blatant dehumanization" (p. 901) was associated with aggressive tendencies against respective groups (Kteily et al., 2015). This type of dehumanization has an implicit component and is not necessarily confined to people with illiberal ideologies (Petsko et al., 2021). Results on the in- and outgroup perceptions of vaccine skeptics and advocates showed that groups blatantly dehumanized each other and that people felt dehumanized in that way by the other group (Izydorczak & Dolinski, 2024).[74] Since blatant dehumanization was positively linked to mechanistic dehumanization (Kteily et al., 2015), technological interventions that are suspected of meddling with traits associated with human nature may also yield the perception that other beings are not only *less* equipped with these features but may be treated as a different evolutionary group. If it were impossible for humans to see specific out-groups as having a different evolutionary status than themselves, the emergence and acknowledgment of a non-animal-like post-Human would be considerably harder.

Indeed, one of the most dehumanized groups is one of *Homo sapiens'* closest ancestors: *Homo neanderthalensis.* This manifests in the significant effort to downplay the psychological and cultural achievements of our extinct fellow *Homo* (Fernández-Armesto, 2004/2005).[75] The cited evidence exemplifies the main aspect of contemporary dehumanization: even if the other may *look human,* they are not granted the full range of implied capacities (Smith, 2016). Once again, note the anthropological evidence from Praet (2014). Here, the described communities affirm the physical existence and visual similarity of those not belonging to their community but insist that others do not qualify as Human. Even if people use perceptual cues to assert the alleged essence and they can stretch their categorization to unusually appearing entities (Rothbart & Taylor, 1992), having an anthropomorphic body does not inevitably lead to categorization as fully human. Historically speaking, Western conceptions of humanness from the fifth to the thirteenth century were conceptually open to include beings with little to no physical similarity to modern humans. (Fernández-Armesto, 2004/2005). According to Fernández-Armesto, it was only after that that people increasingly tied humanness to a "normal" body. Moreover, he argues that empirically derived correlations between physical and mental abnormalities fueled dehumanization processes. More blatantly, dehumanization by caricaturing or describing the physical attributes of outgroups in an animalistic way has a long

[74] Other as Kteily et al. (2015), the authors did not calculate differences in humanness ascription based on a 0-100 rating scale but created a binary outcome, treating values < 100 as evidence for blatant dehumanization.

[75] See also Agar (2010) who argued that the relation of the post-Human to the Human may resemble the one of *Homo sapiens* to *Homo neanderthalensis* in terms of the mentioned reproductive barriers.

history (Eken & Taluğ, 2023; N. Haslam, 2006; Kteily et al., 2015). There is also evidence that people are more likely to dehumanize persons with low body height (Kunst et al., 2019). While the latter study did not employ the dehumanization scale that captures the denial of traits associated with human nature, a recent investigation found mechanistic dehumanization effects on people with physically disabling spinal cord damage (Sitruk et al., 2023). Recall the conceptualizations of Human Enhancement as assessed by giving growth hormones to people with a related deficiency or a genetic disposition for shortness (Gyngell & Selgelid, 2016). Note further the empirically shown benefits of using exoskeletons for patients with the mentioned spinal cord injuries (L. Miller et al., 2016). Even if classifying these two interventions as treatment, their technological effect may ameliorate dehumanization effects. If advocates are correct in their assertion that Human Enhancement is *not* dehumanizing (Wilson & Haslam, 2009), this may be due to the capacity to yield outcomes associated with a human norm. In that sense, the idea of Human Enhancement as means to attain "true" humanness (Hauskeller, 2013) seems not far-fetched.

In summary, empirical evidence across various types of dehumanization and several technological examples suggests that people can perceive enhancement using others as lacking relevant Human semantics. Moreover, dehumanization can also entail the denial of an evolutionary status. Even if the opposite effects are also conceivable and must be seen in the manifold of Human Enhancement, examining dehumanizing mechanisms allows for informed hypotheses about how *we* will react to beings whose appearance, capabilities or behavior differ from what we consider relevant to the Human.

11.2.2. Self-post-Humanization

The possibility of losing the Human builds upon a hypothetical change in the individually adopted and collectively shared self-understanding of those beings that currently identify themselves with the Human (Hauskeller, 2013). However, the evidence cited so far did not address the matter of self-understanding. The extent to which individuals perceive their in-group dehumanized by others is called "metadehumanization" (Kteily & Bruneau, 2017, p. 490). The self-issued denial of one's own human characteristics is commonly called "self-dehumanization" (Bastian & Crimston, 2014, p. 242). Drawing upon a wide range of empirical evidence, it was proposed that individuals can internalize metadehumanization and thus engage in self-dehumanization (Demoulin et al., 2021). Thus, for those who consider themselves humans, dehumanizing peer responses may trigger the production (or dismantling) of Human-related semantics.

Demoulin et al. cite, for example, Loughnan et al. (2017), who showed that when women recalled situations in which they felt reduced to their bodily characteristics, it led to self-dehumanization regarding traits associated

with human nature, as well as less self-ascribed warmth. We can link this to appearance enhancements like Botox but also make-up. The latter can trigger dehumanization processes by reducing the ascribed agency of the evaluated woman (Kellie et al., 2021). Yet, in this study, participants did not see themselves as less human after virtually applying make-up. Nonetheless, feeling increasingly evaluated in terms of physical attractiveness may be an important predictor for lasting cosmetic interventions (Calogero et al., 2010). Recall also the potential dehumanization of females who fail to meet stereotypical expectations (Section 9.4.1). If one does not perform their gender right, and gender is crucial for being ascribed as human (A. E. Martin & Mason, 2022), respective individuals may be more likely to affirm the external judgment.

Further evidence for the internalization of perceived dehumanization was provided for alcohol-abusing individuals (Fontesse et al., 2021).[76] In this study, self-dehumanization fully mediated metadehumanization's effect on anxious and depressive affects. Another study revealed that employees integrated the metadehumanization experienced in organizational settings, making them more likely to self-deny traits associated with human nature (Nguyen et al., 2022). Here, metadehumanization was measured by past experiences of feeling instrumentalized, and its effect on self-dehumanization was partially mediated by the perceived requirement to modulate emotions in accordance with organizational guidelines. Considering the prevalence of exploiting mood regulation substances in order to cope with imposed demands (Bagusat et al., 2018), including those met at the workplace (Franke et al., 2013), this should raise warning signs concerning enhancement *without organizational knowledge* but *by organizational virtue* (Döbler et al., 2024). Noticed disparities between individual emotions and organizational standards could also be tackled by explicitly prescribing technological aid, which would then be *enhancement by organizational order* (Döbler et al., 2024). This would yield a worrying precedent of how organizational power transgresses into the mental realm of their members (see Appel, 2008; Pustovrh et al., 2018) and eventually create self-dehumanizing employees. Dobson's findings elucidate this possibility (2020). He showed that feeling inauthentic, mediated by a lack of experienced autonomy, can contribute to self-dehumanization as measured by the self-assessed ability for cognitive agency and general experience. Moreover, these feelings could be triggered by contemplating situations where they experienced little autonomy at the workplace. Given previously found concerns that Human Enhancement may impoverish authenticity and autonomy (e.g., Fitz et al., 2014; Sample et al., 2020, 2022; Sattler et al., 2022; Schönthaler et al., 2022), intervening with this variable may privilege

[76] Using drugs for social skill enhancement (Müller & Schumann, 2011) qualifies alcohol as enhancement. However, dehumanization in Fontesse et al. (2021) was tied to pathological alcohol abuse, not sub-clinical "normal" use.

dehumanization processes. However, note that individuals may use Human Enhancement to achieve an authentic expression of themselves (Elliott, 2011; Iftode et al., 2024; Riis et al., 2008; Williams & Steffel, 2014), which then would be beneficial for humanization.

Self-dehumanization must not necessarily stem from metadehumanization. Recall the mythical Garden, in which humans gained moral agency. Further note that individuals who showcase moral superiority and impeccability are considered "ideal" but not "true" humans (Phillips, 2023).[77] This has interesting implications for enhancing moral capabilities, as proposed by Persson and Savulescu (2012). If this creates beings too perfect to be human, dehumanization may happen due to the non-embodiment of Human moral imperfection. Yet, post-Human beings must not inevitably share our understanding of what is right or wrong (Coeckelbergh, 2013). If we conceive them, for instance, as equipped with superior cognitive capabilities (Bostrom, 2013b), we face the possibility that the latter must not necessarily correlate with pursuing goals favorable for other beings (Bostrom, 2012; Torres, 2018; cf. Ćirković, 2019). On a more tangible level, people evaluated hypothetical invasive appearance-enhancing implants as leading to more immorality than physical training (H. Zhang et al., 2024). The level of expected moral misdemeanor mediated the effect of enhancement type on assumed identity alterations so that people were assumed to change because of their changed moral capacities. The same study showed that using invasive implants to alter emotional capacities leads to stronger assumed identity alterations than if aimed at cognitive enhancement. The authors explained their hypotheses and results by previous findings showing the subjective importance of emotional and moral capacities for individual identity (Riis et al., 2008) and individual self-continuity (Molouki & Bartels, 2017). Molouki and Bartels (2017) specifically found that people considered a profound, unspecified alteration or deterioration in moral capacities or personality variables as indicating a stronger interference with their self-continuity than memory abilities. Moreover, the disruptive effect was less pronounced when these capabilities were imagined changing for the better. Although reflecting laypersons' attitudes, this has interesting implications for any arguments that discuss a self-continuity-breaking effect of cognitive enhancement (e.g., Agar, 2014).

The crucial role of moral conduct becomes clearer, considering that dehumanization processes and harm intentions can be triggered if individuals violate group norms (Kteily et al., 2015; Phillips, 2023). Inspired by the proposed role of moral capacities for humanness (N. Haslam, 2006), it was further shown that people who were primed to think of one instance where they acted immorally attributed less agentic and emotional capabilities to themselves (Kouchaki et al., 2018). The same study also showed that when participants recalled situations where

[77] Adversaries often argue that flaws and failure are critical for our human nature (Sharon, 2014).

they felt deprived of the full range of human capacities, they were more likely to act unethically. One suggested explanation by the authors is that people "excuse" (p. 1244) moral misdemeanors by adopting a dehumanized self-conception, which, by being less capable of feeling responsible, is also less moral. As discussed further, this research partially concurs with other findings summarized by Bastian and Crimston (2014) in their theory about self-dehumanization mechanisms. According to them, self-dehumanization and humanization are highly interactional. They propose that people self-dehumanize as a reaction to being excluded socially or being aware of the harm they have inflicted upon others. Bastian and Crimston also argue that being dehumanized can motivate people to engage in compensatory pro-sociality. Here, Kouchaki et al. (2018) diverge and argued that self-dehumanization can also amplify causing factors, i.e., violation of moral norms. Further testing this hypothesis across several cross-cultural samples, feeling generally objectified by others was shown to be linked to self-dehumanization (not differentiated between animalistic and mechanistic types), which then predicted lower intentions to act prosocially (Z. Zhang & Chen, 2024). In addition, feeling dehumanized by one's organization in concert with a more lenient attitude to resolve conflicts can predict revengefulness and, subsequently, deviant behavior at the workplace (Stinglhamber et al., 2023). Furthermore, veterans who reported having killed in the line of duty reported identity conflicts, social isolation, and described themselves in self-dehumanizing terms. These veterans also partially reported that killing strengthened affective tendencies to harm other people (Purcell et al., 2016). In their comprehensive approach, Demoulin et al. (2021) acknowledge some of the here-discussed results and install self-dehumanization as linked to metadehumanization and previous moral misconduct. If a neoliberal environment incentivizes illicit behavior, such as engagement with cognitive enhancement drugs (Döbler et al., 2024; Pulfrey & Butera, 2013), discussed findings elucidate the possible self-dehumanization to meet market demands as discussed in Section 7.4.1. Yet, self-dehumanization is not inevitable (Bastian & Crimston, 2014). Howe et al. (2022) showed that if confronted with stimuli that animalized Black persons, Black participants "rehumanized" (p. 258) themselves, i.e., reported richer pictures of their emotional capacities and themselves as individuals. Regardless of these intricacies, integrating issued judgments and evaluations concerning the lack of humanness into one's self-conception highlights the identificatory role of Human semantics.

Taken together, these findings suggest that diverging morals or values that incline group separation do not necessarily stem from technological interventions alone (see Agar, 2014) but are also influenced by past dehumanization processes to which I attune my performance of the Human. Self-dehumanization effects based on uttered or assumed social judgments may initiate and perpetuate a feedback loop that results in the (self-)denial

of relevant semantics but also the perpetuation of the dehumanization-triggering behavior (Demoulin et al., 2021; Kouchaki et al., 2018; Smith, 2016; Z. Zhang & Chen, 2024). If post-Human conduct appears highly immoral to those identifying as human, group demarcation is further fostered. This would support Moffett's (2013) claim that continuous competition with other groups privileges the emergence and acceleration of group-identity markers. In other words, the self-conception as post-Human may emerge by being classified by others as not being identifiable with semantics of the Human. Self-identification based on previous or subsequent acting in discordance with the same semantics may then facilitate further post-humanization.

11.2.3. A different value

The previous section concurs with the idea that, apart from a biologically focused understanding (Wilson & Haslam, 2012), human nature can be linked to human values (Bain et al., 2006). This stretches beyond the moral realm. Agar (2014) proposed that post-Humans will value experiences and themselves differently than their human progenitor and that this will eventually foster group separation (Agar, 2010; cf. Bostrom, 2003c; cf. Buchanan, 2011). Yet, different from separation over already altered values, I want to emphasize values as a matter of constituting the identity of the Human.

Bailey et al. (2021) showed that besides assuming a biologically rooted essence, people also draw on values to determine whether individuals "essentially" qualify as members of groups. Crucially, such an essence-equals-values perspective logically dodges the issue of essentialistic immutability but was nonetheless positively correlated with beliefs affirming biology-based essentialism (Bailey et al., 2021). This may explain why Haslam et al. (2005) found that the perception of personality and values as representative of human nature did not correlate with their assumed immutability. Although seen as partially socially constructed, values can be linked to essentialistic humanness (Bain et al., 2006; N. Haslam et al., 2005). Bain et al. (2006) revealed a significant correlation between ratings on value importance and the belief that they indicate human nature. Furthermore, they showed that participants favored the protection of values more passionately if these values were seen as profoundly linked to human nature and that this perception could be manipulated. Bain et al. conclude that the concept of human nature explains some aspects of how humans establish a hierarchy of values and thus structure their personal relation to these values. Valuing and adopting specific values are central to one's identity (Hitlin, 2003; Sagiv et al., 2017; Yue et al., 2022)[78] and rely on our current being and existential relationships (Coeckelbergh, 2013). The

[78] Cited evidence on value importance relies on the *Schwartz Value Survey* (Schwartz, 1992). Bain et al. (2006) also used this set to obtain ratings on whether selected values were linked to human nature.

identificatory role of values is emphasized, considering their link to personality (Parks-Leduc et al., 2015). This holds interesting implications for the genetic engineering of personality traits in a way that prioritizes those values/personality traits that are seen as indicative of human nature (see Döbler & Carbon, 2025). Under the adversaries' assumption that meddling with what we deem central to our essence enunciates the loss of the Human (Wilson, 2014; Wilson & Haslam, 2009), the subsequent emergence of the post-Human may also be the result of re-evaluating and re-structuring our psychological essence that is derived from our values.

Contemporary humans already build parts of their identity around the demarcation from or identification with historical values (e.g., national identity, Parekh, 1995). This is a general aspect of the perceived collective continuity of groups (Sani et al., 2008). If a disruption in historically shared values could inflict fragmentation on the perception of group (species) continuity, a disagreement in adopted values may indeed accelerate differentiation between groups, as proposed by Agar (2010, 2014). This may yield an enhancement-induced difference in self-ascribed value and, thus, a demarcation alongside the lines of species-dependent moral status (Agar, 2014; Hauskeller, 2016). This does not necessarily require the futuristic examples as discussed by Agar (2014). If I deem freedom central to human nature (Bain et al., 2006) and see an enhancement like vaccination as violating it (Ginossar et al., 2022), the latter may appear threatening the Human. Without freedom, we may stop seeing ourselves as "true" humans, even though nothing has changed in our DNA.[79] It is not about whether a "real" essence is changed, but whether the assumption and reactions enact the loss of what was valued.[80]

11.3. Cave speculation!

Cited evidence supports the theoretical position that technoscientific inventions may trigger dehumanization processes, which eventually lead to self-dehumanization and personal loss of the Human. Nonetheless, dehumanization is not dependent on technological interventions or social interaction but can also emerge through widespread manipulations of the environment (Shi et al., 2022). Still, (self-)dehumanization as an aftershock of Human Enhancement may demand special attention. This is due to the enhancement's interference with interpersonally relevant attributions (Grewal et al., 2020). If so, it occurs in response to a technological intervention *done to somebody*. These judgments then may be more likely to be integrated due to their emergence being clearly attributed to an *alteration of myself*.

[79] Hayles (1999) also claims that it does not take biological alteration for her posthuman to emerge.
[80] This is similar to the view that the moral status of something is constituted by human actions that affirm this status (Coeckelbergh, 2023). See also Smith (2016) on the link between perception and action concerning dehumanization.

For humans, dehumanization can be an adverse experience (Golossenko et al., 2023), while for any post-Humans, this could simply be an accurate description. Moreover, it is questionable if post-Humans would consider themselves as *less* human or not just radically different or even superior. Here, the attribute post- could also be understood as a humanness-upgrade so that related beings view everybody else as an appropriate target for (self-)dehumanization (Hauskeller, 2016).[81] Additionally, dehumanization neither entails inevitable aggressiveness towards the target nor necessarily comprises all traits of the dehumanized individual or group in the same way (Over, 2021). Moreover, all reported studies used categorically human participants and applied specific, yet reductionist instruments to measure dehumanization.[82] Thus, they presupposed identification with what is to be denied and are confined to the version of the Human that the used questionnaires reflect. Cited research and the phenomenon only map identifying *less* with one particular conceptualization of the Human (Demoulin et al., 2021) and do not address whether people stop identifying themselves as human.

This critique was also raised against the general phenomenon (Over, 2021). Due to the evolutionary primacy of visual inter- and intraspecies recognition, Smith (2016) expresses skepticism about the possibility that people can categorically deny the human identity of others. He further argues that this yields a specific type of dehumanization where others are seen as metaphysical "monsters" (2016, p. 432), i.e., borderline beings characterized by a mixture of human and non- or sub-human features (see also Fernández-Armesto, 2004/2005). According to Smith, the latter aspect can also manifest in ascribing superhuman powers. Here, Smith draws on a study by Waytz et al. (2015), showing that White persons were more likely to ascribe superhuman and magical powers to Black than to White peers. A recent study replicated these core findings with substantially smaller effect sizes but also pointed out that the original finding of attributing abilities incompatible with the laws of physics is highly suspect of being a methodological artifact and caused by extreme outliers in the data (Solanki & Cesario, 2023). Interestingly, Praet (2014) also refers to "Monsters" or "Beast (p. 98) to conceptualize how the Indigenous communities that conflate group membership with categorical humanness view outsiders. He argues that not belonging to the group of *Chachi*, for example, gives rise to a whole being "incommensurable" with the way of life of the *Chachi* but also "equivalent" in terms of physical appearance (2014, p. 99). Interestingly, many of the reviewed communities hold rituals where members may temporarily switch categories, for instance, by consuming

[81] In this scenario, there would still be a group separation based on different self-conceptions.
[82] Polemically speaking, we cannot be sure since a manipulation check to determine whether participants consider themselves humans is usually not done in psychological research outside solving CAPTCHAs.

beer. However, in other communities, the consumption of beer is necessary to qualify as Human (Praet, 2014).[83] Alcohol can be seen as Human Enhancement (Döbler & Carbon, 2024; see also Müller & Schumann, 2011). Here, we have the conceptual proof that this Human Enhancement can contingently yield the loss *or* attainment of being Human. Where Smith expresses skepticism, Praet provides widespread anthropological evidence of diverse rituals, ceremonies, practices, etc., in which participating members can temporarily lose their status as Humans and become Monsters so that they conceptually share no features with Humans.

Still, it remains speculative whether the described social psychological process can yield the radical result of not identifying as being human at all. After all, being post-Human is more than a short-term effect in the context of psychological inquiry; it requires a *lasting* change in self-concept. If we share the skepticism of Smith (2016), the process of (self-)dehumanization may be confined to the *inhuman* and not stretch toward the categorically *non-human*. However, I would rebut that if the other is treated *as if* being *non-human* and this behavior resonates within social interactions and self-dehumanization, the so enacted reality brings the categorical difference into existence and fosters its adaptation by involved agents (see Žižek, 1989/2008). In terms of the (post-)Human "a bad ontology may be a useful epistemology" (Gil-White, 2001, p. 518).

Cited evidence provides one perspective of how social interaction fosters separation processes on the level of the species self-concept. It is understandable if my argumentation evokes disbelief. However, on what ground do we assume that the Human and our identification with this category are sacrosanct? Identification entails relation, and if we have learned one thing from postphenomenology, then that technology and Human Enhancement shape how we relate and experience the world and ourselves on an individual and cultural level (Döbler & Carbon, 2024; Ihde, 1979, 1990). Here, self-post-Humanization is considered a process of non-identification. Linking it to the potentially dehumanizing effects of Human Enhancement as well as their social embedding, we can hypothesize that how we make sense of the way we treat each other, depending on the technology we applied to ourselves, may initiate and solidify losing the Human.

11.4. A historical loss

I have described psychological processes of how individuals may cease to identify with the Human. However, how do we make sense of this possibility in an intersubjective and cultural sphere? And most importantly, what factors influence the transition from individual non-identification into a collective endorsement of being post-Human? I

[83] Anecdotal evidence collected by the author in Bamberg supports the idea that the extensive consumption of beer can deteriorate the perceived humanness of peers.

will present tentative hypotheses about how historicized versions of the Human and post-Human may emerge and are employed in the Human Enhancement debate.

The starting point is the claim that the normative sense-making function of the Human serves adversaries and advocates as a myth-based justification to motivate rejection or affirmation of Human Enhancement (Hauskeller, 2016). Such strategic reference to historically sedimented versions of the Human in the Human Enhancement debate is widely acknowledged (e.g., Caulfield & Brownsword, 2006; Hauskeller, 2013, 2016; Sharon, 2014; Simon, 2019). While adversaries seek to protect the current state, advocates may even go so far as to argue that the enhanced future human is the "true" one (Hauskeller, 2013, 2016). They, thus, generalize the desirability of individual transformation over time (see Molouki & Bartels, 2017) towards the species level. This shows how we do not exclusively deal with the self-continuity of a single individual (e.g., Agar, 2014; DeGrazia, 2005; cf. Wilson, 2014) but collectively orchestrated actions to achieve a more beneficial state of Humanity's future members (Hauskeller, 2016; Simon, 2019). However, being the result of the proliferation of increasingly potent Human Enhancement, the post-Human could endanger the continuity of "the universality of human experiences" that allow for transgenerational identification, i.e., ending the "human story" (Agar, 2014, p. 200). This opportunity is very much welcomed by the advocates (Simon, 2019). For instance, Bostrom (2013b) explicitly claimed that using Human Enhancement to become a different kind of (post?)human being is generally favorable. Here, we see the transhuman drive to replace a particular historical conception of the Human with a new post-Human one (Simon, 2019).

It should be clear now that this idea is controversially discussed. Rejecting or endorsing the underlying enhancement goals demands collective action. Here, the necessary socio-political activation builds upon the evoked sense of the aforementioned historical continuity of the to-be-activated group in relation to the respective outcomes and individual agents (Reicher, 2008). In other words, we must argue that pursuing the enhancement effort will benefit or harm *ourselv*es *as individuals* and *ourselves as humans* in the form of succeeding generations. This may be relatively easy for globally orchestrated vaccination campaigns whose endorsement or rejection likewise can promise a 'back-to-normal.' But if advocates and adversaries evoke arguments about whether being post-Human will be favorable or unbearable (e.g., Agar, 2014; Bostrom, 2013b; Hauskeller, 2013), their arguments require contrasting the historical continuity of the Human as worth protecting or necessary to transgress to the unrealized post-Human continuity that serves as an additional starting point. Hence, they need to establish two senses of perceived collective continuity and navigate the transition from one to the other (see Simon, 2019). The

communicative effort to either prevent or accelerate specific types of Human Enhancement is grounded in its projected and discursively established causal role that inscribes a welcomed/feared end to the narratively established collective continuity of the Human.[84]

This continuity appears to be a contemporary success story: Despite all cultural developments and technological adaptations, we consider ourselves to belong to the same species as our prehistoric ancestors. The post-Human in the human-capability-transcending-based understanding of the term is not here yet (Bostrom, 2013b). The dominant collective continuity is the one of the Human. As usual, our individual narrative identity is built, contrasted, and informed against this overarching collective continuity (Fivush et al., 2008; Haraldsson & McLean, 2022; Reicher, 2008; Sani et al., 2007, 2008). This partly happens in the context of the myriad practices commemorating past generations and their achievements. These ways of maintaining a psychological, continuous connection with the dead and the past are often rooted in material culture (e.g., Krzyżanowska, 2016; Mansouri & Shad Ghazvini, 2021; D. Miller & Parrott, 2009; Sani et al., 2008) but also vibrate in social practices and institutions (e.g., Reicher, 2008) and shared narratives (e.g., Haraldsson & McLean, 2022; Sijilmassi et al., 2024). Yet, these examples may be highly specific and culturally confined. Mapping the entire history of humans seems more challenging. Still, there may be some practices that perfectly exemplify the general processes of how we as individuals adopt, communicate, and reason with one particular version of the Human.

So-called "evolutionary epics" denote a genre of literature that identifies significant events within human history and attempts to craft a meaningful narrative of its past but also its potential future (Hesketh, 2015; Raipola, 2022). This genre dates back to the 19th century (Hesketh, 2015), a time when Western scholars began to investigate human history as a unidirectional and universal strand (Simon, 2019). According to Raipola, recent examples like Yuval Harari's "Sapiens" (2013) are meant to create a comprehensive, coherent, and expositional historical account of humanity's current state, establish a transgenerational distinctly human "sense of identity and belonging" as well as leave "the reader with [a] clear universal story of cause and effect" (2022, p. 221). These epics are not the only way humans explore and understand themselves, but may serve as an illustrative example here. In general, Raipola (2022) argues that narratives located at the intersection of science communication and folk-psychology seek to effectively "discuss entities and processes foreign to our common embodied experience in order to help us 'make sense' of these abstract and complex phenomena" (p. 216). In that sense, they are not a neutral collection

[84] Simon (2019) provides a comprehensive macroscale critique of how these processes manifest within a Western-biased conception of human history but is not concerned with the psychological mechanisms of these processes.

of facts, but have a distinct mythological, norm-conveying undertone (Hauskeller, 2016; Raipola, 2022). By exploiting effective communicational strategies to foster identification with acting individuals and generations whose experiences are not our own (Raipola, 2022), these narratives are producers and propagators of one version of the Human in its sense-making, norm conveying but also continuity establishing function. They do not only set a starting point for humanity, but also create the narrative arch of beginning, middle (time of reception), and end at a comprehensive historical scale (Raipola, 2022). In this function, the end alters the meaning and interpretation of what occurred before (Mishler, 2006).

This becomes visible in how these narratives project the upcoming evolutionary trajectory of its protagonist. Evolutionary epics were and are often explicitly framed as necessary for helping humans to capitalize on their self-actualization capabilities and — by understanding their place in the history of the earth or universe — transcend their current condition (Hesketh, 2015). This is especially evident in Harari's "Sapiens" (2013), in which he draws an evolutionary line from our ape-like ancestors to our almost divine but reckless biotechnologically capable successors who must now carefully contemplate the next step for their future (Raipola, 2022). This resonates with the Human Enhancement debate, where authors are equally concerned about the "human story" as a "complex, multibranched narrative" (Agar, 2014, p. 200). It is this story that transhumanism and related ideologies reduce to allegedly necessary evolutionary progression (Hauskeller, 2016; Simon, 2019). This goes so far as to frame past and projected technological expansion as a "story of the *destiny* of the human-machine civilization" (Kurzweil, 2005, p. 5, my italics). Such causality-conveying narratives reconstruct and enact the Human's perceived historical continuity (see Sani et al., 2008). Any so-established continuity projects into the past and future (Reicher, 2008) and does not only establishes the Human's endurance in time but can be used to project his upcoming transcendence (Hauskeller, 2016). Implications of this are observable within the Human Enhancement debate when authors naturalize enhancement efforts as historical practice yet emphasize the differing potential of contemporary or future technologies (e.g., Agar, 2014; Allhoff et al., 2010; Döbler & Carbon, 2024; Greely, 2006). Especially the transhuman essentialistic naturalization of transgressing our limitations (Hauskeller, 2016), establishes continuous patterns of behavior as a foundation for the Human's perceived cultural continuity (see Sani et al., 2008). However, the historical and cultural continuity of the practice that shall elevate or impair our current continuity is imposed on our ancestors. The current effort is justified not only by utilizing a historical reference but also by narratively reshaping the meaning of the same practice as either continuity establishing or breaking.

According to Agar (2014), arguing about our progenitors always entails "imaginative interpretation" (p. 199). Although admitting that our prehistoric ancestors probably had different experiences than modern humans, Agar claims that they would still have identified them as experienced *by a human*. I only partially support this argument. If conscious, these beings, whom we now regard as prehistoric humans, had experiences that they experienced *themselves*. Moreover, our ancestors may have relied on social cues and mechanisms for group- and species-demarcation so that the group they belonged to could be identified as *themselves,* i.e., consisting of comparable members (Moffett, 2013). However, Agar intended not to highlight the grouping of visually or behaviorally similar life forms but to argue for a transhistorical understanding of these beings *as humans* as linked to *ourselves*. Agar's position presupposes that our ancestors entertained a similar version of the Human, i.e., shared the semantics as we do.[85] By proposing the transgenerational existence of distinctly "*human* experiences" (2014, p. 200, original italics), Agar drafts the cornerstones of the common human-focused narrative that revolves around a shared sense of values and activities (see Raipola, 2022). This becomes clearer when he proposes that post-Humans will value activities and practices differently than we do. However, while our ancestors probably identified their peers, *their* understanding of what it means to be in this group is partially reconstructed to ensure the historical continuity of the Human. Hence, Agar is right when stating that "questions about the first human invite human beings to speculate about how far they can veridically project themselves into the past" (2014, p. 199). But he fails to acknowledge that any *identification* of these beings as human is already such a backward projection of current semantics and knowledge. This shows how the mythological selectivity and sense-making function of the Human (Hauskeller, 2009) may yield a diversity-neglecting reconstruction of its continuity (see Graeber & Wengrow, 2022; Raipola, 2022) and how the idea that there is some time-enduring historical group called humanity is much more ideologically influenced than it seems (Simon, 2019).

Here, the dispositional inclination and advantage to perceive collective and individual developments as continuous (Sedikides et al., 2023) creates the possibility for exploitation (Sani et al., 2008). This is comprehensively shown in the emergence, propagation, and psychological function of so-called "historical myths" (Sijilmassi et al., 2024, p. 1). Crafted from three components, i.e., *"deep"* and *"ancient roots"* (p. 5, my italics) that allegedly determine an *overlap of relevant experiences* and are conserved due to the *group's existence as a continuous entity*, historical myths can be understood as strategically employed meta-narratives to motivate collaborative peer behavior (Sijilmassi et al., 2024). Moreover:

[85] Agar's position, therefore, denies Bostrom's (2005a) claim that our ancestors would view us as post-Humans.

> because humans intuitively think of groups as having time-enduring properties, historical events that affected some group-level trait in the past—for instance, an important war that has brought country members together—can be perceived as having an enduring impact in the present. (Sijilmassi et al., 2024, p. 10)

Besides a wide range of historical examples, Sijilmassi et al. draw upon already discussed research on essentialism and self-/collective continuity as the psychological foundation for their theory. Still, one of the most important requirements for exploiting historical myths may be that human self-interpretation is malleable and thus conditional on socio-material processes and practices. The examples by Sijilmassi et al. primarily concern ethnic and national identities. Still, we may apply this theory to the mythological, norm-conveying function of the Human (see Hauskeller, 2009).[86] For a social group conception to motivate collective action, agents must provide a definition of who is to be addressed (Reicher, 2008). If the Human shall motivate its preservation or transgression, fixating it in the form of a historical myth may be beneficial.

Let us create our own historical myth. Concerning the ancient roots and continuity, we rely on science. This way, we can date the first archaeological records of *Homo sapiens* to ~300kya (Richter et al., 2017) and use genotypic information to link these beings to their contemporary kinship (see Fernández-Armesto, 2004/2005). This is akin to private DNA-heritage analysis. Through this practice, individuals can explore their genetic heritage and biologically connect with myths, narratives, and their family destiny through the power of technoscience (Hirschman, 2010). Psychological essentialism builds upon the assumption of deeply rooted shared essence (N. Haslam & Whelan, 2008). Evaluating social groups in this regard can correlate positively with the perceived collective continuity of one's nation (Siromahov et al., 2020). In this sense, propagating one version of the essentialistic Human seems privileged by this myth component.

What about similar experiences? Let us join Agar (2014): Albeit culturally diverse, we can easily entertain the assertion that similarities in our cognitive and sensory phenotypes yield comparable general phenomenological results. Given that underlying processes are seen as shaped by a long evolutionary trajectory, their presence also affirms our historical roots. Moreover, humanization can also be expressed as a set of attributed psychological features (H. M. Gray et al., 2007; N. Haslam, 2006; Wilson & Haslam, 2012). Thus, the assignment of this label

[86] Despite meeting in one of the hottest phases of the Cold War, USSR leader Mikhail Gorbachev assured US President Ronald Reagan that he would grant military support in the case of an alien invasion (Charbonneau, 2021; Lewis, 2015). See Charbonneau (2021) for a historical perspective on this report and how it inspired universalistic humanistic rhetoric by Carl Sagan. The expressed commitment to species unification in the face of external threats shows the rare yet strategic function of appealing to the shared basis of being human under the proposed mechanism.

further justifies a shared experiential foundation. This concurs with linking "true" humanness to emotional receptivity (Phillips, 2022) and, therefore, the general ability to have affective experiences.

Nonetheless, this historical myth is contingent. We are free to add semantics that are considered necessarily human. Maybe a lasting yet endangered human essence that serves as a cohesive foundation for our identity and thus defies all differentiation based on visual diversity (e.g., Fukuyama, 2004; Hauskeller, 2016)? Or the observation that "the human desire to acquire new capacities is as ancient as our species itself" (Bostrom, 2005c, p. 1), which then justifies the transhuman myth that technoscience will pave the way to paradise (Hauskeller, 2016)? More neutrally, we could also argue that it is "in our nature" to contemplate how our past will be utilized in the future (Reicher, 2008, p. 156), so we should be concerned about determining whether Human Enhancement may endanger the latter (Agar, 2014)? All these versions operate with one historized version of the Human to justify enhancement conduct and showcase how past contingencies can be meaningfully integrated into a contemporary Human that is meant to be preserved or transgressed (see Simon, 2019; Section 10.3). This highlights how, in general, existing narrative guiding stones may mitigate enhancement-induced identity interferences (Iftode et al., 2024). If the effects of disruptive technology are integrated into a myth, the post-Human may be less likely. Yet, if my myth is adamant about what constitutes the Human, disruptions may question the suitability of its main protagonist.

Similar to the mentioned evolutionary epics, historical myths rearrange information about the past to motivate action. They capitalize on the normative and future-oriented sense-making function of selected semantics of the Human (see Hauskeller, 2016) and the fact that perceived collective continuity builds upon an assumed strong causality of past occurrences (Sijilmassi et al., 2024). Historical myths in the here described sense are used whenever transhumanists link the history of humanity to technological mastery over nature, install the post-Human as a desirable milestone, or when adversaries draw upon past disastrous consequences that arose from this drive for control (see T. K. Browne & Clarke, 2020; Hauskeller, 2013, 2016). Enriched with a technoscientific flavor, evoked arguments demonstrate how the crafted and retold myths and fantasies refer to our technological environment and how various technologies mediate our experiences (Ihde, 2011a). Nick Bostrom, for instance, explicitly clothed his call for prolonging the human life span through technology into the shape of a fable, portraying death through aging as "dragon tyrant" (Bostrom, 2005b, p. 273). Moreover, Ray Kurzweil (2005) provides a series of linear and exponential graphs meant to convey the necessity to accelerate the displayed

unstoppable technological progress (cf. More, 2013b).[87] He also compares technology to enabling evolutionary progress, like the opposable thumb. Thus, he embeds past and future technological developments into an evolutionary narrative of progress enriched with spiritual and romantic ideas of the complete dissolution of humans into machines (Coeckelbergh, 2017). By framing them as evolutionary iterations, Kurzweil changes the meaning of *contingent* technological breakthroughs as *necessary* for paving the way for those realized later (see Žižek, 2014).

This elucidates the strategic employment of the Human. But if we examine his temporal progression toward being post-Human (see Simon, 2019), when will it be lost precisely? According to Buchanan (2011), the post-Humanizing potential of biotechnological enhancements hinges upon their ability to realize a novel quality of capabilities. He also suggests that this process may happen 'cumulatively' by approaching decisive points-of-no-return, whose surpassing hinders identifying with past generations. Agar concurs by stating that even if radical enhancement was widespread, humanity would not suddenly cease to exist. Instead, we would view a "gradually eroding [of] features of ourselves that we rightly value" (Agar, 2014, p. 198). Note in this regard, Hauskeller's (2013) criticism of what he calls "argument from graduality" (p. 124), i.e., the idea that iterative substitution of biological tissue through cybernetic substrates does *not* change the identity of the respective person because of the absence of any singular radical transformation. Hauskeller points out that even though identity change may happen little by little, perception of the outcome implies the occurrence of change, even without being able to determine the exact point when a qualitative change happened. He further argues that this also applies to any change in whatever we understand as humanness. Even if not happening immediately, a categorical non-identification with the Human may result from slow but unperceived change (Hauskeller, 2013).[88] In historical parallel, even Charles Darwin admitted that his account of evolution was unable to pinpoint the exact moment when *Homo sapiens* emerged as clearly distinguishable species (Fernández-Armesto, 2004/2005). Fernández-Armesto uses this fact within his argument on the contingencies of our species-self-concept and eventual inability to recognize the loss of the same. Yet, even if the initial point-of-no-return was initially not noticed, nothing hinders us from positing and fixating it at some contingent moment in time (Mishler, 2006; Žižek, 2014) and arguing that it was a specific enhancement that has necessarily caused it.

We can find a similar phenomenon in the construction of our narrative identity, encapsulated and shared in the form of a life story (McAdams, 2001; Mishler, 2006). One common strategy to make sense of past adverse events

[87] For a comprehensive analysis of the "Mythologies of Transhumanism" and the arguments of Bostrom, Kurzweil and others see the eponymous book by Hauskeller (2016).
[88] The association with perceptual change blindness is unignorable (Hamilton et al., 2008)

is framing them as alleged necessity to yield positive outcomes (McAdams & McLean, 2013). Mishler (2006) argues that so established "Turning points" (p. 38) constitute moments in life that help to make sense of one's past by changing and reordering its meaning. A longitudinal study on the perception of events like relocation, starting university, or graduating from high school showed that over 15 months, events gained attributed causality for one's perspective on the world but became less emotionally important (Haehner et al., 2022). Studies like this show the mechanisms of how people's perception of the past is attuned to their current condition and creates a historically coherent and continuous self that is expected to prolong in the future (see Sedikides et al., 2023). Similar to the historized narratives, we make "the past fit for the future" (Reicher, 2008, p. 145)—at least until reevaluation.

Related mechanisms also happen on a cultural and species level. Graeber and Wengrow (2022) recently examined different theories on human cultural development. According to them, anthropological theories, especially those dealing with the emergence of social inequality, explain this state by one of two mythologically charged and simplistic narratives: Either by referring to an inherently rapacious human nature that necessitates contemporary social inequality or by bemoaning a perished paradise whose loss was similarly necessitated by socio-technological developments like agriculture and subsequent population settlements (see also Fernández-Armesto, 2004/2005). This paradise cannot be understood in the sense of a pre-technological garden; it is a mythological but forever lost state of balance and egalitarian co-existence (Graeber & Wengrow, 2022). Highlighting the role of science in this process, Graber and Wengrow show how these different accounts assign new meaning to historical occurrences. This resembles other narrative efforts that streamline contingency to necessity and create an outcome characterized by a smooth trajectory of occurrences which "'will have been' necessary" for the emergence of the present (Black, 2021; Žižek, 2014, p. 146). The result of trading contingency against definiteness is a historicized continuity of the relevant entity that justifies the behavior by aligning the past with the future (Reicher, 2008).

Psychological theories play an interesting role here. If a theory of action like the famous *Rubicon model* is formulated in 1987 (Heckhausen & Gollwitzer, 1987), its content extends to the past, allowing for a psychological assessment of the actual historical event of Caesar crossing the Rubicon. The theory changes nothing about the physical relocation of troops that took place in 49 BCE, but re-assigns meaning by positing psychological processes to explain the mind of Caesar. In fact, Heckhausen and Gollwitzer explicitly referred to Caesar in their paper. Unless psychology rejects the historical continuity of these fundamental processes and thereby dismantles the historical continuity of the so-emerging version of the Human, it implicitly claims historical validity and thus can change the meaning of the past in terms of the assumed and implied psychological processes (for a discussion of

the historical dimension of psychology see Muthukrishna et al., 2021). Interestingly, moral psychologist Jonathan Haidt (2013) also uses the Rubicon metaphor to posit the evolutionary development of *shared intentionality* as a key moment for the emergence of group morals. Remember that the ability to enact shared moral values is pivotal for attributed humanness (Phillips, 2023). Haidt (2013) further claims that the Rubicon metaphor stands for initializing "an unstoppable train of events with momentous consequences," suggests that "it's great fun to look back at history and identify Rubicon crossings" (p. 237) and subsequently frames these crossings as leading to our current bio-social human condition. Despite all the enjoyment, we do not deal with simple retrospection here. Instead, such looking back in time is *retroactive* (see Black, 2021)*:* the allegedly naturally appearing crossings are only there because we dared to look from today's perspective, so that the assertion that the relevant events were "unstoppable" is a retroactive transformation from contingency to necessity (see Žižek, 2014). Such reframing successfully applies perceived collective continuity and its motivational function: "The more a given construction can be represented as self-evident—as necessary rather than contingent—the more convincing it will be" (Reicher, 2008, pp. 149–150).[89]

Given the social aspect of conveying and affirming the Human, social interactions, historical narratives, and personal contingencies provide a constant source of novel information that requires sense-making and allows re-assessment of the past (De Jaegher & Di Paolo, 2007; Di Paolo, 2015; Haraldsson & McLean, 2022; Mishler, 2006). The same is true for technoscientifically produced insights. Here, psychological research is one alternative practice that reveals, objectifies, informs, affirms, and disseminates individual experiences about the Human (Fahrenberg, 2003/2011). So-informed narratives then provide an easy-to-adopt yet partially reductionistic intersubjective epistemic ground for assessing reality (Raipola, 2022). If I link essentialistic qualities of the Human to one specific genetic makeup, then only science can inform me whether this alleged essence was lost. In that sense, science and psychology can create but also shatter humanity on a cultural level. This is especially evident for the infamous Freudian "narcissistic injuries" that are said to have fundamentally shaken our self-perception (Fahrenberg, 2003/2011). As the summary provided by Fahrenberg (2003/2011) shows, psychology (Freud) is hereby granted

[89] Note the reception of the famous phrase Ceasar allegedly said while crossing the Rubicon: "*alea iacta est!*" Perpetuated through the "Asterix" comic books, this phrase is often mistranslated as "Der Würfel ist gefallen [The die is fallen]" (Goscinny & Uderzo, 1973/2016, p. 5, my translation). Yet the correct translation would be: "Der Würfel ist geworfen [The die is cast]." The latter does not imply that history is already decided but is currently and contingently unfolding. The false translation suggests that Ceasar was always the historical Ceasar the great strategist, who already knew what would happen (see Žižek, 2014). Without translating it, Heckhausen and Gollwitzer (1987) use "alea iacta est" to illustrate the passage from action-planning to post-planning executing phase. Since an undecided and contingent future requires more behavioral adjustment than one unfolding according to a pre-manufactured and intended plan, they could have had the wrong translation in mind.

equally corrosive potential as cosmology (Copernicus), biology (Darwin), or the potential success in the search for extraterrestrial intelligence. In that context, novel information produced by science can bust previous myths that emerged by the same means (Fernández-Armesto, 2004/2005; Graeber & Wengrow, 2022). If technoscience, including Human Enhancement, co-narrates our past, present, and future (Coeckelbergh, 2017), so produced insights may trigger "what goes on all the time, that is, the continuous process we engage in of reconstructing the meanings of past experiences and remaking our selves in both small and big ways" (Mishler, 2006, p. 41).

As an encultured practice, Human Enhancement adds additional content and chapters to the human story. However, we should not see the latter as passive knowledgeable documentation of our past but highlight how its content must be intersubjectively enacted (see Stetsenko & Arievitch, 2004). This happens by behaviorally affirming a history of technoscientific revelations and adaptations meant to address perceived inadequacies — by doing Human Enhancement. The produced artifacts and effects may, in hindsight, be integrated as leading to the point where we are now (e.g., Döbler & Carbon, 2024) or narratively posed as necessarily having ended our narrative continuity (see Agar, 2014). On the cultural level, Simon (2019) argued that the disruption between Human and post-Human renders establishing a historical continuity encompassing both conceptions impossible. Moreover, he claims that any notion of the post-Human necessarily constructs a historical human meant to be left behind. This theoretical proposition and the here cited psychological evidence on how we make sense of our past suggests that losing the Human is not only losing a status quo but also reshaping the history that constituted it and with which we identify. Yet, it seems unnecessary to form a continuous transition as long as some form of connection is maintained. Thus, I do not problematize the possible emergence of the post-Human in the same way as Simon but argue that even a story full of discontinuities and radical changes can be reattuned to appear sufficiently continuous, similar to how our current life and history does to us.[90] Simon may be right from a logical point of view, but psychologically speaking, any *perceived* collective continuity (Sani et al., 2008) is prone to fall for any influences that suggest that perception and action are not about objective but enacted reality (Varela et al., 1991/1993) and that making sense of ourselves involves constantly reconstructing the past (Di Paolo, 2015).

Hence, semantics produced by Human Enhancement may indeed endanger our continuation *as humans*. Thus, I reject the position of Fernández-Armesto (2004/2005), according to which our inability to precisely define the character of our species identity entails the inability to recognize its dissolution. I also disagree with Clark (2003),

90 Note, for example, how Carl Sagan's famous accentuation that humans consist of the elements of dead stars (Sagan, 1973), creates a continuity of matter in the universe under the explicit acknowledgement of radical breaks.

who claimed that the predisposition to embody and integrate the effects of external means renders our self-identity indestructible. The Human is contingent, so any present conceptualization may appear as the logical outcome of the past. But this is the effect of how we arrange semantics and events to understand and identify ourselves. The flexibility of the Human semantics does neither entail that we cannot operate with this concept nor that the flexibility of semantics necessitates the inevitable resilience of the concept itself (see Hauskeller, 2013).

Let us revisit what we have started with: The Fall of Man. Is this not the ultimate historical myth? One that condensates our whole experience and being to have emerged from one singular, ground-breaking moment in time but also fixates an irrevocably lost past (see Žižek, 2014). How this narrative re-structure the past may be best visible in a Hegelian understanding, according to which "what the Bible calls 'Fall' is nothing more than the passage from animal life to human existence proper. *It is thus the Fall itself which creates the dimension from it is the Fall."* (Žižek, 2014, p. 42, original italics). Historical myths and evolutionary epics strategically use one temporarily fixed Human. In the Human Enhancement debate, they produce what appears necessary to be enacted, preserved, or transgressed by the power of technology (see also Simon, 2019). Yet, their contingency and functionality create and simultaneously undermine any so conveyed perpetuation.

Seeing the loss of identification mentioned above in context with how we construct, maintain, and eventually renegotiate the collective continuity of the Human, I hypothesize that the emergence of the post-Human can be perceived through the lens of a fixated historized collective continuity, whose divergences with the Human may result from a gradual process that *appears* as a sudden break. This may then be attributed to the dissemination of a particular enhancement. Thus, the post-Human is not the necessary end of the Human. Yet, it may be necessitated by our efforts to make sense of the contingent developments we identified in the cultural and biological evolution that appear to have created ourselves as humans.

If post-Humans can identify themselves, one could generalize these thoughts to beings with comparable reflexivity as humans and who try to make sense of the emergence of their categorically differing species self-concept. In both perspectives, the post-Human includes the lost perceived collective continuity of the Human as necessary condition for emergence (see Simon, 2019). It conserves it. Looking back and making sense of what happened, the future of the Human *appears as* the past for the post-Human (cf. Simon, 2019). The historical loss of the Human gives rise to the historical post-Human myth.

12. Conclusion

Aiming for effective engagement with a dynamic world forces us to actively and constantly adapt (Di Paolo, 2005; Thompson & Stapleton, 2009). The manifested adaptivity is our ability to change to cope with change — it relies on making sense of ourselves and the conditions of the environment (Di Paolo, 2005). Thus, the adaptation of the environment (Kirsh, 1996) or exercising agency through technology (Ihde, 1990) to adapt and enhance ourselves can be understood as a functional attempt to confront imposed demands from various sources (Döbler & Carbon, 2024). Using increasingly potent technologies for this transformative engagement with ourselves and the world harbors profound ethical questions, but also fuels well-known aspirations about transcending our limitations (Allhoff et al., 2010). Discussed and researched manifestations of Human Enhancement addressed efforts to protect ourselves against physiological threats (Döbler & Carbon, 2023), to meet the demands of "artificial" environments like the modern workplace or education system (Döbler et al., 2024), and the extent to which we may rely on it to translate purely socially conveyed norms like stereotypes to the physiological level (Döbler & Carbon, 2025). Considering technology's impact on our lives and self-understanding (Coeckelbergh, 2013; Ihde, 1979, 1990; Rosenberger & Verbeek, 2015), related adaptivity becomes a matter of establishing a beneficial trajectory, which will either lead us to a glorious, technologically enhanced future or maintain a currently valued state of ourselves. Yet, as my research shows, reducing the Human Enhancement debate to dystopian and utopian accounts neglects the phenomenon's pervasiveness and how socio-material and ideological contexts already urge and naturalize enhancement.

By bringing forth and significantly shaping our experiences and insights, technoscientific practices, including Human Enhancement, can shape the understanding of ourselves and the environment and thus give rise to a specific understanding of subjectivity and self-understanding (Döbler & Carbon, 2024; Ihde, 1979; Ihde & Malafouris, 2019; Sharon, 2014; Verbeek, 2005). As comprehensively argued, our identity as humans is and has been constantly adapted according to past and new semantics. Optimistically, I highlighted some cases in which Human Enhancements can help to enact valued semantics. Pessimistically, the Human may be flexible but not indestructible (Hauskeller, 2013). Hence, novel ways of technological adaptations of the human body *may* go too far and produce semantics so incompatible that no more sense can be made of the Human. The results may be so scandalous that we cease to be identified or identify as "true" Humans. For some, current biotechnologies like vaccination or the prospect of widespread genetic engineering may foreshadow such developments. Others seek to embrace the increasing capabilities of biotechnology and want to exploit its transformative power. In either case,

adversaries and advocates strategically operate with a historized version of the contemporary Human who stands in a direct yet somewhat discontinuous relationship with its potential post-Human successor (Simon, 2019). The character of this post-Human remains speculative, as does whether it will ever see the dawn of the world. Hence, nobody can identify the exact enhancement that renders the Human lost, nor if this loss will ever happen (Buchanan, 2011; Fernández-Armesto, 2004/2005). Thus, the psychological mechanisms described here allow for a careful glimpse into the *possibility* of the lost Human. Even if we enhance those capabilities deemed central to human nature, *the post-Human is not inevitable.*

Evaluating behavior meant to foster adaptation is open for reassessment (Di Paolo, 2015). Thus, any adaptation can only be assessed in hindsight. By making sense of our past and its actualized and bygone possibilities, we can inform future plans for action and adaptation (Di Paolo, 2015; Žižek, 2023). This flexibility highlights how the Human is employed to make sense of our existence (Hauskeller, 2009) and how we were able to integrate past social, material, and political change without breaking an underlying perceived collective continuity (Hamilton et al., 2008; Sani et al., 2008). Still, revisiting our condition and perceived past change may convey the impression that produced semantics are impossible to integrate into the historical and shared understanding of the Human (Hauskeller, 2013). This is the moment when general non-identification with this identity *appears necessary.* Thus, when it comes to noticing the lost Human, we might find ourselves in the position of the famous Owl of Athena (Hegel, 1821/1911): flying when the sun has set and always arriving too late at the scene.

Losing the Human seems like the inversion of the event this doctoral dissertation started with: The eviction from the mythical garden because of the enhancement efforts of our biblical ancestors. Eating from the Tree of Knowledge *created* and emphasized what is eternally lost but is desired to return to (Žižek, 2014). Given the recent evidence that "true" humans are morally imperfect (Phillips, 2023), we could even claim that Human Enhancement created the first Human. Populating the earth, we still fantasize about the lost pre-technological Garden and the capabilities that technologies might give us (Ihde, 1990). Human Enhancement is the concentrated practice of this ambivalence — "It is the alleged solution and the potential problem" (Döbler & Carbon, 2024, p. 597). Doing Human Enhancement may lead us to a path that ends with remorse or rejoicing that the contingent decision of walking was the decisive moment in time that has necessarily disrupted our identity. If this point is ever reached, the adaptations of ourselves involved will have enunciated not the dawn but the dusk of humanity.

13. References

@1wsky. (2022, June 19). [Online post]. https://x.com/1wsky/status/1538508280451964928?s=20

Aagaard, J. (2016). Introducing postphenomenological research: A brief and selective sketch of phenomenological research methods. *International Journal of Qualitative Studies in Education*, *30*(6), 519–533. https://doi.org/10.1080/09518398.2016.1263884

Adams, G., Estrada-Villalta, S., Sullivan, D., & Markus, H. R. (2019). The psychology of neoliberalism and the neoliberalism of psychology. *Journal of Social Issues*, *75*(1), 189–216. https://doi.org/10.1111/josi.12305

Agar, N. (2010). *Humanity's end: Why we should reject radical enhancement*. MIT Press.

Agar, N. (2014). *Truly human enhancement: A philosophical defense of limits*. MIT Press.

Airenti, G. (2018). The Development of Anthropomorphism in Interaction: Intersubjectivity, Imagination, and Theory of Mind. *Frontiers in Psychology*, *9*, 2136. https://doi.org/10.3389/fpsyg.2018.02136

Allenby, B. R., & Sarewitz, D. R. (2011). *The techno-human condition*. MIT Press.

Allhoff, F., Lin, P., Moor, J., & Weckert, J. (2010). Ethics of human enhancement: 25 Questions & answers. *Studies in Ethics, Law, and Technology*, *4*(1), 1–39. https://doi.org/10.2202/1941-6008.1110

Almeida, M., & Diogo, R. (2019). Human enhancement: Genetic engineering and evolution. *Evolution, Medicine, and Public Health*, *2019*(1), 183–189. https://doi.org/10.1093/emph/eoz026

Alspaugh, A., Barroso, J., Reibel, M., & Phillips, S. (2020). Women's Contraceptive Perceptions, Beliefs, and Attitudes: An Integrative Review of Qualitative Research. *Journal of Midwifery & Women's Health*, *65*(1), 64–84. https://doi.org/10.1111/jmwh.12992

Álvarez, M. P. (2011). The magnetism of neuroimaging: Fashion, myth and ideology of the brain. *Papeles Del Psicólogo*, *32*(2), 98–112.

Appel, J. M. (2008). When the boss turns pusher: A proposal for employee protections in the age of cosmetic neurology. *Journal of Medical Ethics*, *34*(8), 616–618. https://doi.org/10.1136/jme.2007.022723

Bagusat, C., Kunzler, A., Schlecht, J., Franke, A. G., Chmitorz, A., & Lieb, K. (2018). Pharmacological neuroenhancement and the ability to recover from stress—A representative cross-sectional survey among the German population. *Substance Abuse Treatment, Prevention, and Policy*, *13*(1), 37. https://doi.org/10.1186/s13011-018-0174-1

Bailey, A. H., Knobe, J., & Newman, G. E. (2021). Value-based essentialism: Essentialist beliefs about social groups with shared values. *Journal of Experimental Psychology: General*, *150*(10), 1994–2014. https://doi.org/10.1037/xge0000822

Bain, P. G., Kashima, Y., & Haslam, N. (2006). Conceptual beliefs about human values and their implications: Human nature beliefs predict value importance, value trade-offs, and responses to value-laden rhetoric. *Journal of Personality and Social Psychology*, *91*(2), 351–367. https://doi.org/10.1037/0022-3514.91.2.351

Bal, P. M., & Dóci, E. (2018). Neoliberal ideology in work and organizational psychology. *European Journal of Work and Organizational Psychology*, *27*(5), 536–548. https://doi.org/10.1080/1359432X.2018.1449108

Ballone, C., Pacilli, M. G., Teresi, M., Palumbo, R., & Pagliaro, S. (2023). Attitudes moralization and outgroup dehumanization in the dynamic between pro- vs. Anti-vaccines against COVID-19. *Journal of Community & Applied Social Psychology*, *33*(5), 1297–1308. https://doi.org/10.1002/casp.2718

Banazadeh, M., Abiri, A., Poortaheri, M. M., Asnaashari, L., Langarizadeh, M. A., & Forootanfar, H. (2024). Unexplored power of CRISPR-Cas9 in neuroscience, a multi-OMICs review. *International Journal of Biological Macromolecules*, *263*, 130413. https://doi.org/10.1016/j.ijbiomac.2024.130413

Bandura, A. (2006). Toward a psychology of human agency. *Perspectives on Psychological Science*, *1*(2), 164–180. https://doi.org/10.1111/j.1745-6916.2006.00011.x

Banjo, O. C., Nadler, R., & Reiner, P. B. (2010). Physician attitudes towards pharmacological cognitive enhancement: Safety concerns are paramount. *PloS One*, *5*(12), 14322. https://doi.org/10.1371/journal.pone.0014322

Bärnighausen, T., Bloom, D. E., Cafiero-Fonseca, E. T., & O'Brien, J. C. (2014). Valuing vaccination. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(34), 12313–12319. https://doi.org/10.1073/pnas.1400475111

Barrett, L. F., Quigley, K. S., & Hamilton, P. (2016). An active inference theory of allostasis and interoception in depression. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1708), 20160011. https://doi.org/10.1098/rstb.2016.0011

Bastian, B., & Crimston, D. (2014). Self-dehumanization. *Testing, Psychometrics, Methodology in Applied Psychology*, *3*, 241–250. https://doi.org/10.4473/TPM21.3.1

Bastian, B., Denson, T. F., & Haslam, N. (2013). The Roles of Dehumanization and Moral Outrage in Retributive Justice. *PLoS ONE*, *8*(4), e61842. https://doi.org/10.1371/journal.pone.0061842

Baum, M., Sattler, S., & Reimann, M. (2023). Towards an understanding of how stress and resources affect the nonmedical use of prescription drugs for performance enhancement among employees. *Current Psychology*, *42*(6), 4784–4801. https://doi.org/10.1007/s12144-021-01873-7

Becker, M., Repantis, D., Dresler, M., & Kühn, S. (2022). Cognitive enhancement: Effects of methylphenidate, modafinil, and caffeine on latent memory and resting state functional connectivity in healthy adults. *Human Brain Mapping*, *43*(14), 4225–4238. https://doi.org/10.1002/hbm.25949

Beinsteiner, A. (2019). Cyborg agency: The technological self-production of the (post-)human and the anti-hermeneutic trajectory. *Thesis Eleven*, *153*(1), 113–133. https://doi.org/10.1177/0725513619863855

Bell, J. D., & Macuga, K. L. (2022). Are tools truly incorporated as an extension of the body representation?: Assessing the evidence for tool embodiment. *Psychonomic Bulletin & Review*, *29*(2), 343–368. https://doi.org/10.3758/s13423-021-02032-6

Bergen, J. P., & Verbeek, P.-P. (2021). To-Do Is to Be: Foucault, Levinas, and Technologically Mediated Subjectivation. *Philosophy & Technology*, *34*(2), 325–348. https://doi.org/10.1007/s13347-019-00390-7

Bernard, P., Content, J., Servais, L., Wollast, R., & Gervais, S. (2020). An Initial Test of the Cosmetics Dehumanization Hypothesis: Heavy Makeup Diminishes Attributions of Humanness-Related Traits to Women. *Sex Roles*, *83*(5–6), 315–327. https://doi.org/10.1007/s11199-019-01115-y

Betsch, C., Schmid, P., Heinemeier, D., Korn, L., Holtmann, C., & Böhm, R. (2018). Beyond confidence: Development of a measure assessing the 5C psychological antecedents of vaccination. *PloS One*, *13*(12), 0208601. https://doi.org/10.1371/journal.pone.0208601

Bevens, C. L., & Loughnan, S. (2019). Insights into Men's Sexual Aggression Toward Women: Dehumanization and Objectification. *Sex Roles*, *81*(11–12), 713–730. https://doi.org/10.1007/s11199-019-01024-0

Bickford, A. (2019). "Kill-Proofing" the Soldier. *Current Anthropology*, *60*(S19), 39–48. https://doi.org/10.1086/700028

Black, J. (2021). Retroactive causation and the temporal construction of news: Contingency and necessity, content and form. *Distinktion: Journal of Social Theory*, *22*(1), 44–59. https://doi.org/10.1080/1600910X.2020.1792957

Blaine, B., & McElroy, J. (2002). Selling Stereotypes: Weight Loss Infomercials, Sexism, and Weightism. *Sex Roles*, *46*(9/10), 351–357. https://doi.org/10.1023/A:1020284731543

Blondeel, K., Vasconcelos, S., García-Moreno, C., Stephenson, R., Temmerman, M., & Toskin, I. (2018). Violence motivated by perception of sexual orientation and gender identity: A systematic review. *Bulletin of the World Health Organization*, *96*(1), 29–41. https://doi.org/10.2471/BLT.17.197251

Bosschaert, M. T., & Blok, V. (2022). The 'empirical' in the empirical turn: A critical analysis. *Foundations of Science*, *28*, 783–804. https://doi.org/10.1007/s10699-022-09840-6

Bosson, J. K., Wilkerson, M., Kosakowska-Berezecka, N., Jurek, P., & Olech, M. (2022). Harder Won and Easier Lost? Testing the Double Standard in Gender Rules in 62 Countries. *Sex Roles*, *87*(1–2), 1–19. https://doi.org/10.1007/s11199-022-01297-y

Bostrom, N. (2002). Existential risks: Analyzing human extinction scenarios and related hazards. *Journal of Evolution and Technology*, *9*(1).

Bostrom, N. (2003a). Astronomical Waste: The Opportunity Cost of Delayed Technological Development. *Utilitas*, *15*(3), 308–314. https://doi.org/doi:10.1017/S0953820800004076

Bostrom, N. (2003b). *The Transhumanist FAQ*. World Transhumanist Association. https://nickbostrom.com/views/transhumanist.pdf

Bostrom, N. (2003c). Transhumanist values. In F. Adams (Ed.), *Ethical Issues for the 21st Century* (pp. 3–14). Philosophical Documentation Center Press.

Bostrom, N. (2005a). In defense of posthuman dignity. *Bioethics*, *19*(3), 202–214. https://doi.org/10.1111/j.1467-8519.2005.00437.x

Bostrom, N. (2005b). The fable of the dragon tyrant. *Journal of Medical Ethics*, *31*(5), 273–277. https://doi.org/10.1136/jme.2004.009035

Bostrom, N. (2005c). The History of Transhumanist Thought. *Journal of Evolution and Technology*, *14*(1), 1–25.

Bostrom, N. (2012). The Superintelligent Will: Motivation and Instrumental Rationality in Advanced Artificial Agents. *Minds & Machines*, *22*(2), 71–85. https://doi.org/10.1007/s11023-012-9281-3

Bostrom, N. (2013a). Existential Risk Prevention as Global Priority. *Global Policy*, *4*(1), 15–31. https://doi.org/10.1111/1758-5899.12002

Bostrom, N. (2013b). Why I want to be a posthuman when I grow up. In M. More & N. Vita-More (Eds.), *The Transhumanist Reader* (pp. 28–53). John Wiley & Sons.

Bostrom, N., & Roache, R. (2008). Ethical issues in human enhancement. In J. Ryberg, T. Petersen, & C. Wolf (Eds.), *New waves in applied ethics* (pp. 120–152). Pelgrave Macmillan.

Bostrom, N., & Savulescu, J. (2009). Human Enhancement Ethics: The State of the Debate. In J. Savulescu & N. Bostrom (Eds.), *Human Enhancement* (pp. 1–22). Oxford Univ. Press.

Brand, R., Wolff, W., & Ziegler, M. (2016). Drugs As Instruments: Describing and Testing a Behavioral Approach to the Study of Neuroenhancement. *Frontiers in Psychology*, *7*, 1226. https://doi.org/10.3389/fpsyg.2016.01226

Branigan, A. R., McCallum, K. J., & Freese, J. (2013). Variation in the Heritability of Educational Attainment: An International Meta-Analysis. *Social Forces*, *92*(1), 109–140. https://doi.org/10.1093/sf/sot076

Breyl, M. (2020). Triangulating Neanderthal cognition: A tale of not seeing the forest for the trees. *Wiley Interdisciplinary Reviews. Cognitive Science*, *12*(2), 1545. https://doi.org/10.1002/wcs.1545

Brown, S. (2015). 'They think it's all up to the girls': Gender, risk and responsibility for contraception. *Culture, Health & Sexuality*, *17*(3), 312–325. https://doi.org/10.1080/13691058.2014.950983

Browne, M. (2018). Epistemic divides and ontological confusions: The psychology of vaccine scepticism. *Human Vaccines & Immunotherapeutics*, *14*(10), 2540–2542. https://doi.org/10.1080/21645515.2018.1480244

Browne, T. K. (2017). Why parents should not be told the sex of their fetus. *Journal of Medical Ethics*, *43*(1), 5–10. https://doi.org/10.1136/medethics-2015-102989

Browne, T. K., & Clarke, S. (2020). Bioconservatism, bioenhancement and backfiring. *Journal of Moral Education*, *49*(2), 241–256. https://doi.org/10.1080/03057240.2019.1576125

Bruner, E., Battaglia-Mayer, A., & Caminiti, R. (2023). The parietal lobe evolution and the emergence of material culture in the human genus. *Brain Structure and Function*, *228*(1), 145–167. https://doi.org/10.1007/s00429-022-02487-w

Brunyé, T. T., Brou, R., Doty, T. J., Gregory, F. D., Hussey, E. K., Lieberman, H. R., Loverro, K. L., Mezzacappa, E. S., Neumeier, W. H., Patton, D. J., Soares, J. W., Thomas, T. P., & Yu, A. B. (2020). A Review of US Army Research Contributing to Cognitive Enhancement in Military Contexts. *Journal of Cognitive Enhancement*, *4*(4), 453–468. https://doi.org/10.1007/s41465-020-00167-3

Buchanan, A. E. (2009). Human nature and enhancement. *Bioethics*, *23*(3), 141–150. https://doi.org/10.1111/j.1467-8519.2008.00633.x

Buchanan, A. E. (2011). *Beyond humanity?: The ethics of biomedical enhancement*. Oxford Univ. Press. https://doi.org/10.1093/acprof:oso/9780199587810.001.0001

Bunn, P. (2022). Silicon Valley Stoics? Life-Hacking, Transhumanism, and Stoic Therapy. *The Political Science Reviewer*, *46*(1), 1–28.

Butler, J. (1988). Performative Acts and Gender Constitution: An Essay in Phenomenology and Feminist Theory. *Theatre Journal*, *40*(4), 519–531. https://doi.org/10.2307/3207893

Butnor, A., & MacKenzie, M. (2022). Enactivism and Gender Performativity. In K. Maitra & J. McWeeny (Eds.), *Feminist Philosophy of Mind* (pp. 190–206). Oxford University PressNew York. https://doi.org/10.1093/oso/9780190867614.003.0011

Calogero, R. M., Pina, A., Park, L. E., & Rahemtulla, Z. (2010). Objectification Theory Predicts College Women's Attitudes Toward Cosmetic Surgery. *Sex Roles*, *63*(1–2), 32–41. https://doi.org/10.1007/s11199-010-9759-5

Caplan, A. L. (2009). Good, Better, or Best? In J. Savulescu & N. Bostrom (Eds.), *Human Enhancement* (pp. 199–209). Oxford Univ. Press.

Carroll, L. S. L. (2017). A comprehensive definition of technology from an ethological perspective. *Social Sciences*, *6*(4), 126. https://doi.org/10.3390/socsci6040126

Cassese, E. C. (2021). Partisan Dehumanization in American Politics. *Political Behavior*, *43*(1), 29–50. https://doi.org/10.1007/s11109-019-09545-w

Cassioli, F., & Balconi, M. (2022). Degree of enhancement: A theoretical and formal definition. *Frontiers in Psychology*, *13*, 1072423. https://doi.org/10.3389/fpsyg.2022.1072423

Castelo, N., Schmitt, B., & Sarvary, M. (2019). Human or Robot? Consumer Responses to Radical Cognitive Enhancement Products. *Journal of the Association for Consumer Research*, *4*(3), 217–230. https://doi.org/10.1086/703462

Caulfield, T., & Brownsword, R. (2006). Human dignity: A guide to policy making in the biotechnology era? *Nature Reviews Genetics*, *7*(1), 72–76. https://doi.org/10.1038/nrg1744

Cavazza, N., Guidetti, M., & Butera, F. (2015). Ingredients of gender-based stereotypes about food. Indirect influence of food type, portion size and presentation on gendered intentions to eat. *Appetite*, *91*, 266–272. https://doi.org/10.1016/j.appet.2015.04.068

Caviola, L., & Faber, N. S. (2015). Pills or push-ups? Effectiveness and public perception of pharmacological and non-pharmacological cognitive enhancement. *Frontiers in Psychology*, *6*, 1852. https://doi.org/10.3389/fpsyg.2015.01852

Chadwick, R. (2009). Therapy, Enhancement and Improvement. In B. Gordijn & R. Chadwick (Eds.), *Medical Enhancement and Posthumanity* (Vol. 2, pp. 25–38). Springer Netherlands.

Charbonneau, R. (2021). *Mixed Signals: Communication with the Alien in Cold War Radio Astronomy [Dissertation]* [University of Cambridge]. https://doi.org/10.17863/CAM.76362

Chen, C., Cui, Z., & Chen, Y. (2023). A randomized controlled trial of an information intervention to bolster COVID-19 vaccination intention among people with purity concerns. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association*, *42*(9), 686–697. https://doi.org/10.1037/hea0001295

Chevallereau, T., Maurage, P., Stinglhamber, F., & Demoulin, S. (2021). Sex-based and beauty-based objectification: Metadehumanization and emotional consequences among victims. *British Journal of Social Psychology*, *60*(4), 1218–1240. https://doi.org/10.1111/bjso.12446

Chong, K. P. L., Guo, J. Z., Deng, X., & Woo, B. K. P. (2020). Consumer Perceptions of Wearable Technology Devices: Retrospective Review and Analysis. *JMIR mHealth and uHealth*, *8*(4), e17544. https://doi.org/10.2196/17544

Christy, A. G., Schlegel, R. J., & Cimpian, A. (2019). Why do people believe in a "true self"? The role of essentialist reasoning about personal identity and the self. *Journal of Personality and Social Psychology*, *117*(2), 386–416. https://doi.org/10.1037/pspp0000254

Chu, C., & Martin, A. E. (2021). The primacy of communality in humanization. *Journal of Experimental Social Psychology*, *97*, 104224. https://doi.org/10.1016/j.jesp.2021.104224

Ćirković, M. M. (2019). Space colonization remains the only long-term option for humanity: A reply to Torres. *Futures*, *105*, 166–173. https://doi.org/10.1016/j.futures.2018.09.006

Clark, A. (2003). *Natural-born cyborgs: Minds, technologies, and the future of human intelligence*. Oxford University Press.

Clark, A. (2007). Re-inventing ourselves: The plasticity of embodiment, sensing, and mind. *Journal of Medicine and Philosophy*, *32*(3), 263–282. https://doi.org/10.1080/03605310701397024

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *The Behavioral and Brain Sciences*, *36*(3), 181–204. https://doi.org/10.1017/S0140525X12000477

Clark, A. (2019). Consciousness as Generative Entanglement. *The Journal of Philosophy*, *116*(12), 645–662. https://doi.org/10.5840/jphil20191161241

Clarke, L. H., & Bundon, A. (2009). From 'The Thing to Do' to 'Defying the Ravages of Age': Older Women Reflect on the Use of Lipstick. *Journal of Women & Aging*, *21*(3), 198–212. https://doi.org/10.1080/08952840903054757

Clynes, M. E., & Kline, N. S. (1960). Cyborgs and space. *Astronautics*, 26-27/74-76.

Coeckelbergh, M. (2013). *Human being @ risk: Enhancement, technology, and the evaluation of vulnerability transformations* (Vol. 12). Springer.

Coeckelbergh, M. (2017). *New romantic cyborgs: Romanticism, information technology, and the end of the machine*. MIT Press.

Coeckelbergh, M. (2018). Technology games: Using Wittgenstein for understanding and evaluating technology. *Science and Engineering Ethics*, *24*(5), 1503–1519. https://doi.org/10.1007/s11948-017-9953-8

Coeckelbergh, M. (2023). How to do robots with words: A performative view of the moral status of humans and nonhumans. *Ethics and Information Technology*, *25*(3), 44. https://doi.org/10.1007/s10676-023-09719-5

Coenen, C. (2014). Transhumanism and its Genesis: The Shaping of Human Enhancement Discourse by Visions of the Future. *Humana Mente Journal of Philosophical Studies*, *7*(26), 35–58.

Connell, R. (2010). Understanding Neoliberalism. In S. Braedley (Ed.), *Neoliberalism and everyday life* (pp. 22–36). McGill-Queen's Univ. Press.

Connors, M. H., Langdon, R., & Coltheart, M. (2014). Misidentification delusions. In D. Bhugra & G. S. Malhi (Eds.), *Troublesome disguises* (1st ed., pp. 167–185). Wiley. https://doi.org/10.1002/9781118799574.ch13

Conrad, E. C., Humphries, S., & Chatterjee, A. (2019). Attitudes toward cognitive enhancement: The role of metaphor and context. *AJOB Neuroscience*, *10*(1), 35–47. https://doi.org/10.1080/21507740.2019.1595771

Corazza, O., Martinotti, G., Santacroce, R., Chillemi, E., Di Giannantonio, M., Schifano, F., & Cellek, S. (2014). Sexual enhancement products for sale online: Raising awareness of the psychoactive effects of yohimbine, maca, horny goat weed, and Ginkgo biloba. *BioMed Research International*, *2014*, 841798. https://doi.org/10.1155/2014/841798

Coveney, C., Williams, S. J., & Gabe, J. (2019). Enhancement imaginaries: Exploring public understandings of pharmaceutical cognitive enhancing drugs. *Drugs: Education, Prevention and Policy*, *26*(4), 319–328. https://doi.org/10.1080/09687637.2019.1593318

Cruz, S., Sumstine, S., Mendez, J., & Bavarian, N. (2017). Health-compromising practices of undergraduate college students: Examining racial/ethnic and gender differences in characteristics of prescription stimulant misuse. *Addictive Behaviors*, *68*, 59–65. https://doi.org/10.1016/j.addbeh.2017.01.016

@CumberpatchM. (2024a, January 24). [Online post]. https://x.com/CumberpatchM/status/1750061027964723246?s=20

@CumberpatchM. (2024b, January 24). [Online post]. https://x.com/CumberpatchM/status/1750063995141124189?s=20

Daniels, N. (2000). Normal functioning and the treatment-enhancement distinction. *Cambridge Quarterly of Healthcare Ethics*, *9*, 309–322. https://doi.org/10.1017/S0963180100903037

Dar-Nimrod, I., & Heine, S. J. (2011). Genetic essentialism: On the deceptive determinism of DNA. *Psychological Bulletin*, *137*(5), 800–818. https://doi.org/10.1037/a0021860

Dattani, S., Rodés-Guirao, L., Ritchie, H., Ortiz-Ospina, E., & Roser, M. (2023). *Life Expectancy*. https://ourworldindata.org/life-expectancy

Davies, B. (2017). Enhancement and the Conservative Bias. *Philosophy & Technology*, *30*(3), 339–356. https://doi.org/10.1007/s13347-016-0245-z

Davis, S. N., & Greenstein, T. N. (2009). Gender Ideology: Components, Predictors, and Consequences. *Annual Review of Sociology*, *35*(1), 87–105. https://doi.org/10.1146/annurev-soc-070308-115920

de Boer, B. (2023). Explaining multistability: Postphenomenology and affordances of technologies. *AI & SOCIETY*, *38*, 2267–2277. https://doi.org/10.1007/s00146-021-01272-3

de Boer, B., Molder, H. T., & Verbeek, P.-P. (2022). 'Braining' psychiatry: An investigation into how complexity is managed in the practice of neuropsychiatric research. *BioSocieties*, *17*(4), 758–781. https://doi.org/10.1057/s41292-021-00242-8

de Grey, A. (2013). The Curate's Egg of Anti-Anti-Aging Bioethics. In M. More & N. Vita-More (Eds.), *The Transhumanist Reader* (pp. 215–219). John Wiley & Sons.

De Jaegher, H., & Di Paolo, E. (2007). Participatory sense-making: An enactive approach to social cognition. *Phenomenology and the Cognitive Sciences*, *6*(4), 485–507. https://doi.org/10.1007/s11097-007-9076-9

De Preester, H. (2011). Technology and the Body: The (Im)Possibilities of Re-embodiment. *Foundations of Science*, *16*(2–3), 119–137. https://doi.org/10.1007/s10699-010-9188-5

DeGrazia, D. (2005). Enhancement technologies and human identity. *Journal of Medicine and Philosophy*, *30*(3), 261–283. https://doi.org/10.1080/03605310590960166

Demoulin, S., Maurage, P., & Stinglhamber, F. (2021). Exploring Metadehumanization and Self-dehumanization From a Target Perspective. In M. Kronfeldner (Ed.), *The Routledge Handbook of Dehumanization* (1st ed., pp. 260–274). Routledge. https://doi.org/10.4324/9780429492464-chapter17

Di Paolo, E. (2005). Autopoiesis, Adaptivity, Teleology, Agency. *Phenomenology and the Cognitive Sciences*, *4*(4), 429–452. https://doi.org/10.1007/s11097-005-9002-y

Di Paolo, E. (2015). Interactive time-travel: On the intersubjective retro-modulation of intentions. *Journal of Consciousness Studies*, *22*(1–2), 49–74.

Di Paolo, E., & De Jaegher, H. (2022). Enactive Ethics: Difference Becoming Participation. *Topoi*, *41*(2), 241–256. https://doi.org/10.1007/s11245-021-09766-x

Diekman, A. B., & Eagly, A. H. (2000). Stereotypes as Dynamic Constructs: Women and Men of the Past, Present, and Future. *Personality and Social Psychology Bulletin*, *26*(10), 1171–1188. https://doi.org/10.1177/0146167200262001

Dietz, P., Striegel, H., Franke, A. G., Lieb, K., Simon, P., & Ulrich, R. (2013). Randomized response estimates for the 12-month prevalence of cognitive-enhancing drug use in university students. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*, *33*(1), 44–50. https://doi.org/10.1002/phar.1166

Dijkstra, A. M., & Schuijff, M. (2016). Public opinions about human enhancement can enhance the expert-only debate: A review study. *Public Understanding of Science*, *25*(5), 588–602. https://doi.org/10.1177/0963662514566748

Dillehay, T. D., Rossen, J., Ugent, D., Karathanasis, A., Vásquez, V., & Netherly, P. J. (2010). Early Holocene coca chewing in northern Peru. *Antiquity*, *84*(326), 939–953. https://doi.org/10.1017/S0003598X00067004

Dings, R. (2018). Understanding phenomenological differences in how affordances solicit action. An exploration. *Phenomenology and the Cognitive Sciences*, *17*(4), 681–699. https://doi.org/10.1007/s11097-017-9534-y

Dings, R. (2021). Meaningful affordances. *Synthese*, *199*(1–2), 1855–1875. https://doi.org/10.1007/s11229-020-02864-0

Dinh, C. T., Humphries, S., & Chatterjee, A. (2020). Public Opinion on Cognitive Enhancement Varies across Different Situations. *AJOB Neuroscience*, *11*(4), 224–237. https://doi.org/10.1080/21507740.2020.1811797

Ditlevsen, K., Glerup, C., Sandøe, P., & Lassen, J. (2020). Synthetic livestock vaccines as risky interference with nature? Lay and expert arguments and understandings of "naturalness." *Public Understanding of Science*, *29*(3), 289–305. https://doi.org/10.1177/0963662520906083

Döbler, N. A., & Bartnik, C. (2022). Normative Affordances Through and By Technology: Technological Mediation and Human Enhancement. *International Journal of Interactive Multimedia and Artificial Intelligence*, *7*(6), 14–23. https://doi.org/10.9781/ijimai.2022.09.006

Döbler, N. A., & Carbon, C.-C. (2021). Vaccination against SARS-CoV-2: A human enhancement story. *Translational Medicine Communications*, *6*, 21. https://doi.org/10.1186/s41231-021-00104-2

Döbler, N. A., & Carbon, C.-C. (2023). Boosting human capacities: Attitudes toward Human Enhancement and vaccination in the context of perceived naturalness and invasiveness. *Discover Psychology*, *3*, 24. https://doi.org/10.1007/s44202-023-00085-3

Döbler, N. A., & Carbon, C.-C. (2024). Adapting Ourselves, Instead of the Environment: An Inquiry into Human Enhancement for Function and Beyond. *Integrative Psychological and Behavioral Science*, *58*(2), 589–637. https://doi.org/10.1007/s12124-023-09797-6

Döbler, N. A., & Carbon, C.-C. (2025). Does creating the perfect child mean enforcing or dismantling normative gender stereotypes? Evidence from an interactive virtual genetic engineering exhibit. *Acta Psychologica*, *254*. https://doi.org/10.1016/j.actpsy.2025.104748

Döbler, N. A., Carbon, C.-C., & Schaub, H. (2024). Human Enhancement Without Organizational Knowledge and by Organizational Order. *Journal of Cognitive Enhancement*, *8*(1–2), 170–183. https://doi.org/10.1007/s41465-023-00278-7

Dobson, K. S. H. (2020). *Inauthenticity & Self-Dehumanization: Disconnection from the Self Causes a Loss of Humanity* [Dissertation]. Northwestern University.

Doudna, J. A., & Charpentier, E. (2014). Genome editing. The new frontier of genome engineering with CRISPR-Cas9. *Science*, *346*(6213), 1258096. https://doi.org/10.1126/science.1258096

Drain, C. (2022). Technics and signs: Anthropogenesis in Vygotsky, Leroi-Gourhan, and Stiegler. *History and Philosophy of the Life Sciences*, *44*(4), 53. https://doi.org/10.1007/s40656-022-00539-2

Dumit, J. (2004). *Picturing personhood: Brain scans and biomedical identity*. Princeton Univ. Press.

Eagly, A. H., Nater, C., Miller, D. I., Kaufmann, M., & Sczesny, S. (2020). Gender stereotypes have changed: A cross-temporal meta-analysis of U.S. public opinion polls from 1946 to 2018. *The American Psychologist*, *75*(3), 301–315. https://doi.org/10.1037/amp0000494

Ebrahimi, O. V., Johnson, M. S., Ebling, S., Amundsen, O. M., Halsøy, Ø., Hoffart, A., Skjerdingstad, N., & Johnson, S. U. (2021). Risk, trust, and flawed assumptions: Vaccine hesitancy during the COVID-19 pandemic. *Frontiers in Public Health*, *9*, 700213. https://doi.org/10.3389/fpubh.2021.700213

Eken, B., & Taluğ, D. Y. (2023). The Visualization of Hate Speeches in Wartime Propaganda Posters. *Art Time*, *4*(1), 30–37. https://doi.org/10.5152/Arttime.2023.1255441

Elliott, C. (2011). Enhancement technologies and the modern self. *The Journal of Medicine and Philosophy*, *36*(4), 364–374. https://doi.org/10.1093/jmp/jhr031

Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On seeing human: A three-factor theory of anthropomorphism. *Psychological Review*, *114*(4), 864–886. https://doi.org/10.1037/0033-295X.114.4.864

Faber, N. S., Häusser, J. A., & Kerr, N. L. (2017). Sleep Deprivation Impairs and Caffeine Enhances My Performance, but Not Always Our Performance. *Personality and Social Psychology Review*, *21*(1), 3–28. https://doi.org/10.1177/1088868315609487

Fahrenberg, J. (2011). *Annahmen über den Menschen: Menschenbilder aus psychologischer, biologischer, religiöser und interkultureller Sicht Texte und Kommentare zur psychologischen Anthropologie [Assumptions about the human being: Images of Man from Psychological, Biological, Religious, and Intercultural Perspectives Texts and Commentaries on Psychological Anthropology]* (3. Auflage). Asanger Verlag. (Original work published 2003)

Favale, A. R. (2022). *The genesis of gender: A Christian theory*. Ignatius Press.

Felig, R. N., Courtney, E. P., Ligman, K. M., Lee, K. J., & Goldenberg, J. L. (2024). Objects Do Not Suffer: An Impact of Mechanistic Dehumanization on Perceptions of Women's Suffering and Lack of Justice in Domestic Assault. *Journal of Interpersonal Violence*, *39*(5–6), 1245–1267. https://doi.org/10.1177/08862605231204897

Fernandez, K., Hamilton, R., Cabrera, L., & Medaglia, J. D. (2022). Context-Dependent Risk & Benefit Sensitivity Mediate Judgments About Cognitive Enhancement. *AJOB Neuroscience*, *13*(1), 73–77. https://doi.org/10.1080/21507740.2021.2001077

Fernández-Armesto, F. (2005). *So You Think You're Human?: A Brief History of Humankind*. Oxford University Press. (Original work published 2004)

Fitz, N. S., Nadler, R., Manogaran, P., Chong, E. W. J., & Reiner, P. B. (2014). Public Attitudes Toward Cognitive Enhancement. *Neuroethics*, *7*(2), 173–188. https://doi.org/10.1007/s12152-013-9190-z

Fitzgerald, W. A. (1997). Engineering perfect offspring: Devaluing children and childhood. *Hastings Constitutional Law Quarterly*, *24*(4), 833–861.

Fivush, R., Bohanek, J. G., & Duke, M. (2008). The Intergenerational Self: Subjective Perspective and Family History. In F. Sani (Ed.), *Self continuity: Individual and collective perspectives* (pp. 131–143). Psychology Press.

Flessner, B. (2018). Die Rückkehr der Magier: Die KI als Lapis philosophorum des 21. Jahrhunderts [The return of the magicians: AI as the lapis philosophorum of the 21st century]. In D. Spreen, B. Flessner, H. M. Hurka, & J. Rüster, *Kritik des Transhumanismus: Über eine Ideologie der Optimierungsgesellschaft* (1st ed., Vol. 32, pp. 63–106). transcript Verlag. https://doi.org/10.14361/9783839442876

Fontesse, S., Demoulin, S., Stinglhamber, F., De Timary, P., & Maurage, P. (2021). Metadehumanization and Self-dehumanization are Linked to Reduced Drinking Refusal Self-Efficacy and Increased Anxiety and Depression Symptoms in Patients with Severe Alcohol Use Disorder. *Psychologica Belgica*, *61*(1), 238. https://doi.org/10.5334/pb.1058

Formanowicz, M., Goldenberg, A., Saguy, T., Pietraszkiewicz, A., Walker, M., & Gross, J. J. (2018). Understanding dehumanization: The role of agency and communion. *Journal of Experimental Social Psychology*, *77*, 102–116. https://doi.org/10.1016/j.jesp.2018.04.003

Foucault, M. (2008). *The birth of biopolitics: Lectures at the Collège de France, 1978-79* (M. Senellart, Ed.; Paperback ed). Palgrave Macmillan.

Franke, A. G., Bagusat, C., Dietz, P., Hoffmann, I., Simon, P., Ulrich, R., & Lieb, K. (2013). Use of illicit and prescription drugs for cognitive or mood enhancement among surgeons. *BMC Medicine*, *11*, 102. https://doi.org/10.1186/1741-7015-11-102

Franke, A. G., Lieb, K., & Hildt, E. (2012). What users think about the differences between caffeine and illicit/prescription stimulants for cognitive enhancement. *PloS One*, *7*(6), 40047. https://doi.org/10.1371/journal.pone.0040047

Fuermaier, A. B. M., Tucha, O., Koerts, J., Tucha, L., Thome, J., & Faltraco, F. (2021). Feigning ADHD and stimulant misuse among Dutch university students. *Journal of Neural Transmission (Vienna, Austria : 1996)*, *128*(7), 1079–1084. https://doi.org/10.1007/s00702-020-02296-7

Fukuyama, F. (2004). Transhumanism. *Foreign Policy*, *144*, 42–43. https://doi.org/10.2307/4152980

Fukuyama, F. (2006). *The End of History and the Last Man: With a New Afterword*. Free Press.

Fuller, S., & Lipiska, V. (2014). *The Proactionary Imperative: A Foundation for Transhumanism*. Palgrave Macmillan.

Gallagher, S. (2017). *Enactivist interventions: Rethinking the mind*. Oxford University Press. https://doi.org/10.1093/oso/9780198794325.001.0001

García, E. (2021). Participatory Sense-Making in Therapeutic Interventions. *Journal of Humanistic Psychology*. https://doi.org/10.1177/00221678211000210

Gerard, J.-F., & Maublanc, M.-L. (2023). Nothing in the Environment Makes Sense Except in the Light of a Living System: Organisms, Their Relationships to the Environment, and Evolution. *Evolutionary Biology*, *50*(1), 18–29. https://doi.org/10.1007/s11692-022-09594-w

Gershon, I. (2011). "Neoliberal Agency." *Current Anthropology*, *52*(4), 537–555. https://doi.org/10.1086/660866

Gil-White, F. J. (2001). Are Ethnic Groups Biological "Species" to the Human Brain?: Essentialism in Our Cognition of Some Social Categories. *Current Anthropology*, *42*(4), 515–553. https://doi.org/10.1086/321802

Ginossar, T., Cruickshank, I. J., Zheleva, E., Sulskis, J., & Berger-Wolf, T. (2022). Cross-platform spread: Vaccine-related content, sources, and conspiracy theories in YouTube videos shared in early Twitter COVID-19 conversations. *Human Vaccines & Immunotherapeutics*, *18*(1), 1–13. https://doi.org/10.1080/21645515.2021.2003647

Golossenko, A., Palumbo, H., Mathai, M., & Tran, H. (2023). Am I being dehumanized? Development and validation of the experience of dehumanization measurement. *British Journal of Social Psychology*, *62*(3), 1285–1329. https://doi.org/10.1111/bjso.12633

Goscinny, R., & Uderzo, A. (with Kabatek, A.). (2016). *Asterix auf Korsika [Asterix in Corsica]* (W. Stegmaier, Ed.; G. Penndorf, Trans.). Egmont. (Original work published 1973)

Graeber, D., & Wengrow, D. (2022). *The dawn of everything: A new history of humanity*. Penguin Books.

Gray, H. M., Gray, K., & Wegner, D. M. (2007). Dimensions of mind perception. *Science*, *315*. https://doi.org/10.1126/science.1134475

Gray, K., DiMaggio, N., Schein, C., & Kachanoff, F. (2023). The Problem of Purity in Moral Psychology. *Personality and Social Psychology Review*, *27*(3), 272–308. https://doi.org/10.1177/10888683221124741

Greely, H. T. (2006). Regulating human biological enhancements: Questionable justifications and international complications. *Santa Clara Journal of International Law*, *4*(2), 87–110.

Grewal, D., Kroschke, M., Mende, M., Roggeveen, A. L., & Scott, M. L. (2020). Frontline cyborgs at your service: How human enhancement technologies affect customer experiences in retail, sales, and service settings. *Journal of Interactive Marketing*, *51*(1), 9–25. https://doi.org/10.1016/j.intmar.2020.03.001

Grinschgl, S., Berdnik, A.-L., Stehling, E., Hofer, G., & Neubauer, A. C. (2023). Who Wants to Enhance Their Cognitive Abilities? Potential Predictors of the Acceptance of Cognitive Enhancement. *Journal of Intelligence*, *11*(6), 109. https://doi.org/10.3390/jintelligence11060109

Grinschgl, S., Tawakol, Z., & Neubauer, A. C. (2022). Human enhancement and personality: A new approach towards investigating their relationship. *Heliyon*, *8*(5), 09359. https://doi.org/10.1016/j.heliyon.2022.e09359

Guardo, C. J., & Bohan, J. B. (1971). Development of a Sense of Self-Identity in Children. *Child Development*, *42*(6), 1909–1921. https://doi.org/10.2307/1127594

Gyngell, C., & Selgelid, M. J. (2016). Human enhancement: Conceptual clarity and moral significance. In S. Clarke, J. Savulescu, T. Coady, A. Giubilini, & S. Sanyal (Eds.), *The Ethics of Human Enhancement* (pp. 111–126). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198754855.003.0008

Habermas, J. (2005). *Die Zukunft der menschlichen Natur: Auf dem Weg zu einer liberalen Eugenik? [The future of human nature: on the road to liberal eugenics?]* (5th ed.). Suhrkamp. (Original work published 2002)

Haehner, P., Kritzler, S., Fassbender, I., & Luhmann, M. (2022). Stability and change of perceived characteristics of major life events. *Journal of Personality and Social Psychology*, *122*(6), 1098–1116. https://doi.org/10.1037/pspp0000394

Haidt, J. (2013). *The righteous mind: Why good people are divided by politics and religion*. Penguin Books.

Hamilton, David. L., Levine, J. M., & Thurston, J. A. (2008). Perceiving Continuity and Change in Groups. In F. Sani (Ed.), *Self continuity: Individual and collective perspectives* (pp. 117–130). Psychology Press.

Hansell, G. R., & Grassie, W. (Eds.). (2011). *H± transhumanism and its critics*. Metanexus.

Haraldsson, K. G., & McLean, K. C. (2022). "My story is not my own": A qualitative analysis of personal and collective continuity. *Qualitative Psychology*, *9*(1), 97–110. https://doi.org/10.1037/qup0000197

Harari, Y. N. (2013). *Eine kurze Geschichte der Menschheit [Sapiens: Brief History of Humankind]*. Pantheon.

Hartfiel, S. (2023). *Die Neuerfindung des Menschen [The reinvention of the human]* (2nd ed.). Dominus-Verlag.

Hartmann, H., Forkmann, K., Schmidt, K., Kleine-Borgmann, J., Albers, J., Wiech, K., & Bingel, U. (2023). Open-label placebo treatment does not enhance cognitive abilities in healthy volunteers. *Scientific Reports*, *13*(1), 19468. https://doi.org/10.1038/s41598-023-45979-3

Haslam, M., Yaden, D., & Medaglia, J. D. (2021). Moral Framing and Mechanisms Influence Public Willingness to Optimize Cognition. *Journal of Cognitive Enhancement*, *5*(2), 176–187. https://doi.org/10.1007/s41465-020-00190-4

Haslam, N. (2000). Psychiatric Categories as Natural Kinds: Essentialist Thinking About Mental Disorder. *Social Research: An International Quarterly*, *67*, 1031–1058.

Haslam, N. (2006). Dehumanization: An Integrative Review. *Personality and Social Psychology Review*, *10*(3), 252–264. https://doi.org/10.1207/s15327957pspr1003_4

Haslam, N., Bain, P., Douge, L., Lee, M., & Bastian, B. (2005). More human than you: Attributing humanness to self and others. *Journal of Personality and Social Psychology*, *89*(6), 937–950. https://doi.org/10.1037/0022-3514.89.6.937

Haslam, N., Kashima, Y., Loughnan, S., Shi, J., & Suitner, C. (2008). Subhuman, Inhuman, and Superhuman: Contrasting Humans with Nonhumans in Three Cultures. *Social Cognition*, *26*(2), 248–258. https://doi.org/10.1521/soco.2008.26.2.248

Haslam, N., Rothschild, L., & Ernst, D. (2000). Essentialist beliefs about social categories. *British Journal of Social Psychology*, *39*(1), 113–127. https://doi.org/10.1348/014466600164363

Haslam, N., & Whelan, J. (2008). Human Natures: Psychological Essentialism in Thinking about Differences between People. *Social and Personality Psychology Compass*, *2*(3), 1297–1312. https://doi.org/10.1111/j.1751-9004.2008.00112.x

Hasse, C. (2008). Postphenomenology: Learning Cultural Perception in Science. *Human Studies*, *31*(1), 43–61. https://doi.org/10.1007/s10746-007-9075-4

Hauskeller, M. (2009). Making sense of what we are: A mythological approach to human nature. *Philosophy*, *84*(1), 95–109. https://doi.org/10.1017/S0031819109000059

Hauskeller, M. (2013). *Better humans?: Understanding the Enhancement Project*. Acumen.

Hauskeller, M. (2016). *Mythologies of Transhumanism*. Springer International Publishing. https://doi.org/10.1007/978-3-319-39741-2

Hayles, N. K. (1999). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics*. University of Chicago Press.

Heckhausen, H., & Gollwitzer, P. M. (1987). Thought contents and cognitive functioning in motivational versus volitional states of mind. *Motivation and Emotion*, *11*(2), 101–120. https://doi.org/10.1007/BF00992338

Hegel, G. W. F. (1911). *Grundlinien der Philosophie des Rechts [Elements of the Philosophy of Right]*. Felix Meiner. (Original work published 1821)

Hendl, T. (2017). A Feminist Critique of Justifications for Sex Selection. *Journal of Bioethical Inquiry*, *14*(3), 427–438. https://doi.org/10.1007/s11673-017-9797-6

Henkel, L., Sprengholz, P., Korn, L., Betsch, C., & Böhm, R. (2022). The association between vaccination status identification and societal polarization. *Nature Human Behaviour*, *7*, 231–239. https://doi.org/10.1038/s41562-022-01469-6

Hesketh, I. (2015). The Recurrence of the Evolutionary Epic. *Journal of the Philosophy of History*, *9*(2), 196–219. https://doi.org/10.1163/18722636-12341300

Hirschman, E. C. (2010). Evolutionary branding. *Psychology & Marketing*, *27*(6), 568–583. https://doi.org/10.1002/mar.20345

Hitlin, S. (2003). Values as the Core of Personal Identity: Drawing Links between Two Theories of Self. *Social Psychology Quarterly*, *66*(2), 118. https://doi.org/10.2307/1519843

Hofmann, B. (2017). Limits to human enhancement: Nature, disease, therapy or betterment? *BMC Medical Ethics*, *18*(1). https://doi.org/10.1186/s12910-017-0215-8

Holland, K. J., Silver, K. E., Cipriano, A. E., & Brock, R. L. (2021). Young Women's Body Attitudes and Sexual Satisfaction: Examining Dehumanization and Communication as Serial Multiple Mediators. *Psychology of Women Quarterly*, *45*(2), 255–266. https://doi.org/10.1177/0361684321994295

Holt, L. J., & Looby, A. (2018). Factors that Differentiate Prescription Stimulant Misusers from those At-Risk for Misuse: Expectancies, Perceived Safety, and Diversion. *Substance Use & Misuse*, *53*(7), 1068–1075. https://doi.org/10.1080/10826084.2017.1392984

Hotze, T. D., Shah, K., Anderson, E. E., & Wynia, M. K. (2011). "Doctor, would you prescribe a pill to help me ... ?" a national survey of physicians on using medicine for human enhancement. *The American Journal of Bioethics*, *11*(1), 3–13. https://doi.org/10.1080/15265161.2011.534957

Howe, L. C., Schumann, K., & Walton, G. M. (2022). "Am I not human?": Reasserting humanness in response to group-based dehumanization. *Group Processes & Intergroup Relations*, *25*(8), 2042–2065. https://doi.org/10.1177/13684302221095730

Hughes, J. J., & Dvorsky, G. (2008). *Postgenderism: Beyond the Gender Binary*. Institute for Ethics and Emerging Technologies.

Humanity+. (n.d.). *Mission—Humanity+*. Retrieved April 3, 2024, from https://www.humanityplus.org/about

Husain, M., & Mehta, M. A. (2011). Cognitive enhancement by drugs in health and disease. *Trends in Cognitive Sciences*, *15*(1), 28–36. https://doi.org/10.1016/j.tics.2010.11.002

Iftode, C., Zorilă, A., Vică, C., & Mihailov, E. (2024). Experimental and relational authenticity: How neurotechnologies impact narrative identities. *Phenomenology and the Cognitive Sciences*, *23*(743–760). https://doi.org/10.1007/s11097-022-09825-7

Ihde, D. (1979). Technology and Human Self-Conception: *Southwestern Journal of Philosophy*, *10*(1), 23–34. https://doi.org/10.5840/swjphil19791012

Ihde, D. (1990). *Technology and the lifeworld: From garden to earth*. Indiana University Press.

Ihde, D. (2009). *Postphenomenology and technoscience: The Peking university lectures*. SUNY press.

Ihde, D. (2011a). Of Which Human Are We Post? In G. R. Hansell & W. Grassie (Eds.), *H± transhumanism and its critics* (pp. 123–135). Xlibris.

Ihde, D. (2011b). Stretching the in-between: Embodiment and beyond. *Foundations of Science*, *16*(2–3), 109–118. https://doi.org/10.1007/s10699-010-9187-6

Ihde, D., & Malafouris, L. (2019). Homo faber revisited: Postphenomenology and Material Engagement Theory. *Philosophy & Technology*, *32*(2), 195–214. https://doi.org/10.1007/s13347-018-0321-7

Ilieva, I., Boland, J., & Farah, M. J. (2013). Objective and subjective cognitive enhancing effects of mixed amphetamine salts in healthy people. *Neuropharmacology*, *64*, 496–505. https://doi.org/10.1016/j.neuropharm.2012.07.021

International Human Genome Sequencing Consortium, Whitehead Institute for Biomedical Research, Center for Genome Research:, Lander, E. S., Linton, L. M., Birren, B., Nusbaum, C., Zody, M. C., Baldwin, J., Devon, K., Dewar, K., Doyle, M., FitzHugh, W., Funke, R., Gage, D., Harris, K., Heaford, A., Howland, J., Kann, L., Lehoczky, J., ... Morgan, M. J. (2001). Initial sequencing and analysis of the human genome. *Nature*, *409*(6822), 860–921. https://doi.org/10.1038/35057062

Iriki, A., & Taoka, M. (2012). Triadic (ecological, neural, cognitive) niche construction: A scenario of human brain evolution extrapolating tool use and language from the control of reaching actions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1585), 10–23. https://doi.org/10.1098/rstb.2011.0190

Irwin, L. N., & Schulze-Makuch, D. (2020). The astrobiology of alien worlds: Known and unknown forms of life. *Universe*, *6*(9), 130. https://doi.org/10.3390/universe6090130

Iyer, A., Jetten, J., & Tsivrikos, D. (2008). Torn between Identities: Predictors of Adjustment to Identity Change. In F. Sani (Ed.), *Self continuity: Individual and collective perspectives* (pp. 187–197). Psychology Press.

Izydorczak, K., & Dolinski, D. (2024). Vaccine Skeptics and Vaccine Enthusiasts: What Is the Intergroup Wall Made Of? *Collabra: Psychology*, *10*(1), 94291. https://doi.org/10.1525/collabra.94291

Jack, A. (2020). The Gender Reveal Party: A New Means of Performing Parenthood and Reifying Gender Under Capitalism. *International Journal of Child, Youth and Family Studies*, *11*(2), 82–93. https://doi.org/10.18357/ijcyfs112202019520

Jasanoff, S., & Kim, S.-H. (2009). Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea. *Minerva*, *47*(2), 119–146. https://doi.org/10.1007/s11024-009-9124-4

Jedwab, A., Vears, D. F., Tse, C., & Gyngell, C. (2020). Genetics experience impacts attitudes towards germline gene editing: A survey of over 1500 members of the public. *Journal of Human Genetics*, *65*(12), 1055–1065. https://doi.org/10.1038/s10038-020-0810-2

Jeffares, B. (2010). The co-evolution of tools and minds: Cognition and material culture in the hominin lineage. *Phenomenology and the Cognitive Sciences*, *9*(4), 503–520. https://doi.org/10.1007/s11097-010-9176-9

Jones, D. G. (2006). Enhancement: Are ethicists excessively influenced by baseless speculations? *Medical Humanities*, *32*(2), 77–81. https://doi.org/10.1136/jmh.2005.000234

Jost, M. (2024). *Augmented Identity: Unveiling the Influence of Cybernetic Enhancements on Personality Perception* [Bachelor thesis]. University of Bamberg.

Judge, T. A., Livingston, B. A., & Hurst, C. (2012). Do nice guys—And gals—Really finish last? The joint effects of sex and agreeableness on income. *Journal of Personality and Social Psychology*, *102*(2), 390–407. https://doi.org/10.1037/a0026021

Juengst, E. T. (1998). What does enhancement mean? In E. Parens (Ed.), *Enhancing Human Traits: Ethical and Social Implications* (pp. 29–47). Georgetown University Press.

Juengst, E. T., Henderson, G. E., Walker, R. L., Conley, J. M., MacKay, D., Meagher, K. M., Saylor, K., Waltz, M., Kuczynski, K. J., & Cadigan, R. J. (2018). Is Enhancement the Price of Prevention in Human Gene Editing? *The CRISPR Journal*, *1*, 351–354. https://doi.org/10.1089/crispr.2018.0040

Kandler, C., Bratko, D., Butković, A., Hlupić, T. V., Tybur, J. M., Wesseldijk, L. W., De Vries, R. E., Jern, P., & Lewis, G. J. (2021). How genetic and environmental variance in personality traits shift across the life span: Evidence from a cross-national twin study. *Journal of Personality and Social Psychology*, *121*(5), 1079–1094. https://doi.org/10.1037/pspp0000366

Kass, L. R. (2003). Ageless bodies, happy souls: Biotechnology and the pursuit of perfection. *The New Atlantis*, *1*, 9–28.

Kata, A. (2012). Anti-vaccine activists, Web 2.0, and the postmodern paradigm—An overview of tactics and tropes used online by the anti-vaccination movement. *Vaccine*, *30*(25), 3778–3789. https://doi.org/10.1016/j.vaccine.2011.11.112

Kellie, D. J., Blake, K. R., & Brooks, R. C. (2021). Behind the makeup: The effects of cosmetics on women's self-objectification, and their objectification by others. *European Journal of Social Psychology*, *51*(4–5), 703–721. https://doi.org/10.1002/ejsp.2767

Kieliba, P., Clode, D., Maimon-Mor, R. O., & Makin, T. R. (2021). Robotic hand augmentation drives changes in neural body representation. *Science Robotics*, *6*(54). https://doi.org/10.1126/scirobotics.abd7935

King James Bible. (2024). King James Bible Online. https://www.kingjamesbibleonline.org/ (Original work published 1769)

Kirsh, D. (1996). Adapting the environment instead of oneself. *Adaptive Behavior*, *4*(3–4), 415–452. https://doi.org/10.1177/105971239600400307

Kiverstein, J. (2012). The Meaning of Embodiment. *Topics in Cognitive Science*, *4*(4), 740–758. https://doi.org/10.1111/j.1756-8765.2012.01219.x

Kleine-Gunk, B., & Sorgner, S. L. (2023). *Homo ex machina: Der Mensch von morgen - Chance und Risiken des Transhumanismus [Homo ex machina: the human of tomorrow - opportunities and risks of transhumanism]*. Goldmann.

Klenk, M. (2021). How do technological artefacts embody moral values? *Philosophy & Technology*, *34*(3), 525–544. https://doi.org/10.1007/s13347-020-00401-y

Kochel, K. P., Miller, C. F., Updegraff, K. A., Ladd, G. W., & Kochenderfer-Ladd, B. (2012). Associations Between Fifth Graders' Gender Atypical Problem Behavior and Peer Relationships: A Short-Term Longitudinal Study. *Journal of Youth and Adolescence*, *41*(8), 1022–1034. https://doi.org/10.1007/s10964-011-9733-8

Kocher, K., Moosmann, C., Drost, F., Schülein, C., Irrgang, P., Steininger, P., Zhong, J., Träger, J., Spriewald, B., Bock, C., Busch, D. H., Bogdan, C., Schubert, B., Winkler, T. H., Tenbusch, M., Schuster, E.-M., & Schober, K. (2024). Adaptive immune responses are larger and functionally preserved in a hypervaccinated individual. *The Lancet Infectious Diseases*, *24*(5), e272–e274. https://doi.org/10.1016/S1473-3099(24)00134-8

Koene, R. A. (2013). Uploading to Substrate-Independent Minds. In M. More & N. Vita-More (Eds.), *The Transhumanist Reader* (pp. 146–156). John Wiley & Sons.

Koenig, A. M. (2018). Comparing Prescriptive and Descriptive Gender Stereotypes About Children, Adults, and the Elderly. *Frontiers in Psychology*, *9*, 1086. https://doi.org/10.3389/fpsyg.2018.01086

Kouchaki, M., Dobson, K. S. H., Waytz, A., & Kteily, N. S. (2018). The Link Between Self-Dehumanization and Immoral Behavior. *Psychological Science*, *29*(8), 1234–1246. https://doi.org/10.1177/0956797618760784

Kourany, J. A. (2014). Human Enhancement: Making the Debate More Productive. *Erkenntnis*, *79*, 981–998. https://doi.org/10.1007/s10670-013-9539-z

Koval, P., Laham, S. M., Haslam, N., Bastian, B., & Whelan, J. A. (2012). Our Flaws Are More Human Than Yours: Ingroup Bias in Humanizing Negative Characteristics. *Personality and Social Psychology Bulletin*, *38*(3), 283–295. https://doi.org/10.1177/0146167211423777

Krapohl, E., Rimfeld, K., Shakeshaft, N. G., Trzaskowski, M., McMillan, A., Pingault, J.-B., Asbury, K., Harlaar, N., Kovas, Y., Dale, P. S., & Plomin, R. (2014). The high heritability of educational achievement reflects many genetically influenced traits, not just intelligence. *Proceedings of the National Academy of Sciences*, *111*(42), 15273–15278. https://doi.org/10.1073/pnas.1408777111

Kristensen, D. B., & Ruckenstein, M. (2018). Co-evolving with self-tracking technologies. *New Media & Society*, *20*(10), 3624–3640. https://doi.org/10.1177/1461444818755650

Krzyżanowska, N. (2016). The discourse of counter-monuments: Semiotics of material commemoration in contemporary urban spaces. *Social Semiotics*, *26*(5), 465–485. https://doi.org/10.1080/10350330.2015.1096132

Kteily, N. S., & Bruneau, E. (2017). Darker Demons of Our Nature: The Need to (Re)Focus Attention on Blatant Forms of Dehumanization. *Current Directions in Psychological Science*, *26*(6), 487–494. https://doi.org/10.1177/0963721417708230

Kteily, N. S., Bruneau, E., Waytz, A., & Cotterill, S. (2015). The ascent of man: Theoretical and empirical evidence for blatant dehumanization. *Journal of Personality and Social Psychology*, *109*(5), 901–931. https://doi.org/10.1037/pspp0000048

Kubrick, S. (Director). (1968). *2001: A Space Odyssey* [Video recording].

Kuljian, O. R., & Hohman, Z. P. (2023). Warmth, competence, and subtle dehumanization: Comparing clustering patterns of warmth and competence with animalistic and mechanistic dehumanization. *British Journal of Social Psychology*, *62*(1), 181–196. https://doi.org/10.1111/bjso.12565

Kunst, J. R., Kteily, N., & Thomsen, L. (2019). "You Little Creep": Evidence of Blatant Dehumanization of Short Groups. *Social Psychological and Personality Science*, *10*(2), 160–171. https://doi.org/10.1177/1948550617740613

Kurzweil, R. (2005). *The singularity is near: When humans transcend biology*. Penguin Books.

Kwisda, K., White, L., & Hübner, D. (2020). Ethical arguments concerning human-animal chimera research: A systematic review. *BMC Medical Ethics*, *21*(1), 24. https://doi.org/10.1186/s12910-020-00465-7

Landry, A. P., Ihm, E., Protzko, J., & Schooler, J. W. (2022). Essentially subhuman: Psychological essentialism facilitates dehumanization. *Peace and Conflict: Journal of Peace Psychology*, *28*(2), 167–176. https://doi.org/10.1037/pac0000587

Lau, R. R., Hartman, K. A., & Ware, J. E. (1986). Health as a value: Methodological and theoretical considerations. *Health Psychology*, *5*(1), 25–43. https://doi.org/10.1037/0278-6133.5.1.25

Levy, N. (2012). Ecological Engineering: Reshaping Our Environments to Achieve Our Goals. *Philosophy & Technology*, *25*(4), 589–604. https://doi.org/10.1007/s13347-012-0065-8

Lewens, T. (2012). Human nature: The very idea. *Philosophy & Technology*, *25*(4), 459–474. https://doi.org/10.1007/s13347-012-0063-x

Lewis, D. (2015). *Reagan and Gorbachev Agreed to Pause the Cold War in Case of an Alien Invasion.* https://www.smithsonianmag.com/smart-news/reagan-and-gorbachev-agreed-pause-cold-war-case-alien-invasion-180957402/

Lilienfeld, S. O., Sauvigné, K. C., Lynn, S. J., Cautin, R. L., Latzman, R. D., & Waldman, I. D. (2015). Fifty psychological and psychiatric terms to avoid: A list of inaccurate, misleading, misused, ambiguous, and

logically confused words and phrases. *Frontiers in Psychology*, *6*, 1100. https://doi.org/10.3389/fpsyg.2015.01100

Lippman, A. (1993). Prenatal Genetic Testing and Geneticization: Mother Matters for All. *Fetal Diagnosis and Therapy*, *8*(1), 175–188. https://doi.org/10.1159/000263886

Little, M. O. (1998). Cosmetic Surgery, suspect Norms, and the Ethics of Complicity. In E. Parens (Ed.), *Enhancing Human Traits: Ethical and Social Implications* (pp. 162–176). Georgetown University Press.

Looby, A., Beyer, D. L., & Zimmerman, L. (2015). Non-medical prescription stimulant use: Investigating modifiable risk factors. *Addiction Research & Theory*, *23*(2), 143–147. https://doi.org/10.3109/16066359.2014.946411

Loughnan, S., Baldissarri, C., Spaccatini, F., & Elder, L. (2017). Internalizing objectification: Objectified individuals see themselves as less warm, competent, moral, and human. *British Journal of Social Psychology*, *56*(2), 217–232. https://doi.org/10.1111/bjso.12188

Lück, H. E., & Miller, R. (Eds.). (2005). *Illustrierte Geschichte der Psychologie [Illustrated history of psychology]*. Beltz.

Machery, E., Olivola, C. Y., Cheon, H., Kurniawan, I. T., Mauro, C., Struchiner, N., & Susianto, H. (2023). Is Identity Essentialism a Fundamental Feature of Human Cognition? *Cognitive Science*, *47*(5), e13292. https://doi.org/10.1111/cogs.13292

Maier, L. J., Ferris, J. A., & Winstock, A. R. (2018). Pharmacological cognitive enhancement among non-ADHD individuals-A cross-sectional study in 15 countries. *The International Journal on Drug Policy*, *58*, 104–112. https://doi.org/10.1016/j.drugpo.2018.05.009

Maier, L. J., Haug, S., & Schaub, M. P. (2015). The importance of stress, self-efficacy, and self-medication for pharmacological neuroenhancement among employees and students. *Drug and Alcohol Dependence*, *156*, 221–227. https://doi.org/10.1016/j.drugalcdep.2015.09.012

Maiese, M. (2022). Mindshaping, Enactivism, and Ideological Oppression. *Topoi*, *41*(2), 341–354. https://doi.org/10.1007/s11245-021-09770-1

Malafouris, L. (2008). At the Potter's Wheel: An Argument for Material Agency. In C. Knappett & L. Malafouris (Eds.), *Material Agency* (pp. 19–36). Springer US. https://doi.org/10.1007/978-0-387-74711-8_2

Malafouris, L. (2013). *How things shape the mind: A theory of material engagement* (First MIT Press paperback edition). The MIT Press.

Malafouris, L. (2014). Creative *thinging*: The *feeling of* and *for clay*. *Pragmatics & Cognition*, *22*(1), 140–158. https://doi.org/10.1075/pc.22.1.08mal

Malafouris, L. (2015). Metaplasticity and the Primacy of Material Engagement. *Time and Mind*, *8*(4), 351–371. https://doi.org/10.1080/1751696X.2015.1111564

Malafouris, L. (2019). Mind and material engagement. *Phenomenology and the Cognitive Sciences*, *18*, 1–17. https://doi.org/10.1007/s11097-018-9606-7

Malafouris, L. (2020). Thinking as "Thinging": Psychology with things. *Current Directions in Psychological Science*, *29*(1), 3–8. https://doi.org/10.1177/0963721419873349

Mann, J. (2023). Cognitive enhancing drug use amongst students in (neoliberal) higher education: A functional response. *Drugs: Education, Prevention and Policy*, *30*(1), 70–80. https://doi.org/10.1080/09687637.2022.2064268

Mansouri, M., & Shad Ghazvini, P. (2021). Memorial Urban Art as an Aesthetic Experience in the City – An Aesthetical Reading of War Murals in Tehran's Urban Landscape. *Art & Perception*, *10*(2), 159–199. https://doi.org/10.1163/22134913-bja10033

Marteau, T., Michie, S., Drake, H., & Bobrow, M. (1995). Public attitudes towards the selection of desirable characteristics in children. *Journal of Medical Genetics*, *32*(10), 796–798. https://doi.org/10.1136/jmg.32.10.796

Martel, M., Cardinali, L., Roy, A. C., & Farnè, A. (2016). Tool-use: An open window into body representation and its plasticity. *Cognitive Neuropsychology*, *33*(1–2), 82–101. https://doi.org/10.1080/02643294.2016.1167678

Martin, A. E., & Mason, M. F. (2022). What does it mean to be (seen as) human? The importance of gender in humanization. *Journal of Personality and Social Psychology*, *123*(2), 292–315. https://doi.org/10.1037/pspa0000293

Martin, C. L., Cook, R. E., & Andrews, N. C. Z. (2017). Reviving Androgyny: A Modern Day Perspective on Flexibility of Gender Identity and Behavior. *Sex Roles*, *76*(9–10), 592–603. https://doi.org/10.1007/s11199-016-0602-5

Martín, D., Rueda, J., Earp, B. D., & Hannikainen, I. R. (2023). Normality and the Treatment-Enhancement Distinction. *Neuroethics*, *16*(2), 13. https://doi.org/10.1007/s12152-023-09519-0

Martin, L. R., & Petrie, K. J. (2017). Understanding the dimensions of anti-vaccination attitudes: The Vaccination Attitudes Examination (VAX) Scale. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *51*(5), 652–660.

McAdams, D. P. (2001). The psychology of life stories. *Review of General Psychology*, *5*(2), 100–122. https://doi.org/10.1037/1089-2680.5.2.100

McAdams, D. P., & McLean, K. C. (2013). Narrative Identity. *Current Directions in Psychological Science*, *22*(3), 233–238. https://doi.org/10.1177/0963721413475622

McLenon, J., & Rogers, M. A. M. (2019). The fear of needles: A systematic review and meta-analysis. *Journal of Advanced Nursing*, *75*(1), 30–42. https://doi.org/10.1111/jan.13818

Medaglia, J. D., Yaden, D. B., Helion, C., & Haslam, M. (2019). Moral attitudes and willingness to enhance and repair cognition with brain stimulation. *Brain Stimulation*, *12*(1), 44–53. https://doi.org/10.1016/j.brs.2018.09.014

Meier, B. P., Dillard, A. J., & Lappas, C. M. (2022). Predictors of the intention to receive a SARS-CoV-2 vaccine. *Journal of Public Health*, *44*(3), 713–715. https://doi.org/10.1093/pubmed/fdab013

Menuz, V., Hurlimann, T., & Godard, B. (2013). Is human enhancement also a personal matter? *Science and Engineering Ethics*, *19*(1), 161–177. https://doi.org/10.1007/s11948-011-9294-y

Midson, S. A. (2018). *Cyborg theology: Humans, technology and god*. I.B. Tauris & Co. Ltd.

Mihailov, E., Rodríguez López, B., Cova, F., & Hannikainen, I. R. (2021). How pills undermine skills: Moralization of cognitive enhancement and causal selection. *Consciousness and Cognition*, *91*, 103120. https://doi.org/10.1016/j.concog.2021.103120

Mihailov, E., & Savulescu, J. (2018). Social Policy and cognitive enhancement: Lessons from chess. *Neuroethics*, *11*(2), 115–127. https://doi.org/10.1007/s12152-018-9354-y

Miller, D., & Parrott, F. (2009). Loss and material culture in South London. *Journal of the Royal Anthropological Institute*, *15*(3), 502–519. https://doi.org/10.1111/j.1467-9655.2009.01570.x

Miller, L. E., Montroni, L., Koun, E., Salemme, R., Hayward, V., & Farnè, A. (2018). Sensing with tools extends somatosensory processing beyond the body. *Nature*, *561*(7722), 239–242. https://doi.org/10.1038/s41586-018-0460-0

Miller, L., Zimmermann, A., & Herbert, W. (2016). Clinical effectiveness and safety of powered exoskeleton-assisted walking in patients with spinal cord injury: Systematic review with meta-analysis. *Medical Devices: Evidence and Research*, *2016*(9), 455. https://doi.org/10.2147/MDER.S103102

Mishler, E. G. (2006). Narrative and identity: The double arrow of time. In A. De Fina, D. Schiffrin, & M. Bamberg (Eds.), *Discourse and Identity* (pp. 30–47). Cambridge University Press. https://doi.org/10.1017/CBO9780511584459.003

Moffett, M. W. (2013). Human Identity and the Evolution of Societies. *Human Nature*, *24*(3), 219–267. https://doi.org/10.1007/s12110-013-9170-3

Mojica, L. (2021). The enactive naturalization of normativity: From self-maintenance to situated interactions. *History and Philosophy of the Life Sciences*, *43*(4), 127. https://doi.org/10.1007/s40656-021-00479-3

Molouki, S., & Bartels, D. M. (2017). Personal change and the continuity of the self. *Cognitive Psychology*, *93*, 1–17. https://doi.org/10.1016/j.cogpsych.2016.11.006

Monterroza-Rios, A. D., & Gutiérrez-Aguilar, C. M. (2022). Enactivism and Material Culture: How Enactivism Could Redefine Enculturation Processes. *Philosophies*, *7*(4), 75. https://doi.org/10.3390/philosophies7040075

Moralfoundations.org. (2023). *Questionnaires | Moral Foundations Theory*. http://moralfoundations.org/questionnaires/

More, M. (2011). True Transhumanism: A Reply to Don Ihde. In G. R. Hansell & W. Grassie (Eds.), *H± transhumanism and its critics* (pp. 136–146). Xlibris.

More, M. (2013a). A Letter to Mother Nature. In *The Transhumanist Reader* (pp. 449–450). John Wiley & Sons.

More, M. (2013b). The philosophy of transhumanism. In M. More & N. Vita-More (Eds.), *The Transhumanist Reader* (pp. 3–17). John Wiley & Sons.

More, M. (2013c). The Proactionary Principle: Optimizing Technological Outcomes. In M. More & N. Vita-More (Eds.), *The Transhumanist Reader* (pp. 258–267). John Wiley & Sons.

Müller, C. P., & Schumann, G. (2011). Drugs as instruments: A new framework for non-addictive psychoactive drug use. *Behavioral and Brain Sciences*, *34*(6), 293–310. https://doi.org/10.1017/S0140525X11000057

Munro, G. D. (2010). The Scientific Impotence Excuse: Discounting Belief-Threatening Scientific Abstracts. *Journal of Applied Social Psychology*, *40*(3), 579–600. https://doi.org/10.1111/j.1559-1816.2010.00588.x

Murofushi, Y., Kawata, Y., Nakamura, M., Yamaguchi, S., Sunamoto, S., Fukamachi, H., Aono, H., Kamihigashi, E., Takazawa, Y., Naito, H., & Hurst, P. (2024). Assessing the need to use sport supplements: The

mediating role of sports supplement beliefs. *Performance Enhancement & Health*, *12*(1), 100269. https://doi.org/10.1016/j.peh.2023.100269

Musk, E. (2024, January 30). [Online post]. X.Com. https://x.com/elonmusk/status/1752118131579867417?s=20

Muthukrishna, M., Henrich, J., & Slingerland, E. (2021). Psychology as a Historical Science. *Annual Review of Psychology*, *72*(1), 717–749. https://doi.org/10.1146/annurev-psych-082820-111436

Myers, S. S., & Patz, J. A. (2009). Emerging Threats to Human Health from Global Environmental Change. *Annual Review of Environment and Resources*, *34*(1), 223–252. https://doi.org/10.1146/annurev.environ.033108.102650

Nagataki, S. (2015). How Does Technology Alter Sports: Body, Space, and Ethics. In J. K. B. O. Friis & R. C. Crease (Eds.), *Technoscience and postphenomenology: The Manhattan papers* (pp. 225–237). Lexington Books.

Napoletano, F., Schifano, F., Corkery, J. M., Guirguis, A., Arillotta, D., Zangani, C., & Vento, A. (2020). The Psychonauts' World of Cognitive Enhancers. *Frontiers in Psychiatry*, *11*, 546796. https://doi.org/10.3389/fpsyt.2020.546796

Narmashiri, A., & Akbari, F. (2023). The Effects of Transcranial Direct Current Stimulation (tDCS) on the Cognitive Functions: A Systematic Review and Meta-analysis. *Neuropsychology Review*. https://doi.org/10.1007/s11065-023-09627-x

Neisser, U. (1976). *Cognition and reality: Principles and implications of cognitive psychology*. Freeman.

Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical Psychology*, *1*(1), 35–59. https://doi.org/10.1080/09515088808572924

Nelson, E. C., Verhagen, T., Vollenbroek-Hutten, M. M. R., & Noordzij, M. L. (2024). When it is part of me, I can do it: Using embodied empowerment to predict adherence to wearable self-care technology. *Computers in Human Behavior*, *158*, 108314. https://doi.org/10.1016/j.chb.2024.108314

Nerlich, B., Dingwall, R., & Clarke, D. D. (2002). The Book of Life: How the Completion of the Human Genome Project was Revealed to the Public. *Health: An Interdisciplinary Journal for the Social Study of Health, Illness and Medicine*, *6*(4), 445–469. https://doi.org/10.1177/136345930200600403

Neufeld, E. (2022). Psychological essentialism and the structure of concepts. *Philosophy Compass*, *17*(5). https://doi.org/10.1111/phc3.12823

Neuralink. (2023). https://neuralink.com/

Newen, A. (2018). The Embodied Self, the Pattern Theory of Self, and the Predictive Mind. *Frontiers in Psychology*, *9*, 2270. https://doi.org/10.3389/fpsyg.2018.02270

Nguyen, N., Maurage, P., & Stinglhamber, F. (2022). Organizational metadehumanization and mechanistic self-dehumanization: The role of surface acting. *Group Processes & Intergroup Relations*, *25*(8), 1983–2002. https://doi.org/10.1177/13684302221095757

Nijssen, S. R. R., Müller, B. C. N., Baaren, R. B. V., & Paulus, M. (2019). Saving the Robot or the Human? Robots Who Feel Deserve Moral Care. *Social Cognition*, *37*(1), 41-S2. https://doi.org/10.1521/soco.2019.37.1.41

Nizzi, M.-C. (2015). Movies and Bodies. In R. Rosenberger & P.-P. Verbeek (Eds.), *Postphenomenological investigations: Essays on human-technology relations* (pp. 85–104). Lexington Books.

Nolan, M. A., & Branscombe, N. R. (2008). Conceptions of the Human Self and Human Rights: Implications for the Psychological Continuity of Less Inclusive Selves. In F. Sani (Ed.), *Self continuity: Individual and collective perspectives* (pp. 201–211). Psychology Press.

Oddens, B. J. (1999). Women's satisfaction with birth control: A population survey of physical and psychological effects of oral contraceptives, intrauterine devices, condoms, natural family planning, and sterilization among 1466 women. *Contraception*, *59*(5), 277–286. https://doi.org/10.1016/S0010-7824(99)00034-7

Okpani, A. I., Adu, P., Paetkau, T., Lockhart, K., & Yassi, A. (2024). Are COVID-19 vaccination mandates for healthcare workers effective? A systematic review of the impact of mandates on increasing vaccination, alleviating staff shortages and decreasing staff illness. *Vaccine*, *42*(5), 1022–1033. https://doi.org/10.1016/j.vaccine.2024.01.041

Olivola, C. Y., & Machery, E. (2014). Is psychological essentialism an inherent feature of human cognition? *Behavioral and Brain Sciences*, *37*(5), 499–499. https://doi.org/10.1017/S0140525X13003841

Ortlieb, S. A., Kügel, W. A., & Carbon, C.-C. (2020). Fechner (1866): The Aesthetic Association Principle—A Commented Translation. *I-Perception*, *11*(3), 2041669520920309.

Over, H. (2021). Seven Challenges for the Dehumanization Hypothesis. *Perspectives on Psychological Science*, *16*(1), 3–13. https://doi.org/10.1177/1745691620902133

Pardo, R., & Calvo, F. (2008). Attitudes Toward Embryo Research, Worldviews, and the Moral Status of the Embryo Frame. *Science Communication*, *30*(1), 8–47. https://doi.org/10.1177/1075547008319432

Parekh, B. (1995). The concept of national identity. *Journal of Ethnic and Migration Studies*, *21*(2), 255–268. https://doi.org/10.1080/1369183X.1995.9976489

Parks-Leduc, L., Feldman, G., & Bardi, A. (2015). Personality Traits and Personal Values: A Meta-Analysis. *Personality and Social Psychology Review*, *19*(1), 3–29. https://doi.org/10.1177/1088868314538548

Persson, I., & Savulescu, J. (2012). *Unfit for the future: The need for moral enhancement*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199653645.001.0001

Peters, T. (2011). Transhumanism and the Posthuman Future: Will Technological Progress Get Us There? In G. R. Hansell & W. Grassie (Eds.), *H± transhumanism and its critics* (pp. 145–175). Xlibris.

Petsko, C. D., Lei, R. F., Kunst, J. R., Bruneau, E., & Kteily, N. (2021). Blatant dehumanization in the mind's eye: Prevalent even among those who explicitly reject it? *Journal of Experimental Psychology: General*, *150*(6), 1115–1131. https://doi.org/10.1037/xge0000961

Pew Research Center. (2016a). *American Voices on Ways Human Enhancement Could Shape Our Future*. https://www.pewresearch.org/science/2016/07/26/american-voices-on-ways-human-enhancement-could-shape-our-future/

Pew Research Center. (2016b). *U.S. Public Wary of Biomedical Technologies to 'Enhance' Human Abilities*. https://www.pewresearch.org/science/2016/07/26/u-s-public-wary-of-biomedical-technologies-to-enhance-human-abilities/#:~:text=For%20example%2C%2047%25%20of%20Americans,results%20in%20physical%20abilities%20%E2%80%9Cfar

Pezzulo, G., Parr, T., & Friston, K. (2024). Active inference as a theory of sentient behavior. *Biological Psychology*, *186*, 108741. https://doi.org/10.1016/j.biopsycho.2023.108741

Pezzulo, G., Rigoli, F., & Friston, K. J. (2018). Hierarchical Active Inference: A Theory of Motivated Control. *Trends in Cognitive Sciences*, *22*(4), 294–306. https://doi.org/10.1016/j.tics.2018.01.009

Phillips, B. (2022). "They're Not True Humans:" Beliefs about Moral Character Drive Denials of Humanity. *Cognitive Science*, *46*(2), e13089. https://doi.org/10.1111/cogs.13089

Phillips, B. (2023). Normative dehumanization and the ordinary concept of a true human. *Current Research in Ecological and Social Psychology*, *5*, 100155. https://doi.org/10.1016/j.cresp.2023.100155

Pienaar, K., Murphy, D. A., Race, K., & Lea, T. (2020). Drugs as technologies of the self: Enhancement and transformation in LGBTQ cultures. *International Journal of Drug Policy*, *78*, 102673. https://doi.org/10.1016/j.drugpo.2020.102673

Piketty, T. (2020). *Kapital und Ideologie [Capital and ideology]*. C.H. Beck.

@POTUS. (2022, January 18). [Online post]. https://x.com/POTUS/status/1538270330095026177?s=20

Powell, R. (2015). In genes we trust: Germline engineering, eugenics, and the future of the human genome. *The Journal of Medicine and Philosophy*, *40*(6), 669–695. https://doi.org/10.1093/jmp/jhv025

Praet, I. (2014). *Animism and the question of life*. Routledge.

Prentice, D. A., & Carranza, E. (2002). What Women and Men Should Be, Shouldn't be, are Allowed to be, and don't Have to Be: The Contents of Prescriptive Gender Stereotypes. *Psychology of Women Quarterly*, *26*(4), 269–281. https://doi.org/10.1111/1471-6402.t01-1-00066

Prentice, D. A., & Miller, D. T. (2007). Psychological Essentialism of Human Categories. *Current Directions in Psychological Science*, *16*(4), 202–206. https://doi.org/10.1111/j.1467-8721.2007.00504.x

President's Council on Bioethics. (2003). *Beyond therapy: Biotechnology and the pursuit of happiness*.

Pugh, J., Kahane, G., & Savulescu, J. (2016). Bioconservatism, partiality, and the human-nature objection to enhancement. *The Monist*, *99*(4), 406–422. https://doi.org/10.1093/monist/onw013

Pulfrey, C., & Butera, F. (2013). Why Neoliberal Values of Self-Enhancement Lead to Cheating in Higher Education: A Motivational Account. *Psychological Science*, *24*(11), 2153–2162. https://doi.org/10.1177/0956797613487221

Purcell, N., Koenig, C. J., Bosch, J., & Maguen, S. (2016). Veterans' Perspectives on the Psychosocial Impact of Killing in War. *The Counseling Psychologist*, *44*(7), 1062–1099. https://doi.org/10.1177/0011000016666156

Pustovrh, T., Mali, F., & Arnaldi, S. (2018). Are better workers also better humans? On pharmacological cognitive enhancement in the workplace and conflicting societal domains. *NanoEthics*, *12*(3), 301–313. https://doi.org/10.1007/s11569-018-0332-y

Pyysiäinen, J. (2021). Sociocultural affordances and enactment of agency: A transactional view. *Theory & Psychology*, *31*(4), 491–512. https://doi.org/10.1177/0959354321989431

Quallo, M. M., Price, C. J., Ueno, K., Asamizuya, T., Cheng, K., Lemon, R. N., & Iriki, A. (2009). Gray and white matter changes associated with tool-use learning in macaque monkeys. *Proceedings of the National Academy of Sciences*, *106*(43), 18379–18384. https://doi.org/10.1073/pnas.0909751106

Racine, E., Sattler, S., & Boehlen, W. (2021). Cognitive enhancement: Unanswered questions about human psychology and social behavior. *Science and Engineering Ethics*, *27*(2), 19. https://doi.org/10.1007/s11948-021-00294-w

Raipola, J. (2022). Narratives on the Large Scale: Historical Narrative Explanations in Popular Science Writing. *Partial Answers: Journal of Literature and the History of Ideas*, *20*(2), 209–230. https://doi.org/10.1353/pan.2022.0013

Ramstead, M. J. D., Veissière, S. P. L., & Kirmayer, L. J. (2016). Cultural affordances: Scaffolding local worlds through shared intentionality and regimes of attention. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01090

Ransom, T. G., & Gallagher, S. (2023). Institutions and other things: Critical hermeneutics, postphenomenology and material engagement theory. *AI & SOCIETY*, *38*, 2189–2196. https://doi.org/10.1007/s00146-020-00987-z

Rasmussen, N. (2012). Weight stigma, addiction, science, and the medication of fatness in mid-twentieth century America. *Sociology of Health & Illness*, *34*(6), 880–895. https://doi.org/10.1111/j.1467-9566.2011.01444.x

Raspe, M., Koch, P., Zilezinski, M., Schulte, K., Bitzinger, D., Gaiser, U., Hammerschmidt, A., Köhnlein, R., Puppe, J., Tress, F., Uden, T., & Nienhaus, A. (2020). Arbeitsbedingungen und Gesundheitszustand junger Ärzte und professionell Pflegender in deutschen Krankenhäusern [Working conditions and health status of young doctors and professional nurses in German hospitals]. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz*, *63*(1), 113–121. https://doi.org/10.1007/s00103-019-03057-y

Redshaw, M., Hockley, C., & Davidson, L. L. (2007). A qualitative study of the experience of treatment for infertility among women who successfully became pregnant. *Human Reproduction*, *22*(1), 295–304. https://doi.org/10.1093/humrep/del344

Reich, J. A. (2016). Of natural bodies and antibodies: Parents' vaccine refusal and the dichotomies of natural and artificial. *Social Science & Medicine*, *157*, 103–110. https://doi.org/10.1016/j.socscimed.2016.04.001

Reicher, S. (2008). Making a Past Fit for the Future: The Political and Ontological Dimensions of Historical Continuity. In F. Sani (Ed.), *Self continuity: Individual and collective perspectives* (pp. 145–158). Psychology Press.

Resnik, D. B., & Vorhaus, D. B. (2006). Genetic modification and genetic determinism. *Philosophy, Ethics, and Humanities in Medicine*, *1*, 9. https://doi.org/10.1186/1747-5341-1-9

Richter, D., Grün, R., Joannes-Boyau, R., Steele, T. E., Amani, F., Rué, M., Fernandes, P., Raynal, J.-P., Geraads, D., & Ben-Ncer, A. (2017). The age of the hominin fossils from Jebel Irhoud, Morocco, and the origins of the Middle Stone Age. *Nature*, *546*(7657), 293–296. https://doi.org/10.1038/nature22335

Rieder, A., Eseryel, U. Y., Lehrer, C., & Jung, R. (2021). Why Users Comply with Wearables: The Role of Contextual Self-Efficacy in Behavioral Change. *International Journal of Human–Computer Interaction*, *37*(3), 281–294. https://doi.org/10.1080/10447318.2020.1819669

Rietveld, E. (2008). Situated Normativity: The Normative Aspect of Embodied Cognition in Unreflective Action. *Mind*, *117*(468), 973–1001. https://doi.org/10.1093/mind/fzn050

Rietveld, E., Denys, D., & van Westen, M. (2018). Ecological-enactive cognition as engaging with a field of relevant affordances: The skilled intentionality framework (SIF). In A. Newen, L. Bruin, & S. Gallagher (Eds.), *The Oxford Handbook of 4E Cognition* (pp. 41–70). Oxford University Press.

Rietveld, E., & Kiverstein, J. (2014). A rich landscape of affordances. *Ecological Psychology*, *26*(4), 325–352. https://doi.org/10.1080/10407413.2014.958035

Riis, J., Simmons, J. P., & Goodwin, G. P. (2008). Preferences for Enhancement Pharmaceuticals: The Reluctance to Enhance Fundamental Traits. *Journal of Consumer Research*, *35*(3), 495–508. https://doi.org/10.1086/588746

Robert Koch-Institut. (2022). *COVID-19-Impfungen_in_Deutschland/Archiv /2022-01-14_Deutschland_Impfquoten_COVID-19.csv*. https://github.com/robert-koch-institut/COVID-19-Impfungen_in_Deutschland/blob/master/Archiv/2022-01-14_Deutschland_Impfquoten_COVID-19.csv

Robert Koch-Institut. (2023). *COVID-19-Impfungen_in_Deutschland/Archiv /2023-04-05_Deutschland_Impfquoten_COVID-19.csv*. https://github.com/robert-koch-institut/COVID-19-Impfungen_in_Deutschland

Robert-Demontrond, P. (2022). Contributions of post-phenomenology to the study of the consumption of technical objects: Principles and applicative perspectives – Illustrated by the case of self-tracking. *Recherche et Applications En Marketing (English Edition)*, *37*(4), 99–121. https://doi.org/10.1177/20515707221138413

Roberts, C. A., Jones, A., Sumnall, H., Gage, S. H., & Montgomery, C. (2020). How effective are pharmaceuticals for cognitive enhancement in healthy adults? A series of meta-analyses of cognitive performance during acute administration of modafinil, methylphenidate and D-amphetamine. *European*

Neuropsychopharmacology : The Journal of the European College of Neuropsychopharmacology, *38*, 40–62. https://doi.org/10.1016/j.euroneuro.2020.07.002

Rochat, P., Broesch, T., & Jayne, K. (2012). Social awareness and early self-recognition. *Consciousness and Cognition*, *21*(3), 1491–1497. https://doi.org/10.1016/j.concog.2012.04.007

Roesler, E., Manzey, D., & Onnasch, L. (2021). A meta-analysis on the effectiveness of anthropomorphism in human-robot interaction. *Science Robotics*, *6*(58), eabj5425. https://doi.org/10.1126/scirobotics.abj5425

Rolla, G., & Novaes, F. (2022). Ecological-enactive scientific cognition: Modeling and material engagement. *Phenomenology and the Cognitive Sciences*, *21*(3), 625–643. https://doi.org/10.1007/s11097-020-09713-y

Rose, D. E. (2018). Tracing the Subjectivities of the Changing Human: Hegel, Self-Understanding, and Posthuman Objective Freedom. *Journal of Posthuman Studies*, *2*(2), 190–212. https://doi.org/10.5325/jpoststud.2.2.0006

Rosenberger, R., & Verbeek, P.-P. (2015). A Field Guide to Postphenomenology. In R. Rosenberger & P.-P. Verbeek (Eds.), *Postphenomenological investigations: Essays on human-technology relations* (pp. 9–41). Lexington Books.

Rossen, I., Hurlstone, M. J., Dunlop, P. D., & Lawrence, C. (2019). Accepters, fence sitters, or rejecters: Moral profiles of vaccination attitudes. *Social Science & Medicine (1982)*, *224*, 23–27. https://doi.org/10.1016/j.socscimed.2019.01.038

Roth, J., Huber, M., Juenger, A., & Liu, J. H. (2017). It's about valence: Historical continuity or historical discontinuity as a threat to social identity. *Journal of Social and Political Psychology*, *5*(2), 320–341. https://doi.org/10.5964/jspp.v5i2.677

Rothbart, M., & Taylor, M. (1992). Category labels and social reality: Do we view social categories as natural kinds? In G. R. Semin & K. Fiedler (Eds.), *Language, interaction and social cognition* (pp. 11–36). Sage Publications, Inc.

Rudman, L. A., & Mescher, K. (2012). Of Animals and Objects: Men's Implicit Dehumanization of Women and Likelihood of Sexual Aggression. *Personality and Social Psychology Bulletin*, *38*(6), 734–746. https://doi.org/10.1177/0146167212436401

Rudman, L. A., Moss-Racusin, C. A., Glick, P., & Phelan, J. E. (2012). Reactions to Vanguards: Advances in Backlash Theory. In P. G. Devine & E. A. Plant (Eds.), *Advances in Experimental Social Psychology* (pp. 167–227). Elsevier. https://doi.org/10.1016/B978-0-12-394286-9.00004-4

Rudman, L. A., Moss-Racusin, C. A., Phelan, J. E., & Nauts, S. (2012). Status incongruity and backlash effects: Defending the gender hierarchy motivates prejudice against female leaders. *Journal of Experimental Social Psychology*, *48*(1), 165–179. https://doi.org/10.1016/j.jesp.2011.10.008

Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, *88*(1), 4–27. https://doi.org/10.1002/sce.10101

Sætra, H. S., & Danaher, J. (2022). To Each Technology Its Own Ethics: The Problem of Ethical Proliferation. *Philosophy & Technology*, *35*(4), 93. https://doi.org/10.1007/s13347-022-00591-7

Sagan, C. (1973). *The Cosmic Connection: An Extraterrestrial Perspective*. Dell Publishing CO., INC.

Sagiv, L., Roccas, S., Cieciuch, J., & Schwartz, S. H. (2017). Personal values in human life. *Nature Human Behaviour*, *1*(9), 630–639. https://doi.org/10.1038/s41562-017-0185-3

Saguy, T., Reifen-Tagar, M., & Joel, D. (2021). The gender-binary cycle: The perpetual relations between a biological-essentialist view of gender, gender ideology, and gender-labelling and sorting. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *376*(1822), 20200141. https://doi.org/10.1098/rstb.2020.0141

Salvi, M. (2002). Genetics' dreams in the post genomics era. *Medicine, Health Care and Philosophy*, *5*(1), 73–77. https://doi.org/10.1023/A:1014233218050

Samorini, G. (2019). The oldest archeological data evidencing the relationship of Homo sapiens with psychoactive plants: A worldwide overview. *Journal of Psychedelic Studies*, *3*(2), 63–80. https://doi.org/10.1556/2054.2019.008

Sample, M., Boehlen, W., Sattler, S., Blain-Moraes, S., & Racine, E. (2022). Brain-Computer Interfaces, Inclusive Innovation, and the Promise of Restoration: A Mixed-Methods Study with Rehabilitation Professionals. *Engaging Science, Technology, and Society*, *8*(2). https://doi.org/10.17351/ests2022.961

Sample, M., Sattler, S., Blain-Moraes, S., Rodríguez-Arias, D., & Racine, E. (2020). Do Publics Share Experts' Concerns about Brain–Computer Interfaces? A Trinational Survey on the Ethics of Neural Technology. *Science, Technology, & Human Values*, *45*(6), 1242–1270. https://doi.org/10.1177/0162243919879220

Sandberg, A. (2013). Morphological Freedom—Why we not just want It, but need it. In M. More & N. Vita-More (Eds.), *The Transhumanist Reader* (pp. 58–64). John Wiley & Sons.

Sandbrink, J. D., Johnson, K., Gill, M., Yaden, D. B., Savulescu, J., Hannikainen, I. R., & Earp, B. D. (2024). Strong Bipartisan Support for Controlled Psilocybin Use as Treatment or Enhancement in a

Representative Sample of US Americans: Need for Caution in Public Policy Persists. *AJOB Neuroscience*, *15*(2), 82–89. https://doi.org/10.1080/21507740.2024.2303154

Sandel, M. J. (2009). The case against perfection: What's wrong with designer children, bionic athletes, and genetic engineering. In J. Savulescu & N. Bostrom (Eds.), *Human Enhancement* (pp. 71–90). Oxford Univ. Press.

Sani, F., Bowe, M., & Herrera, M. (2008). Perceived Collective Continuity: Seeing Groups as Temporally Enduring Entities. In F. Sani (Ed.), *Self continuity: Individual and collective perspectives* (pp. 159–172). Psychology Press.

Sani, F., Bowe, M., Herrera, M., Manna, C., Cossa, T., Miao, X., & Zhou, Y. (2007). Perceived collective continuity: Seeing groups as entities that move through time. *European Journal of Social Psychology*, *37*(6), 1118–1134. https://doi.org/10.1002/ejsp.430

Sattler, S. (2016). Cognitive Enhancement in Germany. In F. Jotterand & V. Dubljevic (Eds.), *Cognitive Enhancement* (pp. 159–180). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199396818.003.0011

Sattler, S., Forlini, C., Racine, E., & Sauer, C. (2013). Impact of contextual factors and substance characteristics on perspectives toward cognitive enhancement. *PloS One*, *8*(8), 71452. https://doi.org/10.1371/journal.pone.0071452

Sattler, S., Häusser, J. A., & Faber, N. S. (2023). Working with a sleep-deprived or a cognitively enhanced team member compromises motivation to contribute to group performance. *European Journal of Social Psychology*, *53*(6), 1231–1244. https://doi.org/10.1002/ejsp.2971

Sattler, S., Jacobs, E., Singh, I., Whetham, D., Bárd, I., Moreno, J., Galeazzi, G., & Allansdottir, A. (2022). Neuroenhancements in the military: A mixed-method pilot study on attitudes of staff officers to ethics and rules. *Neuroethics*, *15*(11). https://doi.org/10.1007/s12152-022-09490-2

Sattler, S., Mehlkop, G., Bahr, V., & Betsch, C. (2021). Why Parents Misuse Prescription Drugs to Enhance the Cognitive Performance of Healthy Children: The Influence of Peers and Social Media. *Journal of Drug Issues*, *51*(3), 461–482. https://doi.org/10.1177/0022042621994547

Sattler, S., Mehlkop, G., Graeff, P., & Sauer, C. (2014). Evaluating the drivers of and obstacles to the willingness to use cognitive enhancement drugs: The influence of drug characteristics, social environment, and personal characteristics. *Substance Abuse Treatment, Prevention, and Policy*, *9*, 8. https://doi.org/10.1186/1747-597X-9-8

Sattler, S., & Pietralla, D. (2022). Public attitudes towards neurotechnology: Findings from two experiments concerning Brain Stimulation Devices (BSDs) and Brain-Computer Interfaces (BCIs). *PloS One*, *17*(11), 0275454. https://doi.org/10.1371/journal.pone.0275454

Sattler, S., Van Veen, F., Hasselhorn, F., El Tabei, L., Fuhr, U., & Mehlkop, G. (2024). Prevalence of Legal, Prescription, and Illegal Drugs Aiming at Cognitive Enhancement across Sociodemographic Groups in Germany. *Deviant Behavior*, 1–35. https://doi.org/10.1080/01639625.2024.2334274

Sattler, S., & Von Dem Knesebeck, O. (2022). Effort-Reward Imbalance at Work and Prescription Drug Misuse-Prospective Evidence from Germany. *International Journal of Environmental Research and Public Health*, *19*(13). https://doi.org/10.3390/ijerph19137632

Savulescu, J. (2001). Procreative Beneficence: Why We Should Select The Best Children. *Bioethics*, *15*(5–6), 413–426. https://doi.org/10.1111/1467-8519.00251

Savulescu, J. (2005). New breeds of humans: The moral obligation to enhance. *Reproductive BioMedicine Online*, *10*(S1), 36–39. https://doi.org/10.1016/S1472-6483(10)62202-X

Savulescu, J., Sandberg, A., & Kahane, G. (2011). Well-Being and Enhancement. In G. Kahane, J. Savulescu, & R. H. J. Meulen (Eds.), *Enhancing human capacities* (pp. 1–18). Wiley-Blackwell. https://doi.org/10.1002/9781444393552.ch1

Scharff, C. (2016). The Psychic Life of Neoliberalism: Mapping the Contours of Entrepreneurial Subjectivity. *Theory, Culture & Society*, *33*(6), 107–122. https://doi.org/10.1177/0263276415590164

Schelle, K. J., Faulmüller, N., Caviola, L., & Hewstone, M. (2014). Attitudes toward pharmacological cognitive enhancement-a review. *Frontiers in Systems Neuroscience*, *8*, 53. https://doi.org/10.3389/fnsys.2014.00053

Schelle, K. J., Olthof, B. M. J., Reintjes, W., Bundt, C., Gusman-Vermeer, J., & van Mil, A. C. C. M. (2015). A survey of substance use for cognitive enhancement by university students in the Netherlands. *Frontiers in Systems Neuroscience*, *9*, 10. https://doi.org/10.3389/fnsys.2015.00010

Scheske, C., & Schnall, S. (2012). The ethics of "Smart Drugs": Moral judgments about healthy people's use of cognitive-enhancing drugs. *Basic and Applied Social Psychology*, *34*(6), 508–515. https://doi.org/10.1080/01973533.2012.711692

Scheufele, D. A., Xenos, M. A., Howell, E. L., Rose, K. M., Brossard, D., & Hardy, B. W. (2017). U.S. attitudes on human genome editing. *Science*, *357*(6351), 553–554. https://doi.org/10.1126/science.aan3708

Schleim, S. (2020). Neuroenhancement as Instrumental Drug Use: Putting the Debate in a Different Frame. *Frontiers in Psychiatry*, *11*, 567497. https://doi.org/10.3389/fpsyt.2020.567497

Schmidl, A. (2022). *Relationen: Eine postphänomenologische Soziologie der Körper, Technologien und Wirklichkeiten [Relations: A post-phenomenological sociology of bodies, technologies and realities]*. Velbrück Wissenschaft.

Schönthaler, E. M. D., Hofer, G., Grinschgl, S., & Neubauer, A. C. (2022). Super-Men and Wonder-Women: The relationship between the acceptance of self-enhancement, personality, and values. *Journal of Cognitive Enhancement*, *6*, 358–372. https://doi.org/10.1007/s41465-022-00244-9

Schwartz, S. H. (1992). Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries. In *Advances in Experimental Social Psychology* (Vol. 25, pp. 1–65). Elsevier. https://doi.org/10.1016/S0065-2601(08)60281-6

Secomandi, F. (2015). Bodies as Technology How Can Postphenomenologists Deal with the Matter of Human Technique? In R. Rosenberger & P.-P. Verbeek (Eds.), *Postphenomenological investigations: Essays on human-technology relations* (pp. 105–121). Lexington Books.

Sedikides, C., Hong, E. K., & Wildschut, T. (2023). Self-Continuity. *Annual Review of Psychology*, *74*(1), 333–361. https://doi.org/10.1146/annurev-psych-032420-032236

Selinger, E. (2015). Don Ihde's Relevance to the Gun Debates. In J. K. B. O. Friis & R. C. Crease (Eds.), *Technoscience and postphenomenology: The Manhattan papers* (pp. 205–209). Lexington Books.

Shakeel, S., Iffat, W., Qamar, A., Butt, F., Ghuman, F., Ahsan Mallick, I., Ur Rehman, A., & Jamshed, S. (2021). Concept generation of cognitive enhancement: Healthcare professionals' approach towards the impact and utilization of cognitive enhancers in academic context. *Heliyon*, *7*(10), 08118. https://doi.org/10.1016/j.heliyon.2021.e08118

Sharon, T. (2014). *Human Nature in an Age of Biotechnology: The Case for Mediated Posthumanism*. Springer Netherlands. https://doi.org/10.1007/978-94-007-7554-1

Shi, J., Wang, X., & Chen, Z. (2022). Polluted humanity: Air pollution leads to the dehumanization of oneself and others. *Journal of Environmental Psychology*, *83*, 101873. https://doi.org/10.1016/j.jenvp.2022.101873

Siipi, H. (2008). Dimensions of naturalness. *Ethics and the Environment*, *13*(1), 71–103. https://doi.org/10.2979/ete.2008.13.1.71

Sijilmassi, A., Safra, L., & Baumard, N. (2024). 'Our Roots Run Deep': Historical Myths as Culturally Evolved Technologies for Coalitional Recruitment. *Behavioral and Brain Sciences*, *47*, 1–44. https://doi.org/10.1017/S0140525X24000013

Simon, Z. B. (2019). The story of humanity and the challenge of posthumanity. *History of the Human Sciences*, *32*(2), 101–120. https://doi.org/10.1177/0952695118779519

Siromahov, M., Buhrmester, M., & McKay, R. (2020). Beliefs in national continuity are related to essentialist thinking and to perceptions of the nation as a family. *Nations and Nationalism*, *26*(4), 845–863. https://doi.org/10.1111/nana.12640

Sitruk, J., Summers, K. M., & Lloyd, E. P. (2023). Dehumanizing disability: Evidence for subtle and blatant dehumanization of people with physical disabilities. *Current Research in Ecological and Social Psychology*, *5*, 100162. https://doi.org/10.1016/j.cresp.2023.100162

Smith, D. L. (2014). Dehumanization, Essentialism, and Moral Psychology. *Philosophy Compass*, *9*(11), 814–824. https://doi.org/10.1111/phc3.12174

Smith, D. L. (2016). Paradoxes of Dehumanization. *Social Theory and Practice*, *42*(2), 416–443. https://doi.org/10.5840/soctheorpract201642222

Snure Beckman, E., Deuitch, N., Michie, M., Allyse, M. A., Riggan, K. A., & Ormond, K. E. (2019). Attitudes Toward Hypothetical Uses of Gene-Editing Technologies in Parents of People with Autosomal Aneuploidies. *The CRISPR Journal*, *2*(5), 324–330. https://doi.org/10.1089/crispr.2019.0021

Solanki, P., & Cesario, J. (2023). The nature of racial superhumanization bias. *The Journal of Social Psychology*, *164*(6), 947–963. https://doi.org/10.1080/00224545.2023.2218995

Sorgner, S. L. (2015). The Future of Education: Genetic Enhancement and Metahumanities. *Journal of Evolution and Technology*, *25*(1), 31–48. https://doi.org/10.55613/jeet.v25i1.38

Sorgner, S. L. (2020). *On transhumanism* (S. Hawkins, Trans.). The Pennsylvania State University press.

Sorgner, S. L. (2023). *We have always been cyborgs: Digital data, gene technologies, and an ethics of transhumanism*. Bristol University Press.

Sparrow, R. (2007). Procreative Beneficence, Obligations, and Eugenics. *Genomics, Society and Policy*, *3*(3), 43–59. https://doi.org/10.1186/1746-5354-3-3-43

Sparrow, R. (2015). Enhancement and Obsolescence: Avoiding an "Enhanced Rat Race." *Kennedy Institute of Ethics Journal*, *25*(3), 231–260. https://doi.org/10.1353/ken.2015.0015

Sparrow, R. (2019). Yesterday's Child: How Gene Editing for Enhancement Will Produce Obsolescence-and Why It Matters. *The American Journal of Bioethics*, *19*(7), 6–15. https://doi.org/10.1080/15265161.2019.1618943

Spille, L., Fendel, J. C., Seuling, P. D., Göritz, A. S., & Schmidt, S. (2023). Open-label placebos—A systematic review and meta-analysis of experimental studies with non-clinical samples. *Scientific Reports*, *13*(1), 3640. https://doi.org/10.1038/s41598-023-30362-z

Spreen, D. (2018). Politische Ökonomie nach dem Menschen: Die transhumane Herausforderung [Political economy after the human: The transhuman challenge]. In D. Spreen, B. Flessner, H. M. Hurka, & J. Rüster, *Kritik des Transhumanismus: Über eine Ideologie der Optimierungsgesellschaft [Critique of transhumanism: On an ideology of the optimization society]* (pp. 15–62). transcript Verlag. https://doi.org/10.14361/9783839442876

Sprengholz, P., Henkel, L., Böhm, R., & Betsch, C. (2023). Historical narratives about the COVID-19 pandemic are motivationally biased. *Nature*, *623*, 588–593. https://doi.org/10.1038/s41586-023-06674-5

Steinhoff, J. (2014). Transhumanism and Marxism: Philosophical Connections. *Journal of Evolution and Technology*, *24*(2), 1–16. https://doi.org/10.55613/jeet.v24i2.18

Stetsenko, A., & Arievitch, I. M. (2004). The Self in Cultural-Historical Activity Theory: Reclaiming the Unity of Social and Individual Dimensions of Human Development. *Theory & Psychology*, *14*(4), 475–503. https://doi.org/10.1177/0959354304044921

Stiegler, B. (2022). *Adapt! On a new political imperative*. Fordham University Press.

Stinglhamber, F., Nguyen, N., Ohana, M., Lagios, C., Demoulin, S., & Maurage, P. (2023). For whom and why organizational dehumanization is linked to deviant behaviours. *Journal of Occupational and Organizational Psychology*, *96*(1), 203–229. https://doi.org/10.1111/joop.12409

Stotzer, R. L. (2009). Violence against transgender people: A review of United States data. *Aggression and Violent Behavior*, *14*(3), 170–179. https://doi.org/10.1016/j.avb.2009.01.006

Stout, D., & Hecht, E. E. (2017). Evolutionary neuroscience of cumulative culture. *Proceedings of the National Academy of Sciences*, *114*(30), 7861–7868. https://doi.org/10.1073/pnas.1620738114

Straub, I. (2016). 'It looks like a human!' The interrelation of social presence, interaction and agency ascription: A case study about the effects of an android robot on social agency ascription. *AI & SOCIETY*, *31*(4), 553–571. https://doi.org/10.1007/s00146-015-0632-5

Tafreshi, D., Slaney, K. L., & Neufeld, S. D. (2016). Quantification in psychology: Critical analysis of an unreflective practice. *Journal of Theoretical and Philosophical Psychology*, *36*(4), 233–249. https://doi.org/10.1037/teo0000048

Tang-Péronard, J. L., & Heitmann, B. L. (2008). Stigmatization of obese children and adolescents, the importance of gender. *Obesity Reviews*, *9*(6), 522–534. https://doi.org/10.1111/j.1467-789X.2008.00509.x

Thomas, A. (2022). Transhumanism and advanced capitalism: Elitist logics and dangerous implications. In P. Jorion (Ed.), *Humanism and its Discontents* (pp. 151–180). Springer International Publishing. https://doi.org/10.1007/978-3-030-67004-7_10

Thompson, E., & Stapleton, M. (2009). Making Sense of Sense-Making: Reflections on Enactive and Extended Mind Theories. *Topoi*, *28*(1), 23–30. https://doi.org/10.1007/s11245-008-9043-2

Thweatt-Bates, J. (2016). *Cyborg selves: A theological anthropology of the posthuman*. Routledge. (Original work published 2012)

Tipler, C. N., & Ruscher, J. B. (2019). Dehumanizing representations of women: The shaping of hostile sexist attitudes through animalistic metaphors. *Journal of Gender Studies*, *28*(1), 109–118. https://doi.org/10.1080/09589236.2017.1411790

Torres, P. (2018). Space colonization and suffering risks: Reassessing the "maxipok rule." *Futures*, *100*, 74–85. https://doi.org/10.1016/j.futures.2018.04.008

Triberti, S., & Riva, G. (2015). Being present in action: A theoretical model about the "Interlocking" between intentions and environmental affordances. *Frontiers in Psychology*, *6*, 2052. https://doi.org/10.3389/fpsyg.2015.02052

Tsoukas, H., & Vladimirou, E. (2001). What is Organizational Knowledge? *Journal of Management Studies*, *38*(7), 973–993. https://doi.org/10.1111/1467-6486.00268

Uher, J. (2018). Quantitative Data From Rating Scales: An Epistemological and Methodological Enquiry. *Frontiers in Psychology*, *9*, 2599. https://doi.org/10.3389/fpsyg.2018.02599

Urquiza-Haas, E. G., & Kotrschal, K. (2015). The mind behind anthropomorphic thinking: Attribution of mental states to other species. *Animal Behaviour*, *109*, 167–176. https://doi.org/10.1016/j.anbehav.2015.08.011

Utych, S., & Fowler, L. (2021). More human than human: The consequences of positive dehumanization. *Administrative Theory & Praxis*, *43*(2), 190–208. https://doi.org/10.1080/10841806.2020.1829258

Van Den Eede, Y. (2015). Tracing the Tracker: A Postphenomenological Inquiry into Self-Tracking Technologies. In R. Rosenberger & P.-P. Verbeek (Eds.), *Postphenomenological investigations: Essays on human-technology relations* (pp. 143–158). Lexington Books.

Van Dijke, I., Bosch, L., Bredenoord, A. L., Cornel, M., Repping, S., & Hendriks, S. (2018). The ethics of clinical applications of germline genome modification: A systematic review of reasons. *Human Reproduction*, *33*(9), 1777–1796. https://doi.org/10.1093/humrep/dey257

van Veen, F., Sattler, S., Mehlkop, G., & Hasselhorn, F. (2022). Feigning Symptoms to Obtain Prescription Stimulants: A Vignette-Based Study on Its Conditions. *Journal of Drug Issues*, *52*(2), 225–249. https://doi.org/10.1177/00220426211055433

Varela, F. J., Thompson, E., & Rosch, E. (1993). *The embodied mind: Cognitive science and human experience* (14th ed.). MIT Press. (Original work published 1991)

Various. (2013). Transhumanist Declaration (2012). In M. More & N. Vita-More (Eds.), *The Transhumanist Reader* (pp. 54–55). John Wiley & Sons.

Verbeek, P.-P. (2005). *What things do*. Pennsylvania State University Press.

Verbeek, P.-P. (2008). Cyborg intentionality: Rethinking the phenomenology of human–technology relations. *Phenomenology and the Cognitive Sciences*, *7*(3), 387–395. https://doi.org/10.1007/s11097-008-9099-x

Verbeek, P.-P. (2011). *Moralizing technology: Understanding and designing the morality of things*. University of Chicago Press.

Verbeek, P.-P. (2014). Some Misunderstandings About the Moral Significance of Technology. In P. Kroes & P.-P. Verbeek (Eds.), *The Moral Status of Technical Artefacts* (pp. 75–88). Springer Netherlands. https://doi.org/10.1007/978-94-007-7914-3_5

Vignemont, F. (2011). Embodiment, ownership and disownership. *Consciousness and Cognition*, *20*(1), 82–93. https://doi.org/10.1016/j.concog.2010.09.004

Virenque, L., & Mossio, M. (2024). What is Agency? A View from Autonomy Theory. *Biological Theory*, *19*(1), 11–15. https://doi.org/10.1007/s13752-023-00441-5

Wagner, K., Maslen, H., Oakley, J., & Savulescu, J. (2018). Would you be willing to zap your child's brain? Public perspectives on parental responsibilities and the ethics of enhancing children with transcranial direct current stimulation. *AJOB Empirical Bioethics*, *9*(1), 29–38. https://doi.org/10.1080/23294515.2018.1424268

Wagner, R. (1882). *Parsifal [Opera]*.

Wang, H., & Yang, H. (2019). Gene-edited babies: What went wrong and what could go wrong. *PLOS Biology*, *17*(4), e3000224. https://doi.org/10.1371/journal.pbio.3000224

Waytz, A., Hoffman, K. M., & Trawalter, S. (2015). A Superhumanization Bias in Whites' Perceptions of Blacks. *Social Psychological and Personality Science*, *6*(3), 352–359. https://doi.org/10.1177/1948550614553642

West, C., & Zimmerman, D. H. (1987). Doing gender. *Gender and Society*, *1*(2), 125–151. https://www.jstor.org/stable/189945

Weststrate, N. M. (2021). Using Life Story Methods to Illuminate Cultural-Historical Dimensions of LGBTQ+ Identity Development Across Generations. In K. C. McLean (Ed.), *Cultural Methods in Psychology* (pp. 3–44). Oxford University Press. https://doi.org/10.1093/oso/9780190095949.003.0001

Wheeler, M., & Clark, A. (2008). Culture, embodiment and genes: Unravelling the triple helix. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *363*(1509), 3563–3575. https://doi.org/10.1098/rstb.2008.0135

Whyte, S., Torgler, B., & Harrison, K. L. (2016). What women want in their sperm donor: A study of more than 1000 women's sperm donor selections. *Economics & Human Biology*, *23*, 1–9. https://doi.org/10.1016/j.ehb.2016.06.001

Wiegel, C., Sattler, S., Göritz, A. S., & Diewald, M. (2016). Work-related stress and cognitive enhancement among university teachers. *Anxiety, Stress, & Coping*, *29*(1), 100–117. https://doi.org/10.1080/10615806.2015.1025764

Wilbrand, K. (2022). Wir brauchen Technologieoffenheit [We need openess to technology]. *MTZ - Motortechnische Zeitschrift*, *83*(2–3), 66–66. https://doi.org/10.1007/s35146-021-0786-2

Williams, E. F., & Steffel, M. (2014). Double Standards in the Use of Enhancing Products by Self and Others. *Journal of Consumer Research*, *41*(2), 506–525. https://doi.org/10.1086/676750

Wilson, S. G. (2014). Enhancement and Identity: A Social Psychological Perspective. In S. J. Thompson (Ed.), *Global Issues and Ethical Considerations in Human Enhancement Technologies:* (pp. 241–256). IGI Global. https://doi.org/10.4018/978-1-4666-6010-6

Wilson, S. G., & Haslam, N. (2009). Is the Future more or less Human? Differing Views of Humanness in the Posthumanism Debate. *Journal for the Theory of Social Behaviour*, *39*(2), 247–266. https://doi.org/10.1111/j.1468-5914.2009.00398.x

Wilson, S. G., & Haslam, N. (2012). Reasoning about human enhancement: Towards a folk psychological model of human nature and human identity. In R. Luppicini (Ed.), *Handbook of Research on Technoself: Identity in a Technological Society* (pp. 175–188). IGI Global. https://doi.org/10.4018/978-1-4666-2211-1

Wilson, S. G., & Haslam, N. (2013). Humanness beliefs about behavior: An index and comparative human-nonhuman behavior judgments. *Behavior Research Methods*, *45*(2), 372–382. https://doi.org/10.3758/s13428-012-0252-7

Winkler, A., & Hermann, C. (2019). Placebo- and Nocebo-Effects in Cognitive Neuroenhancement: When Expectation Shapes Perception. *Frontiers in Psychiatry*, *10*, 498. https://doi.org/10.3389/fpsyt.2019.00498

Wirtz, D., Kruger, J., Scollon, C. N., & Diener, E. (2003). What to Do on Spring Break? The Role of Predicted, On-Line, and Remembered Experience in Future Choice. *Psychological Science*, *14*(5), 520–524. https://doi.org/10.1111/1467-9280.03455

Wittgenstein, L. (1970). *Über Gewißheit* (G. M. E. Anscombe & G. H. Wright, Eds.). Suhrkamp.

Wolff, W., & Brand, R. (2013). Subjective stressors in school and their relation to neuroenhancement: A behavioral perspective on students' everyday life "doping." *Substance Abuse Treatment, Prevention, and Policy*, *8*, 23. https://doi.org/10.1186/1747-597X-8-23

Wolff, W., Brand, R., Baumgarten, F., Lösel, J., & Ziegler, M. (2014). Modeling students' instrumental (mis-) use of substances to enhance cognitive performance: Neuroenhancement in the light of job demands-resources theory. *BioPsychoSocial Medicine*, *8*, 12. https://doi.org/10.1186/1751-0759-8-12

Xiao, D., Zhang, W., Wang, Q., Li, X., Zhang, Y., Rasouli, J., Casella, G., Ciric, B., Curtis, M., Rostami, A., & Zhang, G.-X. (2021). CRISPR-mediated rapid generation of neural cell-specific knockout mice facilitates research in neurophysiology and pathology. *Molecular Therapy Methods & Clinical Development*, *20*, 755–764. https://doi.org/10.1016/j.omtm.2021.02.012

Xie, Y., Ren, Y., Niu, C., Zheng, Y., Yu, P., & Li, L. (2023). The impact of stigma on mental health and quality of life of infertile women: A systematic review. *Frontiers in Psychology*, *13*, 1093459. https://doi.org/10.3389/fpsyg.2022.1093459

Yoo, K., Sohn, W. S., & Jeong, Y. (2013). Tool-use practice induces changes in intrinsic functional connectivity of parietal areas. *Frontiers in Human Neuroscience*, *7*. https://doi.org/10.3389/fnhum.2013.00049

Yue, T., Fu, A., Xu, Y., & Huang, X. (2022). The rank of a value in the importance hierarchy of values affects its relationship to self-concept: A SC-IAT study. *Current Psychology*, *41*(10), 7290–7296. https://doi.org/10.1007/s12144-020-01320-z

Zhang, H., Xuan, Z., Yu, F., Ding, X., & Han, Y. (2024). Crafting the modern Prometheus: Navigating morality and identity in the age of cyborg enhancements. *Philosophical Psychology*, 1–34. https://doi.org/10.1080/09515089.2024.2382297

Zhang, Z., & Chen, Z. (2024). Nonhuman treatment reduces helping others: Self-dehumanization as a mechanism. *Frontiers in Psychology*, *15*, 1352991. https://doi.org/10.3389/fpsyg.2024.1352991

Žižek, S. (2008). *The sublime object of ideology*. Verso. (Original work published 1989)

Žižek, S. (2014). *Event: Philosophy in transit*. Penguin Books.

Žižek, S. (2017). *Incontinence of the Void: Economico-Philosophical Spandrels*. The MIT Press. https://doi.org/10.7551/mitpress/11413.001.0001

Žižek, S. (2021). *Hegel im verdrahteten Gehirn [Hegel in a wired brain]*. S. Fischer.

Žižek, S. (2023, January 12). Haben wir eine Zukunft? [Do we have a future?]. *Die Zeit*.

14. Eigenanteil

Eigenanteil gemäß §8 Abs. 3, S. 2 der Promotionsordnung der Fakultäten Humanwissenschaften und Geistes und Kulturwissenschaften an der Otto-Friedrich-Universität Bamberg.

Part	CRediT author statement, as reported in the publication
The present document (excluding Appendices 1 – 3.1.)	NAD: Conceptualization, Writing
Appendix 1 - Döbler, N. A., & Carbon, C.-C. (2023). Boosting human capacities: Attitudes toward Human Enhancement and vaccination in the context of perceived naturalness and invasiveness. *Discover Psychology*, *3*, 24. https://doi.org/10.1007/s44202-023-00085-3	NAD constructed the surveys, formulated items, analyzed the data, wrote the original draft, and revised the manuscript. CCC provided supervision over all processes.
Appendix 2 - Döbler, N. A., Carbon, C.-C., & Schaub, H. (2024). Human Enhancement Without Organizational Knowledge and by Organizational Order. *Journal of Cognitive Enhancement*, *8*(1–2), 170–183. https://doi.org/10.1007/s41465-023-00278-7	NAD: conceptualization; writing - original draft; writing - revision CCC: conceptualization; supervision HS: conceptualization; writing - original draft
Appendix 3 - Döbler, N. A., & Carbon, C.-C. (2025). Does creating the perfect child mean enforcing or dismantling normative gender stereotypes? Evidence from an interactive virtual genetic engineering exhibit. *Acta Psychologica*, 254. https://doi.org/10.1016/j.actpsy.2025.104748 .	NAD: Conceptualization; Hypotheses; Data analysis; Figure preparation; Writing original draft; Writing revision CCC: Conceptualization; Supervision; Writing - Review & Editing.

15. Copyright

16. Publication list

The following is a list of all publications the author was involved in before publishing this Ph.D. thesis. Those underscored are the three publications that build the corpus of this publication-based thesis.

Döbler, N. A., & Carbon, C.-C. (2025). *Will they come in peace? On psychological investigations into the representation of extraterrestrial life [Poster].* 47th European Conference on Visual Perception, Mainz.

Döbler, N. A., & Carbon, C.-C. (2025). *The case against intelligence—Why SETI is searching for the wrong concept [Poster].* 2025 Penn State SETI Symposium, State College, PA.

Döbler, N. A., Pastukhov, A., & Carbon, C.-C. (2025). *Where we have gone before – On the role of perceived collective continuity on the support of SETI, and L estimations in the Drake equation [Talk].* 2025 Penn State SETI Symposium, State College, PA.

Pletziger, J., Döbler, N. A., & Carbon, C.-C. (2025). *More than War and Peace: Analyzing museum's visitors' messages to extraterrestrials [Talk].* Exploring Otherness on Earth and beyond: Bridging the gap between natural sciences, social sciences and humanities, Berlin.

Döbler, N. A., Pastukhov, A., & Carbon, C.-C. (2025). Exploring the Hypothetical Impact of Genetic Engineering on Ethnicity: An Analysis of a Large-Scale Data Set Retrieved From a Museal Setting. *Bioethics*. https://doi.org/10.1111/bioe.70005

Döbler, N. A., & Carbon, C.-C. (2025). Does creating the perfect child mean enforcing or dismantling normative gender stereotypes? Evidence from an interactive virtual genetic engineering exhibit. *Acta Psychologica*, *254*. https://doi.org/10.1016/j.actpsy.2025.104748

Döbler, N. A. (2024). *Postphenomenology & SETI: Revealing technofantasies [Talk].* 2024 Assembly of the Order of the Octopus, Green Bank, WV.

Döbler, N. A., & Carbon, C.-C. (2024). Adapting Ourselves, Instead of the Environment: An Inquiry into Human Enhancement for Function and Beyond. *Integrative Psychological and Behavioral Science*, *58*(2), 589–637. https://doi.org/10.1007/s12124-023-09797-6

Döbler, N. A., & Carbon, C.-C. (2024). *Human Enhancement in health and everyday settings: Contemporary and future perspectives [Talk].* 16. Jahrestagung der dggö - Ethik und Ökonomie im Gesundheitssystem, Halle (Saale).

Döbler, N. A., & Carbon, C.-C. (2024). Inferring their minds and analysing our beliefs: On the contribution of (exo)psychology to the search for extraterrestrial intelligence. *International Journal of Astrobiology*, *23*. https://doi.org/10.1017/S1473550424000156

Döbler, N. A., & Carbon, C.-C. (2024). *Searching for false negatives: On the necessity of extraterrestrial participation for human recognition and beyond [Talk].* KAVLI-IAU SYMPOSIUM (IAUS 387): (Toward) Discovery of Life Beyond Earth and its Impact, Durham, UK.

Döbler, N. A., & Carbon, C.-C. (2024). *Why the mind? Understanding why cognitive enhancement is so tempting [Talk].* Interdisciplinary Perspectives on Neuroenhancement: Current Developments and Impact on the Individual and Society, Bielefeld, Germany.

Döbler, N. A., Carbon, C.-C., & Schaub, H. (2024). Human Enhancement Without Organizational Knowledge and by Organizational Order. *Journal of Cognitive Enhancement*, *8*(1–2), 170–183. https://doi.org/10.1007/s41465-023-00278-7

Döbler, N. A., Pastukhov, A., & Carbon, C.-C. (2024). *Exploring the impact of genetic engineering on race: An analysis of a large scale dataset with high ecological validity [Talk].* 17th World Congress of Bioethics, Doha.

Jost, M., Döbler, N. A., & Claus-Christian Carbon. (2024). *Augmented Identity: Unveiling the Influence of Cybernetic Enhancements on Personality Perception [Poster].* 46th European Conference on Visual Perception. https://doi.org/10.13140/RG.2.2.25932.83842

Döbler, N. A. (2024). *Everybody's Foe? On the Ideological Reasons to Reject or Endorse Human Enhancement and Transhumanism [Talk].* 17th World Congress of Bioethics, Doha.

Della Guardia, J., Döbler, N. A., & Carbon, C.-C. (2023). *Space Refuge: A case report on Cyberpunk Edgerunners [Poster].* Space Science in Context. https://doi.org/10.13140/RG.2.2.10492.21124

Döbler, N. A., & Carbon, C.-C. (2023). Affordances in outer space: Forms of life, material engagement, and meaning within space exploration and SETI. *Acta Astronautica*, *210*, 350–363. https://doi.org/10.1016/j.actaastro.2023.05.034

Döbler, N. A., & Carbon, C.-C. (2023). Boosting human capacities: Attitudes toward Human Enhancement and vaccination in the context of perceived naturalness and invasiveness. *Discover Psychology*, *3*, 24. https://doi.org/10.1007/s44202-023-00085-3

Döbler, N. A., Della Guardia, J., & Carbon, C.-C. (2023). Do aliens get depressed? [Poster]. *Space Science in Context*. https://doi.org/10.13140/RG.2.2.24595.55849

Döbler, N. A., El Amri, Y., & Carbon, C.-C. (2023). Is there anybody out there? Can individual loneliness, need for closure, and religiosity predict the belief in extraterrestrial life and intelligence? *Discover Psychology*, *3*(1), 21. https://doi.org/10.1007/s44202-023-00076-4

Döbler, N. A., & Carbon, C.-C. (2023). *Advances in exopsychology [Talk]*. 2023 Penn State SETI Symposium, State College, PA.

Döbler, N. A., Raab, M., & Carbon, C.-C. (2023). *Subjective Theories about ET [Poster]*. 2023 Penn State SETI Symposium, State College, PA. https://doi.org/10.5281/zenodo.8014111

Döbler, N. A. (2022). Where will they be: Hidden implications of solutions to the Fermi paradox. *International Journal of Astrobiology*, *21*(4), 200–204. https://doi.org/10.1017/S147355042200012X

Döbler, N. A., & Bartnik, C. (2022). Normative Affordances Through and By Technology: Technological Mediation and Human Enhancement. *International Journal of Interactive Multimedia and Artificial Intelligence*, *7*(6), 14–23. https://doi.org/10.9781/ijimai.2022.09.006

Döbler, N. A., & Bartnik, C. (2022). Normative Affordances through Technology: A Postphenomenological Perspective. In J. F. Paz Santana, D. H. La Iglesia, & A. J. López Rivero (Eds.), *New Trends in Disruptive Technologies, Tech Ethics and Artificial Intelligence [Online ahead of print]* (pp. 145–156). Springer International Publishing. https://doi.org/10.1007/978-3-030-87687-6_15

Döbler, N. A., & Carbon, C.-C. (2022). *Exopsychology and the human perspective on the extraterrestrial (mind) [Poster]*. The First Penn State SETI Symposium. https://doi.org/10.5281/zenodo.6669976

Döbler, N. A., Della Guardia, J., & Carbon, C.-C. (2022). Stumbling affords remembrance: Perceptual and behavioral engagement with a Holocaust memorial. Perception, 51(1_suppl), 133–134. https://doi.org/10.13140/RG.2.2.27212.69764/1

Haqq-Misra, J., Ashtari, R., Benford, J., Carroll-Nellenback, J., Döbler, N. A., Farah, W., Fauchez, T. J., Gajjar, V., Grinspoon, D., Huggahalli, A., Kopparapu, R. K., Lazio, J., Profitiliotis, G., Sneed, E. L., Varghese, S. S., & Vidal, C. (2022). *Opportunities for technosignature science in the planetary science and astrobiology decadal survey*. arXiv. https://doi.org/10.48550/arXiv.2209.11685

Döbler, N. A., & Carbon, C.-C. (2021). The View From Somewhere: Perspective and Relational Foundation of Outer Space Perception. Perception, 50(1_suppl), 180–181. https://doi.org/10.13140/RG.2.2.17167.51369/1

Döbler, N. A., & Carbon, C.-C. (2021). Vaccination against SARS-CoV-2: A human enhancement story. *Translational Medicine Communications*, *6*. https://doi.org/10.1186/s41231-021-00104-2

Döbler, N., & Raab, M. (2021). Thinking ET: A Discussion on Exopsychology. *Acta Astronautica*, *189*, 699–711. https://doi.org/10.1016/j.actaastro.2021.09.032

Raab, M. H., Döbler, N. A., & Carbon, C.-C. (2021). A Game of Covid: Strategic thoughts about a ludified pandemic. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.607309

Döbler, N. A. (2020). The concept of developmental relativity: Thoughts on the technological synchrony of interstellar civilizations. *Space Policy*, *54*, 101391. https://doi.org/10.1016/j.spacepol.2020.101391

17. Appendix

The following Appendix contains core papers 1-3. Besides that, the Supplementary of Döbler and Carbon (2023) and Döbler and Carbon (2025) as found online are also included.

Guide

Discover Psychology

Discover

Research

Boosting human capacities: attitudes toward Human Enhancement and vaccination in the context of perceived naturalness and invasiveness

Niklas Alexander Döbler[1,2,3] · **Claus-Christian Carbon**[1,2,3]

Received: 1 June 2023 / Accepted: 21 August 2023
Published online: 18 September 2023

Abstract
Vaccinations are instances of Human Enhancement (HE) because, as biotechnologies, they are capable of augmenting the human body's capacities. We hypothesized that vaccination refusal, as observed during the COVID-19 pandemic, indicates a belief system that also determines attitudes toward HE. Rejection of both may be linked to well-known motives: invasiveness and alleged unnaturalness. We tested the relationship between these two phenomena by conducting two online surveys ($N = 314$ and $N = 300$; 81.5%/85.7% vaccinated against SARS-CoV-2 and 18.5%/14.33% not). We also examined if getting enhanced (vaccinated) can induce a relational change toward the environment. Study 1 suggested that greater willingness to use methods to enhance cognitive abilities was more likely when methods must be infrequently used and were deemed natural and non-invasive. An affirmative attitude toward naturalness correlated negatively with the willingness to use. Interaction effects suggested increased importance of naturalness and invasiveness associated variables for unvaccinated participants. Interacting with vaccination status, affirmative attitudes toward naturalness were negatively associated with attitudes toward vaccinations and HE. Qualifying vaccination as HE did not reliably predict attitude toward vaccination or HE. Getting vaccinated led to psychological relief. We explored predictors of vaccination intention. Study 2 showed that unvaccinated perceived the vaccine as less natural but as invasive as vaccinated participants. Perceived naturalness and invasiveness were decisive for vaccination refusal. Findings suggest that rejecting vaccination against SARS-CoV-2 may indicate motives associated with rejecting other HE means and may be a valuable behavioral sample to assess a person's broader belief system.

Keywords Cognitive enhancement · Human enhancement · Naturalness · Vaccinations · Vaccine hesitancy

1 Introduction

Vaccination, intended to improve the natural capacity of the human body, is an example of *Human Enhancement* [1]. This term is used to describe techno-scientific interventions intended to create improved, optimized, or even "better" humans [2–4]. Vaccination exemplifies that one of the key aspects of the embodied technologies employed in Human

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s44202-023-00085-3.

✉ Niklas Alexander Döbler, niklas.doebler@uni-bamberg.de | [1]Department for General Psychology and Methodology, University of Bamberg, Bamberg, Germany. [2]Research Group EPÆG (Ergonomics, Psychological Æsthetics, Gestalt), Bamberg, Germany. [3]Bamberg Graduate School of Affective and Cognitive Sciences (BaGrACS), Bamberg, Germany.

Enhancement is that they are done to ourselves [5].[1] The human target renders the related ethical arguments notoriously utopian or dystopian [4, 5, 7, 8]. Hence, Human Enhancement is a highly controversial phenomenon [4, 9].

Effective April 2023, ~ 13% of the German population older than 18 years have not received any dose of vaccination against SARS-CoV-2 [10]. Even after the extended costless availability of different and far-reaching advertising campaigns, some people refused to receive this enhancement.[2] To increase vaccination uptake, it has been proposed that vaccination advertising campaigns should be tailored to the moral foundation and worldview of the target audience [12, 13]. This requires an understanding that goes beyond the superficial notion of vaccination as a disease-fighting measure everyone should be happy to embrace. Supposing that vaccine skepticism reflects strong core beliefs about the association between agency, nature, spirituality, and individual health [14], this paper seeks to investigate if and how these underlying beliefs are related to the attitude toward technological improvement (specifically, Human Enhancement). Given that Human Enhancement can transform the perception and experience of risk [2], vaccination amid a global pandemic seemed a convenient opportunity to explore the practical psychological effects of Human Enhancement in practice. Moreover, vaccination is a perfect example of how we employ Human Enhancement to adapt ourselves to a potentially hazardous environment [5].

Experts and laypeople can have diverging models and assessments of the ontology, functioning, and risks of vaccination [15, 16]. In scientific and public discussions, how we talk about technical concepts matters [17]. A more differentiated perspective on vaccination as Human Enhancement can improve our understanding of both phenomena and inform the public and policymakers on two highly polarizing issues. Future vaccination campaigns or other mass distributions of Human Enhancement may benefit from a comprehensive overview of possible criticism and conceptual clarity.

Numerous scholarly works have thoroughly examined attitudes towards each subject [18–22], and some authors have raised the issue of classifying vaccination as Human Enhancement [e.g., 1, 6, 23, 24]. However, the current literature has not established a direct empirical link between attitudes toward vaccination, vaccination behavior, and attitudes toward Human Enhancement. To our knowledge, and besides a small pilot study [1], this article is the first attempt to close this gap.

2 The Human Enhancement debate

The debate on Human Enhancement is characterized by a diversity of definitions [25]. Some conceptualizations focus on interventions that surpass the conventional boundaries of human abilities, while others consider the natural functioning of humans as the normative benchmark. Alternative approaches posit that any form of augmentation, regardless of degree, can be categorized as Human Enhancement [25]. The proportion of historical and contemporary techniques/technologies considered Human Enhancement varies depending on the definition used [1, 6, 26]. These "conventional," "natural," or "historical" examples may be seen as less morally suspicious [6, 27, 28]. Nevertheless: Human Enhancement is a fundamental aspect of how we live [29]. Besides all these aspects, Human Enhancement serves the overarching goal of adapting ourselves to the demands placed upon us rather than modifying the environment to mitigate the same demands [5]. In the case of vaccination, this means that instead of adapting the environment to stop disease transmission (e.g., travel restrictions, material obstacles to ensure social distancing), we are intervening with the human body to boost its defense capabilities against the same disease.

In use for centuries, vaccination exemplifies that "historical" does not automatically mean "uncontroversial" [1]. What qualifies vaccination as an instance of Human Enhancement is using (bio)technology to improve human defensive capabilities to a level they do not possess [1]. Although vaccination is not usually explicitly referred to as Human Enhancement, reasons to reject Human Enhancement in general, and vaccinations, in particular, may be two sides of the same coin [1]. Some, for instance, consider the technological process of introducing synthetic biology in vaccination development as an act of "playing God" [15], an all too familiar accusation leveled against specific enhancements and their biotechnological realization [9, 30–33].

[1] Mass distribution of vaccination can of course create positive network effects by mitigating further spread of the disease [1, 6] Still, it is at foremost an intervention that targets a single human being.

[2] 67.5% of the population of Europe and parts of Asia (e.g., Russia, Turkey, Kazakhstan) have at least received one dose of vaccination against SARS-CoV-2 [11].

Critics of Human Enhancement fear backfiring and disastrous side effects such as alienation from our not enhanced peers, losing what makes us human, and sealing the end of our species [7, 27, 31, 34, 35]. The American President's Council on Bioethics warned against the hubris and disrespect of the given if humans consider treating their bodies and minds as mere raw materials open to deliberate manipulation [9]. On the other hand, advocates stress the importance of exploring different modes of being [8] and the beneficial effects of widespread enhancement [36]. The potential for improved performance through Human Enhancement was acknowledged from commercial [37] and military perspectives [38, 39].

Empirical evidence on public attitudes shows that people are concerned about safety, social coercion, and fairness [40]. These arguments translate into a seemingly moderate to strong negative public opinion on Human Enhancement [41]. Laypersons and medical professionals acknowledge certain issues discussed in the academic debate (e.g., losing our humanness, issues of personhood). However, these abstract concerns are often overshadowed by more concrete worries about safety and personal side effects [33, 42–44]. Yet, a recent apprehension is that extreme situations like pandemics function as a backdoor that may render ethically more suspicious forms of Human Enhancement more acceptable [45].

Reflecting on the debate about the overarching concept of Human Enhancement, the discourse surrounding vaccination, with all its hopes and concerns, builds on one central premise: It is considered possible to influence the condition of an individual significantly and eventually an entire species through the use of (bio)technology [1]. The decisive factor is how this goal and the employed means are evaluated.[3]

2.1 The role of (perceived) naturalness

People were found to be less accepting of unknown pharmaceutical pills than natural supplements when used by employees and were less likely to use them themselves. However, there was no difference compared to pharmaceutical pills explicitly framed as safe [47]. Naturalness was an important factor in the moral evaluation of cognitive enhancement, but only when framing the means as explicitly natural or artificial [18]. Marteua et al. [48] report that 41% of their participants would enhance intelligence in their future child using vitamin supplements, but only 11% would employ genetic engineering for the same outcome. Furthermore, research suggests a preference for natural painkillers over their synthetic counterparts [49]. Importantly, these drugs may also fall into the realm of Human Enhancement.

Individual purity concerns, i.e., an aversion against acts considered 'unnatural' or suspected to violate the sanctity of something, play a crucial role in the negative evaluation of cognitive Enhancement [50, 51] and vaccination [12]. Naturalness bias and the belief that natural immunity is superior to vaccination-induced immunity hinder vaccination intention and behavior [52–56]. Perceived unnaturalness is also prevalent in online discourse among vaccination critics [57, 58].

But as with Human Enhancement [25], there is conceptual confusion about what naturalness means. The term may refer to the properties of an object or describe its history [13, 59]. Inconsistent use of the term may contribute to differences in how experts and laypersons understand it in the context of vaccination [15]. The debate over "natural" versus "unnatural" methods of Human Enhancement parallels this confusion [6, 27]. Yet, in both cases, nature is used as a moral standard to evaluate the moral value of technological interventions [60].

2.2 The role of (perceived) invasiveness

People are more reluctant to an enhancement if the method is invasive [18, 47, 51, 61, 62]. One study found that the mode of administration influenced the moral perception of different cognitive enhancement means, with injection being evaluated more negatively than beverages [18].

Efforts to supply vaccination by injection can be tempered by fear of needles [63], and more disgust toward injections was identified as related to one facet of anti-vaccination attitudes [64]. Furthermore, some arguments raised by the anti-vaccination movement build on the alleged detrimental effects of the vaccine [57], which can—logically speaking—only be exercised from within the body. As vaccination is often applied by injection, the association of literally piercing the fleshly boundaries of the bodily self may negatively modulate the reluctance to this type of intervention [65]. Hence, their evaluation may also reside in the broader moral significance attached to invasiveness, which may also transpire in the assessment of other forms of Human Enhancement.

There is an apparent focus within the ethical debate of Human Enhancement on those interventions that directly cross the line between what is considered "outside" and "inside" [27]. This focus has been criticized in the past [5, 6, 26,

[3] For a comprehensive overview about the philosophical debate see [4, 27, 46] and for a review on empirical found concerns see [40, 41].

66]. Still, the debate on Human Enhancement prominently features controversial technologies like genetic engineering, "smart drugs," and invasive brain-computer interfaces, which share a unifying trait: they only function from "within."

3 Hypotheses

The snapshot from the literature fosters the impression that some reasons to reject vaccination mirror general concerns against Human Enhancement. Yet, because vaccination is a manifestation of the overarching concept of Human Enhancement, these concerns are, conceptually speaking, derivations instead of parallels. Both phenomena aim to intervene with the individual body and directly concern important aspects such as autonomy, health, and the relationship between nature and technology. Thus, rejecting a tangible manifestation such as vaccination (e.g., against SARS-CoV-2) is supposed to be indicative of beliefs that also influence the attitude toward Human Enhancement in general. Hence, vaccination behavior should be a meaningful predictor of attitude toward Human Enhancement. Conceptually plausible, this link is testable and demands further empirical inquiry to assess the existence and strength of associations.

A stark hypothesis arises: People who reject a vaccination against SARS-CoV-2 do so mainly because they see it as an unnatural and invasive technological intervention. This rejection, grounded in derivations of concerns against Human Enhancement in general, may be generalized to vaccination behavior against other diseases. However, we must also account for the qualification of vaccination as an instance of Human Enhancement and reasons to reject technological interventions in general. Hence, seen more differentiated, while also acknowledging other important reasons for vaccination hesitancy [21] and the presence of a fundamental belief structure that may underly this behavior [14, 64], we can reformulate this hypothesis as follows: *Reasons for rejecting vaccination against SARS-CoV-2 may be linked to a pronounced emphasis on perceived invasiveness and naturalness. As these factors are also negatively linked to attitudes toward Human Enhancement, these derivations of general concerns about technological improvement might explain vaccination reluctance among the unvaccinated, but also possible rejection of Human Enhancement (H1).*"

Vaccination status is conceived as an indicative behavioral sample for the underlying belief system. When evaluating whether to pursue interventions with the human body, the suggested "pronounced emphasis" should show itself in an intensification of the negative roles of invasiveness, respectively, an intensification of the positive role of perceived naturalness / negative role of unnaturalness. Translated and operationalized to a testable setting, people who reject vaccination against SARS-CoV-2 should demonstrate a different perception and higher affirmation of what is deemed natural [see 56]. Hence, it must be explored how rejection of vaccination is situated within the broad debate about the relationship between humans and nature and how persons evaluate different interventions and phenomena. Suppose vaccination skepticism indicates a fundamental belief about a "natural" approach to health [14]. In that case, this behavior should be positively associated with rejecting other means of technological interventions, especially if they are deemed unnatural. Moreover, we expect that attitudes toward Human Enhancement and vaccination should be negatively linked with a high affirmation of naturalness in general.

In light of the invasive nature of vaccinations and the documented correlation between aversion against invasiveness and vaccine hesitancy [64], we also anticipate that for individuals who remain unvaccinated against SARS-CoV-2, negative effects of perceived invasiveness on the adoption of other means of Human Enhancement should be more substantial.

Perceived unnaturalness and invasiveness are not seen as unimportant for vaccinated people. Nonetheless, we expect meaningful differences between people vaccinated against SARS-CoV-2 and those who are not. Suppose the influence of perceived naturalness and invasiveness is moderated by vaccination status against SARS-CoV-2. In that case, the conclusion that concrete vaccination behavior is partially linked to a stronger emphasis on the related variables is supported. By examining the influence of these motives, we can evaluate whether they are as fundamental as suggested. Our hypothesis also suggests a differing perception of the invasiveness and naturalness of vaccination among vaccinated and unvaccinated and that these perceptions are decisive for vaccine refusal.

Evaluating the psychological effect of vaccine application, we must first note that the necessity to vaccinate presupposes a certain vulnerability and individual or societal risk. This risk is neither completely subjective nor objective but results from the relationship between the individual and the socio-material environment [2]. Indeed, a perception of low risk was also linked to vaccine hesitancy [21]. Human Enhancement may influence this relationship and transform risk and its perception [2]. Put very broadly, a potential transformation of risk means that besides improving a given capacity, *Human Enhancement can also constitute an altered relationship between oneself and the environment (H2)*. We discuss the theoretical foundation of this claim elsewhere and state that the relation-altering capacity of Human Enhancement is one of its most defining features [5]. To operationalize this hypothesis, it is essential to employ a measurement that

assesses whether and how implementing the enhancement (vaccination) alters an individual's subjective perception and evaluation of their environment. Although some fear the power of Human Enhancement to cause irreparable damage to values and relationships [9, 67], the question seems not to be about whether we should change our relationship with the environment but rather about which changes are desirable [2]. This societal discourse will benefit from insights into how exactly specific enhancements affect the relationship of individuals to themselves and their environment.

4 Study 1

We approach the hypothesized connection between Human Enhancement and vaccination attitudes through the lens of the assumed importance of naturalness and invasiveness. By considering vaccinations within the framework of Human Enhancement, we seek to contribute to the ongoing discussion and emphasize the significance of comprehending the motivations and evaluations surrounding a diverse range of enhancements [41, 68]. Besides the possible elucidation of motives for individual vaccine hesitancy, this study may enrich the empirical debate about Human Enhancement by linking the abstract with the concrete and clarifying how attitudes toward "conventional" enhancements like vaccination relate to more futuristic examples. It may further demonstrate the robustness of previous findings on adopting means of Human Enhancement. Lastly, we may be able to locate the rejection of Human Enhancement in a broader system of attitudes and beliefs.

To better situate the belief system of those who reject the SARS-CoV-2 vaccine despite its widespread availability and public awareness of the pandemic in early 2022, we collected data on a broader range of controversial phenomena. This allows assessing beliefs associated with vaccination behavior beyond the "classic" examples like low-risk perception, structural barriers, or safety and efficacy concerns [21].

In a previous study [1] with $N = 67$ (97% vaccinated against SARS-CoV-2 or willing to do so), participants were asked to rate different examples of their qualification as an instance of Human Enhancement. To further investigate public opinion on this issue, we wanted to include a more heterogeneous sample with the number of unvaccinated participants corresponding to the proportion in Germany when the present study was conducted.

4.1 Methods

4.1.1 Participants

An online survey was completed by $N = 316$ persons. Two people were excluded because they indicated they were only checking out the survey or felt compelled to give incorrect answers. No other exclusions were made. The complete dataset comprised $N = 314$ persons (*Male* = 134, *Female* = 172, *Other* = 6, *NA* = 2; $M_{Age} = 34.9$ [Range: 16–65] years). One participant's age was coded *NA* due to its initial statement of being over 120 years old. However, other answers of the participants were not overly suspicious.

We recruited participants from various sources (University e-mail-System, Facebook, Twitter, Reddit, and online survey distributors). To recruit unvaccinated participants, we posted the survey link to several Facebook groups whose names and descriptions suggest a critical attitude towards disease control measures of the corona pandemic or vaccination per se. We also reached out to groups that discussed the SARS-CoV-2 pandemic in general and those that discussed alternative and naturopathic medicine. We are aware of the possible bias through online recruitment, especially regarding anti-vaccination discourse [57, 58]. This method was chosen to spread the survey beyond the usual psychological student-for-course-credit samples, which were also suspected of holding more favorable attitudes toward vaccination. Limitations are discussed in more detail at the end of the paper.

Overall, 256 individuals (81.5%) reported having received at least one vaccination dose against SARS-CoV-2 (*Vaccinated*), and $n = 58$ (18.5%) did not receive vaccination against SARS-CoV-2 (Unvaccinated).[4] At the end of the data sampling, the proportion of German citizens above 18 years who had received at least one dose of vaccine against

[4] This terminology can only be interpreted in regard to the vaccination against SARS-CoV-2. We have no information on whether people have received any other vaccination in their lifetime.

Table 1 Presented means of memory enhancement

Intervention type	Coded application frequency
Administration of a drug in the form of pills*	Once | Daily
Injection of a drug into the arm*	Once | Daily
Administration of a plant-based drug*	Once | Daily
Brain surgery	Once
Implantation of an electronic device into the brain	Once
Completion of a cognitive training program	Once
Special raw food diet	Frequent
Daily meditation	Daily

In the case of Brain surgery, Implantation of an electronic device, completion of a cognitive training program, and raw food diet frequency were not explicitly mentioned but coded afterward. The other interventions were presented and assessed with the respective explicitly named frequencies. *=Intervention was included in the "Interventions with parallel frequencies" model (Table 4). These interventions are also more "classical" examples of Human Enhancement. Heterogeneity of the examples is owed to the fact that there is no definitive definition of Human Enhancement. Depending on conceptualization, some examples do not qualify as Human Enhancement. Examples were chosen to be intuitively linked to memory enhancement and to reflect different conceptualizations as broadly as possible

SARS-CoV-2 was 84.8% [69]. So the ratio of vaccinated to unvaccinated persons in our sample approximated the ones in the overall population.

4.1.2 Measures

If not stated otherwise, items used a 7-point Likert scale on which the maximum represented the highest affirmation. A complete list of questions asked is provided in the Supplementary.

Enhancement rating (15 items)*:* Similar to a previous study [1], participants were introduced to the concept of Human Enhancement. They were told that this term has no standard definition but generally refers to technologies that help expand people's abilities. Participants rated different phenomena on whether they represented an example of Human Enhancement. The examples were self-collected based on what is discussed as an instance of Human Enhancement in the literature and under different conceptualizations.[5]

Attitudes on ethically controversial topics (10 items): People were asked to state their attitude toward phenomena like Human Enhancement, vaccination in general, space colonization, and genetic manipulation of animals, plants, or humans ("Based on what you personally know about the following topics and what is reported in the media. What is your attitude toward:…"). Phenomena were selected to represent practical yet ethically controversial topics, examine potential distinctions between vaccinated and unvaccinated individuals, and gain a deeper understanding of the beliefs held by the unvaccinated.

Willingness to use: Participants were introduced to the following scenario: *Imagine the possibility of changing your memory to the extent that exceeds your current level by far. You would remember things much better and would no longer have to rely on shopping lists reminders on your cell phone or calendar. You would also find it much easier to learn new things. Which of the following means would you use for this? All methods have the same effect and have no adverse side effects.* They were then invited to state their *willingness to use* different means for their benefit and rated how *invasive* and *natural* they perceived these interventions. These variables were meant to examine whether their effect differed across people vaccinated against SARS-CoV-2 and those who were not, i.e., if we can assume a different emphasis. Intervention examples were chosen to reflect a mixture of invasive and natural means to improve cognitive abilities that, depending on the conceptualization [25], qualify as instances of Human Enhancement (Table 1). Measuring the willingness to use an enhancement is common when assessing attitudes toward Human Enhancement [see 33, 44, 62, 70, 71].

[5] Depending on employed conceptualization, some examples would not qualify as Human Enhancement. We nevertheless attempted to map the debate as broad as possible.

Naturalness attitude (7 items)*:* This self-developed scale was meant to reflect on the subjective evaluation of naturalness and an affirmative relationship toward nature. The intention was not to invoke a specific notion of naturalness but leave the interpretation of this term to the participants. Examples: "How much do you agree on the following statements:… What is natural is also good; Humans and nature have separated too much; The so-called conventional medicine (Schulmedizin) is unnatural" This scale was employed to clarify an individual's relationship towards nature and naturalness. Items were inspired by arguments in the back-then COVID-19 discourse [e.g., 72] and tropes in the general Human Enhancement debate [e.g., 4, 73].

Vaccination status, intention, and COVID: People were asked for the number of vaccination doses they have received against SARS-CoV-2, how many they are planning to get in the future (absolute amount), and if they are generally concerned with keeping their vaccination status against other diseases updated.[6] Current and planned vaccinations were accessed categorically (0–3 doses) with the possibility to answer by free text. Participants also indicated whether they were confirmed to be infected with SARS-CoV-2 (Y/N) and how much they identified with their vaccination status. Vaccination status was meant to measure vaccination hesitancy/behavior and related attitudes directly.

Effects of vaccination status (11/9 items): The scale was self-developed and was meant to reflect on the psychological effects of vaccination. It was employed to reveal how enhanced (vaccinated) participants negotiate the relation between themselves and the environment. Example: "Based on the number of doses of vaccine you have received to date against SARS-CoV-2 (coronavirus), how true are the following statements about you: My social environment reacts negatively to my vaccination status." Items were inspired by discourses about individual participation and discriminating experiences based on vaccination status. Higher values suggest more positive effects.

Support of disease control measures (12 items)*:* Examples were self-collected based on what has been discussed to contain the pandemic (general vaccine mandate) or were employed in various countries, including Germany. The scale was meant to clarify whether unvaccinated participants only reject the vaccination or are generally critical against any disease control measures. Example: "I support the following government actions around the spread of coronavirus: mask mandate; curfews".

Improvements after the first (possible) dose (5 items)*:* People were asked if their feelings right after the first vaccine dose improved or worsened compared to the time before. ("Compared to when you did not receive a vaccine dose, how much did your feelings, thoughts, and behavior change at the time just after you received the first vaccination?"). Participants who had not received a vaccination were instructed to refer to the time when they were theoretically able to get vaccinated. Values below four indicated a worsening; four indicated no change, and ratings above indicated an improvement. It was meant to explore how the administration of an example of Human Enhancement influenced the perception and experience of participants amid a pandemic. Any change within the vaccinated suggests a relational change compared to the "pre-enhanced" self.

4.1.3 Procedure

To test our hypotheses, we conducted an online study using *LimeSurvey* [74] that was in full accordance with the ethical guidelines of the University of Bamberg. The link was distributed by the sources mentioned in the *Participants* section. It was approved by an umbrella evaluation for psychophysical testing of the university of Bamberg ethics committee (Ethikrat der Universität Bamberg) on August 18, 2017.

After consenting to the use of their data, participants filled out sociodemographic information and completed the measures as stated above. University students and participants from online survey distributors could apply for course credit or other benefits from the particular website. The survey language was German. Data sampling occurred from January 1st, 2022, to January 14th, 2022. Data analysis occurred once the sampling was stopped at $N = 316$.

4.2 Results

Data analysis was primarily conducted with *R* (4.2.2). Models were calculated using the *brms* library (2.18) [75]. Bayesian models ran four sampling chains, 10,000 iterations, with 5,000 warm-up iterations each. When equality of variance was not present, degrees of freedom were corrected using the Welch approximation. All *p*-values are two-sided. If not stated otherwise, data from all 314 participants were included.

[6] At the time of data sampling, people vaccinated with a single dose of Janssen® by Johnson & Johnson had the legal status of being fully vaccinated. Participants were instructed to count a first dose of this vaccine as two and add subsequent doses by one.

Table 2 Distribution of vaccination status

Received doses of vaccines at the time of the data sampling		
0 Doses	58	Sum of unvaccinated people: 58
1 Dose	4	Sum of vaccinated people: 256
2 Doses	65	
3 Doses	187	
Planned number of doses		
0 Doses	54	
1 Dose	0	
2 Doses	18	
3 Doses	132	
3 + Doses	20	
As much as needed	74	
Undecided	3	
NA	13	

Many people used the free-text option to answer the question about the planned vaccinations, stating that they either consider getting as many vaccine doses as needed or required (as needed) or a specific number of doses greater than three (3 +). Some people were unsure (undecided) or left an incomprehensible answer (*NA*). Eight participants (2.55%) reported that they planned to receive fewer doses than they already had. It is possible they misread the question and stated the relative amount of planned doses, not the absolute. Their planned vaccine doses were also coded *NA*

4.2.1 Overview and rationale of analysis

After a descriptive account of vaccination status during sampling and intended doses (*Current and planned vaccinations*), we proceed with internal consistencies and differences between unvaccinated and vaccinated participants (*Scales and comparison between vaccinated and unvaccinated*). We conducted these analyses to investigate whether unvaccinated individuals exhibit more positive attitudes toward nature. Additionally, we aimed to contextualize the decision to reject vaccination within broader controversial discussions and the COVID-19 discourse. Subsequently, we aimed to examine the psychological effects of receiving the vaccine by analyzing the self-reported psychological effects of getting vaccinated.

To better understand public perception, we compared ratings on whether a phenomenon qualifies as Human Enhancement (*Human Enhancement Ratings*). We aimed to shed light on a possible gap between academic and public perception of the issue and determine what interventions might be relevant to the general discourse.

Hereafter, we investigated whether vaccination status indicates a stronger emphasis on perceived naturalness and invasiveness and how this relates to the willingness to use other means considered Human Enhancement. This was done by examining the willingness to use means for memory enhancement and potential differences between invasiveness and naturalness ratings of the same interventions (*Willingness to use, perceived naturalness, and perceived invasiveness of cognitive enhancement methods*).

We then analyzed potential parallels between predictors of attitude towards vaccination and Human Enhancement. This was mainly done to clarify the role of the suspected importance of the general attitude toward naturalness for unvaccinated participants and to investigate if participants reject vaccination because they see it as Human Enhancement (*Attitude toward vaccination/Human Enhancement*).

We lastly, predicted future vaccination intention (*Vaccination intention – More doses?/Exact number of doses*) to further elaborate on the importance of naturalness attitude and attitude toward Human Enhancement and vaccination for prospective vaccination behavior. Here, we also examined whether the perceived benefits of the vaccination predict the intention to receive more. For readability and because this question was not the decisive factor for this study, most of the related analyses and discussion can be found in the Supplementary.

4.2.2 Current and planned vaccinations

Table 2 shows the distribution inside the groups. Figure 1 shows the association between current and planned received doses in the absolute amount of received and planned doses. A comprehensive overview can be found in the Supplementary.

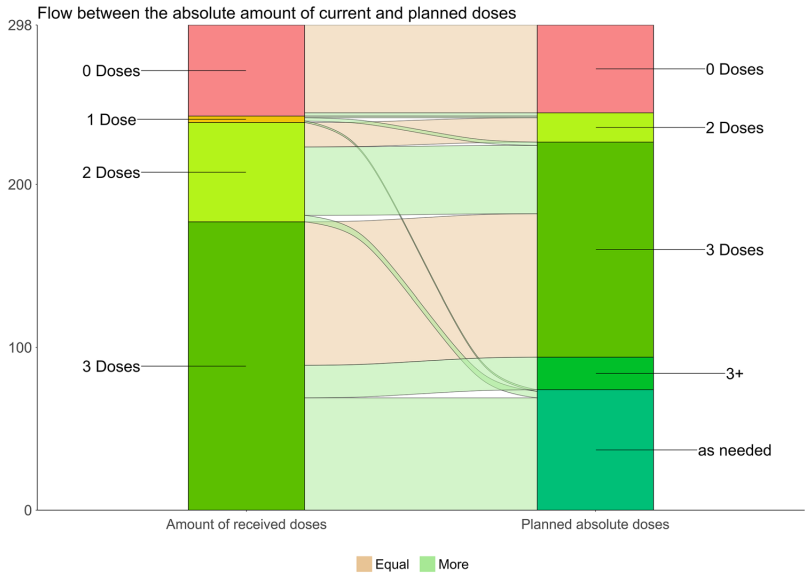


Fig. 1 Association between the absolute received and absolute planned doses. NA's and "Undecided" of planned doses are not shown. Of the three undecided persons, one had received three, one two, and one zero doses. Hence, n = 298. Complete numeric overview is provided in the supplementary

4.2.3 Scales and comparison between vaccinated and unvaccinated participants

Sum-scores of the effects of the vaccination status (internal consistency, Cronbach's α = 0.76, Confidence Interval = $CI_{95\%}$ [0.72, 0.80]), improvements after (possible) first dose (α = 0.83, $CI_{95\%}$ [0.81, 0.86]), naturalness attitude (α = 0.79, $CI_{95\%}$ [0.76, 0.83]), and approval for disease control measures attitude (α = 0.94, $CI_{95\%}$ [0.93, 0.95]) were calculated. Some items were reverse-coded after the *check.keys* method of the R *psych* (2.1.9.) package [76] identified them as negatively correlated with the first component of the employed principal component analysis (PCA). Since the effects of the vaccination status scale contained items directly referring to the vaccination ("I feel better than before the vaccination," "I feel technologically enhanced"), these two items were dropped when analyzing sum scores between vaccinated and unvaccinated and resulted in a Cronbach's α = 0.72 $CI_{95\%}$ [0.68, 0.77]. An overview can be found in the supplementary. Table 3 shows selected differences, and Fig. 2 detailed answers to the improvements after the first (possible) dose scale for vaccinated participants only.

4.2.4 Human Enhancement ratings

Cybernetic prostheses ($M = 5.54$, $SD = 1.80$), Cochlear implants ($M = 5.46$, $SD = 2.01$), followed by neuroenhancement drugs ($M = 4.92$, $SD = 1.84$), were rated most exemplarily for being an enhancement among all participants (Max = 7). Vaccinations ranked eight of fifteen ($M = 3.51$, $SD = 2.25$). A graphical overview of the enhancement ratings is provided in the Supplementary.

Unvaccinated participants rated drugs to increase life expectancy ($t_{(312)} = -3.41$, $p < 0.001$, $d = -0.50$ [−0.79, −0.21]) and neuroenhancement drugs ($t_{(312)} = -2.32$, $p = 0.021$, $d = -0.34$ [−0.63, −0.05]) as less exemplarily for being an instance of Human Enhancement. There were no differences regarding the other phenomena (all $p > 0.09$), including vaccinations ($t_{(312)} = -0.63$, $p = 0.529$, $d = -0.09$ [−0.38, 0.20]).

Table 3 Differences between vaccinated and unvaccinated participants

		Unvaccinated		Vaccinated		*t* (df)	*d* [CI95%]
		Mean	*SD*	*Mean*	*SD*		
Attitude toward…	Vaccination	2.76	1.58	6.47	1.00	− 17.12 (67.70)*	− 3.29 [− 3.67, − 2.90]
	Space colonization	2.69	2.00	3.65	2.02	− 3.28 (312)*	− 0.48 [− 0.77, − 0.19]
	Human interference with nature	3.40	1.46	4.02	1.40	− 3.03 (312)*	− 0.44 [− 0.73, − 0.15]
	Human Enhancement	3.43	1.69	4.75	1.32	− 5.60 (73.48)*	− 0.95 [− 1.25, − 0.66]
	Homeopathy	4.98	1.83	2.52	1.81	9.33 (312)*	1.36 [1.05, 1.66]
	Alternative healing practitioners	5.33	1.69	2.75	1.76	10.11 (312)*	1.47 [1.16, 1.78]
	Genetic engineering of plants	1.71	1.18	3.73	1.82	− 10.49 (126.5)*	− 1.17 [− 1.47, − 0.87]
	Genetic engineering of animals	1.28	0.77	2.49	1.62	− 8.50 (186.84)*	− 0.81 [− 1.10, − 0.51]
	Genetic engineering of humans	1.31	0.90	2.46	1.62	− 7.40 (152.82)*	− 0.76 [− 1.05, − 0.47]
	Anthroposophy	4.17	1.81	2.61	1.61	6.53 (312)*	0.95 [0.65, 1.25]
Vaccination status important for identity		3.62	2.53	4.16	2.04	− 1.51 (74.81)	− 0.25 [− 0.53, 0.04]
Support of disease control measures		25.38	14.91	62.14	13.60	− 18.25 (312)*	− 2.65 [− 3.00, − 2.30]
Naturalness attitude		37.22	7.91	26.97	7.83	8.99 (312)*	1.31 [1.00, 1.61]
Keeping up with vaccinations generally		3.03	2.19	5.08	1.81	− 7.46 (312)*	− 1.09 [− 1.38, − 0.79]
Improvement after the (possible) first dose		17.12	3.72	23.33	4.36	− 10.04 (312)*	− 1.46 [− 1.77, − 1.15]
Effect of vaccination status (reduced)		33.46	9.61	46.48	7.68	− 9.64 (74.36)*	− 1.61 [− 1.93, − 1.30]
I feel vulnerable		3.28	2.28	2.84	1.89	1.54 (312)	0.22 [− 0.06, 0.51]
I feel liberated		3.45	2.56	4.46	1.61	− 2.88 (67.60)*	− 0.55 [− 0.84, − 0.26]
I am relaxed as I go through the world		4.48	2.04	3.59	1.60	3.11 (73.81)*	0.53 [0.24, 0.82]
The disease appears less dangerous to me		4.22	2.36	4.06	1.89	0.49 (73.34)	0.08 [− 0.21, 0.37]
I feel left out		4.98	2.10	1.39	1.09	12.67 (64.12)*	2.70 [2.34, 3.06]

Indented items are exemplary items of the effect of the vaccination status scale. A graphical overview is provided in Additional file 1. *=$p < 0.05$, and the credibility interval of the posterior of mean differences does not include 0. *SD*=Standard deviation. *d*=Cohen's *d* with 95% confidence interval. Size of the effects according to Cohen [77]: 0.2–0.5: small, 0.5–0.8: medium, > 0.8: large. Max values: attitude toward items, vaccination status importance, keeping up with vaccinations, and indented items=7; support of disease control measures=84; naturalness attitude=49; improvements after first possible dose=35; effect of vaccination status (two items dropped)=63. Welch approximation was conducted when degrees of freedom (*df*) are not 312

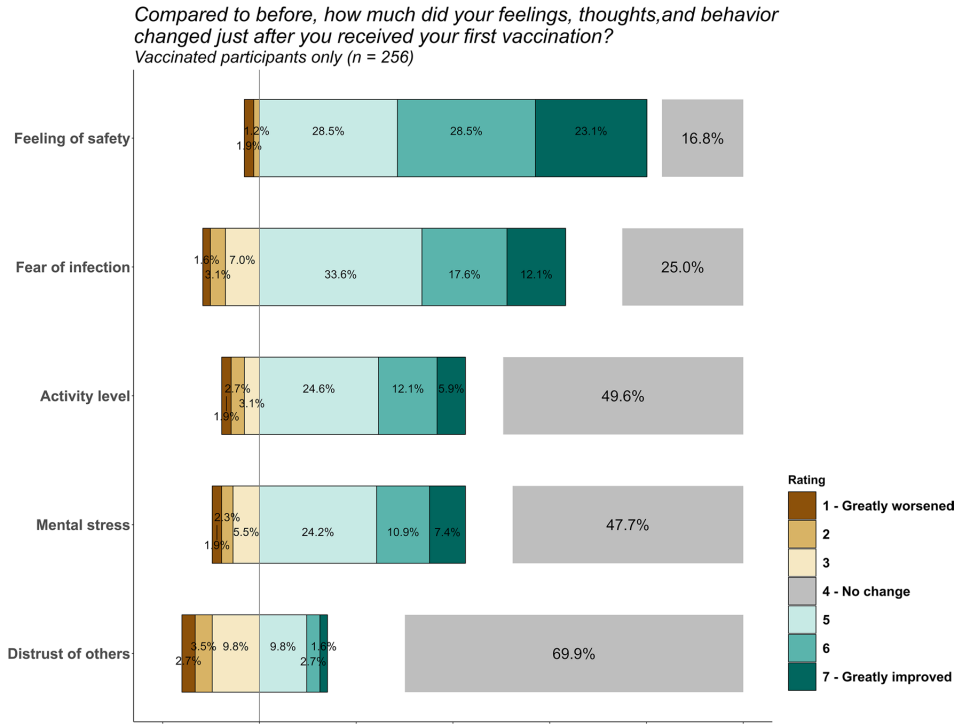


Fig. 2 Detailed answers of the Improvements after first (possible) dose scale for vaccinated participants only. We interpret responses to these items as indicative of the psychological effect of vaccination, i.e., Human Enhancement

4.2.5 Willingness to use, perceived naturalness, and perceived invasiveness of cognitive enhancement methods

Unvaccinated participants rated the one-time administration of a drug in the form of pills ($t_{(312)} = 5.90$, $p < 0.001$, $d = 0.86$ [0.56, 1.15]), one-time injection of a drug into the arm ($t_{(312)} = 6.67$, $p < 0.001$, $d = 0.97$ [0.67, 1.27]), one-time administration of a plant-based drug ($t_{(312)} = 2.91$, $p = 0.004$, $d = 0.42$ [0.13, 0.71]), daily administration of a drug in the form of pills ($t_{(312)} = 4.96$, $p < 0.001$, $d = 0.72$ [0.43, 1.01]) and the daily injection of a drug into the arm ($t_{(312)} = 3.85$, $p < 0.001$, $d = 0.55$ [0.27, 0.84]) higher in invasiveness than vaccinated participants. Credible intervals of posterior differences also did not include 0. There were no significant differences in the other examples (all p's > 0.09).

Concerning perceived naturalness, unvaccinated participants rated the one-time administration of a drug in the form of pills ($t_{(312)} = -4.07$, $p < 0.001$, $d = -0.59$ [– 0.88, – 0.30]), one-time injection of a drug into the arm ($t_{(312)} = -4.65$, $p < 0.001$, $d = -0.68$ [– 0.97, – 0.39]), daily administration of a drug in the form of pills ($t_{(312)} = -3.11$, $p = 0.002$, $d = -0.45$ [– 0.74, – 0.16]) and the daily injection of a drug into the arm ($t_{(312)} = -2.89$, $p = 0.004$, $d = -0.42$ [– 0.71, – 0.13]) as less natural than vaccinated participants. Credible intervals of posterior differences also did not include 0. There were no significant differences in the other examples (all p's > 0.06).

Ratings of willingness to use, perceived naturalness, and perceived invasiveness displayed a rating tendency to the extreme (Fig. 9). We chose a mixed-model Bayesian ordered cumulative regression to account for these non-Gaussian distributions. Attitude toward Human Enhancement, perceived invasiveness, perceived naturalness, application frequency, vaccination status, and interactions with vaccination status, except application frequency, were set as population-level effects. These effects represent effects that should be consistent across examples [78]. Participant and intervention type (left column Table 1, drugs, diet, etc.) were set as group-level effects. This allows for variation around group means that

Table 4 Estimates of willingness to use an intervention to boost cognitive performance

Predictor	All interventions					
	Model 1			Model 5		
	Odds ratio (OR; Median)	95% credible interval (CI)	pd	OR	95%CI	pd
Perceived invasiveness	0.76	0.72–0.81	100.00%	0.59	0.52–0.67	100.00%
Perceived naturalness	1.61	1.52–1.71	100.00%	2.24	2.00–2.52	100.00%
Attitude Human Enhancement	1.44	1.23–1.68	100.00%	1.41	1.05–1.88	98.60%
Naturalness attitude	0.97	0.94–0.99	99.20%	0.96	0.90–1.01	92.30%
Vaccinated	2.24	1.25–4.06	99.70%	1.77	0.13–24.39	66.20%
Vaccinated × perceived invasiveness				1.37	1.20–1.56	100.00%
Vaccinated × perceived naturalness				0.66	0.58–0.75	100.00%
Vaccinated × att. Human Enhancement				1.06	0.76–1.48	63.40%
Vaccinated × naturalness attitude				1.01	0.95–1.07	59.50%
Frequent use	0.72	0.08–6.86	62.20%	0.80	0.08–9.11	57.20%
One-time use	5.31	4.40–6.43	100.00%	6.1	5.04–7.38	100.00%
Group-level effects						
Sd (Intervention type)	3.34	2.07–10.10		3.99	2.32–14.49	
Sd (Participant)	5.47	4.64–6.62		5.83	4.91–7.06	
LOO-information criterion	9615.2 (112.0)			9448.7 (113.4)		
Predictor	Interventions with parallel frequencies					
	Model 6			Model 10		
	OR	95%CI	pd	OR	95%CI	pd
Perceived invasiveness	0.63	0.56–0.70	100.00%	0.55	0.43–0.69	100.00%
Perceived naturalness	1.87	1.68–2.09	100.00%	3.15	2.55–3.93	100.00%
Attitude Human Enhancement	1.84	1.39–2.44	100.00%	1.44	0.87–2.37	92.20%
Naturalness attitude	0.94	0.90–0.99	99.00%	0.88	0.81–0.97	99.70%
Vaccinated	7.80	2.83–22.83	100.00%	0.85	0.03–23.44	53.70%
Vaccinated × perceived invasiveness				1.20	0.92–1.56	91.10%
Vaccinated × perceived naturalness				0.51	0.41–0.64	100.00%
Vaccinated × att. Human Enhancement				1.39	0.81–2.43	88.70%
Vaccinated × naturalness attitude				1.07	0.98–1.18	93.00%
One-time use	10.9	8.48–14.03	100.00%	12.64	9.78–16.46	100.00%
Group-level effects						
Sd (Intervention type)	1.80	1.23–10.86		1.88	1.25–12.38	
Sd (Participant)	22.94	16.48–33.25		25.37	18.17–37.58	
LOO-information criterion	4383.5 (88.6)			4323.4 (90.3)		

Note. Information on the posterior distribution of the calculated mixed-model Bayesian ordered cumulative regression. Daily use and not being vaccinated were reference categories to the respective predictors. Priors for the predictors: N (0,2). Thresholds (not shown) and *sd* = Student's *t*-distribution, ν = 3, μ = 0, σ = 2.5 (brms default). Parallel frequency (Models 6–10) means that we included only those interventions that were explicitly recorded twice in terms of the required frequency of use (Daily or Once, see Table 1). In these models, no interventions needed "frequent" use. More information is provided in the Supplementary. Number of data points for models 1–5 = 3454; models 6–10 = 1884. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0 (or one if converted to OR), as indicated by the coefficient median. Linear combination and interpretation of coefficient estimates may be eased by transforming them back via log transformation

may differ from the general average [78]. We did so because we were interested in the general role of the fixed effects across various interventions that may differ in their mean willingness to use. Interaction effects with vaccination status were modeled to test for the special emphasis unvaccinated participants were expected to put on these variables.

2 × 5 models were constructed to explore possible interaction effects and account for frequency and type asymmetry. Models 1–5 considered all interventions, and Models 6–10 only included interventions whose required application frequency was assessed symmetrically (i.e., once as a daily and once as a one-time intervention). For a comprehensive comparison, Table 4 features the models without interactions and those that employed interactions between perceived

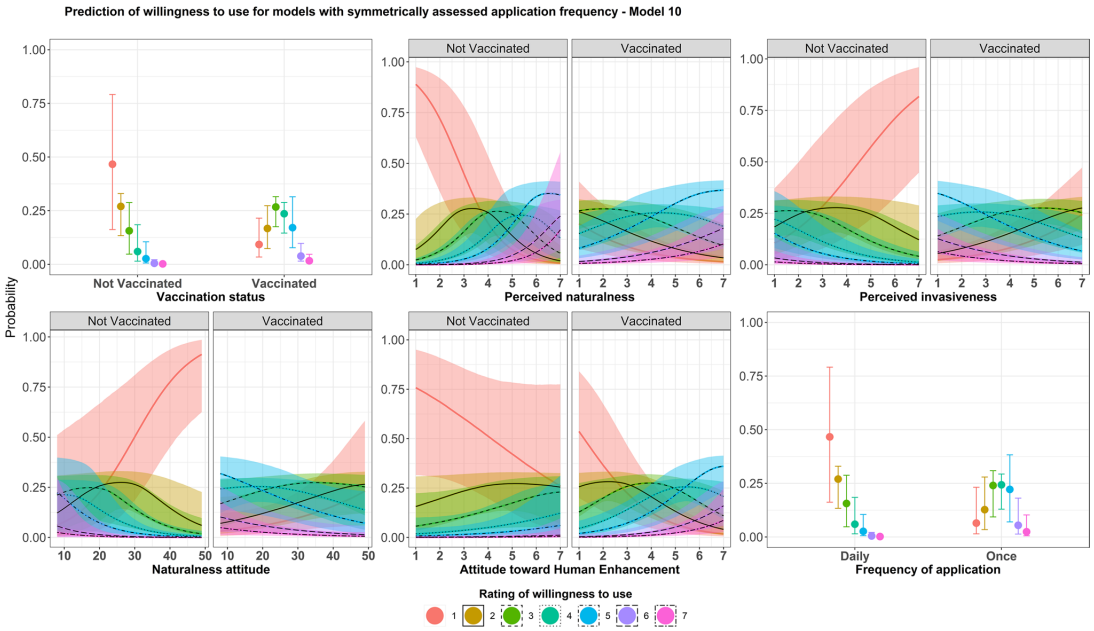


Fig. 3 Visualization of the conditional prediction of willingness to use for models with symmetrically assessed application frequency. Table 4—Model 10. Shaded areas represent 95% credible intervals. Curves correspond to the draws from the expected value of the posterior predictive distribution. For better visibility, group level effects are not displayed. Each curve represents the probability (Y-axis) to respond with the respective rating (color and linetype) given value of the predictor (X-axis). When conditioning on one predictor, the others are by default set to their mean/reference category by *brms*

naturalness, perceived invasiveness, attitude toward Human Enhancement, and naturalness attitude. A complete overview can be found in the Supplementary. Figure 3 depicts effects of model number 10.

4.2.6 Attitude toward vaccination

Estimates of conducted linear Bayesian regression are shown in Table 5 and represent two different models, one with and one without interaction terms. Five models, each with another interaction term, were constructed to explore the role of the different variables and approximate the variable combination that provided the best fit. The complete overview can be found in the supplementary. Figure 4 shows the predictions of Model 5.

We constructed a different model to explore possible post hoc effects among the vaccinated. We employed the positive effect of vaccination status, improvement after first dose, identification with enhancement status, naturalness attitude, and attitude toward Human Enhancement as predictors. The choice of predictors was guided by the idea that these variables may reflect post hoc relevant processes that may eliminate the effect of naturalness attitude and attitude toward Human Enhancement. Results suggest a positive effect of effects of vaccination status $\beta = 0.23$, $CI_{95\%}$ [0.14–0.33] probability of direction = 100%, the identification with the vaccination status $\beta = 0.07$, $CI_{95\%}$ [0.01–0.14] probability of direction = 98.70%, and a negative effect of naturalness attitude $\beta = -0.18$, $CI_{95\%}$ [− 0.24 - − 0.11] probability of direction = 100%. Other effects were less clear (probabilities of direction = 51.4–53.5%). The model can be found in the Supplementary.

4.2.7 Attitude toward Human Enhancement

After visually inspecting the correlations between the coefficient distributions of our Bayesian linear regression, we observed that predictor weights of attitude on vaccination and vaccination status were rather highly correlated. Although

Table 5 Estimating Attitude toward vaccination

Predictors	Model 1			Model 5		
	β (Median)	95% Credible Interval (CI)	pd	β	95%CI	pd
Enhancement Rating vaccinations	0.02	− 0.04 - 0.08	73.50%	0.16	0.02 - 0.30	98.70%
Attitude Human Enhancement	0.09	0.02 - 0.16	99.50%	0.28	0.15 - 0.42	100.00%
Vaccinated	1.60	1.42 - 1.78	100.00%	1.32	1.10 - 1.54	100.00%
Naturalness attitude	− 0.28	− 0.35 - − 0.21	100.00%	− 0.44	− 0.61 - − 0.27	100.00%
ER vaccinations × vaccinated				− 0.14	− 0.30 - 0.02	95.80%
Att. HE × vaccinated				− 0.26	− 0.42 - − 0.10	100.00%
Naturalness attitude × vaccinated				0.20	0.02 - 0.38	98.40%
R^2 Bayes	0.70			0.72		
LOO-information criterion	524.7 (46.1)			508.7 (52.0)		

Note. Information on the posterior distribution of the calculated Bayesian linear regression. Priors for the predictors: *N*(0,1). Intercept = Student's *t*-distribution, ν = 3, μ = 0.7, σ = 2.5 (*brms* default). *Sd* = Student's *t*-distribution, ν = 3, μ = 0, σ = 2.5 (*brms* default). Estimates are standardized effect sizes. LOO-information criterion (standard error in parentheses): Lower values indicate a better model fit. Each model ran four sampling chains with 1e4 iterations and 5000 warm-up draws. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0, as indicated by the coefficient median

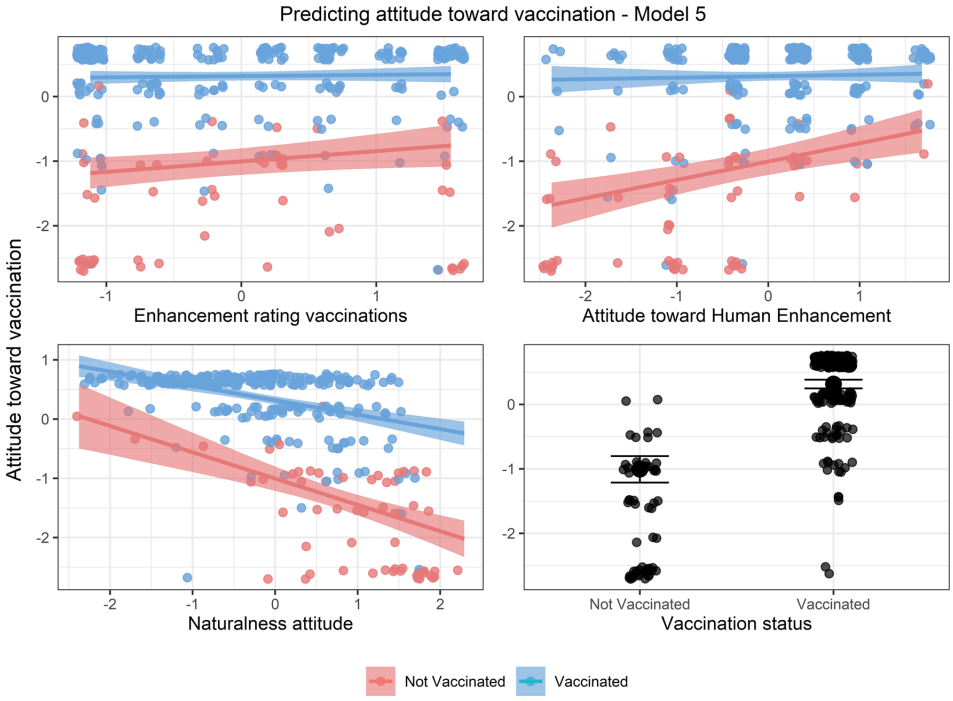


Fig. 4 Conditional interaction effects and effects of the vaccination status of the model with the lowest LOO-information criterion (Table 5—Model 5). The shaded area represents 95% credible interval. Values are scaled and centered. When conditioning on one predictor, the others are, by default, set to their mean/reference category by *brms*. Curves correspond to the draws from the expected value of the posterior predictive distribution. Points represent empirical data and are jittered for better readability

interaction effects inevitably create predictor correlations, we wanted to reduce the potential influence of multicollinearity on this model at least a bit while maintaining a theoretical foundation of predictor choices. Vaccination status was theorized to be the more concrete reflection of attitudes toward vaccination and the underlying belief system. Hence, we dropped attitude on vaccination as a predictor and calculated the models presented here.

Table 6 Estimating attitude toward Human Enhancement

Predictors	Model 1			Model 4		
	β (Median)	95%CI	pd	β	95%CI	pd
Enhancement Rating vaccinations	0.17	0.07 - 0.27	100.00%	− 0.22	− 0.45 - 0.01	97.10%
Vaccinated	0.51	0.22 - 0.79	100.00%	0.38	0.04 - 0.72	98.50%
Naturalness attitude	− 0.31	− 0.42- − 0.20	100.00%	− 0.49	− 0.74 - − 0.24	100.00%
ER vaccinations × vaccinated				0.47	0.23 - 0.73	100.00%
Naturalness attitude × vaccinated				0.22	− 0.05 - 0.50	94.40%
R^2 Bayes	0.219			0.264		
LOO-information criterion	823.5 (26.00)			809.7 (25.7)		

Information on the posterior distribution of the calculated Bayesian linear regression. Priors for the predictors: normal distributed, μ = 0, σ = 1. Intercept = Student's t-distribution, v = 3, μ = 0.7, σ = 2.5 (*brms* default). *Sd* = Student's *t*-distribution, v = 3, μ = 0, σ = 2.5 (*brms* default). Estimates are standardized effect sizes. LOO-information criterion (standard error in parentheses): Lower values indicate a better model fit. Each model ran four sampling chains, each with 1e4 iterations and 5000 warm-up draws. CI = Credible interval. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0, as indicated by the coefficient median

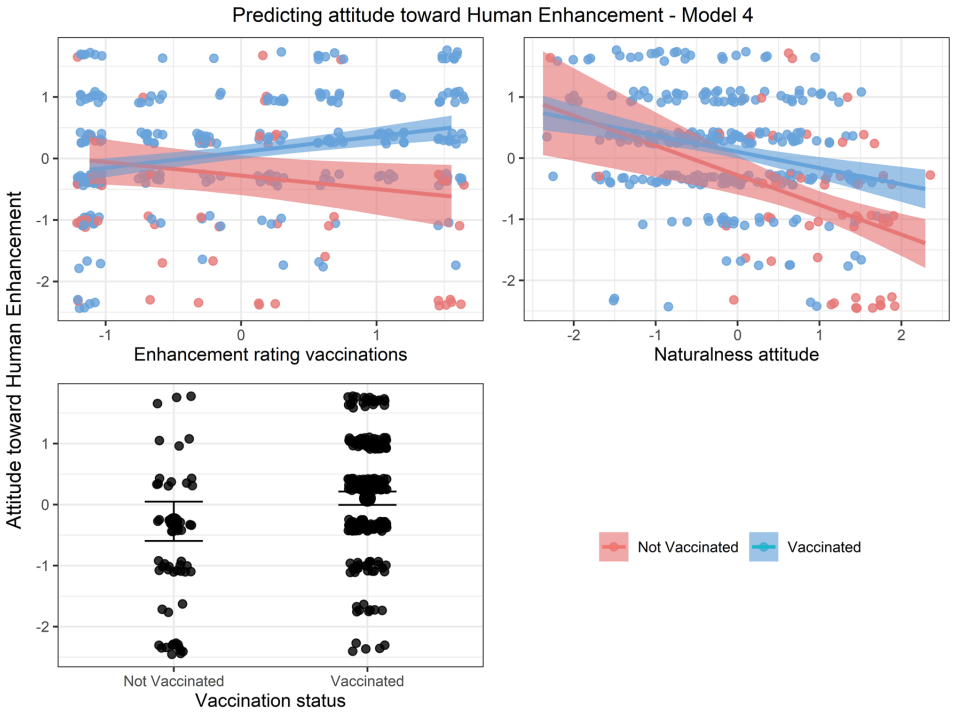


Fig. 5 Conditional interaction effects and effects of the vaccination status of the model with the lowest LOO-information criterion (Model 4). The shaded area represents 95% credible interval. Curves correspond to the draws from the expected value of the posterior predictive distribution. Values are scaled and centered. When conditioning on one predictor, the others are, by default, set to their mean/reference category by *brms*. Points represent empirical data and were jittered for better readability

Four models, each employing different interaction terms, were constructed. After noticing the model-dependent change of effect direction of rating vaccinations as an example of Human Enhancement and its interaction with vaccination status, we explored a three-way interaction between these variables. For better comparison with Fig. 4 and as it has a slighter better model fit, we visualize the coefficients from Model 4 (Table 6) in Fig. 5. Still, including the three-way interaction suggests that the interaction effect between vaccination status and enhancement rating of vaccinations

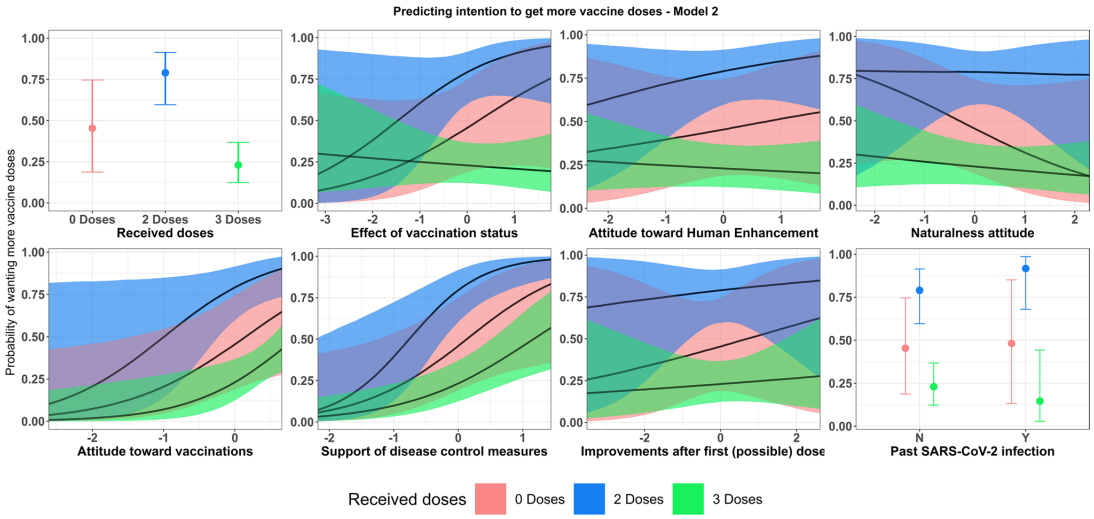


Fig. 6 Results of Model 2 that only included participants with 0, 2, or 3 received doses. The shaded areas represent 95% credible intervals. Curves correspond to the draws from the expected value of the posterior predictive distribution. Values are scaled and centered. When conditioning on one predictor, the others are by default set to their mean/reference category by *brms*. This model excluded participants that have only received one doses and those whose answers on vaccination intention could not be interpreted. Since it used data of unvaccinated participants, we employed the reduced effect of vaccination status scale in which two items were dropped. Prior for predictors = *N* (0,1). Attitude toward vaccination was retained as predictor along received doses because we were interested if there are meaningful differences among groups

increases the attitude toward Human Enhancement for vaccinated participants only. The coefficients of all models can be found in the Supplementary.

4.2.8 Vaccination intention—more doses?

The supplementary features logistic regressions exploring which variables predict participants' intention to receive more doses. Figure 6 visualizes the effects of one of the models, excluding the participants who received only one dose.

Another important finding was that in a different model that solely used the data of the unvaccinated participants, the most certain effect on whether to receive more doses (i.e., get vaccinated at all) was the negative influence of naturalness attitude $OR = 0.26$, $CI_{95\%}$ [0.06, 1.03], probability of direction = 97.20%.

4.2.9 Vaccination intention—exact number of doses

As the decision to get no more doses is not equivalent to the decision to not get vaccinated at all, bayesian ordinal regressions were calculated considering only participants who had already received two or three doses. We separated the data as the number of received doses cannot logically predict each outcome (boostered participants cannot plan to get only two doses). We did not predict the exact number of doses for unvaccinated participants and those who received only one dose because the sample size was too small. A full overview can be found in the Supplementary. Figure 7 visualizes the effects of the two models with the best fit.

5 Study 2

In response to extensive feedback from multiple peer reviewers, who pointed out the absence of data regarding public perception of the vaccine against SARS-CoV-2, we aimed to address this gap by conducting a second study. This was meant to test our hypothesis' prediction that people not vaccinated against SARS-CoV-2 deem the vaccination more unnatural and more invasive than vaccinated people and that these factors play a crucial role in their decision

Discover Psychology (2023) 3:24 | https://doi.org/10.1007/s44202-023-00085-3 Research

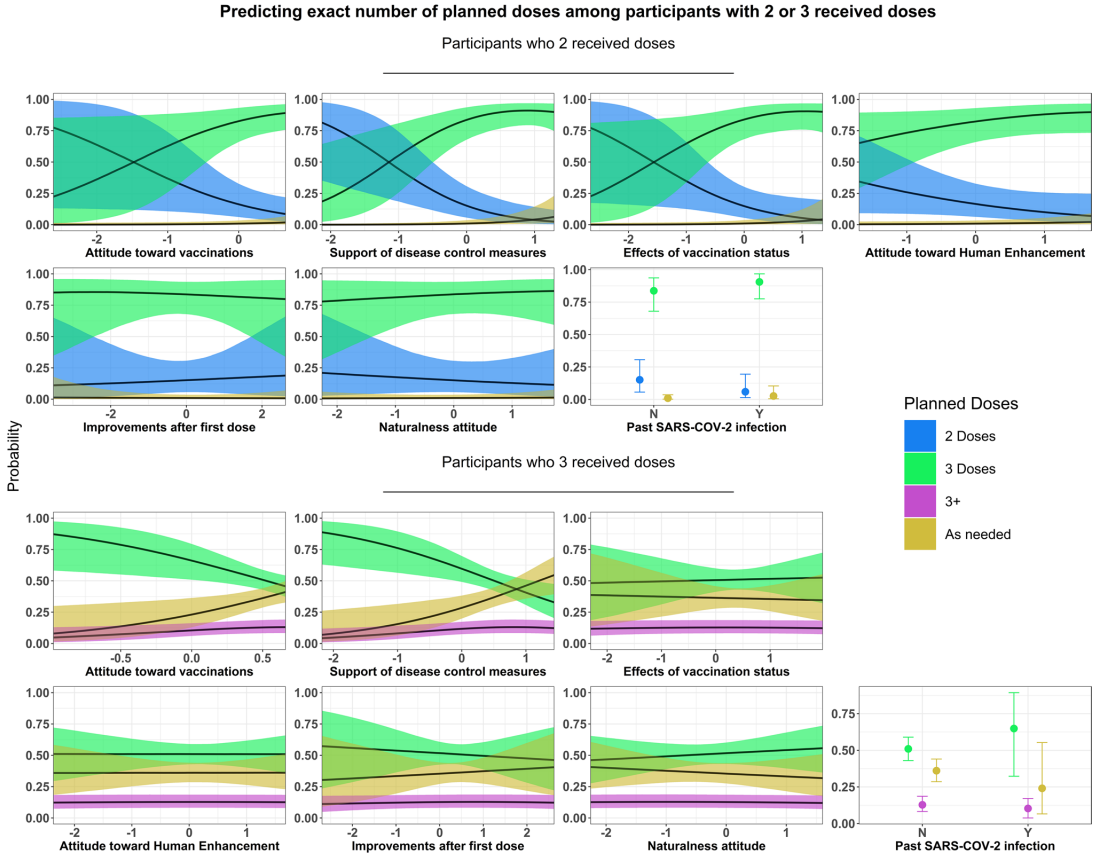


Fig. 7 Results from the respective models, that included attitude toward vaccination. The shaded areas represent 95% credible intervals. Curves correspond to the draws from the expected value of the posterior predictive distribution. Values are scaled and centered. When conditioning on one predictor, the others are by default set to their mean/reference category by *brms*. Since the models do not used data of unvaccinated participants, the complete effect of vaccination status scale was used. Prior for predictors = *N* (0,1). Attitude toward vaccination was retained as predictor we were interested if there are meaningful differences among groups

to reject vaccination. We furthermore wanted to validate the final willingness to use the model (parallel frequencies) by predicting data it had never seen before.

5.1 Methods

5.1.1 Participants

Participants were again recruited from the same sources as in the first study, including Facebook groups hosting a critical discourse on vaccination. An apriori power analysis for an independent t-test determined sample size. Following the differences in the magnitude of the perception of invasiveness in our first study, we set the expected effect size to $d = 0.50$, the desired power to 0.80, and alpha to 0.05. We furthermore accounted for the uneven distribution of unvaccinated

and vaccinated participants in the German population in May of 2023 (13/87% [10]) and set the allocation ratio to 6.7. This yielded a required sample size of at least $N = 222$ (29 unvaccinated, 193 vaccinated).

The survey was completed by $N = 301$. We overpowered the study to mitigate eventual data loss due to dishonest answers. This was done primarily for unvaccinated participants, as members of the Facebook groups often expressed hostile attitudes regarding our call for participation. Furthermore, members of the two groups did not participate at even rates, so an imbalance on the side of the vaccinated participants resulted in the necessity to recruit more unvaccinated.[7]

One person was excluded because they indicated they were seven years old while also having no educational degree. No other exclusions were made. The complete dataset comprised $N = 300$ persons (*Male* = 129, *Female* = 163, *Other* = 2, *NA* = 6; $M_{Age} = 33.9$ [Range: 18–81] years). One participant's age was coded *NA* due to the initial statement of being over 8461 years old. Other responses of this participant were not overly suspicious. Vaccination status against SARS-CoV-2 was distributed as follows: *Unvaccinated* ($n = 43$, 14.33%) and *Vaccinated* ($n = 257$, 85.67%).

5.1.2 Measures

If not stated otherwise, items used a 7-point Likert scale on which the maximum represented the highest affirmation. A complete list of items is provided in the Supplementary.

Willingness to use. Participants were introduced to the same scenario and measurements as in the first study. However, we only used examples with parallel frequencies (Table 1).

Vaccination status. "Have you ever received a vaccination against SARS-CoV-2?" (Y/N).

Vaccine features: Participants were asked to rate how much the following features apply to the vaccination against SARS-CoV-2: naturalness, invasiveness, effectivity, and safety. Additional categories were introduced to compare ratings on the former two with general concerns about vaccination and Human Enhancement. Considering the initial study's findings, which revealed a correlation between the refusal of the specific SARS-CoV-2 vaccine and general resistance to vaccination, we again chose vaccination against SARS-CoV-2 as context. Despite the diminished prominence of COVID-19 discussions in the German public in May 2023, it was the most recent, prevalent and extensive discourse surrounding vaccinations.

Vaccine features importance: The participants were questioned regarding the importance they attributed to their perception of the aforementioned features when deciding about (not) getting vaccinated against SARS-CoV-2.

Attitude. People were again introduced to the notion of Human Enhancement and stated their attitude toward this phenomenon and vaccination in general.

Naturalness attitude. Same scale as in the first study.

5.1.3 Procedure

To test our hypotheses, we conducted an online study using *LimeSurvey* [74] that was in full accordance with the ethical guidelines of the University of Bamberg. The link was distributed by the sources mentioned in the Participants section. It was approved by an umbrella evaluation for psychophysical testing of the University of Bamberg ethics committee (Ethikrat der Universität Bamberg) on August 18, 2017.

After consenting to the use of their data, participants filled out sociodemographic information and completed the measures as stated above. University students and participants from online survey distributors could apply for course credit or other benefits from the particular website. The survey language was German. Data sampling occurred from May 12th, 2023, to May 22nd, 2023. Data analysis occurred after having recruited $N = 301$ participants.

5.2 Results

When equality of variance was not present, degrees of freedom were corrected using the Welch approximation. All p-values are two-sided.

[7] The supplementary features repeated analysis that combined random samples from both groups to a total sample of 222 with the original proportions. Results of these analysis support the analysis done with the sample of $N = 300$. So even under the original estimation, we would have most certainly found similar effects as reported here.

5.2.1 Overview and rationale of analysis

To gain insight into the suitability of our measures, we start our analysis by examining the internal consistency of the naturalness attitude scale and compare its sum score and attitudes toward vaccination and Human Enhancement along the line of vaccination status. We also analyze if participants rate the means for cognitive enhancement differently regarding invasiveness and naturalness (*Scales and comparison between vaccinated and unvaccinated*).

We then evaluate how vaccinated and unvaccinated perceive the vaccination against SARS-CoV-2 and how much the perceived qualities of the vaccine contributed to the decision whether to receive it. This was done to test for the assumptions that unvaccinated participants deem the vaccine as more unnatural and more invasive and, due to the hypothesized special emphasis, attach particular importance to their perception (*Perception of vaccination against SARS-Cov-2*).

To ensure model robustness, we integrated novel data regarding people's willingness to utilize cognitive enhancement methods. This additional dataset was employed to validate the final model constructed in the initial study (*Model evaluation*).

5.2.2 Scales and comparison between vaccinated and unvaccinated

Internal consistency of the naturalness attitude scale was α = 0.77, credible interval—CI95% [0.74, 0.81].[8] Unvaccinated participants held a less affirming attitude toward Human Enhancement: $t_{(298)} = -8.27$, $p < 0.001$; $d = -1.36$ [− 1.70, − 1.02] and vaccination in general $t_{(48.82)} = -9.50$, $p < 0.001$; $d = -2.04$ [− 2.40, − 1.67] while scoring higher in naturalness attitude compared to their vaccinated counterparts: $t_{(298)} = 8.49$, $p < 0.001$; $d = 1.40$ [1.06, 1.74]. Credible interval of posterior differences did not include 0.

Our first study found that unvaccinated participants rated some means for cognitive enhancement higher in invasiveness than vaccinated participants. In the second study, these differences were either not as strong or not significant: one-time administration of a drug in the form of pills ($t_{(298)} = 1.95$, $p = 0.052$, $d = 0.32$ [0.00, 0.64]), one-time injection of a drug into the arm ($t_{(298)} = 2.64$, $p = 0.009$, $d = 0.43$ [0.11, 0.76], credible interval of posterior differences did not include 0), one-time administration of a plant-based drug ($t_{(298)} = 0.43$, $p = 0.66$, $d = 0.07$ [− 0.49, 0.77]), daily administration of a drug in the form of pills ($t_{(298)} = 2.07$, $p = 0.04$, $d = 0.34$ [0.16, 0.67], credible interval of posterior differences contained just 0), the daily injection of a drug into the arm ($t_{(48.7)} = 0.19$, $p = 0.85$, $d = 0.04$ [− 0.28, 0.37]) and daily administration of a plant-based drug ($t_{(298)} = 1.25$, $p = 0.21$, $d = 0.21$ [− 0.11, 0.53]).

Similar to our first study, unvaccinated participants rated the one-time administration of a drug in the form of pills ($t_{(298)} = -3.16$, $p = 0.002$, $d = -0.52$ [− 0.85, − 0.19]), one-time injection of a drug into the arm ($t_{(298)} = -3.59$, $p < 0.001$, $d = -0.59$ [− 0.92, − 0.26]), daily administration of a drug in the form of pills ($t_{(68.93)} = -5.34$, $p < 0.001$, $d = -0.72$ [− 1.05, − 0.40]), the daily injection of a drug into the arm ($t_{(298)} = -2.31$, $p = 0.02$, $d = -0.38$ [− 0.70, − 0.06]) as less natural than vaccinated participants. Credible interval of posterior differences did not include 0 (other *p's* > 0.20).

5.2.3 Perception of vaccination against SARS-Cov-2

Figure 8 displays how participants perceive the vaccination against SARS-CoV-2 regarding certain features and how important the perceived features were for their decision to accept or reject the vaccination. Analysis and figures were done with *ggstatsplot* for R (0.10.0) [79].

A repeated measure ANOVA revealed significant differences in the importance among the unvaccinated $F_{(2.51, 105.44)} = 3.33$, $p = 0.03$, $\widehat{\omega_p^2} = 0.001$. But post hoc pairwise *t*-tests failed to reach significance after correcting the alpha level (*p's* > 0.07—Supplementary). Here, the importance of perceived naturalness was the lowest among all features.

Noticing that some vaccinated participants deemed the perceived invasiveness as somewhat meaningful for their decision to get vaccinated, we explored correlations between the measures and across group lines (Supplementary). We expected that vaccinated people who reported higher importance of perceived invasiveness do so because they deem the vaccine less invasive. However, the analysis revealed a positive yet non-significant correlation between perceived invasiveness and the importance of this feature, $r = 0.16$, $p > 0.05$. Within this group, the importance of perceived invasiveness

[8] We reversed one item (Humans are the crown of creation) in accordance with the findings of the first study. However, in this sample this item was not negatively correlated with the PCA's component. To ensure comparability and due to theoretical consideration about the scales purpose, we nevertheless decided for reversing it. If employed in future research, this item should be critically examined.

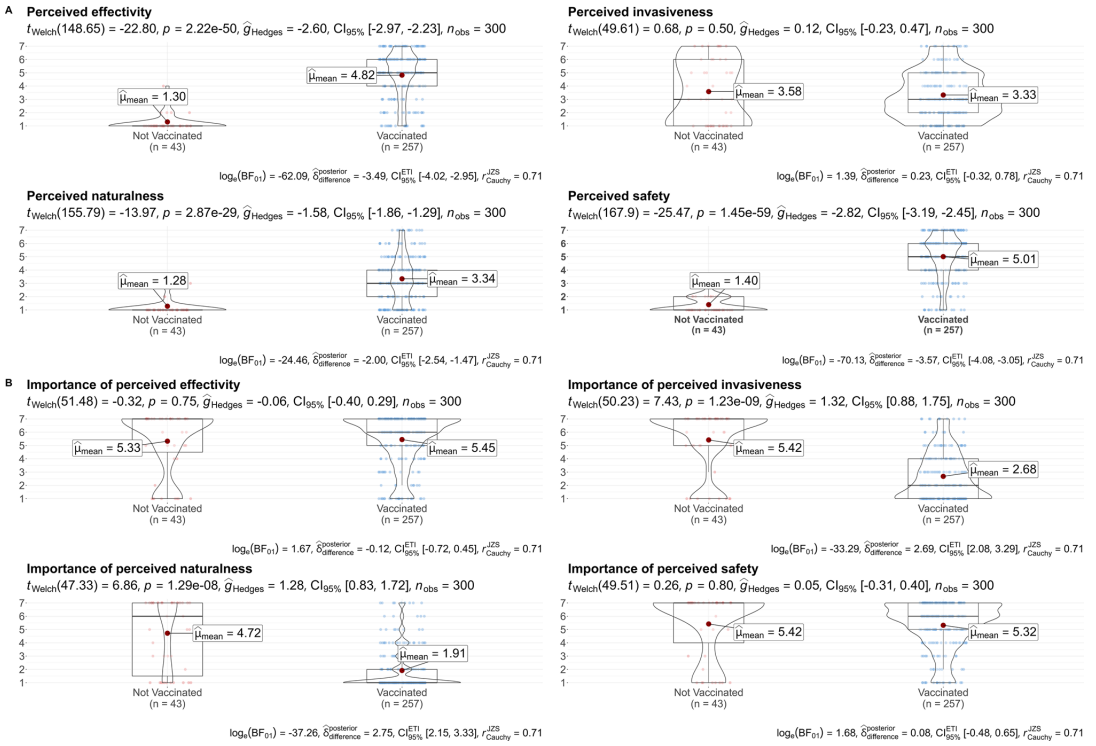


Fig. 8 Perception how vaccination against SARS-CoV-2 possesses a certain feature (**A**) and the importance of this perception for the decision whether to get vaccinated or not (**B**)

only correlated significantly with the importance of perceived naturalness $r = 0.40$, and the importance of perceived safety $r = 0.24$, p's < 0.05. This brief analysis cannot resolve the role of perceived invasiveness within vaccinated participants. We found a similar pattern of correlations within the vaccinated participants ($r_{\text{perceived invasiveness – invasiveness importance}} = 0.17$, $p > 0.05$ and $r_{\text{importance naturalness – invasiveness importance}} = 0.67$, $_{\text{importance safety – invasiveness importance}} = 0.76$, p's < 0.05.

5.2.4 Model evaluation

Figure 9 shows the prediction of Model 10 (Table 4) for the data of our studies.

6 General discussion

We conducted two online studies ($N = 314$ and $N = 300$) to contextualize the relationship between vaccination behavior/intention and the rejection of Human Enhancement. Our findings indicate that individuals who reject vaccination against SARS-CoV-2 hold stronger beliefs in favor of naturalness and value this feature more than those vaccinated. Unvaccinated participants also seemed to devalue invasiveness more than their vaccinated counterparts. To our knowledge, this is the first link between concrete vaccination behavior (in Germany) amidst a global pandemic and the Human Enhancement debate. Besides replicating other findings from the empirical research on Human Enhancement, our data also shows that attitudes toward vaccination and Human Enhancement are likely to be influenced negatively by a more affirmative attitude toward naturalness. An effect that seems stronger for unvaccinated

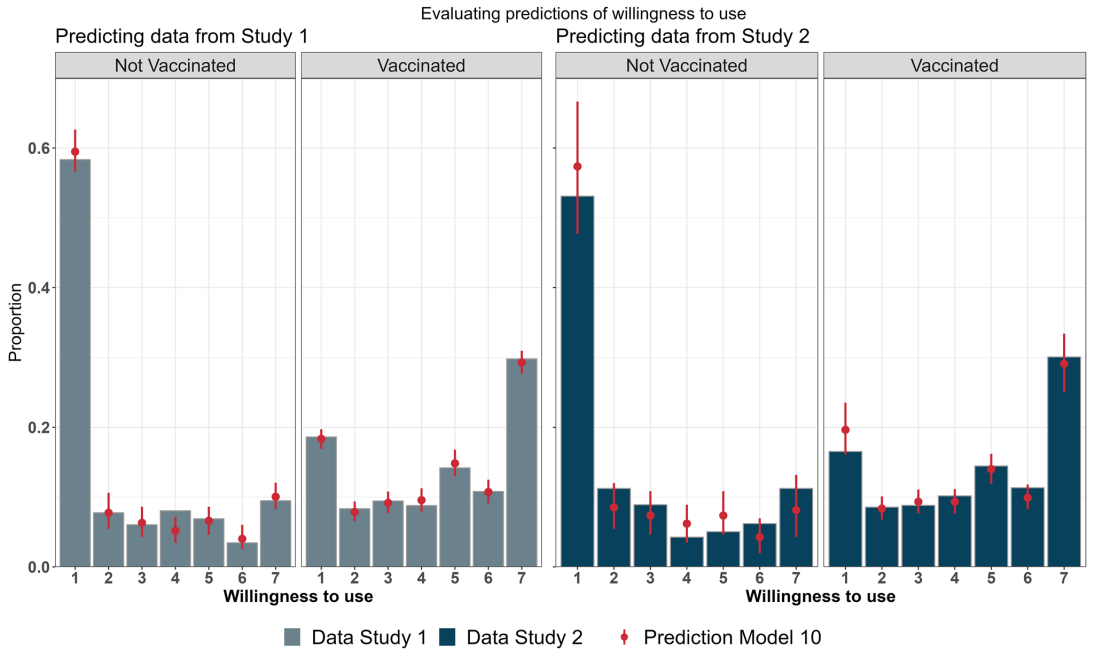


Fig. 9 Predictions were generated by the pp_check method of *brms*. Random levels for participants were generated by allowing new levels, sampled from a Gaussian distribution with [0, *SD* (Random factor participants)]. Lines represent the 95% credible interval and dots the median

participants. Rejecting vaccination appears to be indicative of a set of beliefs that reaches beyond the engagement with this particular enhancement and may explain the rejection of other examples and the general phenomenon.

Reported attitudes revealed that those not vaccinated favored phenomena commonly associated with alternative medicine and disfavored those that imply human interference with nature of various kinds. This hints toward a stable set of naturalness-related and affirming beliefs associated with rejecting vaccination against SARS-CoV-2.

This can be linked to a recent study by Fasce et al. [20]. Employing thematic analysis, they identified 11 "attitude roots," i.e., psychological predispositions that may explain why people reject vaccination. Within their framework, the appeal to naturalness can fall under the theme "Natural is best," which is grouped with other themes such as "Science denial" and "Alternative medicine" under the root "Unwarrented beliefs." If supplied by religious motives, the same appeal may be characterized as being determined by the root "Religious concerns" and the themes of "Impurity," respectively, "Appeal to natural order." The issue of invasiveness may be fueled by the root "Fear and phobias" and its related themes of "Safety concerns." Comparing the general differences between unvaccinated and vaccinated in our samples, we can also spot traces of other attitude roots, such as "Distorted risk perception." This fits well with recent findings revealing substantial positive correlations between psychological constructs associated with attitude roots and the general endorsement of anti-vaccination arguments, including those unassigned to the specific root [80]. How the different anti-vaccination attitudes roots translate to attitudes toward Human Enhancement, in general, remains unclear. Yet, the results of our study point toward a possible association with at least one root.

Findings substantiate the impression that Human Enhancement is commonly understood and defined in terms of invasiveness and the material presence of the technology in question. The lack of the latter may explain why vaccinations were not seen as prime examples of Human Enhancement, similar to a previous study [1]. Interestingly, enhancement ratings of unvaccinated participants differed from vaccinated only in two cases that are extensively covered by the literature as prime examples of Human Enhancement: Drugs to increase life expectancy and drugs to enhance cognitive functioning [4].

A more positive attitude toward Human Enhancement, higher perceived naturalness of means, lower invasiveness, low application frequency, and a lower affirmative attitude toward naturalness predicted a higher willingness to use means

of cognitive enhancement across several models with sufficient certainty. Among individuals not vaccinated against SARS-CoV-2, perceived naturalness was reliably more influential than among vaccinated participants. Our models also yielded evidence for interaction effects between vaccination status and naturalness attitude (Parallel frequencies model only), respectively, perceived invasiveness. Although estimates of the latter were somewhat uncertain, visual analysis of the models' coefficients suggested that being unvaccinated amplified the detrimental impact of attitudes towards naturalness and perceived invasiveness on willingness to use. Still, findings indicate that, in a context with supplementary background information, the perceived naturalness of the intervention appears to carry greater weight than the more general attitude towards naturalness. The interaction effect of vaccination status and perceived invasiveness was reliably present when all interventions were included in the model. However, this effect was less certain in the sub-models that comprised only a portion of the interventions. Models with all interventions included highly invasive procedures, such as electronic device implantation and brain surgery, while the sub-models excluded these interventions. Yet, the sub-models featured more "classical" examples of Human Enhancement, while the former models included interventions not regularly discussed in the debate.

The negative impact of perceived invasiveness when contemplating means to enhance cognitive functions is concurrent with other studies [18, 51, 61, 62]. Considering the somewhat inconsistent findings regarding the positive effects of naturalness on adopting cognitive enhancement [18, 47], our research further clarifies this relation. It suggests a positive link between the perceived naturalness of means and the willingness to adopt them. Additionally, it elucidates the role of affirmative attitudes towards naturalness, which partially reaches beyond a specific enhancement's features.

The addition of interaction terms led to improvements in model fit but rendered the effect of vaccination status highly uncertain. This may suggest that it is not the vaccination status per se that matters but rather the individual valuation of intervention properties that also manifests in vaccination behavior. This was further supported by the finding of the first and partially second study that unvaccinated participants rated the administration of drugs as pills or injections as more invasive and less natural. Although the invasiveness results were less robust, this suggests a differing perception and emphasis on variables consistently predicting the general willingness to use different cognitive enhancement methods. Feature properties are important, yet perception and evaluation of these properties seem linked to a broader belief system.

The fact that perceived naturalness, invasiveness, and affirmative attitude toward naturalness were very likely to impact the willingness to use cognitive enhancement, especially for the unvaccinated, may be explained by a close association of these features with purity concerns. It has been shown that this moral foundation, concerned with whether something violates the purity of something, influences both attitudes toward vaccination [12, 65] and cognitive enhancement [50, 51]. Most recently, Chen et al. [65] revealed the close association between the perception that vaccination against SARS-CoV-2 is impure and that the human body is sacred. Importantly the items used in this study contained a direct reference to the eligibility of moral statements based on alleged unnaturalness [81]. Chen et al. [65] point out that the body-membrane-breaking application of vaccination may trigger purity-related concerns. They also found that perceiving the vaccination as impure fully mediated the link between purity moral foundation and vaccination status. Thus, the aversion to technological interventions deemed unnatural and invasive and the strong affirmation of naturalness, in general, may hint toward a strong moral foundation of purity that deserves further investigation.

General willingness to use the interventions appeared relatively low, especially for the unvaccinated participants (Fig. 9). Effects at the group level showed a considerable variation across intervention types and participants. Credible intervals of the ratings often overlapped, hindering a clear distinction between predicted ratings. However, we could identify a trend for the probability of the lowest rating. This may result from a general reluctance to use cognitive enhancement means [62, 70] and a moderate to strong negative attitude toward various phenomena related to Human Enhancement in general [41]. Moreover, unlike other studies [e.g., 51, 82, 83], we evaluated if participants would use the enhancement on themselves. There is evidence that people are reluctant to use enhancement for themselves while being more permissive to the use by others [47].

The final model employing interventions with parallel frequencies exhibited respectable predictive capabilities, albeit with some shortcomings observed specifically among unvaccinated individuals and concerning extreme ratings.

Interactions between vaccination status and naturalness attitude predicted attitudes toward Human Enhancement and vaccination across several models. Explained variance was consistently higher for attitude toward vaccination, probably due to the close association with vaccination status. The interaction effects further support our hypothesis that a stronger emphasis on naturalness is one link between the rejection of vaccinations and attitude toward Human Enhancement. However, this association was not as certain when predicting attitudes toward Human Enhancement.

The predictive power of ratings of vaccination, as an example of Human Enhancement, on attitude toward vaccination and Human Enhancement was inconsistent or relatively weak (See Supplementary). Given the possibilities of interferences due to contemplating vaccination as an instance of Human Enhancement, we have no conclusive evidence for the claim that participants reject/accept vaccination due to classifying it as Human Enhancement. Having a particular attitude toward vaccination and contemplating whether it is Human Enhancement directly intertwines the two assessments. There may be some association, but overall, vaccination was not classified as a prime example of Human Enhancement. Affirmation or rejection of the two phenomena must not necessarily stem from explicit conceptualization. One can reject vaccination without knowing about Human Enhancement or be affirmative to the prospect of cognitive enhancement without acknowledging that vaccination is Human Enhancement. Still, what may link the evaluation of vaccination and Human Enhancement may be a set of underlying, fundamental beliefs. This is consistent with the observation that one general factor can explain over half of the variance in the willingness to use various Human Enhancement associated means [33] and the idea of anti-vaccination attitude roots [20].

Given the cross-sectional nature of our studies, inferring effects are possible. We can not rule out that vaccinated participants' attitudes toward vaccination changed after receiving the vaccine. Suggesting some form of post-hoc reasoning, an alternative model predicting the attitude toward vaccination suggests that among vaccinated participants, attitude toward Human Enhancement was less important than naturalness attitude, the positive effects of vaccination status, and identification with vaccination status. Especially those who endorse vaccination the highest may have experienced strengthened confidence in vaccination throughout the pandemic [84]

Vaccinations seemingly modulate the relationship toward oneself and the environment. Vaccinated participants reported that their feeling of safety improved after receiving the vaccine. Seemingly trivial, these findings exemplify that Human Enhancement can transform risk perception [2] and can yield an adaptation to a hazardous environment [5]. Interestingly, vaccinated people, although better protected against the disease [85, 86], reported no differing feelings of vulnerability compared to unvaccinated people. In addition, unvaccinated participants reported being more relaxed. Reports of decreasing immune protection combined with the back-then dominance of virus variant B.1.1.529 ("Omicron") in Germany may have fostered increased concerns among vaccinated people. Our data suggest that receiving a vaccination does not render the virus perception-wise harmless. A decrease is not an elimination but must first be understood relative to an individual baseline, which may differ between vaccinated and unvaccinated and may be hard to decrease due to general carelessness.

Discriminatory disease containment measures may have contributed to increased feelings of being left out reported by unvaccinated participants. In that case, getting not enhanced modulates the relation to the social environment. Possible social influence, coercion, and division are prevalent topics in the Human Enhancement debate [26, 27, 40, 70, 71, 87, 88]. Any so-experienced coercion to enhance, regardless of origin, can directly interfere with the subjective notion of autonomy and bodily integrity. The sometimes violent and aggressive civic protest of opponents of disease control measures and vaccination can be interpreted as the counter-reaction to a social and political environment to which the unvaccinated do not want to adapt with the help of Human Enhancement [see 5].

Models predicting vaccination intention suggested a negative effect of naturalness attitude for unvaccinated participants. However, the limited number of unvaccinated participants intending to receive the vaccine rendered the generalizability of this effect unclear. Visual inspection also suggests the universal effect of attitude toward vaccinations and the support of disease control measures when predicting vaccine intention and the exact number of desired doses. In the latter case, the naturalness attitude had no effect. Probably because these analyses only featured individuals that were already vaccinated. Logically, those most concerned about their safety engage in the most protective behavior and higher adherence to health measures [89]. Therefore, the positive effect of supporting disease control measures in predicting vaccination intention may reflect one's perception of the virus's severity.

The design of the first study could not reveal if participants rejected the SARS-CoV-2 vaccine *because* they deemed it unnatural and invasive. Our second study aimed at addressing this gap and revealed that unvaccinated participants evaluated the vaccine against SARS-CoV-2 as less natural, safe, and efficient but similarly invasive as vaccinated participants. Nevertheless, perceived unnaturalness and moderate invasiveness were cited as somewhat equally influential in the decision not to be vaccinated as the perceived lack of safety and efficacy. Although individual vaccine hesitancy is a multifactorial phenomenon [14, 21, 90], the acceptance of SARS-CoV-2 vaccination appears to be closely tied to confidence in the vaccine's safety and effectiveness. Conversely, vaccine rejection also seems linked to the belief that the vaccine is unnatural, with a particular emphasis on this perception and concerns regarding invasiveness. We present meaningful associations of individual vaccine hesitancy that align with previous theoretical and empirical insights.

Affirmative attitudes toward naturalness do not simply change because one gets vaccinated, but they seem to play an important gatekeeping role in the decision per se. This effect seems to transpire to other instances of Humen Enhancement and hinges on the technological intervention's perceived features.

6.1 Limitations and directions for future research

The unvaccinated participants in our studies were also targeted through Facebook groups deemed critical to disease control measures. It is unclear if the members of the respective groups are representative of other unvaccinated participants, but also how many were redirected from the groups. Ubiquitous advertisements to receive the vaccination, a discourse that put heavy pressure on everybody to get vaccinated, and the fact that at the time of the first study, 85% of the German population above 18 years were vaccinated at least once [69] suggests that the remaining ~ 15% unvaccinated persons are likely to represent an ideological hard kernel. Still, the applicability of our results to vaccine hesitancy beyond a global pandemic, especially during the early stages of a vaccination campaign against another disease, is restricted. Comparison between unvaccinated persons who are and are not engaged in the public anti-vaccination movement remains an interesting topic for future research. Future research should also investigate the relation between conspiracy theories and a certain appeal to natural immunity [56, 80].

We do not know if the attitude toward vaccination was already low before the pandemic or if the ubiquitous discussion of this issue has polarized vaccinated and unvaccinated. Data sampling for the second study occurred in May 2023, when COVID-19 had practically disappeared from the German public discourse. This may have influenced the assessment of reasons for vaccination behavior.

Overall, the evidence for our hypotheses is weakened by the correlative and cross-sectional operationalization of the study that allows for no causal inference. Moreover, some participants may not be vaccinated for medical reasons or have just recovered from the disease.

There might be a cultural bias to our findings, especially when assessing the attitude toward phenomena like anthroposophy and alternate healing practitioners that has an influential tradition in Germany (Supplementary). Given the relatively small sample size, including the low prevalence of people who have received only one dose, and the possible bias, it is recommended that future studies employ larger cross-cultural samples.

Employed items were not part of a preexisting psychometric instrument and should be tested for validity. This especially concerns measurements of naturalness attitude. Within the first study, items directly referring to the vaccination's effect are of limited use when answered by unvaccinated participants. Future studies should make sure to attune item formulation to unvaccinated participants better. The drop in internal consistency when excluding logically inconsistent items of the vaccination status scale further urges psychometric inquiry.

Besides the adoption of vaccination, our fictional scenarios only assessed willingness to use methods for cognitive enhancement, which is just one subfraction of Human Enhancement. Linking our findings to factual engagement with cognitive enhancement or other enhancement types other than vaccination seems promising. When assessing the willingness to use a method for cognitive enhancement, interventions should be more balanced and presented more realistically. A scenario in which side effects of the administration of plant-based drugs are communicated to have the same potential side effects as brain surgery demands improvement.

Perceptions of vaccines' invasiveness and naturalness require further investigation. This may be done by experimentally manipulating the administration method in hypothetical scenarios or comparing historical vaccine uptake data concerning the administration method (nasal vs. injection vs. oral). Studies should also examine if there is any difference in the perception depending on the vaccination mechanism. Still, concrete vaccination behavior is a problem difficult to study in a laboratory and experimental context. Quantitative measures should be enriched by qualitative accounts that elaborate more deeply on the individual motives and conceptual understandings [e.g., 15, 91].

7 Conclusion

As deadly viruses like SARS-CoV-2 continue to exist and will develop in the future, humanity's environment poses threats we are not fully adapted to. Rather than relying solely on external disease control measures, people have been adapting to potentially dangerous environments through vaccination for about three centuries. The reluctance to adopt this adaptive enhancement strategy, executed rapidly with innovative technology, appears to correlate with a heightened repugnance to accept interventions viewed as invasive and unnatural. This suggests that skepticism of the particular can transpire to rejection of the general. Rejecting vaccination can have fatal consequences, as the struggle against

pandemics demands collaborative action and compliance with disease control measures [92]. Our studies provided initial evidence of aspects worth exploring further when planning future vaccination campaigns and other efforts to mass distribute Human Enhancement.

Acknowledgements NAD wants to thank Dorothee Busch for her support in preparing this manuscript and the idea sparking discussions on this issue. Thanks to Alexander (Sasha) Pastukhov for his helpful and encouraging comments on the work process. Many thanks to the anonymous reviewers for their helpful criticism. The authors would like to disclose the assistance of ChatGPT, a language model developed by OpenAI, during the revision. It was exclusively utilized for language and expression refinement and generated no novel ideas.

Author contributions NAD constructed the surveys, formulated items, analyzed the data, wrote the original draft, and revised the manuscript. CCC provided supervision over all processes. All authors read and approved the final manuscript.

Funding Open Access funding enabled and organized by Projekt DEAL. No funding involved.

Data availability The datasets supporting the conclusions of this article are available in the OSF repository, 10. 17605/OSF.IO/HWK5Q—https://osf.io/hwk5q/

Code availability Not applicable.

Declarations

Ethics approval and consent to participate The study was in full accordance with the ethical guidelines of the University of Bamberg. It was approved by an umbrella evaluation for psychophysical testing of the University of Bamberg ethics committee (Ethikrat der Universität Bamberg) on August 18, 2017. All participants were informed about their data protection rights and approved the usage of their data prior to the questionnaire. Written informed consent was obtained from all participants.

Consent for publication Not applicable.

Competing interests The authors declare that they have no competing interests.

References

1. Döbler NA, Carbon C-C. Vaccination against SARS-CoV-2: a human enhancement story. Transl Med Commun. 2021. https://doi.org/10.1186/s41231-021-00104-2.
2. Coeckelbergh M. Human being @ risk: Enhancement, technology, and the evaluation of vulnerability transformations: Springer; 2013.
3. Coeckelbergh M. Human development or human enhancement? A methodological reflection on capabilities and the evaluation of information technologies. Ethics Inf Technol. 2011;13:81–92. https://doi.org/10.1007/s10676-010-9231-9.
4. Hauskeller M. Better humans? Understanding the enhancement project. Durham: Acumen; 2013.
5. Döbler NA, Carbon C-C. Adapting Ourselves, Instead of the environment: An inquiry into human enhancement for function and beyond. Integr Psychol Behav Sci. 2023. https://doi.org/10.1007/s12124-023-09797-6.
6. Buchanan AE. Beyond humanity? The ethics of biomedical enhancement. Oxford: Oxford Univ. Press; 2011.
7. Agar N. Humanity's end: Why we should reject radical enhancement. Cambridge: MIT Press; 2010.
8. Bostrom N. Why I want to be a posthuman when I grow up. In: More M, Vita-More N, editors. The transhumanist reader. Chichester: John Wiley & Sons; 2013. p. 28–53.
9. President's Council on Bioethics. Beyond therapy: Biotechnology and the pursuit of happiness.
10. Robert Koch-Institut. COVID-19-Impfungen_in_Deutschland/Archiv /2023-04-05_Deutschland_Impfquoten_COVID-19.csv. 2023. https://github.com/robert-koch-institut/COVID-19-Impfungen_in_Deutschland/blob/140f419ae81dc19dbe741ef8fc6d7231f752f2d4/Archiv/2023-04-05_Deutschland_Impfquoten_COVID-19.csv. Accessed 12 May 2023.

11. World Health Organization. WHO/Europe Covid-19 vaccine programme monitor. 2023. https://worldhealthorg.shinyapps.io/EURO_COVID-19_vaccine_monitor/. Accessed 3 Jan 2023.
12. Rossen I, Hurlstone MJ, Dunlop PD, Lawrence C. Accepters, fence sitters, or rejecters: moral profiles of vaccination attitudes. Soc Sci Med. 2019;224:23–7. https://doi.org/10.1016/j.socscimed.2019.01.038.
13. Trzebiński W. How perceiving vaccines as 'natural' shapes vaccination attitudes: a worldview perspective. In: Wojtysiak-Kotlarski M, Pietrasieński P, Marciniak B, editors. Entrepreneurship, economic development and public policy in the post-pandemic world. Warszawa: SGH Oficyna Wydawnicza; 2022. p. 29–35.
14. Browne M. Epistemic divides and ontological confusions: the psychology of vaccine scepticism. Hum Vaccin Immunother. 2018;14:2540–2. https://doi.org/10.1080/21645515.2018.1480244.
15. Ditlevsen K, Glerup C, Sandøe P, Lassen J. Synthetic livestock vaccines as risky interference with nature? Lay and expert arguments and understandings of "naturalness." Public Underst Sci. 2020;29:289–305. https://doi.org/10.1177/0963662520906083.
16. Jee BD, Uttal DH, Spiegel A, Diamond J. Expert-novice differences in mental models of viruses, vaccines, and the causes of infectious disease. Public Underst Sci. 2015;24:241–56. https://doi.org/10.1177/0963662513496954.
17. Carbon C-C. Good, bad and ugly genes? Science matters, also in terms of terminology and word usage. Open Psychol. 2021. https://doi.org/10.1515/psych-2020-0109.
18. Scheske C, Schnall S. The ethics of "Smart Drugs": moral judgments about healthy people's use of cognitive-enhancing drugs. Basic Appl Soc Psychol. 2012;34:508–15. https://doi.org/10.1080/01973533.2012.711692.
19. Sharif S, Guirguis A, Fergus S, Schifano F. The use and impact of cognitive enhancers among university students: a systematic review. Brain Sci. 2021. https://doi.org/10.3390/brainsci11030355.
20. Fasce A, Schmid P, Holford DL, Bates L, Gurevych I, Lewandowsky S. A taxonomy of anti-vaccination arguments from a systematic literature review and text modelling. Nat Hum Behav. 2023. https://doi.org/10.1038/s41562-023-01644-3.
21. Betsch C, Schmid P, Heinemeier D, Korn L, Holtmann C, Böhm R. Beyond confidence: development of a measure assessing the 5C psychological antecedents of vaccination. PLoS ONE. 2018;13:e0208601. https://doi.org/10.1371/journal.pone.0208601.
22. Tomljenovic H, Bubic A, Erceg N. It just doesn't feel right—the relevance of emotions and intuition for parental vaccine conspiracy beliefs and vaccination uptake. Psychol Health. 2020;35:538–54. https://doi.org/10.1080/08870446.2019.1673894.
23. Daniels N. Normal functioning and the treatment-enhancement distinction. Camb Q Healthc Ethics. 2000;9:309–22. https://doi.org/10.1017/S0963180100903037.
24. Allenby BR, Sarewitz DR. The techno-human condition. Cambridge: MIT Press; 2011.
25. Gyngell C, Selgelid MJ. Human enhancement: conceptual clarity and moral significance. In: Clarke S, Savulescu J, Coady T, Giubilini A, Sanyal S, editors. The ethics of human enhancement. Oxford: Oxford University Press; 2016. p. 111–26. https://doi.org/10.1093/acprof:oso/9780198754855.003.0008.
26. Greely HT. Regulating human biological enhancements: Questionable justifications and international complications. Santa Clara J Int Law. 2006;4:87–110.
27. Allhoff F, Lin P, Moor J, Weckert J. Ethics of human enhancement: 25 Questions & answers. Stud Ethics Law Technol. 2010;4:1–39. https://doi.org/10.2202/1941-6008.1110.
28. Bostrom N, Sandberg A. Cognitive enhancement: methods, ethics, regulatory challenges. Sci Eng Ethics. 2009;15:311–41.
29. Döbler NA, Bartnik C. Normative affordances through technology: a postphenomenological perspective. In: de Paz Santana JF, de La Iglesia DH, López Rivero AJ, editors. New trends in disruptive technologies, tech ethics and artificial intelligence. Cham: Springer International Publishing; 2022. p. 145–56. https://doi.org/10.1007/978-3-030-87687-6_15.
30. Dupuy J-P. Cybernetics is antihumanism: advanced technologies and the rebellion against the human condition. In: Hansell GR, Grassie W, editors. H± transhumanism and its critics. Philadelphia: Xlibris; 2011. p. 227–48.
31. Kass LR. Ageless bodies, happy souls: biotechnology and the pursuit of perfection. The New Atlantis. 2003;1:9–28.
32. Kotze M. The theological ethics of human enhancement: Genetic engineering, robotics and nanotechnology. In die Skriflig/In Luce Verbi. 2018. https://doi.org/10.4102/ids.v52i3.2323.
33. Schönthaler EMD, Hofer G, Grinschgl S, Neubauer AC. Super-Men and Wonder-Women: the relationship between the acceptance of self-enhancement, personality, and values. J Cogn Enhancement. 2022. https://doi.org/10.1007/s41465-022-00244-9.
34. Fukuyama F. Transhumanism. 2009. https://foreignpolicy.com/2009/10/23/transhumanism/. Accessed 3 Aug 2023.
35. Browne TK, Clarke S. Bioconservatism, bioenhancement and backfiring. J Moral Educ. 2020;49:241–56. https://doi.org/10.1080/03057240.2019.1576125.
36. Persson I, Savulescu J. Unfit for the future: the need for moral enhancement. Oxford: Oxford University Press; 2012.
37. Grewal D, Kroschke M, Mende M, Roggeveen AL, Scott ML. Frontline cyborgs at your service: how human enhancement technologies affect customer experiences in retail, sales, and service settings. J Interact Mark. 2020;51:9–25. https://doi.org/10.1016/j.intmar.2020.03.001.
38. Ministry of Defence. Human augmentation—the dawn of a new paradigm: A strategic implications project; 2020.
39. Bickford A. "Kill-Proofing" the soldier. Curr Anthropol. 2019;60:S39–48. https://doi.org/10.1086/700028.
40. Schelle KJ, Faulmüller N, Caviola L, Hewstone M. Attitudes toward pharmacological cognitive enhancement-a review. Front Syst Neurosci. 2014;8:53. https://doi.org/10.3389/fnsys.2014.00053.
41. Dijkstra AM, Schuijff M. Public opinions about human enhancement can enhance the expert-only debate: a review study. Public Underst Sci. 2016;25:588–602. https://doi.org/10.1177/0963662514566748.
42. Kostick-Quenet K, Kalwani L, Koenig B, Torgerson L, Sanchez C, Munoz K, et al. Researchers' ethical concerns about using adaptive deep brain stimulation for enhancement. Front Hum Neurosci. 2022. https://doi.org/10.3389/fnhum.2022.813922.
43. Sample M, Sattler S, Blain-Moraes S, Rodríguez-Arias D, Racine E. Do publics share experts' concerns about brain-computer interfaces? A trinational survey on the ethics of neural technology. Sci Technol Human Values. 2020;45:1242–70. https://doi.org/10.1177/0162243919879220.
44. Sample M, Boehlen W, Sattler S, Blain-Moraes S, Racine E. Brain-computer interfaces, inclusive innovation, and the promise of restoration: a mixed-methods study with rehabilitation professionals. Engaging STS. 2022. https://doi.org/10.17351/ests2022.961.

45. Mitrović V. Double effects of the pandemic (corona). Sociološki pregled. 2020;54:609–26. https://doi.org/10.5937/socpreg54-27764.
46. Hansell GR, Grassie W, editors. H± transhumanism and its critics. Philadelphia: Xlibris; 2011.
47. Conrad EC, Humphries S, Chatterjee A. Attitudes toward cognitive enhancement: the role of metaphor and context. AJOB Neurosci. 2019;10:35–47. https://doi.org/10.1080/21507740.2019.1595771.
48. Marteau T, Michie S, Drake H, Bobrow M. Public attitudes towards the selection of desirable characteristics in children. J Med Genet. 1995;32:796–8. https://doi.org/10.1136/jmg.32.10.796.
49. Meier BP, Dillard AJ, Osorio E, Lappas CM. A behavioral confirmation and reduction of the natural versus synthetic drug bias. Med Decis Making. 2019;39:359–69. https://doi.org/10.1177/0272989X19838527.
50. Mihailov E, Rodríguez López B, Cova F, Hannikainen IR. How pills undermine skills: moralization of cognitive enhancement and causal selection. Conscious Cogn. 2021;91:103120. https://doi.org/10.1016/j.concog.2021.103120.
51. Haslam M, Yaden D, Medaglia JD. Moral framing and mechanisms influence public willingness to optimize cognition. J Cogn Enhanc. 2021;5:176–87. https://doi.org/10.1007/s41465-020-00190-4.
52. Ebrahimi OV, Johnson MS, Ebling S, Amundsen OM, Halsøy Ø, Hoffart A, et al. Risk, trust, and flawed assumptions: vaccine hesitancy during the COVID-19 pandemic. Front Public Health. 2021;9:700213. https://doi.org/10.3389/fpubh.2021.700213.
53. Martin LR, Petrie KJ. Understanding the dimensions of anti-vaccination attitudes: the Vaccination Attitudes Examination (VAX) Scale. Ann Behav Med. 2017;51:652–60. https://doi.org/10.1007/s12160-017-9888-y.
54. Meier BP, Dillard AJ, Lappas CM. Predictors of the intention to receive a SARS-CoV-2 vaccine. J Public Health (Oxf). 2021. https://doi.org/10.1093/pubmed/fdab013.
55. Dibonaventura MD, Chapman GB. Do decision biases predict bad decisions? Omission bias, naturalness bias, and influenza vaccination. Med Decis Making. 2008;28:532–9. https://doi.org/10.1177/0272989X07312723.
56. Žeželj I, Petrović M, Ivanović A, Kurčubić P. I trust my immunity more than your vaccines: "Appeal to nature" bias strongly predicts questionable health behaviors in the COVID-19 pandemic. PLoS ONE. 2023;18:e0279122. https://doi.org/10.1371/journal.pone.0279122.
57. Kata A. Anti-vaccine activists, Web 2.0, and the postmodern paradigm—an overview of tactics and tropes used online by the anti-vaccination movement. Vaccine. 2012;30:3778–89. https://doi.org/10.1016/j.vaccine.2011.11.112.
58. Kata A. A postmodern Pandora's box: anti-vaccination misinformation on the Internet. Vaccine. 2010;28:1709–16. https://doi.org/10.1016/j.vaccine.2009.12.022.
59. Siipi H. Dimensions of naturalness. Ethics Environ. 2008;13:71–103.
60. Curry O. Who's afraid of the naturalistic fallacy? Evol Psychol. 2006;4:234–47. https://doi.org/10.1177/147470490600400120.
61. Whitman D, Love J, Rainville G, Skufca L. U.S. public opinion & interest on human enhancement technology; 2018.
62. Sattler S, Pietralla D. Public attitudes towards neurotechnology: findings from two experiments concerning Brain Stimulation Devices (BSDs) and Brain-Computer Interfaces (BCIs). PLoS ONE. 2022;17:e0275454. https://doi.org/10.1371/journal.pone.0275454.
63. McLenon J, Rogers MAM. The fear of needles: a systematic review and meta-analysis. J Adv Nurs. 2019;75:30–42. https://doi.org/10.1111/jan.13818.
64. Hornsey MJ, Harris EA, Fielding KS. The psychological roots of anti-vaccination attitudes: a 24-nation investigation. Health Psychol. 2018;37:307–15. https://doi.org/10.1037/hea0000586.
65. Chen C, Cui Z, Chen Y. A randomized controlled trial of an information intervention to bolster COVID-19 vaccination intention among people with purity concerns. Health Psychol. 2023. https://doi.org/10.1037/hea0001295.
66. Bostrom N, Roache R. Ethical issues in human enhancement. In: Ryberg J, Petersen T, Wolf C, editors. New waves in applied ethics. Pelgrave Macmillan; 2008. p. 120–52.
67. Davies B. Enhancement and the Conservative Bias. Philos Technol. 2017;30:339–56. https://doi.org/10.1007/s13347-016-0245-z.
68. Racine E, Sattler S, Boehlen W. Cognitive enhancement: unanswered questions about human psychology and social behavior. Sci Eng Ethics. 2021;27:19. https://doi.org/10.1007/s11948-021-00294-w.
69. Robert Koch-Institut. COVID-19-Impfungen_in_Deutschland/Archiv /2022-01-14_Deutschland_Impfquoten_COVID-19.csv. https://github.com/robert-koch-institut/COVID-19-Impfungen_in_Deutschland/blob/master/Archiv/2022-01-14_Deutschland_Impfquoten_COVID-19.csv. Accessed 12 May 2023.
70. Sattler S, Forlini C, Racine E, Sauer C. Impact of contextual factors and substance characteristics on perspectives toward cognitive enhancement. PLoS ONE. 2013;8:e71452. https://doi.org/10.1371/journal.pone.0071452.
71. Sattler S, Mehlkop G, Graeff P, Sauer C. Evaluating the drivers of and obstacles to the willingness to use cognitive enhancement drugs: the influence of drug characteristics, social environment, and personal characteristics. Subst Abuse Treat Prev Policy. 2014;9:8. https://doi.org/10.1186/1747-597X-9-8.
72. Nachtwey O, Schäfer R, Frei N. Politische Soziologie der Corona-Proteste [Political sociology of corona protests]; 17.12.2020.
73. Bostrom N. The history of transhumanist thought. J Evol Technol. 2005;14.
74. Limesurvey GmbH. LimeSurvey: An Open Source survey tool. Hamburg; 2003.
75. Bürkner P-C. brms: an R Package for Bayesian multilevel models using Stan. J Stat Soft. 2017. https://doi.org/10.18637/jss.v080.i01.
76. Revelle W. psych: Procedures for psychological, psychometric, and personality research. 2021.
77. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed.; 1988.
78. Brown VA. An Introduction to Linear Mixed-Effects Modeling in R. Adv Methods Pract Psychol Sci. 2021;4:251524592096035. https://doi.org/10.1177/2515245920960351.
79. Patil I. Visualizations with statistical details: the 'ggstatsplot' approach. JOSS. 2021;6:3167. https://doi.org/10.21105/joss.03167.
80. Holford DL, Fasce A, Costello TH, Lewandowsky S. Psychological profiles of anti-vaccination argument endorsement. Sci Rep. 2023;13:11219. https://doi.org/10.1038/s41598-023-30883-7.
81. Moralfoundations.org. Questionnaires | Moral Foundations Theory. 04.08.2023. http://moralfoundations.org/questionnaires/. Accessed 4 Aug 2023.
82. Shakeel S, Iffat W, Qamar A, Butt F, Ghuman F, Ahsan Mallick I, et al. Concept generation of cognitive enhancement: healthcare professionals' approach towards the impact and utilization of cognitive enhancers in academic context. Heliyon. 2021;7:e08118. https://doi.org/10.1016/j.heliyon.2021.e08118.

83. Hotze TD, Shah K, Anderson EE, Wynia MK. "Doctor, would you prescribe a pill to help me… ?" A national survey of physicians on using medicine for human enhancement. Am J Bioeth. 2011;11:3–13. https://doi.org/10.1080/15265161.2011.534957.
84. Sobierajski T, Rzymski P, Wanke-Rytt M. Impact of the COVID-19 pandemic on attitudes toward vaccination: representative study of polish society. Vaccines (Basel). 2023. https://doi.org/10.3390/vaccines11061069.
85. Kow CS, Hasan SS. Real-world effectiveness of BNT162b2 mRNA vaccine: a meta-analysis of large observational studies. Inflammopharmacology. 2021;29:1075–90. https://doi.org/10.1007/s10787-021-00839-2.
86. Liu Q, Qin C, Liu M, Liu J. Effectiveness and safety of SARS-CoV-2 vaccine in real-world studies: a systematic review and meta-analysis. Infect Dis Poverty. 2021;10:132. https://doi.org/10.1186/s40249-021-00915-3.
87. Menuz V, Hurlimann T, Godard B. Is human enhancement also a personal matter? Sci Eng Ethics. 2013;19:161–77. https://doi.org/10.1007/s11948-011-9294-y.
88. Forlini C, Racine E. Autonomy and coercion in academic "cognitive enhancement" using methylphenidate: perspectives of key stakeholders. Neuroethics. 2009;2:163–77. https://doi.org/10.1007/s12152-009-9043-y.
89. DiMatteo MR, Haskard KB, Williams SL. Health beliefs, disease severity, and patient adherence: a meta-analysis. Med Care. 2007;45:521–8. https://doi.org/10.1097/MLR.0b013e318032937e.
90. Soares P, Rocha JV, Moniz M, Gama A, Laires PA, Pedro AR, et al. Factors associated with COVID-19 vaccine hesitancy. Vaccines (Basel). 2021. https://doi.org/10.3390/vaccines9030300.
91. Semle R, Raab MH. Da kann doch kein Mensch gesund bleiben. Gesundheitsbezogene Verschwörungstheorien in subjektiven Theorien über Gesundheit und Krankheit—eine Untersuchung mit der Heidelberger Struktur-Lege-Technik ["No one is supposed to stay healthy that way". Health-related conspiracy theories in subjective theories about health and disease—an investigation with the Heidelberg structure-formating technique]. Forum: Qualitative Sozialforschung. 2021;22.
92. Raab MH, Döbler NA, Carbon C-C. A Game of Covid: strategic thoughts about a ludified pandemic. Front Psychol. 2021. https://doi.org/10.3389/fpsyg.2021.607309.

Supplementary

General

We ran all models ran for four sample chains, 10,000 iterations each with 5,000 warm-up iterations. All models converged (*R*-hat < 1.05) [1]. We used rather uninformative priors due to missing knowledge about the adequacy of the items used here and the novel population and situation. All Data and models can be found in detail here: DOI 10.17605/OSF.IO/HWK5Q / https://osf.io/hwk5q/. To access models you need RStudio and the "read_rds" function of the "readr" package.

Contact: Niklas Döbler, niklas.doebler@uni-bamberg.de

Study 1

Current and planned doses

Table S1. **Detailed analysis of received and planned doses**

Received Doses	**Planned Doses**	***n***
0 Doses	0 Doses	54
0 Doses	Undecided	1
0 Doses	2 Doses	2
0 Doses	*NA*	1
1 Dose	2 Doses	1
1 Dose	3 Doses	2
1 Dose	As needed	1
2 Doses	Undecided	1
2 Doses	2 Doses	15
2 Doses	3 Doses	42
2 Doses	As needed	4
2 Doses	*NA*	3
3 Doses	Undecided	1
3 Doses	3 Doses	88
3 Doses	3+	20
3 Doses	As needed	69
3 Doses	*NA*	9

Table S2. Received Number of Vaccine Doses

	0 Doses (*n*=58)	1 Dose (*n*=4)	2 Doses (*n*=65)	3 Doses (*n*=187)	Overall (*n*=314)
More doses?					
No (Equal)	54 (93.1%)	0 (0%)	15 (23.0%)	88 (47.1%)	157 (50.0%)
More	2 (3.4%)	4 (100%)	46 (70.8%)	89 (47.6%)	141 (44.9%)
NA	2 (3.4%)	0 (0%)	4 (6.2%)	10 (5.3%)	16 (5.1%)

Note. People undecided about their future vaccination status were coded as *NA*.

Enhancement ratings:

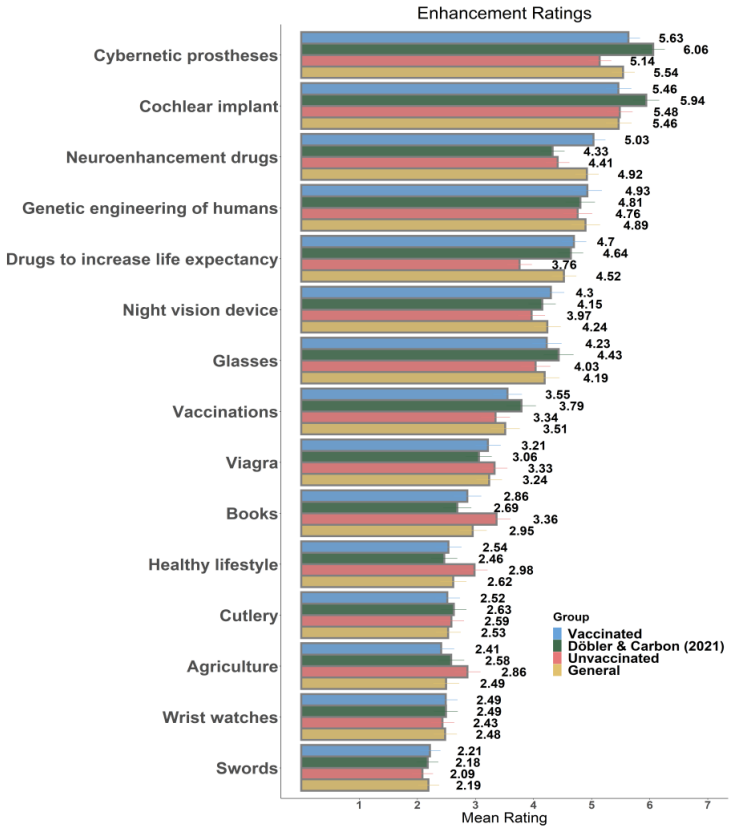


Figure S1. Enhancement ratings. Error bars indicate 95% Confidence Intervals (CIs). Döbler and Carbon (2021) used the same examples [2].

In the former study, participants were given an exemplary definition "Human enhancement can be defined as the improvement of humans by technological means" [3], while in the present study, they were only told that this term has no standard definition but that it generally refers to technologies that help expand people's abilities.

Among vaccinated participants, ratings of vaccinations as an example of Human Enhancement and feelings of being technologically enhanced correlated positively, $t_{(254)} = 5.25$, $p < .001$, $r = 0.31$ [0.20,0.42]

Compared to our earlier study [2], mean ratings of neuroenhancement drugs, $t_{(379)} = -2.39$, $p = .017$, $d = -0.32$ [-0.59,-0.06], and cybernetic prostheses, $t_{(379)} = 2.17$, $p = .031$, $d = 0.29$ [0.03,0.57], were lower, respectively higher than in the present study.

Discussion:

There were no differences in these ratings across vaccination status groups, except in terms of Drugs to increase life expectancy and drugs to enhance cognitive functioning. These enhancements were rated as less exemplary while also being considered crucial for the "Enhancement Project" and the desire to radically emancipate from the human condition [4–6]. While there are reasons to reject radically enhanced cognitive functions based on a "conservative bias" that values the status quo more than a promised, more valuable future condition, radical life expectancy enhancement cannot be rejected on the same ground [7]. Further research should investigate which conceptualization of Human Enhancement is publicly predominant.

Vaccinated participants reported feeling more technologically enhanced. Unvaccinated participants are unlikely to affirm this statement, as it indirectly refers to being vaccinated. However, one must note the low affirmation of this statement among vaccinated individuals and the possibility of a confounding effect due to asking whether participants consider vaccinations as Human Enhancement. Ratings of vaccinations as examples of Human Enhancement and feelings of being technologically enhanced correlated moderately positively among vaccinated participants.

Enhancement examples:

Participants also had the opportunity to state which enhancement they are using in their daily lives. We categorized the answers but refrained from reporting them in the manuscript after critically assessing the possibility that the examples were confounded with the enhancement ratings question. The respective data is provided in the OSF.

Willingness to use

We chose a cumulative mixed-model Bayesian ordered logistic regression to account for the highly non-normal distribution of Use ratings (Figure 1). Unlike other surveys, the intervention characteristics were rated by the participants themselves and were not pre-set by the researchers (besides frequency of application). The interaction terms were implemented to reflect the hypothesized different salience of attributes. The density of willingness to use and thresholds suggests that people are generally more adverse to using the enhancement at all. Similar findings are reported by Sattler et al. [8]. Priors for the predictors: N(0,2). Thresholds and *SD* = Student's *t*-distribution, $\nu = 3$, $\mu = 0$, $\sigma = 2.5$. Values were non-scaled and not centered due to the necessity for the outcome to be a positive value. Priors were chosen to reflect this.

The following pages feature more detailed information about the models presented in the manuscript. First, those that assessed all possible interventions and then those that only used the ones with parallel frequencies.

Table S3. Mean and standard deviations of used examples (All participants – First Study)

Example	Use Mean	Use *SD*	Invasiveness Mean	Invasiveness *SD*	Naturalness Mean	Naturalness *SD*
Daily Administration of a drug in the form of pills	3.50	2.22	4.70	1.86	2.23	1.44
Daily Administration of a plant-based drug	3.98	2.15	4.04	1.82	3.96	1.78
Daily Injection of a drug into the arm	2.41	1.79	5.54	1.60	1.90	1.33
Daily Meditation	4.57	2.05	2.42	1.87	5.66	1.71
Special raw food diet	3.53	1.86	2.69	1.66	5.03	1.65
Once Completion of a cognitive training program	5.26	1.65	2.34	1.57	5.22	1.54
Once Administration of a drug in the form of pills	4.72	2.35	3.84	2.00	2.63	1.56
Once Administration of a plant-based drug	5.30	2.07	3.18	1.82	4.54	1.76
Once Brain surgery	1.86	1.43	6.76	0.87	1.36	0.97
Once Implantation of an electronic device into the brain	2.10	1.58	6.70	0.99	1.27	0.92
Once Injection of a drug into the arm	4.50	2.42	4.47	1.88	2.36	1.48

Table S4. Estimates of willingness to use an intervention to boost cognitive performance

	All Interventions														
	Model 1			Model 2			Model 3			Model 4			Model 5		
Predictor	Odds ratio (OR; Median)	95% Credible Interval (CI)	pd	OR	95%CI	pd	OR	95%CI	pd	OR	95%CI	pd	OR	95%CI	pd
Perceived invasiveness	0.76	0.72 – 0.81	100%	0.76	0.72 – 0.80	100%	0.59	0.52 – 0.66	100%	0.59	0.52 – 0.67	100%	0.59	0.52 – 0.67	100%
Perceived naturalness	1.61	1.52 – 1.71	100%	2.53	2.29 – 2.80	100%	2.23	1.99 – 2.50	100%	2.23	1.99 – 2.51	100%	2.24	2.00 – 2.52	100%
Attitude Human Enhancement	1.44	1.23 – 1.68	100%	1.48	1.27 – 1.73	100%	1.47	1.25 – 1.72	100%	1.41	1.06 – 1.89	99.10%	1.41	1.05 – 1.88	98.60%
Naturalness attitude	0.97	0.94 – 0.99	99.20%	0.96	0.94 – 0.99	99.50%	0.97	0.94 – 0.99	99.40%	0.96	0.94 – 0.99	99.40%	0.96	0.90 – 1.01	92.30%
Vaccinated	2.24	1.25 – 4.06	99.70%	16.56	8.11 – 34.25	100%	2.8	1.01 – 7.83	97.60%	2.31	0.45 – 11.09	84.40%	1.77	0.13 – 24.39	66.20%
Vaccinated x Perceived naturalness				0.57	0.51 – 0.62	100%	0.66	0.59 – 0.75	100%	0.66	0.59 – 0.75	100%	0.66	0.58 – 0.75	100%
Vaccinated x Perceived invasiveness							1.37	1.20 – 1.56	100%	1.37	1.20 – 1.56	100%	1.37	1.20 – 1.56	100%
Vaccinated x Att. Human Enhancement										1.06	0.76 – 1.47	62.60%	1.06	0.76 – 1.48	63.40%
Vaccinated x Naturalness attitude													1.01	0.95 – 1.07	59.50%
Frequent Use	0.72	0.08 – 6.86	62.20%	0.78	0.08 – 8.19	58.50%	0.83	0.07 – 9.45	56.10%	0.81	0.07 – 9.18	56.90%	0.8	0.08 – 9.11	57.20%
One-Time Use	5.31	4.40 – 6.43	100%	5.84	4.82 – 7.10	100%	6.11	5.02 – 7.40	100%	6.1	5.05 – 7.40	100%	6.1	5.04 – 7.38	100%
Group-level effects															
sd(Intervention type)	3.34	2.07 - 10.10		3.76	2.24 - 12.88		4.03	2.33 - 17.15		4.04	2.31 - 14.49		3.99	2.32 - 14.49	
sd(Participant)	5.47	4.64 - 6.62		5.75	4.86 - 6.69		5.81	4.91 - 7.05		5.84	4.92 - 7.07		5.83	4.91 - 7.06	
LOO-information criterion	9,615.2 (112.0)			9,467.4 (114.1)			9,447.9 (113.3)			9,447.7 (113.4)			9,448.7 (113.4)		
	Interventions with parallel frequencies														
	Model 6			Model 7			Model 8			Model 9			Model 10		
Predictor	OR	95%CI	pd	OR	95%CI	pd	OR	95%CI	pd	OR	95%CI	pd	OR	95%CI	pd
Perceived invasiveness	0.63	0.56 – 0.70	100 %	0.63	0.57 – 0.70	100%	0.51	0.41 – 0.64	100%	0.52	0.41 – 0.65	100%	0.55	0.43 – 0.69	100%
Perceived naturalness	1.87	1.68 – 2.09	100 %	3.2	2.66 – 3.87	100%	2.99	2.44 – 3.68	100%	3.03	2.48 – 3.73	100%	3.15	2.55 – 3.93	100%
Attitude Human Enhancement	1.84	1.39 – 2.44	100 %	1.9	1.43 – 2.54	100%	1.88	1.41 – 2.53	100%	1.42	0.86 – 2.29	91.40%	1.44	0.87 – 2.37	92.20%
Naturalness Attitude	0.94	0.90 – 0.99	99 %	0.93	0.89 – 0.98	99.70%	0.93	0.89 – 0.98	99.50%	0.93	0.89 – 0.98	100%	0.88	0.81 – 0.97	99.70%
Vaccinated	7.8	2.83 – 22.83	100 %	58.65	17.42 – 208.26	100%	16.12	2.89 – 91.25	99.90%	4.82	0.39 – 51.82	89%	0.85	0.03 – 23.44	53.70%
Vaccinated x Perceived naturalness				0.5	0.41 – 0.60	100%	0.54	0.43 – 0.67	100%	0.53	0.43 – 0.66	100%	0.51	0.41 – 0.64	100%
Vaccinated x Perceived invasiveness						100%	1.29	1.01 – 1.66	98%	1.26	0.99 – 1.62	96.80%	1.2	0.92 – 1.56	91.10%
Vaccinated x Att. Human Enhancement										1.47	0.86 – 2.51	92.20%	1.39	0.81 – 2.43	88.70%
Vaccinated x Naturalness attitude													1.07	0.98 – 1.18	93%
One-Time Use	10.9	8.48 – 14.03	100 %	12.18	9.45 – 15.76	100%	12.66	9.82 – 16.44	100%	12.72	9.81 – 16.50	100%	12.64	9.78 – 16.46	100%
Group-level effects															
sd(Intervention type)	1.8	1.23 - 10.86		1.87	1.25 - 9.65		1.92	1.26 - 12.67		1.94	1.26 - 20.76		1.88	1.25 - 12.38	
sd(Participant)	22.94	16.48 - 33.25		24.88	17.80 - 36.54		24.94	17.83 - 36.77		25.3	17.93 - 37.15		25.37	18.17 - 37.58	
LOO-information criterion	4,383.5 (88.6)			4,318.7 (89.9)			4,323.6 (89.9)			4,322.5 (89.9)			4,323.4 (90.3)		

Note. Information on the posterior distribution of the calculated mixed-model Bayesian ordered cumulative regression. Daily use and not being vaccinated were reference categories to the respective predictors. Priors for the predictors: N(0,2). Thresholds (not shown) and sd = Student's t-distribution, ν = 3, μ = 0, σ = 2.5 (brms default). Parallel frequency (Models 6-10) means that we included only those interventions that were explicitly recorded twice in terms of the required frequency of use (Daily or Once, see Table 1). In these models, no interventions needed "frequent" use. Number of data points for models 1-5 = 3,454; models 6-10 = 1,884. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0 (or one if converted to OR), as indicated by the coefficient median

Histograms for the willingness to use cognitive enhancement interventions

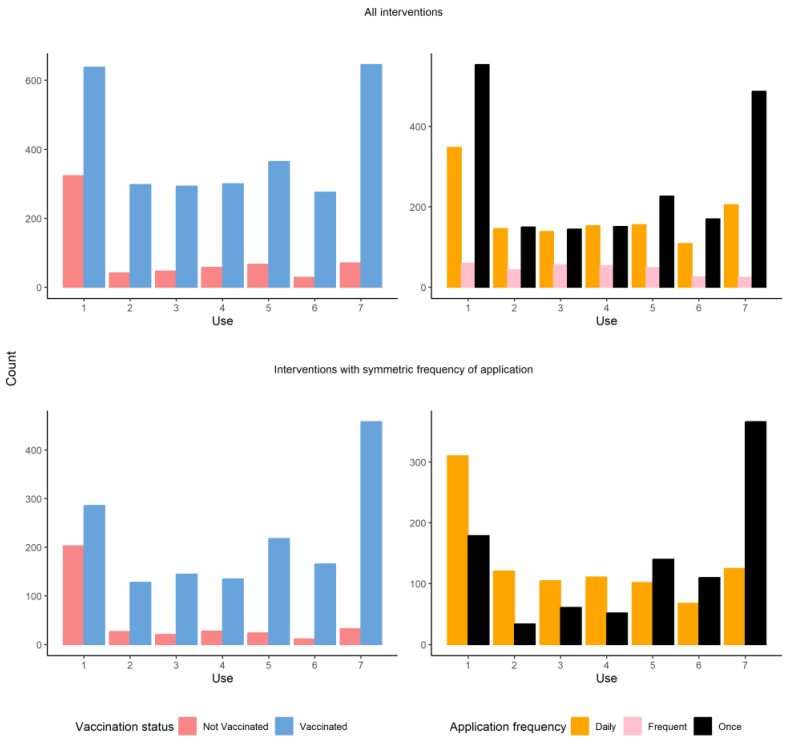


Figure S2. Figure S2: Ratings on "frequent" Enhancement Use are inevitably confounded with ratings on "Special raw food" diet, because this is the only example of this application frequency.

Analysis of the Attitude toward vaccination / Human Enhancement:

We chose vaccination status as a binary variable over the exact number of doses due to the small size of the "1 Dose group". Priors for the predictors were set as being informative $N(0,1)$. For the intercept, *brms's* default settings used a Student's t-distribution ($v = 3$, $\mu = 0.7$ and $\sigma = 2.5$), and for *SD*, a Student's *t*-distribution ($v = 3$, $\mu = 0$ and $\sigma = 2.5$). Family = Gaussian. *VIF* for all predictors < 10, with the exception of Model 5 (Attitude toward vaccination), where Enhancement Rating Vaccinations and Enhancement Rating Vaccinations x Vaccinated = *VIF* > 10.

When predicting attitudes toward Human Enhancement, our first models employed attitudes toward vaccination and vaccination status as predictors. Final version of these models displayed high signs of multicollinearity (*VIF* > 10 and evident visual correlation between predictor estimations). Hence we dropped the attitude toward vaccination because vaccination status was theorized to be the more fundamental measurement since it refers to concrete behavior.

Table S5. Outcome: Attitude toward Vaccination

	Model 1			Model 2			Model 3			Model 4			Model 5		
Predictors	**β (Median)**	**95% Credible Interval (CI)**	**pd**	**β**	**95%CI**	**pd**	**β**	**95%CI**	**pd**	**β**	**95%CI**	**pd**	**β**	**95%CI**	**pd**
Enhancement Rating Vaccinations	**0.02**	**[-0.04, 0.08]**	**73.50%**	**0.09**	**[-0.06, 0.23]**	**88.20%**	**0.05**	**[-0.01, 0.11]**	**93.90%**	**0.02**	**[-0.04, 0.09]**	**78.00%**	**0.16**	**[0.02, 0.30]**	**98.70%**
Attitude Human Enhancement	**0.09**	**[0.02, 0.16]**	**99.50%**	**0.1**	**[0.03, 0.17]**	**99.70%**	**0.32**	**[0.19, 0.44]**	**100.00%**	**0.08**	**[0.01, 0.15]**	**98.90%**	**0.28**	**[0.15, 0.42]**	**100.00%**
Vaccinated	**1.6**	**[1.42, 1.78]**	**100.00%**	**1.59**	**[1.41, 1.77]**	**100.00%**	**1.46**	**[1.27, 1.64]**	**100.00%**	**1.39**	**[1.17, 1.60]**	**100.00%**	**1.32**	**[1.10, 1.54]**	**100.00%**
Naturalness Attitude	**-0.28**	**[-0.35, -0.21]**	**100.00%**	**-0.28**	**[-0.35, -0.21]**	**100.00%**	**-0.28**	**[-0.35, -0.21]**	**100.00%**	**-0.53**	**[-0.70, -0.37]**	**100.00%**	**-0.44**	**[-0.61, -0.27]**	**100.00%**
ER Vaccinations x Vaccinated				**-0.08**	**[-0.25, 0.08]**	**84.40%**							**-0.14**	**[-0.30, 0.02]**	**95.80%**
Att. HE x Vaccinated							**-0.31**	**[-0.46, -0.16]**	**100.00%**				**-0.26**	**[-0.42, -0.10]**	**100.00%**
Naturalness Attitude x Vaccinated										**0.3**	**[0.12, 0.48]**	**100.00%**	**0.2**	**[0.02, 0.38]**	**98.40%**
R^2 Bayes		**0.7**			**0.7**			**0.72**			**0.71**			**0.72**	
LOO-information criterion		**524.7 (46.1)**			**526.4 (45.8)**			**510.7 (51.8)**			**515.9 (48.9)**			**508.7 (52.0)**	

Note. Information on the posterior distribution of the calculated Bayesian linear regression. Priors for the predictors: *N*(0,1). Intercept = Student's *t*-distribution, ν = 3, μ = 0.7, σ = 2.5 (*brms* default). Sd = Student's *t*-distribution, ν = 3, μ = 0, σ = 2.5 (*brms* default). Estimates are standardized effect sizes. LOO-information criterion (standard error in parentheses): Lower values indicate a better model fit. Each model ran four sampling chains, each with 1e4 iterations and 5,000 warm-up draws. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0, as indicated by the coefficient median

Table S6. Estimating Attitude toward Human Enhancement

	Model 1			Model 2			Model 3			Model 4			Model 5		
Predictors	**β (Median)**	**95%CI**	**pd**	**β**	**95%CI**	**pd**	**β**	**95%CI**	**pd**	**β**	**95%CI**	**pd**	**β**	**95%CI**	**pd**
Enhancement Rating Vaccinations	**0.17**	**[0.07, 0.27]**	**100.00%**	**-0.24**	**[-0.46, -0.01]**	**98.00%**	**0.17**	**[0.07, 0.27]**	**100.00%**	**-0.22**	**[-0.45, 0.01]**	**97.10%**	**-0.01**	**[-0.41, 0.39]**	**52.70%**
Vaccinated	**0.51**	**[0.22, 0.79]**	**100.00%**	**0.54**	**[0.26, 0.82]**	**100.00%**	**0.3**	**[-0.05, 0.65]**	**95.60%**	**0.38**	**[0.04, 0.72]**	**98.50%**	**0.36**	**[0.02, 0.70]**	**98.20%**
Naturalness Attitude	**-0.31**	**[-0.42, -0.20]**	**100.00%**	**-0.31**	**[-0.42, -0.20]**	**100.00%**	**-0.54**	**[-0.79, -0.29]**	**100.00%**	**-0.49**	**[-0.74, -0.24]**	**100.00%**	**-0.48**	**-0.73 – -0.24**	**100.00%**
ER Vaccinations x Vaccinated				**0.5**	**[0.24, 0.75]**	**100.00%**				**0.47**	**[0.23, 0.73]**	**100.00%**	**0.25**	**[-0.16, 0.66]**	**88.80%**
Naturalness Attitude x Vaccinated							**0.28**	**[0.01, 0.56]**	**97.70%**	**0.22**	**[-0.05, 0.50]**	**94.40%**	**0.21**	**[-0.05, 0.48]**	**89.90%**
ER Vaccinations x Naturalness Attitude													**-0.17**	**[-0.44, 0.10]**	**94.10%**
ER Vaccinations x Nat. Att x Vaccinated													**0.1**	**[-0.19, 0.38]**	**74.20%**
R^2 Bayes		**0.219**			**0.257**			**0.23**			**0.264**			**0.274**	
LOO-information criterion		**823.5 (26.00)**			**810.1 (25.7)**			**821.5 (25.8)**			**809.7 (25.7)**			**810.6 (25.8)**	

Note. Information on the posterior distribution of the calculated Bayesian linear regression. Priors for the predictors: N(0,1). Intercept = Student's t-distribution, ν = 3, μ = 0.7, σ = 2.5 (*brms* default). Prior for SD = Student's t-distribution, ν = 3, μ = 0, σ = 2.5 (*brms* default). Estimates are standardized effect sizes. LOO-information criterion (standard error in parentheses): Lower values indicate a better model fit. Each model ran four sampling chains, each with 1e4 iterations and 5,000 warm-up draws. CI = Credible interval. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0, as indicated by the coefficient median.

Table S7. Alternative model for attitude toward vaccination

Predictors	*Estimates*	*CI (95%)*	pd
Effect of vaccination status	0.23	0.14 – 0.33	100%
Improvement after first dose	0.00	-0.09 – 0.08	53.50%
Identification with vaccination status	0.07	0.01 – 0.14	98.70%
Naturalness attitude	-0.18	-0.24 – -0.11	100%
Attitude Human Enhancement	0.00	-0.07 – 0.07	51.40%
Observations		256 (Vaccinated only)	
R^2 Bayes		0.323	
LOO		338.7 (48.5)	

This model used the full effect of the vaccination status scale.

Discussion:

The non-predictive power of attitude toward Human Enhancement in this alternative model is concordant with the visual analysis of Model 5, that showed that the same variable seemingly only increased attitude toward vaccination for the unvaccinated participants. The interaction effect seemed to have canceled out the positive effect of attitude towards Human Enhancement. This suggests that unvaccinated tend to be more favorable to a specific biotechnological intervention when they are generally open to the improvement of human capabilities. It is unclear why we do not see a similar association among the vaccinated participants. One possibility would be a ceiling effect concerning the attitude toward vaccination among the vaccinated participants that diminishes the difference between those unfavorable against Human Enhancement and those with more affirmative attitudes.

Differences and distribution of items:

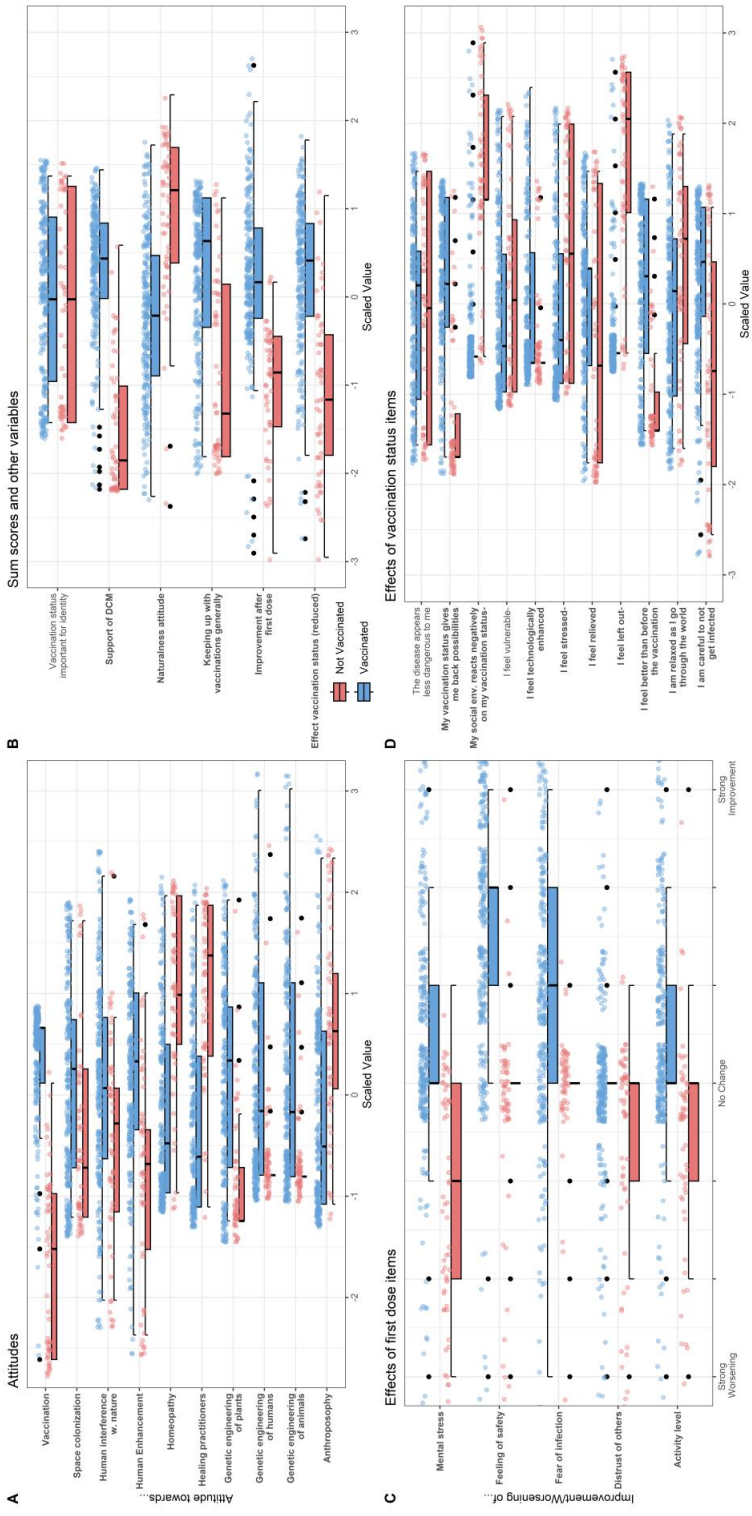


Figure S3 Differences between vaccinated and unvaccinated participants. Bold labels: differences are significant $p < .05$, and the credible interval of posterior differences does not include 0. Figure D: Minus sign behind questions denotes reverse coding. Values are scattered for visibility.

Wanting more doses of vaccine:

After testing for the assumed link between vaccination behavior Human Enhancement and perceived naturalness/invasiveness, we were interested in what drives vaccination intention, especially for already vaccinated and boostered participants. This interest emerged during the data analysis after recognizing that many people stated that they wanted to receive more than three doses (cf. Figure 1, Supplementary).

36.9% (69/187) of the boostered people reported getting as many doses as medically advised or needed. This is 77.5% (69/89) of all boostered participants that want to receive more doses. Out of the n = 65 with two doses, only n = 4 (6.2%) reported wanting more than three doses. We used Bayesian logistic regression to predict whether individuals plan to receive more vaccine doses, regardless of the exact intended amount, and excluded all participants whose intention was either not comprehensible or indecisive.

Due to the underrepresentation of some groups, models were employed using a different subset of the participants. This set either contained only unvaccinated participants, no participants that received one dose, all participants, or vaccinated only. We also calculated one model in which the received number of doses was the sole predictor.

As the exact number of received doses is of interest here, it was decided to implement the respective predictor, not the general vaccination status. The number of received doses was implemented as a factor to evaluate differences between the groups. Note that the 1 Dose group only contains four individuals. Priors for the predictors were set as being uninformative, normally distributed $N(0,1)$. For the intercept, the *brms* default settings used a Student's t-distribution ($\nu = 3$, $\mu = 0$, and $\sigma = 2.5$). Family = Bernoulli.

A model dropping attitude toward vaccination and the number of received doses had a poorer fit than the compared first model (Loo difference = -25.21 (5.8)). Credible intervals

around the estimated Odds ratio always included 1 in this model. The only exception was the Support of disease control measures OR = 3.31, $_{95\%}$CI [2.23, 5.10]. Since more differs depending on already received doses, we employed the exact number as a predictor but acknowledged that the one-dose group is very small.

Table S8. Predicting the plan to get more doses of vaccine

	Model 1			**Model 2**			**Model 3**			**Model 4**			**Model 5**		
Sample	Unvaccinated only			No participants that received one dose			All participants			Vaccinated only			All participants		
Predictors	OR	CI (95%)	pd	OR	CI (95%)	pd	OR	CI (95%)	pd	OR	CI (95%)	pd	OR	CI (95%)	
Att. HE	1.32	0.33 – 5.76	65.10%	1.27	0.48 – 3.42	68.00%	1.24	0.47 – 3.30	66.70%	1.12	0.36 – 3.48	57.30%			
Att. Vac	1.56	0.31 – 8.53	70.50%	3.26	1.08 – 10.60	98.20%	3.00	1.02 – 9.47	97.70%	1.95	0.57 – 6.75	85.90%			
Improve	1.05	0.20 – 6.05	52.00%	1.29	0.44 – 3.90	67.70%	1.32	0.45 – 3.91	69.80%	1.01	0.30 – 3.26	50.80%			
EOVS	2.02	0.44 – 9.76	82.20%	2.09	0.75 – 6.04	91.80%	2.09	0.78 – 5.80	92.50%	1.16	0.35 – 3.90	59.70%			
SDCM	1.77	0.34 – 9.32	75.00%	3.40	1.14 – 10.34	98.60%	3.54	1.23 – 10.58	99%	2.38	0.72 – 7.99	92.50%			
COVID	0.91	0.14 – 5.56	54.00%	1.12	0.28 – 4.50	56.30%	1.25	0.31 – 4.87	62.70%	1.46	0.39 – 5.60	70.90%			
Nat. Att	0.26	0.06 – 1.03	97.20%	0.55	0.21 – 1.38	89.60%	0.51	0.19 – 1.30	92.30%	0.77	0.25 – 2.41	67.10%			
0 Doses					*Reference*			*Reference*						*Reference*	
1 Dose							2.25	0.39 – 13.29	81.30%		*Reference*		6.51	1.51 – 29.36	99.40%
2 Doses				4.62	1.20 – 17.88	98.60%	3.75	1.02 – 14.15	97.60%	2.21	0.54 – 8.91	86.40%	14.63	6.78 – 33.18	100.00%
3 Doses				0.35	0.09 – 1.34	93.90%	0.28	0.07 – 1.05	97%	0.17	0.04 – 0.66	99.50%	5.71	2.93 – 11.73	100.00%
Att. HE x 1 Dose							0.97	0.15 – 6.59	51.10%						
Att. HE x 2 Doses				1.17	0.36 – 3.87	60.50%	1.19	0.36 – 3.83	60.70%	1.23	0.35 – 4.46	62.40%			
Att. HE x 3 Doses				0.71	0.26 – 1.96	74.60%	0.73	0.26 – 2.00	73.50%	0.81	0.25 – 2.62	63.30%			
Att. Vac x 1 Dose							0.64	0.10 – 4.08	67.60%						
Att. Vac x 2 Doses				1.18	0.28 – 5.07	59.40%	1.23	0.30 – 5.28	61.20%	1.75	0.43 – 7.54	77.70%			
Att. Vac x 3 Doses				1.21	0.31 – 4.77	61%	1.26	0.33 – 4.78	62.90%	1.63	0.42 – 6.36	75.40%			
Nat. Att x 1 Dose							0.67	0.10 – 4.20	66.50%						
Nat. Att x 2 Doses				1.77	0.49 – 6.32	81.20%	1.85	0.52 – 6.64	83.20%	1.24	0.32 – 4.89	62.60%			
Nat. Att x 3 Doses				1.56	0.59 – 4.28	81.10%	1.67	0.63 – 4.70	84.90%	1.11	0.34 – 3.59	57.00%			
Improve x 1 Dose							0.82	0.12 – 5.62	58%						
Improve x 2 Doses				0.91	0.25 – 3.16	56.30%	0.89	0.25 – 3.16	57.40%	1.19	0.32 – 4.55	59.90%			
Improve x 3 Doses				0.86	0.27 – 2.63	60.60%	0.83	0.27 – 2.57	62.50%	1.02	0.30 – 3.53	51.10%			
EOVS x 1 Dose							0.76	0.12 – 5.11	60.90%						
EOVS x 2 Doses				1.19	0.31 – 4.61	60%	1.19	0.32 – 4.66	60%	2.02	0.47 – 8.84	82.90%			
EOVS x 3 Doses				0.43	0.14 – 1.24	94.10%	0.42	0.15 – 1.22	94.30%	0.84	0.25 – 2.81	61.10%			
SDCM x 1 Dose							0.88	0.14 – 5.66	55.20%						
SDCM x 2 Doses				1.80	0.48 – 7.10	80.50%	1.77	0.48 – 7.17	80%	2.3	0.57 – 9.38	87.60%			
SDCM x 3 Doses				0.82	0.26 – 2.62	63.10%	0.79	0.25 – 2.48	65.50%	1.13	0.32 – 3.87	57.60%			
COVID x 1 Dose							1.32	0.21 – 8.40	61.30%						
COVID x 2 Doses				2.64	0.53 – 13.72	88.60%	2.48	0.50 – 12.97	86.70%	2.25	0.46 – 11.32	84.00%			
COVID x 3 Doses				0.50	0.11 – 2.35	80.80%	0.47	0.10 – 2.18	83.30%	0.41	0.09 – 1.88	87.30%			
Observations	56			294			298			242			298		
LOO-information criterion	6.6 (2.8)			274.5 (16.8)			278.3 (17.1)			273.4 (14.9)			349.7 (10.2)		

Note. Information on the posterior distribution of the calculated Bayesian logistic regression. Priors for the predictors: normal distributed, N(0,1). Intercept = Student's t-distribution, $\nu = 3$, $\mu = 0$, $\sigma = 2.5$ (brms default). LOO-information criterion (standard error in parentheses): Lower values indicate a better model fit. Each model ran four sampling chains, each with 1e4 iterations and 5,000 warm-up draws. Att. HE = Attitude toward Human Enhancement, Att. Vac = Attitude toward vaccination, Improve = Effects of first (possible) Vaccination, EOVS = Effect of vaccination status, SDCM = Support of disease control measures, COVID = Past SARS-CoV-2 infection, Nat. Att = Naturalness Attitude. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0 (or 1 if converted to OR), as indicated by the coefficient median. Models (1-3) that included data from unvaccinated participants used the reduced EOVS scale, from which two items that directly referred to the vaccination were dropped.

Predicting exact numbers of planned vaccine dose

To avoid logical contradiction between current and desired doses (Boostered participants can only plan to get three or more doses, while people with two doses can desire two or more. In an ordered cumulative logistic regression, the predictor of having had three doses cannot be interpreted on its effect of planning two doses), the data was split. Priors for the predictors were considered uninformative, $N(0,1)$. For the intercept, the *brms* default settings used a Student's *t*-distribution (ν = 3, μ = 0, and σ = 2.5). In this model, we used the complete effect of the vaccination status scale.

All unvaccinated 2/58 (5.2%) who planned to get vaccinated planned to get two doses. All four participants that received one dose stated that they wanted to receive more doses (25%;1/4 = 2 Doses, 50%;2/4 = 3 Doses, 25%;1/4 = As needed), but the sample size was too small.

Table S9. Predicting Desired Doses

Sample

	2 Doses Received						3 Doses Received					
Predictors	OR	95% CI	pd	OR	95% CI	pd	OR	95% CI	pd	OR	95% CI	pd
Attitude Human Enhancement	1.78	[0.87, 3.74]	94.30%	1.84	[0.92, 3.79]	95.70%	1	0.71 – 1.41	50.30%	0.98	[0.70, 1.37]	54.30%
Attitude Vaccination	3.04	[1.01, 9.86]	97.60%				3.59	[1.28, 10.86]	99.30%			
Improvement after first dose	0.9	[0.43, 1.89]	60.80%	0.89	[0.44, 1.84]	62.10%	1.09	[0.68, 1.75]	63.90%	1.09	[0.69, 1.75]	64.20%
Effect of vaccination status	3.09	[1.06, 9.48]	98.00%	3.63	[1.31, 10.91]	99.40%	0.96	[0.58, 1.58]	56.00%	1.02	[0.62, 1.67]	53.80%
Support of disease control measures	4.55	[1.73, 13.02]	99.90%	5.68	[2.22, 16.11]	100.00%	2.16	[1.23, 3.94]	99.70%	2.6	[1.53, 4.61]	100.00%
Past SARS-CoV-2 infection	2.84	[0.81, 10.16]	94.70%	2.66	[0.78, 9.42]	94.30%	0.56	[0.13, 2.21]	79.00%	0.45	[0.11, 1.66]	88.50%
Naturalness attitude	1.2	[0.52, 2.82]	66.40%	0.96	[0.44, 2.10]	54.30%	0.91	[0.62, 1.32]	69.90%	0.81	[0.56, 1.16]	88.20%
LOO-information criterion	58.4 (10.5)			61.0 (10.5)			329.8 (15.1)			334.8 (14.7)		
Observations	61						177					

Note. Information on the posterior distribution of the calculated Bayesian logistic regression. Priors for the predictors: $N(0,1)$. Intercept = Student's *t*-distribution, ν = 3, μ = 0, σ = 2.5 (brms default). LOO-information criterion (standard error in parentheses): Lower values indicate a better model fit. pd is the probability of direction, i.e., the probability that the effect is greater or smaller than 0 (or 1 if converted to OR), as indicated by the coefficient median

Discussion:

Depending on the model's complexity, the odds ratio of wanting more doses when being vaccinated three times compared to zero doses was < 1. Visual inspection of a model that included all but those participants who have only received one dose suggests a general effect of attitude toward vaccinations and the support of disease control measures for vaccine intention. Group-related differences merely influenced the certainty about the effect. Even if effects vary in uncertainty, strength, and alleged direction across participant groups: If examined in a broad context of different variables and interactions, having received three doses alone is insufficient to conclude that these people will further engage in specific vaccination behavior. More important than the mere number are the underlying attitudes.

It is important to note two transition steps when predicting future vaccination doses. First is the decision to get vaccinated at all. The evident differences between vaccinated and unvaccinated participants suggest that this is related to attitudes toward vaccination and the basic notion of the relationship toward nature. This conclusion is supported by the negative influence of naturalness attitude on the intention to get more doses if unvaccinated participants were evaluated alone. Hence, the decision to engage with technological interventions seems to be fundamentally linked to the attitude toward naturalness. Once vaccinated, the second transition is the decision to get more vaccine doses, or more specifically, to plan to get as many doses as medically required or needed. Here, the effect of the individual sets of beliefs and attitudes on naturalness-related questions may not disappear but decrease in importance and gain uncertainty. Wanting more vaccination among the vaccinated participants depends mostly on the attitude toward vaccination and the support of disease control measures. But vaccination intention seems less present for people who have already been "boostered," i.e., received three doses.

When assessing and predicting the exact number of planned vaccinations, it became evident that people with two doses seemed to plan until getting boostered. Only 6.2% of these

participants stated that to receive more than three doses. If willing to receive more doses, boostered participants plan even further. This cannot be explained by the fact that "more" for boostered patients is always more than three doses. 77.5% of participants wanting more doses stated they would receive as many doses as needed without submitting themselves to a specific number. Once again, the support of disease control measures and the attitude toward vaccinations mattered the most here, while the naturalness attitude had no predictive power. In addition, the positive aspect based on their vaccination status mattered only for people having received two doses. Visual inspection of the model also suggested a discernible but uncertain effect of attitude toward Human Enhancement for the intention to get three, respectively, as many doses as needed for participants with two doses. It is generally unclear whether the vaccinated persons are apodictic on the exact number of planned doses. Yet, it seems like there are psychological thresholds, ranging from dose to dose, that must be traversed when planning further ahead.

However, there is evidence for questioning the strength of intention. Consider that data sampling occurred in January 2022. As effective of January 2023, ~18 percent of the German population above 18 years have received more than three vaccine doses [9]. If we compare that number to the 29.9% (94 / 314) of the entire sample, respectively 36.7% (94 / 256)[1] of the vaccinated participants, who stated that they either plan to receive more than three or as many doses as medically necessary, we seem to encounter a gap between intention and actual behavior. However, we do not know how many of our participants put their plans for further vaccinations into action.

Contemplating reasons for getting more doses, another possibility may be that vaccinated people want to receive more doses because of the restrictions imposed on unvaccinated and not boostered persons. Since three doses were often sufficient to circumvent other measures like

[1] No unvaccinated participant reported to want more than 2 doses

mandatory testing, this would explain why vaccination uptake beyond three doses is still relatively low in Germany, even when the pandemic was more prevalent. Another reason lies in the fact that the German Health authorities have not explicitly affirmed the medical necessity for more than three doses unless for people with a certain age, medical history, or occupation [10]. Either way, getting boostered or vaccinated in the first place can be understood as adapting oneself toward a hazardous or socially restrictive environment through technology, i.e., a form of Human Enhancement.

If there is a sufficient supply of vaccines, every citizen is faced with the decision to get vaccinated. This collective interpellation may result in increased polarization [11]. As most unvaccinated people in our first study were not planning to get a vaccination in the future, opinions appear immutable.

Table S10. Items used in the different scales used in Study 1

Question Block	Wording	Item	
Attitude	Based on what you personally know about the following topics and what is reported in the media. What is your attitude toward:	Human interference with nature	Genetic manipulation of animals
		Human Enhancement	Genetic manipulation of humans
		Efforts to colonize space	Anthroposophy
		Vaccinations	Homeopathy
		Genetic manipulation of plants	Healing practitioners
Enhancement Rating	A special type of technology is the so-called "human enhancement." The term "human enhancement" is usually used to describe technologies that help to expand people's abilities. However, there is no standard definition. Evaluate to what extent you think the following examples fall under the term human enhancement.	See. Figure S1 in the Supplementary	
Willingness to use	Imagine the possibility of changing your memory to the extent that exceeds your current level by far. You would remember things much better and would no longer have to rely on shopping lists reminders on your cell phone or calendar. You would also find it much easier to learn new things. Which of the following means would you use for this? All methods have the same effect and have no adverse side effects. Which of the following means would you use for this?	Administration of a drug in the form of tablets (Once/Daily) Injection of a drug into the arm (Once/Daily) Administration of a plant-based drug (Once/Daily) Brain surgery Implantation of an electronic device into the brain Completion of a cognitive training program Special raw food diet Daily meditation	
Invasiveness	How do you rate the previous examples in terms of their invasiveness, that is, the degree to which they interfere with the human body and/or mind.		
Naturalness	How do you rate the previous examples in terms of their naturalness?		
Naturalness attitude	How much do you agree with the following statements?	Humans and nature have separated too much	The self-healing powers of the body are underestimated
		Humans are the crown of creation-	There are some things in the world that humans should not research
		What is natural is also good	Humans should stop trying to control nature
		The so-called conventional medicine (Schulmedizin) is unnatural	
Effects of vaccination status	Based on the number of doses of vaccine you have received to date against SARS-CoV-2 (Coronavirus), how valid are the following statements about you?	I feel relieved	I feel vulnerable-
		I am careful not to get infected	My social environment reacts negatively to my vaccination status-
		My vaccination status gives me back possibilities	I feel left out-
		The disease appears less dangerous to me	I feel better than before the vaccination
		I feel stressed-	I feel technologically enhanced
		I am relaxed as I go through the world	
Support of disease control measures	I support the following government actions around the spread of coronavirus:	General vaccine mandate	Access to certain areas only if tested, vaccinated, or recovered
		Vaccine mandate for certain occupations	Access to certain areas only if vaccinated or recovered
		Closing of schools	Cancellation of mass and cultural events
		Mask mandate	Restrictions for gastronomical enterprises
		Social meeting restrictions	Curfews
		Mandatory testing	Strict quarantine rules
Improvements after the (possible) first dose	Compared to when you did not receive a vaccine dose, how much did your feelings, thoughts, and behavior change at the time just after you received the first vaccination? Note: If you did not receive a vaccination dose, please indicate the change relative to when it would have been theoretically possible for you to receive a vaccination.	Feelings of safety	
		Fear of infection	
		Mental stress	
		Distrust of others	
		Activity level	
Vaccination Status	How many doses of SARS-CoV-2 (Corona virus) vaccine have you received to date? Note: If you were first vaccinated with Johnson&Johnson vaccine, please enter "2" here. So-called "Booster vaccination, "in this case, will then count as "3".	Chose from: 0,1,2,3, Free Text	

Planned Vaccination	How many doses of vaccine against SARS-CoV-2 (Coronavirus) do you plan to receive (as of now)? (How many times do you plan to get vaccinated against Corona?) An initial vaccination with Johnson & Johnson vaccine counts as "2". If you plan to get boostered in this case, enter "3".
Keeping up with vaccination	In general, do you make sure to keep your vaccination status up-to-date against pathogens other than SARS-CoV-2 (Corona virus)? Ex: Tetanus, FSME, Hepatitis etc.
Identity	How much do you identify with your current immunization status?
COVID	Have you been confirmed to be infected with SARS-CoV-2 (Coronavirus)?

Note. Anthroposophy is an esoteric philosophy founded by Rudolf Steiner. It consists of a set of theses mainly concerned with the individual's spiritual development. It is a major part of Waldorf education, which is mainly taught at "Waldorf schools." Germany hosts the highest number of these schools, followed by the U.S. and the Netherlands (https://www.freunde-waldorf.de/fileadmin/user_upload/images/Waldorf_World_List/Waldorf_World_List.pdf). Alternative healing practitioners are part of the German health care system since 1939. They are recognized by law to conduct specific therapies. However, with regularities differing from state to state, no formal education is needed, but only an exam held by health authorities. Alternative healing practitioners are commonly known for focusing on alternative and naturopathic approaches to medicine. Items with an - were reverse coded after being identified as negatively correlated with the first component of principal component analysis. This was done using the check.keys method of the alpha function in the R psych (2.1.9.) package [3].

Study 2

To refute the impression that we overpowered our study in order just to obtain significant results, we proceeded as follows: We randomly split the original data into the proportion suggested by the power analysis (29 Unvaccinated, 193 Vaccinated). We then calculated the *t*-test for all variables within this reduced sample. This process was repeated 1,000 times to account for the random sampling. We then averaged the found Cohens *d*'s, and the group means (Mean d/ Mean vac/unvac). We also calculated the proportion of significant results for each variable across the 1,000 tests. Results are shown in the supplementary. There was no variable in which the reduced sample size yielded different effects than the one reported in the manuscript.

This analysis was done solely after one reviewer made remarks that the overpowering may appear odd. Data analysis for the manuscript occurred as described: Exclusively after we stopped at *N* = 301. Note that our online survey provider can show aggregated response frequency while the survey is still running but does not show individual responses. Hence, we were able to monitor how many unvaccinated had participated without the need to peek into group-related data.

Table S10. Results of sample simulations

variable	Mean d	*SD* d	Mean vac all	*SD* mean vac	Mean unvac all	SD mean unvac	% sig	Significant in manuscript?
Attitude Human Enhancement	-1.37	0.15	4.52	0.05	2.44	0.19	100	Sig
Attittude Vaccination	-2.06	0.19	6.13	0.05	3.05	0.22	100	Sig
Naturalness Attitude	1.40	0.14	25.32	0.26	35.73	0.84	100	Sig
Perception efficacy	-2.11	0.09	4.82	0.06	1.30	0.08	100	Sig
Perception invasiveness	0.14	0.14	3.33	0.06	3.57	0.24	0.70	n.s.
Perception naturalness	-1.27	0.06	3.34	0.06	1.28	0.07	100	Sig
Perception safety	-2.27	0.10	5.01	0.06	1.39	0.07	100	Sig
Importance efficacy	-0.06	0.13	5.45	0.07	5.32	0.24	0	n.s.
Importance invasiveness	1.51	0.17	2.68	0.06	5.41	0.24	100	Sig
Importance naturalness	1.61	0.19	1.91	0.06	4.72	0.27	100	Sig
Importance safety	0.06	0.14	5.32	0.06	5.42	0.26	1.50	n.s.

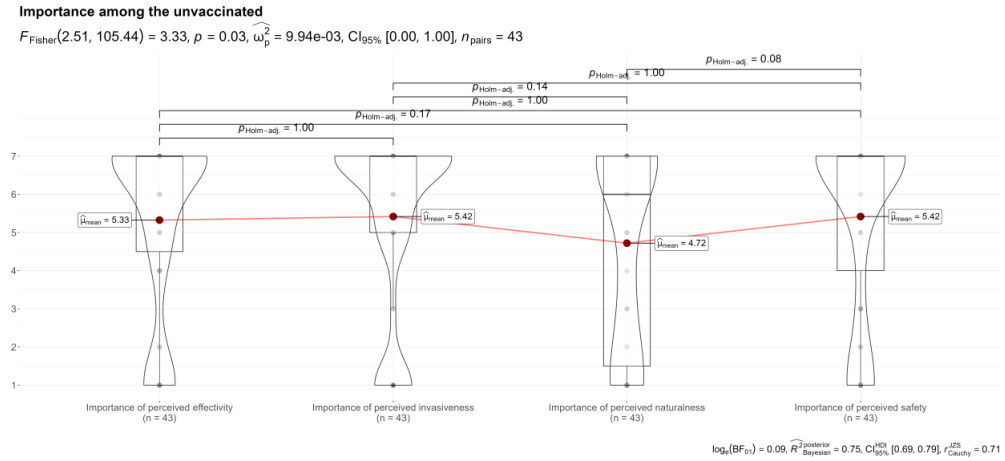


Figure S4

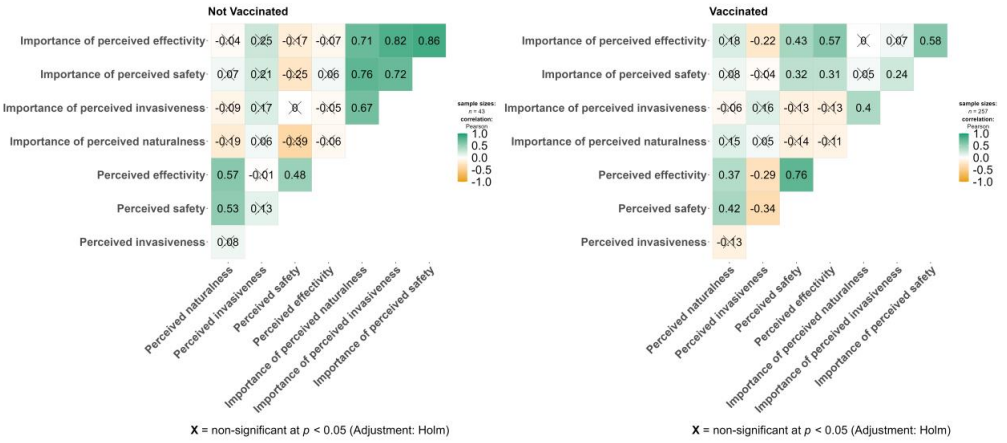


Figure S5

Table S12. Mean and standard deviations of used examples (All participants - Study 2)

Example	Use Mean	Use *SD*	Invasiveness Mean	Invasiveness *SD*	Naturalness Mean	Naturalness *SD*
Daily Administration of a drug in the form of pills	3.89	2.18	4.50	1.88	2.58	1.54
Daily Administration of a plant-based drug	4.21	2.10	4.06	1.88	3.54	1.69
Daily Injection of a drug into the arm	2.51	1.81	5.57	1.73	2.05	1.36
Once Administration of a drug in the form of pills	5.02	2.25	3.54	2.02	3.02	1.64
Once Administration of a plant-based drug	5.26	2.07	3.18	1.95	4.21	1.78
Once Injection of a drug into the arm	4.57	2.38	4.44	1.89	2.55	1.57

Table S11. Items used in the different scales used in Study 2

Question Block	Wording	Item	
Attitude	Explanation: The term “human enhancement” is usually used to describe technologies that help to expand people’s abilities. However, there is no standard definition. What is your attitude toward:	Human Enhancement	
		Vaccinations	
Willingness to use	Imagine the possibility of changing your memory to the extent that exceeds your current level by far. You would remember things much better and no longer rely on shopping lists reminders on your cell phone or calendar. You would also find it much easier to learn new things. Which of the following means would you use for this? All methods have the same effect and have no adverse side effects. Which of the following means would you use for this?	Administration of a drug in the form of tablets (Once/Daily) Injection of a drug into the arm (Once/Daily) Administration of a plant-based drug (Once/Daily)	
Invasiveness	How do you rate the previous examples regarding their invasiveness, that is, the degree to which they interfere with the human body and/or mind?		
Naturalness	How do you rate the previous examples in terms of their naturalness?		
Naturalness attitude	How much do you agree with the following statements?	Humans and nature have separated too much Humans are the crown of creation What is natural is also good The so-called conventional medicine (Schulmedizin) is unnatural	The self-healing powers of the body are underestimated There are some things in the world that humans should not research Humans should stop trying to control nature
Perception of vaccine features	How would you rate the SARS-CoV-2 (coronavirus) vaccination in terms of its...?	Safety Naturalness	Effectivity Invasiveness
Importance of vaccine features	How much did your evaluation of the following factors play a role in your decision whether to get vaccinated against SARS-CoV-2?	Safety Naturalness	Effectivity Invasiveness
Vaccination Status	Have you ever received a vaccination against SARS-CoV-2 (coronavirus)?	Yes, No	

Reflecting on the research process

This research project was inspired by the observation that vaccinations qualify as an instance of Human Enhancement under nearly all used conceptualizations in the literature. Amid the COVID-19 pandemic and the passionate debate about vaccinations and an environment that contains a potentially deadly virus, we developed the idea that people not vaccinated against SARS-CoV-2 may reject this technology for reasons linked to the broader Human Enhancement debate. Among others, reasons for reluctance against the latter are concerns about naturalness and invasiveness. In that sense, we initially hypothesized that people not vaccinated against SARS-CoV-2 reject both the wider concept of Human Enhancement and the specific instance vaccinations due to their characteristics of being an invasive and unnatural technological intervention. To further elaborate on their perception of naturalness, we also collected data on their attitude toward a wide range of phenomena. Evidently, this line of thought assumes that vaccination status as observable behavior is indicative of an underlying set of motivating beliefs and attitudes.

In an earlier version of this manuscript, we formulated these theses somewhat polemically, specific on the topic of COVID-19, but low in precision on how the collected data may or may not actually serve as evidence for them. After a fruitful discussion with the anonymous reviewers, who suggested being more precise with our hypotheses, and a review of suggested literature, we reevaluated our data and how we formulated our hypotheses, models, and conclusions. We came to the insight that our research design, collected data, and constructed models do not support some of our conclusions and, therefore, could not be interpreted as evidence to the level of specificity with which we formulated our first thesis. Taking the reviewers' concerns very seriously, we adjusted the drawn conclusions, recapitulated, and further explained our intentions when conducting the study.

We attempted to be more precise on the connection between our hypotheses and their operationalization within our study. This happened by giving additional thoughts on the underlying processes that may fuel the hypothesized link between concerns about naturalness, invasiveness, and vaccination behavior as indicative behavior of a certain sets of beliefs and how they relate to the debate about Human Enhancement. Reflecting on our initial idea and discussions when planning the study, we suggest that: "*Reasons for rejecting vaccination against SARS-CoV-2 may be linked to a*

pronounced emphasis on perceived invasiveness and naturalness. As these factors are also negatively linked to attitudes toward Human Enhancement, these derivations of general concerns about technological improvement might explain vaccination reluctance among the unvaccinated, but also possible rejection of Human Enhancement (H1).” This is different from our first hypotheses formulation:” a) People who reject a vaccination against SARS-CoV-2 do so mainly because they see it as an unnatural and invasive technological intervention, b) these reasons are more emphasized derivation of the general concerns against Human Enhancement.” After the first rejection of our manuscript, we submitted it to *Discover Psychology.* In an additional round of peer review, the lack of comprehensibility of our hypotheses was criticized again. Thus, we added an extensive discussion of what we mean by “pronounced emphasis” and how our variables and analysis were meant to test this hypothesis.

We consider our reformulation more differentiated and less polemic while not changing the alleged direction of effects. Hence, this approach allows for a more nuanced perspective on the hypothetical link between vaccination behavior and reservations against Human Enhancement while also touching on the suspected underlying evaluation processes. It also considers the academic classification of vaccination as Human Enhancement and the respective classification hierarchy. Moreover, it is semantically more precise while maintaining the original content (Rejection of vaccination is linked to unnaturalness/invasiveness, which means that these variables were decisive, ergo, more important than for vaccinated participants). To test for the reformulated hypotheses, we redesigned and recalculated our statistical models when necessary and reported them in the manuscript (Study 1). These findings were then discussed on how they relate to our hypothesis more deeply. The most significant addition to our models was the implementation of interaction effects with vaccination status to test for the assumed pronounced emphasis (When predicting willingness to use) and the construction of total novel models regarding the attitude toward Human Enhancement.

A more careful elaboration of our hypothesis clarifies the assumed psychological antecedents that are suspected to underlie both rejection of vaccination in particular and Human Enhancement in general. Note that a hypothesis is originally meant to be a yet unproven explanation for a given phenomenon. While we acknowledge the need to formulate it as statistically testable, the hypothesis is

not equivalent to its operationalization. The hypothesis justifies causal inferences for future research. However, as written above, it does not solely focus on vaccination against SARS-CoV-2 but allows us to conclude this specific vaccine rejection toward the general phenomenon. We are also aware that our operationalization cannot seal the final deal but can only provide a snapshot of the assumed explanations and suggested relationships.

We evaluated each statistical analysis from the first version of our manuscript on whether they should be recalculated and did so if the former formulation was insufficient to test our reformulated hypotheses. In both the original and revised version of the manuscript, statistical analyses of both studies were always conducted *after* formulating the hypotheses they referred to.

While we deem a direct causality between concerns about unnaturalness and invasiveness highly probable, the research design of the first study could only reveal the alleged link but provides no further information on causality. Although we critically reflected on this in the manuscript, we were still unsatisfied with this aspect, which was recurringly brought up by the reviewers. After almost finishing the revision of the manuscript, we decided to postpone the review process and conduct the second study and directly assess how unvaccinated and vaccinated participants perceive the vaccination against SARS-CoV-2. This was done to directly test the link between perceived invasiveness and naturalness and vaccination. Limitations of the first study are certainly aggravated due to the dynamic of the pandemic situation and the need to balance robustness and quickness during data collection. Limitations were and are also discussed in the manuscript.

This reflection on the research process is reported for the sake of transparency and to showcase the iterative approach with which we tried to shine light on the alleged connection between vaccination behavior and attitude toward naturalness, invasiveness, and Human Enhancement. Issues that, in this particular combination, have experienced little empirical attention. We are open to criticism and share our data and model for further use in the OSF.

Changes made:

To do justice to the elaboration of our hypotheses, we recalculated our statistical models in Study 1. We introduced new interaction terms that reflect vaccination behavior and the suspected different valuation (vaccination status). We also added naturalness attitude to the models that predicted willingness to use and displayed them in more detail to make the iterative process more comprehensible. Models to predict attitude on Human Enhancement were newly calculated. Various models meant to reveal the percentage of mediation between vaccination status and variables like naturalness attitude were exchanged against models that predicted the attitude toward Human Enhancement. This was done in the context of the comments of one of the reviewers and because the new models were deemed a more suitable test for our reformulated hypotheses of different emphasis (through interaction effects). The same logic applies to modeling the interaction effect when predicting "more" doses. Note, however, that these models were rather exploratory after recognizing that many boostered people wanted to have "more" doses. We also examined invasiveness and naturalness ratings of examples of cognitive enhancement methods.

Study 2 was conducted to fill the data gap on vaccine perception and to test our hypothesis for this instance of Human Enhancement directly.

During the review process, we noticed some mistakes in reporting our data. This mainly concerned the effect of the interaction "ER Vaccinations x Vaccinated" in Model 4 of predicting attitude toward Human Enhancement. This effect is 0.47 instead of -0.47 (as correctly displayed in the Figure). Thus, the final version and preprint may differ in this regard. Other exclusions were the elimination of R^2-Bayes for all but the linear regression models since this measurement is insufficient for these models. Minor changes to the second decimal place were also conducted if previously reported wrong. We also decided to add a "-" before *t*-values and also report them before *d* values to further indicate the direction of effect and maintain interpretability if the CI of *d* includes 0. When summarizing insignificant p-values, sometimes "< "was typed instead of">"; we corrected the mistake.

References

1. Bürkner P-C. brms : An R Package for bayesian multilevel models using Stan. J. Stat. Soft. 2017. doi:10.18637/jss.v080.i01.
2. Döbler NA, Carbon C-C. Vaccination against SARS-CoV-2: A human enhancement story. Translational Medicine Communications 2021. doi:10.1186/s41231-021-00104-2.
3. Coeckelbergh M. Human being @ risk: Enhancement, technology, and the evaluation of vulnerability transformations: Springer; 2013.
4. Bostrom N. Why I want to be a posthuman when I grow up. In: More M, Vita-More N, editors. The Transhumanist Reader. Chichester, West Sussex: John Wiley & Sons; 2013. p. 28–53.
5. Hauskeller M. Better humans?: Understanding the enhancement project. Durham: Acumen; 2013.
6. Agar N. Humanity's end: Why we should reject radical enhancement: MIT Press; 2010.
7. Davies B. Enhancement and the Conservative Bias. Philos Technol. 2017;30:339–56. doi:10.1007/s13347-016-0245-z.
8. Sattler S, Forlini C, Racine E, Sauer C. Impact of contextual factors and substance characteristics on perspectives toward cognitive enhancement. PloS one. 2013;8:e71452. doi:10.1371/journal.pone.0071452.
9. Robert Koch-Institut. COVID-19-Impfungen_in_Deutschland/Archiv /2022-01-14_Deutschland_Impfquoten_COVID-19.csv. https://github.com/robert-koch-institut/COVID-19-Impfungen_in_Deutschland/blob/master/Archiv/2022-01-14_Deutschland_Impfquoten_COVID-19.csv. Accessed 12 May 2023.
10. Robert Koch-Institut. Epidemiologisches Bulletin [Epidemiological bulletin]: STIKO: 22. Aktualisierung der COVID-19-Impfempfehlung [STIKO: 22nd update of the COVID-19 vaccination recommendation]; 6.10.2022.
11. Henkel L, Sprengholz P, Korn L, Betsch C, Böhm R. The association between vaccination status identification and societal polarization. Nat Hum Behav 2022. doi:10.1038/s41562-022-01469-6.

Journal of Cognitive Enhancement (2024) 8:170–183
https://doi.org/10.1007/s41465-023-00278-7

THEORY AND HYPOTHESIS

Human Enhancement Without Organizational Knowledge and by Organizational Order

Niklas Alexander Döbler[1,2,3] · **Claus-Christian Carbon**[1,2,3] · **Harald Schaub**[1,4]

Received: 29 May 2023 / Accepted: 8 November 2023 / Published online: 2 December 2023

Abstract
Organizations strive to ensure and maintain the reliability, safety, security, usability, and competitiveness of their processes, goods, and services. Improvement of employees' skills and abilities contributes to these ends and is a relevant issue for the field of human factors. However, going a step further than designing ergonomics, implementing protocols, and conducting training is the attempt to enhance employee skills directly through various technological means. So-called *Human Enhancement* aims at direct technological interference with the employees' skills and is a notoriously controversial yet deeply historical phenomenon. Drawing from empirical and theoretical literature on Human Enhancement, we seek to provide an initial analysis of this phenomenon in an organizational context. One motivational aspect of contemporary Human Enhancement is the need to meet internal, often self-related, or external, usually social or organizational, demands. Given the different effects and means of Human Enhancement, some forms are illicit, sanctioned, and/or condemned as morally wrong, while others are obligatory and well-established. Enhancement efforts can be based on individual initiative and, hence, *without* organizational knowledge. The opposite of the spectrum are enhancements applied *by* organizational order. We also emphasize how an organizational culture may incentivize engagement with illicit means of Human Enhancement. Potentially linked to safety and security-related aspects, its enhancement effects in relation to these two poles can inform stakeholders in their regulatory decisions.

Keywords Human Factors · Safety · Security · Organizations · Human Enhancement · Cognitive Enhancement

Introduction

Companies spend significant resources to ensure their work processes, products, and services are reliable, secure, safe, usable, and competitive. They have all the reasons to engage in this preventive conduct. Human and technological errors can have disastrous consequences (Dörner & Schaub, 1994). But as technological advances have significantly increased machine safety, human error has become one of the predominant risk factors for working accidents (Reyes et al., 2015; Sánchez-Beaskoetxea et al., 2021); the factor of the human increasingly urges into focus.

Regulatory guidelines are crafted, workplaces are designed under the primacy of (cognitive) ergonomics, and safety and security cultures are employed and promoted. Still, errors happen. The improvement of the material and procedural working environment is not fail-safe. To minimize human-caused errors and subsequent costs, organizations seem to have only one domain left: the immediate improvement of the human worker itself.

Such efforts seem rather uncontroversial and are well-known. Imparting relevant knowledge is integral to any training necessary to ensure and maintain organizational success (Kulkarni, 2013). However, the issue we want to highlight seems to go further. Instead of teaching workers new skills and work techniques, it is also possible to use technology to target their capabilities and performance-relevant outcomes directly. Welcome to the discussion about *Human Enhancement*.

We will begin our inquiry into this phenomenon with a short introduction to different concepts and important

✉ Niklas Alexander Döbler
niklas.doebler@uni-bamberg.de

1 Department of General Psychology and Methodology, University of Bamberg, Bamberg, Germany

2 Research Group EPÆG (Ergonomics, Psychological Æsthetics, Gestalt), Bamberg, Germany

3 Bamberg Graduate School of Affective and Cognitive Sciences (BaGrACS), Bamberg, Germany

4 IABG (Industrieanlagen-Betriebsgesellschaft mbH), Ottobrunn, Germany

discussions that fuse the debate on Human Enhancement. Hereafter, we will propose a framework that suggests that one crucial aspect of using historical, contemporary and future enhancements at the workplace and in other organizations is the continuum between enhancement *without organizational knowledge (WOK)* and enhancement *by organizational order (BOO)*. Our framework may improve understanding of how the potential tension between imposed demands and individual capacities leads to behavior that can violate ethical or organizational standards. Additionally, a careful analysis may reveal scenarios where substantial adaptations of human capabilities are required for successful task execution.

Even though the phenomenon is not new, Human Enhancement conceptually and technologically interferes with the well-known triad of individual, task, and organization. This can produce safety and security-relevant issues, for better or worse.

Human Enhancement

In an almost negligent truncation of the discourse, Human Enhancement attempts to improve people through technology (Coeckelbergh, 2011; Döbler & Carbon, 2023a). A more nuanced perspective recognizes different conceptualizations and disagreements about means and the defining outcomes of Human Enhancement (Gyngell & Selgelid, 2016). Which conceptualization should be used depends largely on the questions asked and the object of inquiry (Gyngell & Selgelid, 2016). Due to its aim of general applicability and non-dependence on concepts like "normal functioning" or "species-typical" (Gyngell & Selgelid, 2016), our arguments orientate at a *functionalist approach*, under which Human Enhancement refers to "alterations that increase some type of functioning" (Gyngell & Selgelid, 2016, p. 120). In this sense, Human Enhancement carried out through its various means can extend the range of things humans can do in a given environment or situation (Döbler & Bartnik, 2022). However, we are limiting the type of alterations to those directly induced by *embodied* technologies (Döbler & Carbon, 2023a), often but not always supported by advances in the biomedical sciences. These interventions are the usual focus in the literature and the most controversial (Agar, 2014; Buchanan, 2011; Hauskeller, 2013). For example, people are usually not reluctant to employ education as means of cognitive improvement but are more unwilling to use drugs or invasive devices for the same purpose (Haslam et al., 2021). The distinction based on embodied technology is also made to ensure identifiability of means for Human Enhancement compared to technology in general (Bostrom & Roache, 2008; Döbler & Carbon, 2023a). It is needed for a differentiated view on human improvement beyond "traditional" means like training or environmental design.

Technological alterations must not inevitably be successful. An intervention implemented with bona fide but mistaken belief in its predicted positive effect can raise important safety and security issues (Döbler & Carbon, 2023a).

Our analysis focuses on the technological measures people use to meet the work environment requirements. Some of these interventions will have significant effects, some will lead to only minor alterations, some bear disruptive potential, and others will be inoperative. However, the motivational background of each application of Human Enhancement in a work context is the idea that technology can be used to directly target specific capabilities of the working Human, to contribute to individual and/or organizational goals (Pustovrh et al., 2018).

There are plenty of examples of historical and contemporary technologies that directly affect the human body and mind to improve their capacities (Agar, 2014; Bostrom & Sandberg, 2009; Döbler & Carbon, 2021; Menuz et al., 2013). Even if conservative definitions of Human Enhancement stress the necessity to improve a capability beyond what is typically feasible for humans (Gyngell & Selgelid, 2016): Human Enhancement is not a matter of science fiction but is already employed in various branches and contexts (Döbler & Carbon, 2021, 2023a; Greely, 2006). Most prominently, means like drugs, implants, or genetic modifications are considered Human Enhancement under nearly all definitions.

Employing pharmacological substances, primarily for improving cognitive abilities, is one of the most predominant issues in the contemporary debate (Banjo et al., 2010; Caviola & Faber, 2015; Farah et al., 2004; Mihailov & Savulescu, 2018; Napoletano et al., 2020; Racine et al., 2021; Sattler et al., 2021; Sattler et al., 2022; Schelle et al., 2014). That also holds for the workplace, where modern pharmacological enhancement efforts can be traced back to the late nineteenth and early twentieth century. Utilized means usually comprised substances like caffeine and nicotine, but also drugs like cocaine and methamphetamine (an ingredient of the infamous "Panzerschokolade" used in WW II to enhance the capabilities of German soldiers) (Pustovrh et al., 2018). Yet, the landscape of potential enhancers is broad (Napoletano et al., 2020). For the most prominent substances (modafinil, methylphenidate, and amphetamine), enhancement effects tend to be small (Roberts et al., 2020). When interpreting these often small and task-specific effects, we must acknowledge the complex dynamic between environment, cognition, and behavior. The mind is much less mechanistic than one might think. Hence, it is much harder to enhance than physical capabilities (Mihailov & Savulescu, 2018).

Even though some interventions may be classified more intuitively as Human Enhancement than drugs to enhance cognitive functioning (Döbler & Carbon, 2021, 2023b), there

are no limitations to the target of the enhancement effort. Strength, life expectancy, cognition, emotions, health, and appearance are all valid and extensively discussed parameters for technological intervention (Bostrom, 2013; Hauskeller, 2013). The broadness of the phenomenon necessitates balancing abstract considerations with practical examples. One of the key aspects of Human Enhancement, connecting all its ramifications, is the employment of technology to adapt a human being to imposed demands rather than manipulating the environment to mitigate the same demands (Döbler & Carbon, 2023a). A case-by-case examination in which existing technologies are deliberately linked to the general Human Enhancement debate can shine essential insights into the practice surrounding these examples (Döbler & Carbon, 2021). Human Enhancement is an auxiliary label to link certain technologies with resembling intentions and effects and evoke similar attitudes (see Döbler & Carbon, 2023a).

One is inclined to diagnose a certain *cognitive enhancement bias* when it comes to the empirical study of the general phenomenon. This means there is a strong focus on means for cognitive enhancement while neglecting other areas. Yet, since cognitive abilities are important for academic (Richardson et al., 2012) and job-related performance (Nye et al., 2022), a heightened though not solitary concentration on cognitive enhancement within the context of human factors and organizational frameworks might be reasonably substantiated. Not because the effects may be very strong but because organizational members have high expectations about the benefits cognitive enhancement may provide them (Döbler & Carbon, 2023a; Holt & Looby, 2018; Ilieva et al., 2013; Sansevere et al., 2022). This position remains sound, with the caveat that we must uphold awareness of Human Enhancement as a broad phenomenon.

Ethical and practical dimensions of Human Enhancement through pharmacological means become even more intricate through the easy-to-use and easy-to-hide administration of its means. How the cognitive enhancing effect in a given context is framed may shape public attitudes (Conrad et al., 2019; cf. Dinh et al., 2020). In addition to ethical inquiries (Banjo et al., 2010; Caviola & Faber, 2015; Mihailov & Savulescu, 2018; Sattler et al., 2022), cognitive enhancement has also drawn epidemiological (Dietz et al., 2013; Maier et al., 2016; Sattler, 2016), psychological (Franke et al., 2017; Racine et al., 2021; Randall et al., 2005), and medical (Husain & Mehta, 2011; Kaye & Darke, 2012; Lynch et al., 2014) attention. This focus is justified. A recent investigation has found that parents' willingness to employ cognitive enhancement drugs to boost their hypothetical child's school performance could be increased depending on the prevalence and reported effects of such behavior, among others (Sattler et al., 2021). The study also revealed that about 4% of the $N = 1323$ surveyed parents had given drugs to their children for cognitive enhancement reasons at least once, even when there was no medical need for it. Another study reported that although the general willingness to use cognitive enhancement drugs was low, two-thirds of those who contemplated the use were willing to feign symptoms to obtain prescription drugs (van Veen et al., 2022).

After a careful analysis, researchers and other stakeholders may conclude that Human Enhancement in the form of specific equipment is already part of a work environment or process (e.g., many employers provide their employees with free coffee). At the same time, emerging technologies may promise a safe and effective boost in performance and hence become a desirable intervention to maintain or increase safety, security, or market competitiveness.

When contemplating the impact of Human Enhancement, we must acknowledge how the respective technologies can potentially interfere with the human body and mind. Read et al. (2021) recently championed a systems-orientated perspective on human error. Following the suggestion of Read et al. and acknowledging how human activities are embedded in a larger socio-technological system, Human Enhancement, as an intervention at the human level of the system, demands special attention.

To benefit from this interdisciplinary and comprehensive approach, we must first identify technologies as instances of Human Enhancement and then link empirical findings about the practice and impact of these technologies to relevant evaluation dimensions. To provide an additional perspective on thinking about Human Enhancement in the context of human factors and a practical tool for assessing potential opportunities and risks, we propose a framework that locates the use of enhancement in the workplace or other organizations between the poles: *without organizational knowledge (WOK)* and *by organizational order (BOO)*.

WOK-BOO Framework

People are confronted with a manifold of tasks, goals, and demands, when working or studying. Some are internal, and some external, but all are incorporated in the broader context of an organizational structured working environment (Deci et al., 2017). Individuals and organizations share an interest in achieving different goals, even though they can have a differing understanding of a "good" level of performance (Bobko & Coella, 1994; Bommer et al., 1995). To gain a relevant outcome, people rely on a wide range of resources and skills. The latter may range from easy-to-learn hand movements, such as balancing two or more plates with one hand, to complex cognitive and behavioral processes requiring years of training, such as surgery.

Individuals may consider their skills and resources insufficient to meet demands. In that case, they could improve

their abilities by training, studying, or avoidance behavior. Another solution would be aiming at improving individual capacities directly by technological means, i.e., Human Enhancement (Döbler & Carbon, 2023a).

We composed the following framework to situate Human Enhancement within the organizational context. Here, individuals must negotiate individual skills and imposed demands. In parallel, the distinct forms of capital that organization members possess can enable their utilization of legal and informal power dynamics over their peers (Ocasio et al., 2020). This may comprise the enactment of organizational norms and regulations and the power to define the situational organization of the organization (Hallett, 2003). This directly touches key values such as bodily autonomy or personal health. These values are prominently discussed in the Human Enhancement debate (Forlini & Racine, 2009; Ireni-Saban & Sherman, 2021; Sample et al., 2020; Sattler et al., 2022). Hence, organizational context may aggravate known issues of the question of whether to use technology with the intention of improving oneself. At the same time, the complexity and manifoldness of Human Enhancement demand careful differentiation, so the proposed framework can also be used to analyze conditions in which not the engagement but the refrainment to use enhancement may raise ethical suspicion.

Although primarily discussed in work or academic settings, our argument can easily be adapted to legal, social, or other evaluative domains in which individuals are confronted with external demands. We also want to acknowledge that people can also be self-employed and not directly submit to organizational order. Yet, their work is embedded in the larger socio-technological sphere and is still subject to external organizational evaluation.

Enhancement Without Organizational Knowledge

Even if effective, Human Enhancement is not inevitably endorsed or allowed by authorities or organizations. Hence, individuals may be interested in obfuscating and conducting their enhancement efforts *without organizational knowledge*. While organizations have the capacity to gather insights into ongoing practices, such as via scholarly investigations or substance examinations, the expression "without organizational knowledge" pertains to the present identification of the enhancement conducting individual.

The prime example here would be doping, which is, strictly speaking, enhancement in the work place, respectively, an amateur setting. In these cases, enhancements may be *too effective*. Organizational reasons for prohibiting the use of these particular instances of Human Enhancement may be maintaining the "integrity of the sport" (World Anti-Doping Agency, 2021) or ensuring fairness and equality in the academic context (Maier et al., 2015). In addition, potential significant health or legal risks may cause organizations and gatekeepers to discourage particular enhancements (Hotze et al., 2011; Shakeel et al., 2021; World Anti-Doping Agency, 2021). If organizations obtain knowledge about the illegitimate use of Human Enhancement, they can exercise their regulatory power and sanction the individual.

However, organizational disapproval does not eliminate the subjective mismatch between capacities and demands. Analyzing responses of 1145 surgeons, Franke et al. (2013) reported that 8.9% of respondents used an illicit or prescription drug for cognitive enhancement purposes at least once in their lifetime. Randomized response technique even suggested a lifetime prevalence of around 20%. In addition, work performance and private life pressure were significant risk factors for using the respective drugs. Also employing randomized response technique in a representative student sample, Dietz et al. (2013) found a 12-month prevalence for using "brain-doping substances" of 20%. A survey of 1572 students found a prevalence of 1.7% for the use of prescription drugs without a prescription and 1.3% for the use of illicit substances for cognitive enhancement purposes (Schelle et al., 2015). Users of the former reported significantly more stress than nonusers, an effect that was not present for the use of illicit drugs. Somewhat similar results are also found for the positive association between prescription and lifestyle drugs and burnout scores in a student sample (Wolff et al., 2014).

The latter studies demonstrate the difficulties in regulating Human (cognitive) Enhancement. The prevalence of so-called lifestyle drugs (caffeine, nicotine, and alcohol) with an enhancement intention was 45.6% (Schelle et al., 2015), respectively 52.3–83.2% (Wolff et al., 2014). Reasonable caffeine and nicotine consumption is generally unobjectionable to organizations. The former may even boost individual and group performance under the right circumstances (Faber et al., 2017). Yet, using less conventional means, due to the social perception processes, may impede performance (Faber et al., 2017; Sattler et al., 2023). Alcohol, however, is a large security and safety risk and is usually heavily regulated.

In the domain of cognitive enhancement, motivations for engaging with Human Enhancement are well-researched. Here, highly competitive environments and related performance pressure have been predictors for real engagement with substances for cognitive enhancement reasons (Franke et al., 2013; Maier et al., 2018; Schelle et al., 2015). There is also weak evidence that people who work in very competitive environments are more willing to enhance their cognitions (Conrad et al., 2019). Low self-efficacy may prone individuals to use cognitive-enhancing substances (van Veen et al., 2022). However, Bagusat et al. (2018) found no effect of self-efficacy, and findings by Maier et al. (2015) suggested that the association of self-efficacy with

pharmacological mood enhancements was more robust than with cognitive enhancement. A recent prospective study revealed that increasing workload alone could predict misuse of prescriptive cognitive-enhancing drugs, but only for individuals who are overcommitted at work (Sattler & von dem Knesebeck, 2022). Employing a representative German sample, Bagusat et al. (2018) revealed that perceived stress was positively associated with using stimulating prescription drugs, while the deficits in recovering from stress contributed to engagement with substances intended to modulate individual mood. In the same study, respondents disclosed that the primary motive for using stimulating prescription drugs was to better cope with stress. In contrast, illicit drugs were primarily used for mood enhancement purposes. Long-term stress may be a universal predictor of a wide range of pharmacological enhancement efforts (Maier et al., 2015)

Employees may even engage with Human Enhancement due to a feeling of responsibility toward their employer (Pustovrh et al., 2018). Reasons for Enhancement without organizational knowledge are undoubtedly manifold and may not stem from pronounced selfishness but rather a strong identification with the organizational goals and values or a high degree of experienced competitiveness.

Suppose applying an illicit or highly controversial enhancement without organizational knowledge is reasonably linked to a higher probability of organizational goal achievement. Suppose further that individuals are aware of this link. In this case, this may be classified as unethical pro-organizational behavior (UPB), which denotes actions "intended to promote the effective functioning of the organization or its members (e.g., leaders) and violate core societal values, mores, laws, or standards of proper conduct" (Umphress & Bingham, 2011, p. 622). The theoretical proposition that high organizational identification is one antecedent of such behavior (Umphress & Bingham, 2011) was supported by a recent meta-analysis (Luan et al., 2022). There may be a direct link between a perceived unethical organizational culture (Vem et al., 2023) and UPB displayed by leaders (Luan et al., 2022). Individuals reported that acceptability to engage with cognitive enhancement also hinges on whether a superior endorses such behavior (Dinh et al., 2020). Some individuals could find themselves part of organizations that promote certain values and social settings conducive to Human Enhancement adoption, albeit without directly imposing such practices. This way, members' engagement may be seen as a "functional response" to the perceived conditions (Mann, 2023, p. 75). For instance, membership in fraternities and sororities is associated with an increased proneness to abuse certain drugs (Benson et al., 2015; McCabe et al., 2005), and students in higher educational systems that emphasize competition and self-entrepreneurship may feel compelled to take the necessary means to ensure effective engagement (Döbler & Carbon, 2023a; Mann, 2023). Thus, enhancement without organizational knowledge can also be motivated *by organizational virtue*.

The fact that illicit enhancement without organizational knowledge may benefit an organization raises significant ethical questions about the organizational context's short- and long-term effects. From a cynical point of view, and taking into account economic considerations, organizations could be considered to be acting reasonably logically if they create, support, or maintain an environment in which members use controversial methods to improve their skills, especially if these efforts ultimately contribute to the success of the organization. Suppose executive members in charge can credibly assure that this behavior occurred without direct organizational knowledge. In that case, any potential legal or health-related price is primarily paid by the organizational members who re-enacted the already existing organizational culture and valid practices (see Hallett, 2003).

Carried out in an organizational setting, the decision to conduct enhancement without organizational knowledge can be influenced by multiple considerations. Notably, individuals' obfuscation may be driven by the prospect of facing moral condemnation from others, fear of legal backlash for unlawful methods, and apprehensions surrounding violating organizational standards. All these reasons are exemplified very well concerning the use of neurocognitive enhancers in an academic setting (Sahakian & Morein-Zamir, 2007; Sharif et al., 2021). This practice is not necessarily illegal but is considered unfair and morally wrong (Faber et al., 2016). Employed means may be illicit (Brand et al., 2016), or their acquisition may be achieved by feigning neurological symptoms (Fuermaier et al., 2021; van Veen et al., 2022). Thus, engagement with this practice may yield ethical issues. These issues, however, may depend on the type of organization and the respective culture. Results from Conrad et al. (2019) and Dinh et al. (2020) suggest that cognitive enhancement receives more approval in work environments as opposed to academic settings. Importantly, this pattern of acceptance remains consistent regardless of whether the job is classified as blue-collar or white-collar (Dinh et al., 2020).

To cover the broadness of this phenomenon in the context of a human factor analysis, one should carefully analyze (A) which technologies in use can be defined as Human Enhancement under a suitable definition, (B) whether the use of these enhancements occurs without organizational knowledge, and (C) how the technologies in question influence performance, the risk for human errors, and are related to the work process in general.

If illegitimate means are employed, this phenomenon can be costly. Organizations should investigate their context on whether it incentivizes engagement with potentially harmful means to boost individual capabilities. Still, Human Enhancement without organizational knowledge is not inevitably a

problem. Yet, it is still worth considering when analyzing and designing a work environment. Even if without tangible effect, the fact that employees engage with the enhancement in the first place provides evidence of a subjective mismatch between environmental and task demands and their capabilities.

Enhancement by Organizational Order

Some organizations may consider specific enhancements as a welcome opportunity to boost employees' performance, establish new products or services, or enhance safety and security. Once again, the extent of this enhancement *by organizational order* (BOO) depends on the conceptualization of Human Enhancement.

A very straightforward example can be found in the military. The US Army employs various Human Enhancement techniques and technologies to directly or indirectly improve the performance and protection of their soldiers (Brunyé et al., 2020). After focusing on external protection for a long time, the development of an internal armor, a so-called "idiophylaxis", i.e., effective internal protection against Nuclear, biological, and chemical threats, has recently become one of the main issues of military technological efforts (Bickford, 2019). This goal should mainly be achieved through general and novel vaccination technologies, which — seen from an academic perspective — are a prime example of Human Enhancement (Döbler & Carbon, 2021). In fact, one of the first things that happens to recruits is the quick administration of various vaccinations, which somewhat inscribes their new identity down to a molecular level (Bickford, 2019).

Apart from the US Army (Brunyé et al., 2020; Emanuel et al., 2019), the British Ministry of Defense (Ministry of Defence, 2020) and the German armed forces (Planungsamt der Bundeswehr, 2013) have shown public interest in various degrees of Human Enhancement, including cybernetic implants. Ordering soldiers to get enhanced is a recognized ethical issue within the military application of Human Enhancement (Ministry of Defence, 2020; Sattler et al., 2022). In this context, goal posts of bioethics, such as the right to life and decision autonomy, are moved (Gross, 2006).

There are also other work contexts where different types of Human Enhancement, some highly controversial, may be mandatory. Genetic engineering could protect astronauts from harmful space radiation during long-term missions to Mars (Szocik et al., 2018; Szocik et al., 2020). Furthermore, Grewal et al. (2020) discussed how some enhancements could improve the customer experience for frontline workers and boost performance in different branches. Moreover, Patel et al. (2021) showed that external electrical neurostimulation could improve surgeons' performance with surgery robots. If proven safe and effective, novel enhancements could become integral to work organization. Such developments could even go so far as organizations sanction members who reject Human Enhancement. However, the fact that an enhancement is safe does not eliminate moral concerns about its application (Maier et al., 2015). Due to vaccination being Human Enhancement (Döbler & Carbon, 2021, 2023b), the legal and ethical issues revolving around a vaccination mandate, for instance, most recently against SARS-CoV-2 in certain professions (Gur-Arie et al., 2021; Hodge et al., 2021), elucidate emerging conflicts related to enhancement BOO. In this case, however, we must also acknowledge that vaccination mandates were and are already required in certain organizational contexts and activities, e.g., medical, early education, or even universally, as with smallpox in Germany up to 1982 (Attwell et al., 2018).

Just because an organization requires its members to enhance does not render the enhancement legal or morally acceptable. Additionally, organizations can apply enhancements to certain individuals without consent. The military, for instance, has an infamous institutional reputation for testing emerging technologies on prisoners of war, civilians, or even their own service members (Gross, 2006; Klee, 2001). Another gruesome example is the ordered administrator of doping substances to uninformed athletes. Such efforts were most infamously systematically practiced in the former German Democratic Republic (GDR) (Franke & Berendonk, 1997). Here, the state-orchestrated effort, which included the application of androgenic steroids to female athletes (including minors), reached deep into athletic and scientific organizations (Franke & Berendonk, 1997) and exemplifies how political Human Enhancement by organizational order can lead to disastrous personal consequences. The idea to enhance human capital was not exclusive to cold-war sports politics. At age 17, Judy Garland, the main star of the "Wizard of Oz," was infamously put under the influence of amphetamine by the movie's film crew to keep her energized. Farren (2010) references this story and highlights how the proposed function of amphetamines mirrors American values like "stamina, dedication, hard work, endurance, and the willingness to repeat mindless actions for hours on end" (p. 11). Organizational-internal demand for the enhancement may rise if it creates a favorable effect for the employee, e.g., by providing a competitive advantage over colleagues. This yields distributional justice concerns. When the supply of advantageous enhancements is limited, the question of who receives the order to enhance or has access to enhancements is crucial. Acknowledging that enhancements are more likely to be disapproved when employed in competitive settings (Dinh et al., 2020; Mihailov et al., 2021) (but see also Conrad et al., 2019), organizations should make related processes transparent and consider the dynamic social effects of their mandate to enhance. Sattler and Häuser (2023) showed the potential for "inter-individual performance" effects by demonstrating that knowledge about the successful enhancement of co-workers impedes work

motivation by diminishing the enhanced workers' perceived competence and warmth.

If means of Human Enhancement can boost performance or other relevant outcomes, ordering their application within the organization's context makes perfect sense. Hence, we should contemplate the extent of leverage the public wants to grant to companies when deciding to enforce enhancement of their employees (Appel, 2008). Such considerations, however, demand a careful analysis of the enhancement and its intended function. Embedded in a socio-technological system, Human Enhancement makes certain products and services possible in the first place. In this sense, enhancements are a constituting factor for an activity or practice. A non-invasive example is diving gear, which allows, among other things, underwater construction. The future will tell which activities and professions can only be realized when employing novel, highly transformative examples of Human Enhancement.

From a human factors perspective, the analysis of enhancement BOO follows the same steps as for enhancement WOK. The only exception is that step B changes to examining which enhancements are used by organizational order. Conducting this analysis may inform organizations about potential ethical pitfalls within their work processes and foster an understanding of the complex relationship between humans, technology, and organizational demands, which yield an explicit call to transform the human body and mind.

Between WOK and BOO

Some gray areas emerge where means are tacitly tolerated. Moreover, some technologies may not be explicitly framed or perceived as an instance of Human Enhancement. Nevertheless, the shared principle of bodily transformation and adaption is reason enough to scrutinize employed technologies for potential security, safety, or related ethical issues (Döbler & Carbon, 2023a).

The aspects described here only cover some motivational aspects of why people enhance themselves or are ordered to do so. In an economic context, a boost in productivity (Shakeel et al., 2021) or the demand for coping with stress (Bagusat et al., 2018) are evident justifications. However, people may also engage privately with Human Enhancement, for instance, due to transhumanist ideology (Bostrom, 2003), citizen scientific interest (Yetisen, 2018), desired authenticity (Elliott, 2011; Parens, 2005), or pure curiosity (Shakeel et al., 2021). Since these enhancement efforts may occur without organizational knowledge, these reasons do not contradict our framework. Within all the possible motivations, we still claim that one of the most defining features of Human Enhancement is that the key approach to these motivations consists of directing the technology toward the human, i.e., the attempt to transforming and adapting *ourselves* instead of the environment (Döbler & Carbon, 2023a).

The perceived mismatch between capabilities and demands or otherwise emerging desire to technologically manipulate the human body may be located in more private and less organizational tasks and contexts. Nevertheless, it is feasible that these more private enhancements impact task-relevant outcomes and processes. Depending on the technology, organizational goals, and rules, some private enhancements are worrisome, while others are negligible. If private enhancements result in a widespread transformation, effects are likely to impact the activities within an organization.

Employees may use technological means to improve themselves that are, by academic definition, Human Enhancement but are not considered as such and/or lack relevance. Knapik et al. (2014) examined the use of dietary supplements by US soldiers. These supplements can be seen as Human Enhancement, but armed forces usually have no reasons to prohibit their use, let alone conduct testing for them in medical examinations. Hence, organizations may be unaware of certain enhancements but have little to no reason to exercise regulatory control unless there is an emerging safety/security violation or another threat.

Both WOK and BOO describe epistemic positions of the organization and are linked to different contextual factors. These positions are intertwined with motivational aspects. WOK processes can refer to organizational contexts that incentivize Human Enhancement, therefore exercising more indirect pressure upon organization members. Within enhancement BOO, however, the organization openly channels motivational demands upon its members.

Our framework is dynamic. Enhancements that were formerly applied by organizational order may become prohibited. If members of the organization still use these enhancements, they are doing this without organizational knowledge. Examples, especially the ones about the state-sponsored doping efforts of the German Democratic Republic (GDR) (Franke & Berendonk, 1997), also highlight a potential clash between different levels of organizations. The described case emphasizes how, at one level (national athletic associations, training groups, etc.), enhancement by organizational order may occur. However, on other transnational levels (e.g., International Olympic committee), the same enhancement endeavor may happen without organizational knowledge. The same is valid for substance abuse in fraternities and sororities (Benson et al., 2015; McCabe et al., 2005). This type of behavior may clash with college and university statutes. Careful examination is necessary to understand how the motivation for enhancement becomes integrated into a specific organizational culture, potentially influencing the willingness to embrace means considered unfavorable by other relevant organizations.

Overall, classification along the WOK-BOO axis may change according to the adopted perspective. Our framework is purposely built to be highly flexible and capable of operating across the complex networks of different organizations, accommodating their potentially divergent goals and strategies.

Safety and Security

Human Enhancement is neither per se morally suspicious (Daniels, 2000; Döbler & Carbon, 2023a) nor inevitably undermines organizational or individual goals, values, and flourishing. Still, some enhancements may come with a significant price, posing unintentional risks from within a system or threaten it from the outside. The former danger is usually framed as safety, the latter as a security issue (Line et al., 2006).

Safety

Cognitive enhancements like modafinil, methylphenidate, and even caffeine can evoke adverse physiological reactions, threatening task-relevant cognitive, emotional, or behavioral processes (Caviola & Faber, 2015), which may then lead to work-related accidents. Physical implants can lead to infections (Yetisen, 2018), threatening the individual employee's health. Safety and concerns about adverse side effects are reasons to refrain from using or advocating certain enhancements or deeming them morally wrong (Schelle et al., 2014). These effects are consistently expressed regarding various technologies, from vaccination (Blaisdell et al., 2016; Dror et al., 2020) over cognitive enhancements (Sattler et al., 2022; Scheske & Schnall, 2012), genetic engineering (Schönthaler et al., 2022), deep brain stimulation (Kostick-Quenet et al., 2022; Schönthaler et al., 2022), to brain-computer interfaces (Sample et al., 2020). The prospect of significant enhancement per se evokes additional ethical unease so that users are not inevitably prone to see an enhancement as justified just because it is safe (Maier et al., 2015).

Even if an enhancement does not offer a significant improvement over traditional means or does not have adverse side effects (Caviola & Faber, 2015), safety concerns and subsequent legal liability could be another factor for organizational reluctance. True to the motto "better safe than sorry," the prospect of legal challenge and claims for damages might be sufficient for organizations to forgo enhancements even if not explicitly mentioned in regulatory frameworks. It is, therefore, necessary to put things into perspective and carefully analyze the suitability of regularities in relationship to the tangible effects of Human Enhancement. To ensure a realistic assessment of capabilities, employees and organizations should be informed whether an enhancement does contribute to task-relevant outcomes. Supposing a tangible and significant enhancement effect, regulation of the enhancement may be codified to address legal issues and other possible conflicts.

Overestimation of the effects of contemporary enhancements (Ilieva et al., 2013; Mihailov & Savulescu, 2018) can also corrupt systems' safety. The promise of quick and reliable performance boosts over more time-intensive training or other measures may lead to putative overconfidence regarding one's allegedly enhanced capabilities. Organizations and individuals rely on a sufficient body of literature to make informed decisions on whether an enhancement improves performance, corrupts it, or can evoke a threat due to a misrecognition of the direction of its effect. Take, for instance, caffeine in a medical setting. Belykh et al. (2018) conducted an in-depth review of various performance-enhancing means and discovered a notable absence of data regarding caffeine's impact on surgical performance. Despite caffeine's widespread use, the authors caution against its pre-surgery consumption. The potential consequences could be fatal if medical professionals overestimate their abilities due to technological modifications.

Security

Another problem is security. This is mainly a concern for enhancements that rely on electronic information processing. Data protection is twofold here. Some enhancements may potentially record uninvolved third parties' environmental and personal data. Others may only process data gathered directly from their users. If these enhancements are part of a larger information technology architecture, the enhancement and potentially the enhanced human could be a potential breaching point for cyber-attacks.

Brain-computer interfaces (BCI), for example, process neuronal activity to control a different system (Kawala-Sterniuk et al., 2021; Steinert et al., 2019). Besides the sensitivity of this data, an external attack on these systems and the causal relationship between their components can have disastrous consequences. If substantially integrated into work processes, for example, to control a drone (Nourmohammadi et al., 2018), a security issue in brain-technology communication can quickly become a safety issue as well. Someone could compromise the BCI and execute the respective behavior while the BCI user would be held responsible for it. Data protection and the emergence of new forms of cyber-attacks are BCI-related concerns shared by laypeople and experts (Sample et al., 2020; Sample et al., 2022).

Potential Benefits

However, Human Enhancement can also contribute to the safety and security of employees and organizations. The already mentioned vaccinations are a powerful biotechnological tool to ensure individual health in a potentially hazardous working environment. Moreover, if effective in their respective target domain, cognitive enhancements can improve safety and security-related performance, such as alertness. It is crucial to weigh the risks and benefits of every enhancement case-by-case.

Evidently, technological alteration of the human body and mind can bring forth new challenges in the field of human factors. The two levels of heuristic analysis are, first, safety and security *of* the enhancement, and second, system safety and security *with* the enhancement.

Implications for Future Research and Practical Application

Human factors research should recognize the emerging and transformative power of Human Enhancement. At the same time, the presence of contemporary enhancements should be acknowledged. Technological interventions of the "human" add complexity to the system-of-systems perspective. Human Enhancement enables organizations and users to target capabilities unachievable by simple training or environmental design. Whether these enhancement efforts prove to be successful is an important question for contemporary and future research. Additionally, it should be examined why people or organizations engage with Human Enhancement in the first place, especially when these enhancements are illicit. A careful case-by-case assessment of work demands and provided means to fulfill them is needed.

Organizational context is a key component when examining Human Enhancement efforts because of the inherent power structure and their potential interplay of demands that push people to adopt certain means. In short, organizations are part of the socio-economic environment humans adapt to using Human Enhancement (see Döbler & Carbon, 2023a). Organizations, employees, and researchers should recognize how the motivation to engage with enhancement in the workplace may stem from the tension between working demands, individual capabilities, and cultural and individual attitudes.

When employees engage with enhancements, important questions emerge. Does social pressure arise on those who do not want to have anything implanted or enhanced? Is the threshold of constantly high-performance demand with toxic stress so far shifted that we may see more or more severe stress and burnout-related failures? This is where we need to integrate studies of workplace safety and psychopathological factors. Research already suggests that social pressure can lead people to favor the use of cognitive enhancement (Dinh et al., 2020; Sattler et al., 2013; Sattler et al., 2014; Wagner et al., 2018).

Enhancement efforts may yield new security and safety issues but also have the potential to enhance these parameters. If so, it is not the engagement but the rejection to employ Human Enhancement that may be morally reprehensible.

It is important to remember that employees are also private persons. Human Enhancement to meet the demands of the workplace, regardless of the consequences of this particular task, always has the potential to spill out either negatively or positively to the private domain (Pustovrh et al., 2018). A comprehensive approach to human factors and Human Enhancement should recognize different roles and how a technological intervention to a specific capability can yield broad, general, but also contrary effects across different areas of life.

The most important insight for practitioners is that Human Enhancement in an organizational context bears the potential for ethical controversies. This is connected to whether the enhancement was rather done without organizational knowledge or by organizational order. If the means are illicit or otherwise ethically suspicious, their employment without organizational knowledge may hint toward the presence of specific conditions that foster the engagement with controversial means. Organizations should seriously contemplate if they want to maintain such context and, if so, at what costs. If realized through similar illicit or controversial means, Human Enhancement by organizational order indicates a certain ethical apathy of the respective authority. The organization may cite plausible reasons. Yet, it should be clear that employees' and other organizational members' bodily autonomy and related values should be held in high(est) regard.

Although embedded in societal structures and contexts (Döbler & Carbon, 2023a; Menuz et al., 2013), Human Enhancement is often seen as a rather individual matter (Elliott, 2011; Sandberg, 2013). Here, enhancement by organizational order emphasizes the important role of employers, companies, and other institutions in adopting technological interventions, thereby *co-producing* (Harbers, 2005) the evaluative context for the same interventions. All persons involved should be attentive to the fact that organizational goals and the means deemed necessary to achieve them are not necessarily uncontroversial. Figure 1 shows an overview of the thoughts presented here.

Conclusion

Being at work, people may use enhancements — some well-known, others novel — due to imposed internal or external demands. Technological interventions in a human

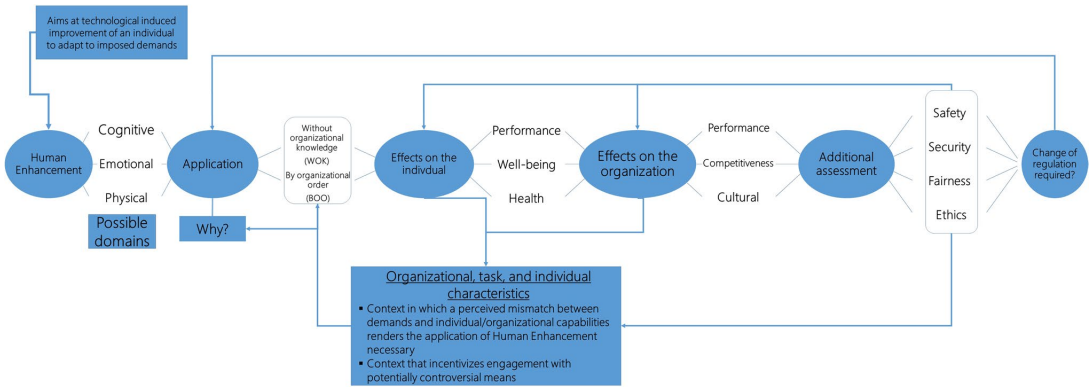


Fig. 1 Summary of the thoughts presented here. Note: this framework is far from being exhaustive but is motivated to make a thought-provoking starting point

factor context are often seen as merely directed at the environment. Human Enhancement, however, emphasizes how it can also be the Human that can be the target of technological improvement (Döbler & Carbon, 2023a).

From the organization's perspective, enhancement behavior occurs between the two poles: without organizational knowledge and by organizational order. Its significance depends on the effects of the enhancement and the relevant tasks. Enhancements can evoke novel safety and security risks.

When designing a work environment to ensure productivity, efficacy, well-being, safety, and security, organizations conduct a somewhat universal intervention. On the contrary, and even if rolled out at a larger scale, Human Enhancement concerns individuals. Yet, in a tight socio-technological system, the intended improvement of a single human can disturb the overall organization of the same system. It is up to human factors to examine how likely the effects will be and contemplate how to deal with the advancing *technologized human-technology* relationship.

Acknowledgements The authors want to thank the two anonymous reviewers whose comments helped to improve the quality of this manuscript. The authors would like to disclose the assistance of ChatGPT during the revision, a language model developed by OpenAI. It was exclusively utilized for language and expression refinement, and no novel ideas or content were generated by the model.

Author Contribution NAD: conceptualization, writing original draft, writing revision
CCC: conceptualization, supervision
HS: conceptualization, writing original draft

Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Competing Interests The authors declare no competing interests.

References

Agar, N. (2014). *Truly human enhancement: A philosophical defense of limits*. MIT Press. http://cognet.mit.edu/book/truly-human-enhancement

Appel, J. M. (2008). When the boss turns pusher: A proposal for employee protections in the age of cosmetic neurology. *Journal of Medical Ethics, 34*(8), 616–618. https://doi.org/10.1136/jme.2007.022723

Attwell, K., Navin, M. C., Lopalco, P. L., Jestin, C., Reiter, S., & Omer, S. B. (2018). Recent vaccine mandates in the United States, Europe and Australia: A comparative study. *Vaccine, 36*(48), 7377–7384. https://doi.org/10.1016/j.vaccine.2018.10.019

Bagusat, C., Kunzler, A., Schlecht, J., Franke, A. G., Chmitorz, A., & Lieb, K. (2018). Pharmacological neuroenhancement and the ability to recover from stress - A representative cross-sectional survey among the German population. *Substance Abuse Treatment, Prevention, and Policy, 13*(1), 37. https://doi.org/10.1186/s13011-018-0174-1

Banjo, O. C., Nadler, R., & Reiner, P. B. (2010). Physician attitudes towards pharmacological cognitive enhancement: Safety concerns are paramount. *PLoS One, 5*(12), e14322. https://doi.org/10.1371/journal.pone.0014322

Belykh, E., Onaka, N. R., Abramov, I. T., Yağmurlu, K., Byvaltsev, V. A., Spetzler, R. F., Nakaj, P., & Preul, M. C. (2018). Systematic review of factors influencing surgical performance: Practical recommendations for microsurgical procedures in neurosurgery. *World Neurosurgery, 112*, e182–e207. https://doi.org/10.1016/j.wneu.2018.01.005

Benson, K., Flory, K., Humphreys, K. L., & Lee, S. S. (2015). Misuse of stimulant medication among college students: A comprehensive review and meta-analysis. *Clinical Child and Family Psychology Review, 18*(1), 50–76. https://doi.org/10.1007/s10567-014-0177-z

Bickford, A. (2019). "Kill-Proofing" the soldier. *Current Anthropology, 60*(S19), S39–S48. https://doi.org/10.1086/700028

Blaisdell, L. L., Gutheil, C., Hootsmans, N. A. M., & Han, P. K. J. (2016). Unknown risks: Parental hesitation about vaccination. *Medical Decision Making: An International Journal of the Society for Medical Decision Making, 36*(4), 479–489. https://doi.org/10.1177/0272989X15607855

Bobko, P., & Coella, A. (1994). Employee reactions to performance standards: A review and research propositions. *Personnel Psychology, 47*(1), 1–29. https://doi.org/10.1111/j.1744-6570.1994.tb02407.x

Bommer, W. H., Johnson, J. L., Rich, G. A., Podsakoff, P. M., & Mackenzie, S. B. (1995). On the interchangeability of objective and subjective measures of employee performance: A meta-analysis. *Personnel Psychology, 48*(3), 587–605. https://doi.org/10.1111/j.1744-6570.1995.tb01772.x

Bostrom, N. (2003). Human genetic enhancements: A transhumanist perspective. *The Journal of Value Inquiry, 37*(4), 493–506.

Bostrom, N. (2013). Why I want to be a posthuman when I grow up. In M. More & N. Vita-More (Eds.), *The transhumanist reader* (pp. 28–53). John Wiley & Sons.

Bostrom, N., & Roache, R. (2008). Ethical issues in human enhancement. In J. Ryberg, T. Petersen, & C. Wolf (Eds.), *New waves in applied ethics* (pp. 120–152). Pelgrave Macmillan.

Bostrom, N., & Sandberg, A. (2009). Cognitive enhancement: Methods, ethics, regulatory challenges. *Science and Engineering Ethics, 15*(3), 311–341.

Brand, R., Wolff, W., & Ziegler, M. (2016). Drugs as instruments: Describing and testing a behavioral approach to the study of neuroenhancement. *Frontiers in Psychology, 7*, 1226. https://doi.org/10.3389/fpsyg.2016.01226

Brunyé, T. T., Brou, R., Doty, T. J., Gregory, F. D., Hussey, E. K., Lieberman, H. R., Loverro, K. L., Mezzacappa, E. S., Neumeier, W. H., Patton, D. J., Soares, J. W., Thomas, T. P., & Yu, A. B. (2020). A review of US Army research contributing to cognitive enhancement in military contexts. *Journal of Cognitive Enhancement, 4*(4), 453–468. https://doi.org/10.1007/s41465-020-00167-3

Buchanan, A. E. (2011). *Beyond humanity? The ethics of biomedical enhancement*. Oxford Univ. Press.

Caviola, L., & Faber, N. S. (2015). Pills or push-ups? Effectiveness and public perception of pharmacological and non-pharmacological cognitive enhancement. *Frontiers in Psychology, 6*, 1852. https://doi.org/10.3389/fpsyg.2015.01852

Coeckelbergh, M. (2011). Human development or human enhancement? A methodological reflection on capabilities and the evaluation of information technologies. *Ethics and Information Technology, 13*(2), 81–92. https://doi.org/10.1007/s10676-010-9231-9

Conrad, E. C., Humphries, S., & Chatterjee, A. (2019). Attitudes toward cognitive enhancement: The role of metaphor and context. *AJOB Neuroscience, 10*(1), 35–47. https://doi.org/10.1080/21507740.2019.1595771

Daniels, N. (2000). Normal functioning and the treatment-enhancement distinction. *Cambridge Quarterly of Healthcare Ethics, 9*, 309–322. https://doi.org/10.1017/S0963180100903037

Deci, E. L., Olafsen, A. H., & Ryan, R. M. (2017). Self-determination theory in work organizations: The state of a science. *Annual Review of Organizational Psychology and Organizational Behavior, 4*(1), 19–43. https://doi.org/10.1146/annurev-orgpsych-032516-113108

Dietz, P., Striegel, H., Franke, A. G., Lieb, K., Simon, P., & Ulrich, R. (2013). Randomized response estimates for the 12-month prevalence of cognitive-enhancing drug use in university students. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy, 33*(1), 44–50. https://doi.org/10.1002/phar.1166

Dinh, C. T., Humphries, S., & Chatterjee, A. (2020). Public opinion on cognitive enhancement varies across different situations. *AJOB Neuroscience, 11*(4), 224–237. https://doi.org/10.1080/21507740.2020.1811797

Döbler, N. A., & Carbon, C.-C. (2021). Vaccination against SARS-CoV-2: A human enhancement story. *Translational Medicine Communications, 6*, 27. https://doi.org/10.1186/s41231-021-00104-2

Döbler, N. A., & Bartnik, C. (2022). Normative affordances through and by technology: Technological mediation and human enhancement. *International Journal of Interactive Multimedia and Artificial Intelligence, 7*(6), 14–23. https://doi.org/10.9781/ijimai.2022.09.006

Döbler, N. A., & Carbon, C.-C. (2023a). Adapting ourselves, instead of the environment: An inquiry into human enhancement for function and beyond. *Integrative Psychological & Behavioral Science*. Advance online publication. https://doi.org/10.1007/s12124-023-09797-6

Döbler, N. A., & Carbon, C.-C. (2023b). Boosting human capacities: Attitudes toward Human Enhancement and vaccination in the context of perceived naturalness and invasiveness. *Discover Psychology, 3*(1), 24. https://doi.org/10.1007/s44202-023-00085-3

Dörner, D., & Schaub, H. (1994). Errors in planning and decision-making and the nature of human information processing. *Applied Psychology, 43*(4), 433–453. https://doi.org/10.1111/j.1464-0597.1994.tb00839.x

Dror, A. A., Eisenbach, N., Taiber, S., Morozov, N. G., Mizrachi, M., Zigron, A., Srouji, S., & Sela, E. (2020). Vaccine hesitancy: The next challenge in the fight against COVID-19. *European Journal of Epidemiology, 35*(8), 775–779. https://doi.org/10.1007/s10654-020-00671-y

Elliott, C. (2011). Enhancement technologies and the modern self. *The Journal of Medicine and Philosophy, 36*(4), 364–374. https://doi.org/10.1093/jmp/jhr031

Emanuel, P., Walper, S., DiEuliis, D., Klein, N., Petro, J. B., & Giordano, J. (2019). *Cyborg soldier 2050: Human/machine fusion and the implications for the future of the DOD*. Army combat capabilities development command chemical biological center.

Faber, N. S., Savulescu, J., & Douglas, T. (2016). Why is cognitive enhancement deemed unacceptable? The role of fairness, deservingness, and hollow achievements. *Frontiers in Psychology, 7*, 232. https://doi.org/10.3389/fpsyg.2016.00232

Faber, N. S., Häusser, J. A., & Kerr, N. L. (2017). Sleep deprivation impairs and caffeine enhances my performance, but not always our performance. *Personality and Social Psychology Review: An Official Journal of the Society for Personality and Social Psychology, Inc, 21*(1), 3–28. https://doi.org/10.1177/1088868315609487

Farah, M. J., Illes, J., Cook-Deegan, R., Gardner, H., Kandel, E., King, P., Parens, E., Sahakian, B., & Wolpe, P. R. (2004). Neurocognitive enhancement: What can we do and what should we do? *Nature Reviews Neuroscience, 5*(5), 421–425.

Farren, M. (2010). *Speed-speed-speedfreak: A fast history of amphetamine*. Feral House. http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10402572

Forlini, C., & Racine, E. (2009). Autonomy and coercion in academic "cognitive enhancement" using methylphenidate: Perspectives of key stakeholders. *Neuroethics, 2*(3), 163–177. https://doi.org/10.1007/s12152-009-9043-y

Franke, W. W., & Berendonk, B. (1997). Hormonal doping and androgenization of athletes: A secret program of the German Democratic Republic government. *Clinical Chemistry, 43*(7), 1262–1279. https://doi.org/10.1093/clinchem/43.7.1262

Franke, A. G., Bagusat, C., Dietz, P., Hoffmann, I., Simon, P., Ulrich, R., & Lieb, K. (2013). Use of illicit and prescription drugs for cognitive or mood enhancement among surgeons. *BMC Medicine, 11*, 102. https://doi.org/10.1186/1741-7015-11-102

Franke, A. G., Gränsmark, P., Agricola, A., Schühle, K., Rommel, T., Sebastian, A., Balló, H. E., Gorbulev, S., Gerdes, C., Frank, B., Ruckes, C., Tüscher, O., & Lieb, K. (2017). Methylphenidate, modafinil, and caffeine for cognitive enhancement in chess: A double-blind, randomised controlled trial. *European Neuropsychopharmacology: The Journal of the European College of Neuropsychopharmacology, 27*(3), 248–260. https://doi.org/10.1016/j.euroneuro.2017.01.006

Fuermaier, A. B. M., Tucha, O., Koerts, J., Tucha, L., Thome, J., & Faltraco, F. (2021). Feigning ADHD and stimulant misuse among Dutch university students. *Journal of Neural Transmission (Vienna, Austria: 1996), 128*(7), 1079–1084. https://doi.org/10.1007/s00702-020-02296-7

Greely, H. T. (2006). Regulating human biological enhancements: Questionable justifications and international complications. *Santa Clara Journal of International Law, 4*(2), 87–110.

Grewal, D., Kroschke, M., Mende, M., Roggeveen, A. L., & Scott, M. L. (2020). Frontline cyborgs at your service: How human enhancement technologies affect customer experiences in retail, sales, and service settings. *Journal of Interactive Marketing, 51*, 9–25. https://doi.org/10.1016/j.intmar.2020.03.001

Gross, M. L. (2006). Bioethics and armed conflict: Moral dilemmas of medicine and war. In *Basic bioethics*. MIT Press https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=3338530

Gur-Arie, R., Jamrozik, E., & Kingori, P. (2021). No jab, no job? Ethical issues in mandatory COVID-19 vaccination of healthcare personnel. *BMJ Globalization and Health, 6*(2). https://doi.org/10.1136/bmjgh-2020-004877

Gyngell, C., & Selgelid, M. J. (2016). Human enhancement: Conceptual clarity and moral significance. In S. Clarke, J. Savulescu, T. Coady, A. Giubilini, & S. Sanyal (Eds.), *The ethics of human enhancement* (pp. 111–126). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198754855.003.0008

Hallett, T. (2003). Symbolic power and organizational culture. *Sociological Theory, 21*(2), 128–149. https://doi.org/10.1111/1467-9558.00181

Harbers, H. (2005). Introduction: Co-production, agency, and normativity. In H. Harbers (Ed.), *Inside the politics of technology: Agency and normativity in the co-production of technology and society* (pp. 9–26). Amsterdam University Press.

Haslam, M., Yaden, D., & Medaglia, J. D. (2021). Moral framing and mechanisms influence public willingness to optimize cognition. *Journal of Cognitive Enhancement, 5*(2), 176–187. https://doi.org/10.1007/s41465-020-00190-4

Hauskeller, M. (2013). *Better humans? Understanding the enhancement project*. Acumen http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10776425

Hodge, J. G., Piatt, J. L., Barraza, L., Freed, R., Ghaith, S., & Wells, N. (2021). Legal challenges underlying COVID-19 vaccinations. *The Journal of Law, Medicine & Ethics: A Journal of the American Society of Law, Medicine & Ethics, 49*(3), 495–499. https://doi.org/10.1017/jme.2021.70

Holt, L. J., & Looby, A. (2018). Factors that differentiate prescription stimulant misusers from those at-risk for misuse: Expectancies, perceived safety, and diversion. *Substance Use & Misuse, 53*(7), 1068–1075. https://doi.org/10.1080/10826084.2017.1392984

Hotze, T. D., Shah, K., Anderson, E. E., & Wynia, M. K. (2011). "Doctor, would you prescribe a pill to help me … ?" A national survey of physicians on using medicine for human enhancement. *The American Journal of Bioethics, 11*(1), 3–13. https://doi.org/10.1080/15265161.2011.534957

Husain, M., & Mehta, M. A. (2011). Cognitive enhancement by drugs in health and disease. *Trends in Cognitive Sciences, 15*(1), 28–36. https://doi.org/10.1016/j.tics.2010.11.002

Ilieva, I., Boland, J., & Farah, M. J. (2013). Objective and subjective cognitive enhancing effects of mixed amphetamine salts in healthy people. *Neuropharmacology, 64*, 496–505. https://doi.org/10.1016/j.neuropharm.2012.07.021

Ireni-Saban, L., & Sherman, M. (2021). Cyborg ethics and regulation: Ethical issues of human enhancement. *Science and Public Policy*, scab058. Advance online publication. https://doi.org/10.1093/scipol/scab058

Kawala-Sterniuk, A., Browarska, N., Al-Bakri, A., Pelc, M., Zygarlicki, J., Sidikova, M., Martinek, R., & Gorzelanczyk, E. J. (2021). Summary of over fifty years with brain-computer interfaces-A review. *Brain Sciences, 11*(1). https://doi.org/10.3390/brainsci11010043

Kaye, S., & Darke, S. (2012). The diversion and misuse of pharmaceutical stimulants: What do we know and why should we care? *Addiction, 107*(3), 467–477. https://doi.org/10.1111/j.1360-0443.2011.03720.x

Klee, E. (2001). *Auschwitz, die NS-Medizin und ihre Opfer [Auschwitz, the NS-medicine and their victims]*. Fischer Taschenbuch.

Knapik, J. J., Steelman, R. A., Hoedebecke, S. S., Farina, E. K., Austin, K. G., & Lieberman, H. R. (2014). A systematic review and meta-analysis on the prevalence of dietary supplement use by military personnel. *BMC Complementary and Alternative Medicine, 14*, 143. https://doi.org/10.1186/1472-6882-14-143

Kostick-Quenet, K., Kalwani, L., Koenig, B., Torgerson, L., Sanchez, C., Munoz, K., Hsu, R. L., Sierra-Mercado, D., Robinson, J. O., Outram, S., Pereira, S., McGuire, A., Zuk, P., & Lazaro-Munoz, G. (2022). Researchers' ethical concerns about using adaptive deep brain stimulation for enhancement. *Frontiers in Human Neuroscience, 16*, 813922. https://doi.org/10.3389/fnhum.2022.813922

Kulkarni, P. O. (2013). A literature review on training & development and quality of work life. *Researchers World, 4*(2), 136–143.

Line, M. B., Nordland, O., Røstad, L., & Tøndel, I. A. (2006). Safety vs. security? (PSAM-0148). In M. G. Stamatelatos & H. S. Blackman (Eds.), *Psam 8: Proceedings of the Eight International Conference on Probabilistic Safety Assessment and Management, May 14-18,2006, New Orleans, Louisiana, USA* (pp. 1202–1210). ASME. https://doi.org/10.1115/1.802442.paper151

Luan, Y., Zhao, K., Wang, Z., & Hu, F. (2022). Exploring the antecedents of unethical pro-organizational behavior (UPB): A meta-analysis. *Journal of Business Ethics*. Advance online publication. https://doi.org/10.1007/s10551-022-05269-w

Lynch, G., Cox, C. D., & Gall, C. M. (2014). Pharmacological enhancement of memory or cognition in normal subjects. *Frontiers in Systems Neuroscience, 8*, 90. https://doi.org/10.3389/fnsys.2014.00090

Maier, L. J., Haug, S., & Schaub, M. P. (2015). The importance of stress, self-efficacy, and self-medication for pharmacological

neuroenhancement among employees and students. *Drug and Alcohol Dependence, 156*, 221–227. https://doi.org/10.1016/j.drugalcdep.2015.09.012

Maier, L. J., Haug, S., & Schaub, M. P. (2016). Prevalence of and motives for pharmacological neuroenhancement in Switzerland—Results from a national Internet panel. *Addiction (Abingdon, England), 111*(2), 280–295. https://doi.org/10.1111/add.13059

Maier, L. J., Ferris, J. A., & Winstock, A. R. (2018). Pharmacological cognitive enhancement among non-ADHD individuals-A cross-sectional study in 15 countries. *The International Journal on Drug Policy, 58*, 104–112. https://doi.org/10.1016/j.drugpo.2018.05.009

Maier, L. J., Liakoni, E., Schildmann, J., Schaub, M. P., & Liechti, M. E. (2015). Swiss university students' attitudes toward pharmacological cognitive enhancement. *PLoS One, 10*(12), e0144402. https://doi.org/10.1371/journal.pone.0144402

Mann, J. (2023). Cognitive enhancing drug use amongst students in (neoliberal) higher education: A functional response. *Drugs: Education, Prevention and Policy, 30*(1), 70–80. https://doi.org/10.1080/09687637.2022.2064268

McCabe, S. E., Knight, J. R., Teter, C. J., & Wechsler, H. (2005). Non-medical use of prescription stimulants among US college students: Prevalence and correlates from a national survey. *Addiction, 100*(1), 96–106.

Menuz, V., Hurlimann, T., & Godard, B. (2013). Is human enhancement also a personal matter? *Science and Engineering Ethics, 19*(1), 161–177. https://doi.org/10.1007/s11948-011-9294-y

Mihailov, E., & Savulescu, J. (2018). Social policy and cognitive enhancement: Lessons from chess. *Neuroethics, 11*(2), 115–127. https://doi.org/10.1007/s12152-018-9354-y

Mihailov, E., Rodríguez López, B., Cova, F., & Hannikainen, I. R. (2021). How pills undermine skills: Moralization of cognitive enhancement and causal selection. *Consciousness and Cognition, 91*, 103120. https://doi.org/10.1016/j.concog.2021.103120

Ministry of Defence. (2020). *Human augmentation – The dawn of a new paradigm: A strategic implications project*. Ministry of Defence https://www.bundeswehr.de/resource/blob/5016368/fdc7f1c529ddfb014d4e321e8b666a2d/210111-sip-ha-data.pdf

Napoletano, F., Schifano, F., Corkery, J. M., Guirguis, A., Arillotta, D., Zangani, C., & Vento, A. (2020). The psychonauts' world of cognitive enhancers. *Frontiers in Psychiatry, 11*, 546796. https://doi.org/10.3389/fpsyt.2020.546796

Nourmohammadi, A., Jafari, M., & Zander, T. O. (2018). A survey on unmanned aerial vehicle remote control using brain–computer interface. *IEEE Transactions on Human-Machine Systems, 48*(4), 337–348. https://doi.org/10.1109/THMS.2018.2830647

Nye, C. D., Ma, J., & Wee, S. (2022). Cognitive ability and job performance: Meta-analytic evidence for the validity of narrow cognitive abilities. *Journal of Business and Psychology*, *37*(6), 1119–1139. https://doi.org/10.1007/s10869-022-09796-1

Ocasio, W., Pozner, J.-E., & Milner, D. (2020). Varieties of political capital and power in organizations: A review and integrative framework. *Academy of Management Annals, 14*(1), 303–338. https://doi.org/10.5465/annals.2018.0062

Parens, E. (2005). Authenticity and ambivalence: Toward understanding the enhancement debate. *Hastings Center Report, 35*(3), 34–41.

Patel, R., Suwa, Y., Kinross, J., Roon, A. von, Woods, A. J., Darzi, A., Singh, H., & Leff, D. R. (2021). Neuroenhancement of surgeons during robotic suturing. *Surgical Endoscopy*. Advance online publication. https://doi.org/10.1007/s00464-021-08823-1

Planungsamt der Bundeswehr. (2013). Human Enhancement: Eine neue Herausforderung für Streitkräfte? A new challenge for the armed forces? (Future Topics). https://www.bundeswehr.de/resource/blob/140504/d757cfdc2b1a467fb7d88544075da1d9/ft-he-data.pdf

Pustovrh, T., Mali, F., & Arnaldi, S. (2018). Are better workers also better humans? On pharmacological cognitive enhancement in the workplace and conflicting societal domains. *NanoEthics, 12*(3), 301–313. https://doi.org/10.1007/s11569-018-0332-y

Racine, E., Sattler, S., & Boehlen, W. (2021). Cognitive enhancement: Unanswered questions about human psychology and social behavior. *Science and Engineering Ethics, 27*(2), 19. https://doi.org/10.1007/s11948-021-00294-w

Randall, D. C., Shneerson, J. M., & File, S. E. (2005). Cognitive effects of modafinil in student volunteers may depend on IQ. *Pharmacology, Biochemistry, and Behavior, 82*(1), 133–139. https://doi.org/10.1016/j.pbb.2005.07.019

Read, G. J. M., Shorrock, S., Walker, G. H., & Salmon, P. M. (2021). State of science: Evolving perspectives on 'human error'. *Ergonomics, 64*(9), 1091–1114. https://doi.org/10.1080/00140139.2021.1953615

Reyes, R. M., de la Riva, J., Maldonado, A., Woocay, A., & de la Rodolfo, O. (2015). Association between human error and occupational accidents' contributing factors for hand injuries in the automotive manufacturing industry. *Procedia Manufacturing, 3*, 6498–6504. https://doi.org/10.1016/j.promfg.2015.07.936

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin*, *138*(2), 353–387. https://doi.org/10.1037/a0026838

Roberts, C. A., Jones, A., Sumnall, H., Gage, S. H., & Montgomery, C. (2020). How effective are pharmaceuticals for cognitive enhancement in healthy adults? A series of meta-analyses of cognitive performance during acute administration of modafinil, methylphenidate and D-amphetamine. *European Neuropsychopharmacology: The Journal of the European College of Neuropsychopharmacology, 38*, 40–62. https://doi.org/10.1016/j.euroneuro.2020.07.002

Sahakian, B., & Morein-Zamir, S. (2007). Professor's little helper. *Nature, 450*(7173), 1157–1159. https://doi.org/10.1038/4501157a

Sample, M., Sattler, S., Blain-Moraes, S., Rodríguez-Arias, D., & Racine, E. (2020). Do publics share experts' concerns about brain–computer interfaces? A trinational survey on the ethics of neural technology. *Science, Technology & Human Values, 45*(6), 1242–1270. https://doi.org/10.1177/0162243919879220

Sample, M., Boehlen, W., Sattler, S., Blain-Moraes, S., & Racine, E. (2022). Brain-computer interfaces, inclusive innovation, and the promise of restoration: A mixed-methods study with rehabilitation professionals. *Engaging Science, Technology, and Society, 8*(2). https://doi.org/10.17351/ests2022.961

Sánchez-Beaskoetxea, J., Basterretxea-Iribar, I., Sotés, I., & Machado, M. D. L. M. M. (2021). Human error in marine accidents: Is the crew normally to blame? *Maritime Transport Research, 2*, 100016. https://doi.org/10.1016/j.martra.2021.100016

Sandberg, A. (2013). Morphological freedom - Why we not just want it, but need it. In M. More & N. Vita-More (Eds.), *The transhumanist reader* (pp. 58–64). John Wiley & Sons.

Sansevere, K. S., Wooten, T., McWilliams, T., Peach, S., Hussey, E. K., Brunyé, T. T., & Ward, N. (2022). Self-reported outcome expectations of non-invasive brain stimulation are malleable: A registered report that replicates and extends Rabipour et al. (2017). *Journal of Cognitive Enhancement*. Advance online publication. https://doi.org/10.1007/s41465-022-00250-x

Sattler, S. (2016). Cognitive enhancement in Germany. In F. Jotterand & V. Dubljevic (Eds.), *Cognitive enhancement* (pp. 159–180). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199396818.003.0011

Sattler, S., & von dem Knesebeck, O. (2022). Effort-reward imbalance at work and prescription drug misuse-prospective evidence from Germany. *International Journal of Environmental Research and Public Health, 19*(13). https://doi.org/10.3390/ijerph19137632

Sattler, S., Forlini, C., Racine, E., & Sauer, C. (2013). Impact of contextual factors and substance characteristics on perspectives toward cognitive enhancement. *PLoS One, 8*(8), e71452. https://doi.org/10.1371/journal.pone.0071452

Sattler, S., Mehlkop, G., Graeff, P., & Sauer, C. (2014). Evaluating the drivers of and obstacles to the willingness to use cognitive enhancement drugs: The influence of drug characteristics, social environment, and personal characteristics. *Substance Abuse Treatment, Prevention, and Policy, 9*, 8. https://doi.org/10.1186/1747-597X-9-8

Sattler, S., Mehlkop, G., Bahr, V., & Betsch, C. (2021). Why parents misuse prescription drugs to enhance the cognitive performance of healthy children: The influence of peers and social media. *Journal of Drug Issues, 51*(3), 461–482. https://doi.org/10.1177/0022042621994547

Sattler, S., Jacobs, E., Singh, I., Whetham, D., Bárd, I., Moreno, J., Galeazzi, G., & Allansdottir, A. (2022). Neuroenhancements in the military: A mixed-method pilot study on attitudes of staff officers to ethics and rules. *Neuroethics, 15*(11). https://doi.org/10.1007/s12152-022-09490-2

Sattler, S., Häusser, J. A., & Faber, N. S. (2023). Working with a sleep-deprived or a cognitively enhanced team member compromises motivation to contribute to group performance. *European Journal of Social Psychology*, ejsp.2971. Advance online publication. https://doi.org/10.1002/ejsp.2971

Schelle, K. J., Faulmüller, N., Caviola, L., & Hewstone, M. (2014). Attitudes toward pharmacological cognitive enhancement-A review. *Frontiers in Systems Neuroscience, 8*, 53. https://doi.org/10.3389/fnsys.2014.00053

Schelle, K. J., Olthof, B. M. J., Reintjes, W., Bundt, C., Gusman-Vermeer, J., & van Mil, A. C. C. M. (2015). A survey of substance use for cognitive enhancement by university students in the Netherlands. *Frontiers in Systems Neuroscience, 9*, 10. https://doi.org/10.3389/fnsys.2015.00010

Scheske, C., & Schnall, S. (2012). The ethics of "Smart Drugs": Moral judgments about healthy people's use of cognitive-enhancing drugs. *Basic and Applied Social Psychology, 34*(6), 508–515. https://doi.org/10.1080/01973533.2012.711692

Schönthaler, E. M. D., Hofer, G., Grinschgl, S., & Neubauer, A. C. (2022). Super-Men and Wonder-Women: The relationship between the acceptance of self-enhancement, personality, and values. *Journal of Cognitive Enhancement*. Advance online publication. https://doi.org/10.1007/s41465-022-00244-9

Shakeel, S., Iffat, W., Qamar, A., Butt, F., Ghuman, F., Ahsan Mallick, I., Ur Rehman, A., & Jamshed, S. (2021). Concept generation of cognitive enhancement: Healthcare professionals' approach towards the impact and utilization of cognitive enhancers in academic context. *Heliyon, 7*(10), e08118. https://doi.org/10.1016/j.heliyon.2021.e08118

Sharif, S., Guirguis, A., Fergus, S., & Schifano, F. (2021). The use and impact of cognitive enhancers among university students: A systematic review. *Brain Sciences, 11*(3). https://doi.org/10.3390/brainsci11030355

Steinert, S., Bublitz, C., Jox, R., & Friedrich, O. (2019). Doing things with thoughts: Brain-computer interfaces and disembodied agency. *Philosophy & Technology, 32*(3), 457–482. https://doi.org/10.1007/s13347-018-0308-4

Szocik, K., Marques, R. E., Abood, S., Kędzior, A., Lysenko-Ryba, K., & Minich, D. (2018). Biological and social challenges of human reproduction in a long-term Mars base. *Futures, 100*, 56–62. https://doi.org/10.1016/j.futures.2018.04.006

Szocik, K., Wójtowicz, T., Boone Rappaport, M., & Corbally, C. (2020). Ethical issues of human enhancements for space missions to Mars and beyond. *Futures, 115*, 102489. https://doi.org/10.1016/j.futures.2019.102489

Umphress, E. E., & Bingham, J. B. (2011). When employees do bad things for good reasons: Examining unethical pro-organizational behaviors. *Organization Science, 22*(3), 621–640. https://doi.org/10.1287/orsc.1100.0559

van Veen, F., Sattler, S., Mehlkop, G., & Hasselhorn, F. (2022). Feigning symptoms to obtain prescription stimulants: A vignette-based study on its conditions. *Journal of Drug Issues, 52*(2), 225–249. https://doi.org/10.1177/00220426211055433

Vem, L. J., Cheah, J.-H., Ng, S. I., & Ho, J. A. (2023). Unethical pro-organizational behavior: How employee ethical ideology and unethical organizational culture contribute. *International Journal of Manpower, 44*(4), 577–598. https://doi.org/10.1108/IJM-11-2021-0635

Wagner, K., Maslen, H., Oakley, J., & Savulescu, J. (2018). Would you be willing to zap your child's brain? Public perspectives on parental responsibilities and the ethics of enhancing children with transcranial direct current stimulation. *AJOB Empirical Bioethics, 9*(1), 29–38. https://doi.org/10.1080/23294515.2018.1424268

Wolff, W., Brand, R., Baumgarten, F., Lösel, J., & Ziegler, M. (2014). Modeling students' instrumental (mis-) use of substances to enhance cognitive performance: Neuroenhancement in the light of job demands-resources theory. *BioPsychoSocial Medicine, 8*, 12. https://doi.org/10.1186/1751-0759-8-12

World Anti-Doping Agency. (2021). *World anti-doping code*. https://www.wada-ama.org/sites/default/files/resources/files/2021_wada_code.pdf

Yetisen, A. K. (2018). Biohacking. *Trends in Biotechnology, 36*(8), 744–747. https://doi.org/10.1016/j.tibtech.2018.02.011

Acta Psychologica 254 (2025) 104748

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Does creating the perfect child mean enforcing or dismantling normative gender stereotypes? Evidence from an interactive virtual genetic engineering exhibit

Niklas A. Döbler *, Claus-Christian Carbon

Department of General Psychology and Methodology, University of Bamberg, Germany
Research Group EPÆG (Ergonomics, Psychological Aesthetics, Gestalt), Germany
Bamberg Graduate School of Affective and Cognitive Sciences (BaGrACS), University of Bamberg, Germany

ARTICLE INFO

Keywords:
Gender
Genetic engineering
Stereotypes
CRISPR/CaS9
Normativity

ABSTRACT

Genetic engineering of humans is a controversial practice with unknown societal effects. Gender constitutes an important evaluative background for human behavior and traits. This manifests within action-guiding normative gender stereotypes. This study investigates to which extent these stereotypes may influence the application of genetic engineering. After highlighting potential motivations to enact stereotypes biotechnologically, we propose two potential strategies. People may design future children in close accordance with contemporary gender stereotypes, e.g., to minimize their risk of being punished for non-confirmation, or may create individuals that counteract these stereotypes, e.g., to create a more gender-egalitarian future. To test these hypotheses, we analyzed a large-scale dataset (13,641 virtual children) from an interactive museum exhibit. Here, visitors could design their "perfect child." Gender-dependent differences in designed Big-5-like personality traits and intelligence, musicality, creativity, and sportiness yielded evidence for behavior predicted by both strategies and were inconclusive regarding the dominance of one strategy. Confirming contemporary stereotypes, children deliberately chosen to be male were designed with lower sensibility but higher sportiness than those deliberately chosen to be female. These effects were accompanied by a relatively higher probability of decreasing sensibility and increasing sportiness of these male children. Non-differences among traits like sociality and conscientiousness disconfirmed normative stereotypes and suggested a more egalitarian design. Effect direction, strength, and certainty depended on whether gender was picked deliberately and other factors. Although the ecological setting and methodological limitations hinder a clear interpretation, we provide initial evidence on how genetically engineered children can "essentially" embody gender normativity.

Abbreviations and glossary

Good-GH: Good-Gender Hypothesis
Eman-GH: Emancipating-Gender Hypothesis
F: Female (Children who were deliberately chosen to be female)
M: Male (Children who were deliberately chosen to be male)
rF: random Female (Children whose randomly assigned female gender was not changed)
rM: random Male (Children whose randomly assigned male gender was not changed)
DGC: Deliberately gendered children (Children whose randomly assigned gender was changed – F/M)
RGC: Randomly gendered children (Children whose randomly assigned gender was not changed – rF/rM)

1. Introduction

Reproductive technologies require weighty decisions about whether and how to intervene in the "natural" processes of parenthood (Ihde, 1990). Prominently, this concerns prenatal diagnostics and the decision as to whether embryos with natural genetic defects should be carried to term. (e.g., Cunningham et al., 2015; Verbeek, 2011). Another decision pertains to choosing a specific sex for the child (e.g., Sharp et al., 2010). The selection of one embryo over the other practiced in this context is a

* Corresponding author at: Markusplatz 3, 96047 Bamberg, Germany.
E-mail address: niklas.doebler@uni-bamberg.de (N.A. Döbler).

https://doi.org/10.1016/j.actpsy.2025.104748
Received 18 September 2024; Received in revised form 19 December 2024; Accepted 20 January 2025
Available online 26 February 2025

broad measure. Yet, advancements in genetic engineering, like the DNA-cutting "genetic scissor" of CRISPR/Cas9, allow for the deletion or addition of genes with unprecedented accuracy (Redman et al., 2016).[1] CRISPR/Cas9 is already used for treating genetic diseases (Khalaf et al., 2020), but it could also influence the genetic basis of personality (Banazadeh et al., 2024). This technology has reignited the ethical debate about the decision to preemptively target embryonic genes in a health-promoting way (Calabrese et al., 2020) and create "perfect" children (Snure Beckman et al., 2019).

Arguments against such practice include the impression that one is "playing God" (Schönthaler et al., 2022, p. 363) or is "meddling with nature" (Pew Research Center, 2016, p. 5). One reason for this unease is so-called *genetic determinism*, i.e., the idea that genes are highly causally responsible for observable differences within humans (Resnik & Vorhaus, 2006). This is often accompanied by so-called genetic essentialism, the belief that our genes harbor a specific "essence," that is not only *causally responsible* for shown behavior but "immutable, fundamental, homogeneous, discrete, [and] natural" (Dar-Nimrod & Heine, 2011, p. 801). Following this assumption, some people may see genetic engineering as either a reliable and direct way to modulate human capacities for good (Dar-Nimrod & Heine, 2011) or an interference with a defining aspect of our identity (Wilson, 2014). Suppose genetic engineering allows for the precise, direct, and highly consequential attunement of natural human features to human norms (Buchanan, 2011): which norms, other than health-related ones, should we adapt to? What "natural" features are a target for change, and what kind of humans are meant to be designed?

Closely linked to gene essentialism is so-called *gender essentialism*, i.e., the belief that the traditional categories of male and female and their related differences can be reduced to a definite biological and genetic makeup (Hendl, 2017; Saguy et al., 2021).[2] Endorsing genetic and gender essentialism can be empirically linked to affirming gender stereotypes (Keller, 2005; Meyer & Gelman, 2016; Nürnberger et al., 2016; Saguy et al., 2021; Weisgram & Bruun, 2018). Stereotypes concern personality, abilities, and behavior- and appearance-related factors (Koenig, 2018). Their content mirrors a normatively gendered, interaction-structuring environment in which deviation from one's "essential" nature can have serious consequences (Butler, 1988; Saguy et al., 2021). Empirically, those who behave stereotype-non-conforming risk negative consequences, and those who issue these consequences may do so to maintain given gender relations (Rudman, Moss-Racusin, Glick, & Phelan, 2012). Stereotyped features like athletic, intellectual abilities and weight (Prentice & Carranza, 2002; Tang-Péronard & Heitmann, 2008) are well-recognized regarding their genetic basis (Willoughby et al., 2019). Given that convictions about gender can be highly naturalized and action-guiding (Butler, 1988; Butnor & MacKenzie, 2022; Saguy et al., 2021) and the manipulation of the human genome is thought to yield significant behavioral differences, normative gender stereotypes could influence which features of the latter are meant to be changed.

Following the call, to use any available knowledge to ensure the child's well-being (Savulescu, 2001) and the beneficial outcomes of adhering to gendered ideals (Rudman, Moss-Racusin, Glick, & Phelan, 2012), targeting what is assumed to be the biological foundation of our behavior and personality may be a tempting strategy to enforce stereotypes and create a "perfect" boy/girl that is unlikely to experience the harsh consequences of gender deviant behavior. This stereotype-enforcing perspective is matched by positions that see emerging biotechnology as the first step into a non-essentialist, gender-transcending society (Hughes & Dvorsky, 2008).

To our knowledge, no empirical study has investigated the link between genetic engineering and normative gender stereotypes. We mean to address this gap on a theoretical and empirical basis. Reflecting on the ethical intricacies of the phenomenon, we will develop two working hypotheses. One argues that parents may genetically engineer their children in accordance with a benign normative standard. Since gender stereotypes could be part of such a standard, we will review how parental actions already enforce or dismantle gender typicality and how these behaviors manifest in contemporary reproductive decisions. Hereafter, we will specify two testable hypotheses on whether people will use genetic engineering to either enforce or dismantle normative gender stereotypes. After discussing their implications, we will empirically test the hypotheses' impact on hypothetical genetic engineering. For that reason, we analyzed data collected from an interactive museum exhibit, where visitors could genetically engineer their "perfect child" by designing gender, health, personality, and talents to their wishes. Given the prospect of emerging biotechnologies with unknown societal consequences, this paper aims to provide insight into the following question: *Suppose parents are interested in the well-being of their child, and gender is a consequential factor for the potential experience of social harm. How will normative conceptions about gender manifest when widespread and precise genetic engineering of humans becomes potentially available?*

2. Theory & hypotheses

Psychological research requires comprehensive theory-building and empirical testing. We hope the theoretical discussion here inspires future research, even if the subsequent investigation cannot address every proposition.

2.1. Working hypothesis A1: Adapting children for good

It should not be too controversial to state that parents are interested in the well-being of their children.[3] Prenatally, pregnant women desire their children to be healthy and adjust their behavior in ways deemed beneficial for this goal (Bondas & Eriksson, 2001). The same study also showed that women were anxious about complications or their parenting abilities. Fathers reported similar worries (Dabb et al., 2023). In this context, the practical and theoretical possibilities of preimplantation/−natal diagnostics and reproductive techniques can inform, mitigate, or validate parental concerns about the child's health (Cunningham et al., 2015; Hodgson & McClaren, 2018). However, availability and obtained information can yield pressure to make the "right" decision about the embryo's fate (Cunningham et al., 2015). Moreover, parents may question their capacity to care for a disabled child and bemoan that the child has fewer opportunities in life (Hodgson et al., 2016). If parental motivations are reliably benign, should they not be interested in "select[ing] the child, of the possible children … who is expected to have the best life, or at least as good a life as the others, based on the relevant, available information" (Savulescu, 2001, p. 415)? Savulescu (2001) originally formulated his "Principle of Procreative Beneficence" concerning preimplantation genetic diagnosis (PGD) and in-vitro fertilization (IVF) and contrasted those interventions against

[1] We will refer to interventions that alter the individual genome as genetic engineering

[2] E.g., "Every cell of the body and the entire body plan and form mark us as either male or female, and it is hard to imagine any more fundamental or essential characteristic of a person." (President's Council on Bioethics, 2003, p. 67)

[3] Of course, there is child-harming behavior by parents, e.g., physical, sexual, or emotional abuse. Reasons for this conduct are complex. For instance, people who experienced abuse themselves reported more favorable attitudes toward abusing infants (Clemens et al., 2020). We do not want to defend these practices, yet emphasize that people may show objectively morally reprehensible conduct out of subjectively justified reasons. Moreover, for some, the act of genetically engineering children may fall under this category (e.g., Hendl, 2017; Sparrow, 2019). Demanding a nuanced investigation, a discussion of these topics is beyond the scope of this paper.

genetic alterations of a chosen embryo. Although it was explicitly meant to communicate a normative appeal, the principle's underlying reasoning seems to describe contemporary attitudes accurately. Parents express support for the idea of discarding genetically impaired embryos (Cunningham et al., 2015). Moreover, people support genetic engineering to enhance resistance against pathogenic agents or eliminate congenital disabilities (Jedwab et al., 2020). While the biotechnological reduction of harm associated with organismic "malfunctions" is far from uncontroversial (e.g., Padden & Humphries, 2020), people still consider these means to ensure their children can live as risk-free as possible.

If parents are generally concerned about their children's well-being, should they not be interested in selecting a child whose features comprehensively increase the probability of favorable outcomes? Indeed, Savulescu (2001) applied his principle not only concerning health but also with respect to characteristics he deems universally beneficial (e.g., intelligence). He even extended his position beyond the context of child selection and claimed that we are '*morally obliged*' to employ genetic engineering to change personality traits that may impair human flourishing (Savulescu, 2005). Prima facie people seem not to concur with this reasoning. Instead, they are much more willing to endorse genetic engineering for treating and preventing medical conditions rather than targeting psychological features for improvement reasons (Jedwab et al., 2020). Compared to people with no children, parents are even more skeptical about genetically engineering human DNA (Jedwab et al., 2020) or interfering with children's characteristics by technological means (Wagner et al., 2018). However, parental motivations to care for their disabled children can manifest in the endorsement of therapeutic genetic manipulation (Snure Beckman et al., 2019). Moreover, a recent study revealed that 2.15 % – 5.75 % of participating U.S. parents have previously administered pharmacological substances without medical indication to their children to improve their cognitive capacities (Sattler et al., 2021). Additionally, general investigations into the attitudes toward genetic engineering (e.g., Marteau et al., 1995; Pew Research Center, 2016; Schönthaler et al., 2022) do not show universal rejection of this intervention. Scheufele et al. (2017) report that 26 % of respondents favored the application of hereditary genetic engineering for purposes other than treatment. A number rising to 39 % when beneficial effects would be non-hereditary. This is mirrored by a cross-country survey, indicating that around 30 % of participants affirmed the employment of genetic engineering for intelligence improvement (Jedwab et al., 2020). Furthermore, several scholars (e.g., Bostrom, 2003; Sorgner, 2015) have argued for this technology's beneficial impact. Despite prevalent ethical concerns, we can reasonably assume at least some support for using biotechnology to directly adapt children to maximize the chance for positive outcomes and minimize the chance of negative outcomes.

Still, genetic engineering is nothing that is taken lightly. Evolutionary-inspired arguments against large-scale interventions with the human gene pool fear the loss of protective variation within the same (Van Dijke et al., 2018; cf. Powell, 2012). However, there are claims that this practice must be implemented if we want to conserve a valued state of general health (Powell, 2015). The empirically observed importance of whether non-treatment interventions yield hereditary effects (Scheufele et al., 2017) and discussion about species-related negative effects (Van Dijke et al., 2018) suggests that people are considering evolutionary consequences. In general, the debate revolves around the idea that shaping individual genomes to a specific ideal may have far-reaching and generationally relevant negative societal, biological, and moral consequences (for an overview, see Van Dijke et al., 2018). This is most evident in the accusations that Savulescu's procreative beneficence re-endorses historical eugenic practices (Sparrow, 2007). This general concern – also mirrored in the genetic engineering debate – is that gene selection may reduce human diversity because decision-makers systematically eliminate features linked to potential individual and social harm (Garland-Thomson, 2020; Padden & Humphries, 2020; Sparrow, 2007; Van Dijke et al., 2018). Sparrow (2007) specifically argued that the social forces that discriminate against different skin colors or sexual orientations pressure parents into selecting children that would swiftly realize a hetero-normative, ethnically homogenous society. Since some people would indeed use genetic engineering to prevent children's homosexuality (Marteau et al., 1995), empirical data supports Sparrow's concerns that the focus on the child's well-being may yield controversial decisions. Savulescu (2001) argued that his principle holds even if possibly entrenching negative social conditions, but emphasized the need for societal measures that mitigate discrimination. However, such policy-focused solutions may not immediately benefit one's child. Hence, it is not surprising that although parents of congenitally ill children feared that genetic engineering could lead to the diminished acceptance and subsequent extinction of humans with disabilities, some of them wanted to use every available means to help their child, even if this perpetuated discriminatory attitudes (Snure Beckman et al., 2019). Despite all valid ethical concerns about the solidification of stereotypes and wrongful societal norms (e.g., Hendl, 2017; Sparrow, 2007), let us approach this issue from the parents' perspective. If they are fundamentally concerned about the well-being of *their* child, and this already motivates a wide range of behaviors before birth: Is it not tempting to use the transformative power of genetic engineering to attune the child to a normative environment, rather than reshaping the environment to meet the child's needs (see Döbler & Carbon, 2024)?

This idea does not require explicitly following the dogma of procreative beneficence. If genetic engineering of humans becomes available, parents will likely contemplate whether their child's genes are adaptive and promote well-being in a given environment. In that case, we assume that the normative dogma and the goal of being good parents leads to the selection of genes that the designers believe will increase the likelihood of a good life for their children (see Bostrom, 2003; Weaver et al., 2020). Thus, people are believed to design children whose chosen features mirror a given value structure. This structure entails *normative* convictions about how children *ought to* be (prescription) or *ought not to* be (proscription) and assumed beneficence of adhering to these norms (see Koenig, 2018). As the cited evidence shows, this will likely eliminate devalued medical conditions and diseases. However, we have also reviewed the contentious idea that normative convictions extend toward psychological features whose potential consequences are deeply socially embedded. Thus, we formulate working hypothesis A1: *When designing a "perfect" child, designers align the configuration of the future child with normative convictions. They will do so to enable the child to live a good life. Most commonly, features like the predisposition of diseases are overwhelmingly eradicated. Less medically speaking, choices regarding traits like personality and talents should be related to common notions about the value of a specific level of feature expressions.*

Apart from the suggested focus on health, what other normative beliefs are so pressing and dominant that parents attune their behavior to them? What environment may they adapt their children to? One answer is a gendered one.

2.2. Working hypothesis A2: Gendered children

Our socio-material environment can be seen as structured in a way that reflects, enforces, and maintains a essence and biology dominated conception of gender and subsequently guides cognitive, behavioral, and social processes (Saguy et al., 2021). Butler (1988) pointed out how gender must be "performed" (p. 527) correctly and how doing so can be seen as adaptive strategic conduct to prevail in a normative social environment. According to her, shown behavior must concur with normative historicized expectations. One way to cultivate normative demands in a socio-material environment is through gender stereotypes (Saguy et al., 2021). Stereotypes about males and females are concerned with many features and are similarly descriptive and normatively pro- and prescriptive (Koenig, 2018; Prentice & Carranza, 2002). They have a pertinent influence on cognitive and social processes (Ellemers, 2018) and can rationalize mistreatment if individuals do not act accordingly

(Rudman, Moss-Racusin, Glick, & Phelan, 2012). Thus, people may be motivated to showcase stereotypical behavior to prevent negative consequences (Rudman, Moss-Racusin, Glick, & Phelan, 2012) and invest resources into complying with what they consider a stereotypical adult male or female (Sanchez & Crocker, 2005). This would be akin to "performing" gender in accordance with historized established norms (Butler, 1988).

Seeing gender stereotypes as cultivated psychological guardrails for successful adaptation, it becomes evident how gender-confirming behavior perpetuates their content (Butler, 1988; Butnor & MacKenzie, 2022; Rudman, Moss-Racusin, Glick, & Phelan, 2012). Crucially, this extends to external evaluators so that their negative or affirmative response to shown behavior may be motivated to reduce future deviation from the established script and maintain gender normativity (Rudman, Moss-Racusin, Glick, & Phelan, 2012). This is emphasized within the rich body of literature on how people are socially, economically, and physically punished if their appearance, personality, or behavior does not comply with contemporary gender stereotypes (e.g., Blondeel et al., 2018; Moss-Racusin et al., 2010; Rudman, Moss-Racusin, Glick, & Phelan, 2012; Rudman, Moss-Racusin, Phelan, & Nauts, 2012; Stotzer, 2009). Being overly agreeable, for instance, leads to lower income for males (Judge et al., 2012), who are expected to be more assertive and agentic (Koenig, 2018; Prentice & Carranza, 2002). For women, displaying agentic assertiveness in job-related contexts reduced likability (Rudman, Moss-Racusin, Phelan, & Nauts, 2012). Evident physical abuse against people who do not identify with their gender assigned at birth shows how peer reactions can be potentially life-threatening (Blondeel et al., 2018; Stotzer, 2009).

Interested in rendering the harsh consequences for non-stereotypical behavior less likely, parents could be inclined to attune children's characteristics and behavior to a pre-given gendered normativity. Indeed, although some parents may report eased expectations about stereotypical behavior, they are unlikely to abandon traditionally gendered ideals completely (Kane, 2006). Moreover, deviations from the normative gender convictions were found to be reciprocally causally related to negative interactions between children and parents (Alanko et al., 2011), and there is evidence that experiencing high conformity with one's assigned gender can be psychologically and socially beneficial (C. L. Martin, Cook, & Andrews, 2017). Parental attunement can manifest subtly in adapting to the environment according to gender stereotypes (Saguy et al., 2021). For instance, parental gender stereotype endorsement was shown to positively influence the children's normative gender stereotypes and predicted furnishing the child's bedroom in a stereotype-matching way (Sutfin et al., 2008). Moreover, it is highly desired for boys to play with gender-matched "masculine" toys but disfavored for them to play with "feminine" ones (Koenig, 2018). The action-guiding power of these stereotypes was shown by their predictive power upon people's reluctance to buy gender atypical toys for children (Weisgram & Bruun, 2018). This shows how, apart from biological determinants, socio-material conditions and parental actions can significantly influence how gender is experienced and expressed by their children (Antoniucci et al., 2023; Davis & Greenstein, 2009). Growing up, children may internalize externally imposed parental and social demands so that they themselves become the pivotal authority for enforcing conformation with one's assigned gender (Jackson et al., 2021).

We can locate the foundation for these processes prior to birth. The most common cases are pregnancy-related ultrasound examinations. Although merely exposing a *biological* feature, prenatal sex revelation may shape the expectations of parents according to *gendered* stereotypes (Browne, 2017). In this sense, these procedures prenatally turn biological sex into social gender (Verbeek, 2011). Imhoff and Hoffmann (2023) assessed which features parents desire within their children before and after their child's sex was revealed this way. Results indicated that fathers shifted their preferred features in a stereotype-conforming direction. Although the effects were not strong and were conditional on parent gender, the authors point out that even minor effects can contribute to a steady perpetuation of normative gender convictions. Parental beliefs about gender can become so decisive that people choose to terminate a pregnancy due to the expected child's gender (Abrejo et al., 2009; Dubuc & Coleman, 2007). But even before the term starts, available technologies allow for the determination and selection of embryonic sex. Here, it was argued that the general practice of *sex selection* in its contemporary (e.g., PGD, IVF) and future manifestations meddles with the parental dogma of unrestricted affection (Hendl, 2017; President's Council on Bioethics, 2003). On a more global scale, implementing such practices was also feared to turn individual benefits into societal disadvantages because it would distort the preferred sex distribution (President's Council on Bioethics, 2003). Savulescu (2001) acknowledges that parents may be inclined to select the socially privileged sex. Yet, he rebutted that this conduct would quickly self-regulate because an uneven sex distribution would diminish the life quality of born men (cf. Sparrow, 2007). Nonetheless, so-called *sex selective abortion* led to an abundance of male children in many countries, including migrant communities in the United Kingdom (Dubuc & Coleman, 2007). In light of the empirical evidence of this practice and proposed arguments in favor of it, Hendl (2017) highlights how selecting for sex is built upon the normative convictions that characterize gender stereotypes. Moreover, she points out how doing so enforces essentialistic views about gender, which effectively undermine egalitarian relationships and constrain children's independence. According to Hendl, this is because sex selection reduces projected behavioral and psychological differences to a genetic basis and, therefore, prenatally imposes parental demands upon the child to act in a stereotype-conforming way. In a similar vein, Browne (2017) accused proponents of sex selection of short-sightedness about systemic relationships and ethical implications. When asked directly for their reasons for pursuing clinical sex selection, couples expressed the hope that it would yield valued gender-related experiences, e.g., walking one's daughter down the aisle as a father (Sharp et al., 2010). In the same study, couples seemed unworried about solidifying discriminative attitudes based on gender. Nonetheless, these results suggest that sex revelation and selection are deeply imbued by expectations regarding gender (Browne, 2017).

Fitzgerald (1997) warned against using gene engineering technology against transgender children to enforce gender conformity. However, sex selection does not inevitably lead to gender-stereotypical behavior (Hendl, 2017). To ensure the latter, one could exaggerate this practice and not only select the general chromosomes but the entire genetic makeup. Thus, application possibilities may reach beyond selecting a particular hoped-for gender identity and stretch toward precisely shaping it according to normative convictions. Under the impression that gender and our genes are highly consequential for our behavior and identity (Dar-Nimrod & Heine, 2011; Haslam & Whelan, 2008), why not implement procreative beneficence and equip the child with a set of features whose composition reflects valued male or female levels? Even if using transformative technological practices to adhere to gender stereotypes may maintain the harmful conditions that gave rise to them (Little, 1998): The motivation to minimize harm or have a "perfect" boy/girl may incline future parents to make controversial decisions. Why spend tiresome hours educating boys and girls on how or how not to behave and use genetic engineering to adapt the child to a gender-normative environment?

However, note the possibility of using this technology the other way around. Instead of enforcing them, people could design children as non-compliant with normative expectations (see Hughes & Dvorsky, 2008). Individuals who do so are called "vanguards" and have the potential to change stereotypes by empirically disproving them (Rudman, Moss-Racusin, Glick, & Phelan, 2012, p. 168). Indeed, parents can enact gender norms in an egalitarian way (Marks et al., 2009). Suppose future parents disvalue gender stereotypes: What better way to call them into question than by genetically establishing their falsification?

These thoughts yield working hypothesis A2: *Due to the evaluative*

dominance of gender, we suspect that perfect children are designed in relation to normative gender stereotypes. What demands further discussion is whether people will use genetic engineering to enact or dismantle normative gender stereotypes.

2.2.1. Enforcing stereotypes: Good-Gender Hypothesis (Good-GH)

Committed to ensuring that their children live as good a life as possible, people may use genetic engineering to design them in accordance with normative stereotypes. Following the benign-motivations reasoning (A1) and importance of gender (A2), this may be driven by the intention to preventively protect children against negative consequences that result from gender stereotype-violating behavior or personality traits (see Rudman, Moss-Racusin, Glick, & Phelan, 2012). Take the finding that agreeableness correlates negatively with income, especially for males (Judge et al., 2012). If parents do not want their male child to be economically punished, the logical choice is to make him not overly agreeable, even if this maintains the existing normative stereotypes that females shall display more agreeableness and males more assertiveness (see Prentice & Carranza, 2002). Even if enforced stereotypes are deemed unfair or untrue, one can still conclude that a child would be better off adhering to them.

Additional influences for enforcing stereotypes may be their cognition-scaffolding function, their perceived importance for structuring gender relations, the belief that they are societally justified (Ellemers, 2018), or one's interest in maintaining hierarchical gender relations (Rudman, Moss-Racusin, Glick, & Phelan, 2012). Preferring stereotypical characteristics within the child may also be linked to the designer endorsing the existence of a gender essence (see Broussard & Warner, 2019; Meyer & Gelman, 2016). Nonetheless, all these motivations converge to the attempt to create "good group member[s]," i.e., individuals whose behavioral and mental features are closely aligned with what is deemed quintessential for a gender (Ellemers, 2018, p. 287). This happens through the biotechnologically aided translation of the designer's stereotype knowledge to the child's genes. Although this may have "bad" societal consequences, children designed to align or even exaggerate contemporary normative gender stereotypes are "good" children in the most general sense: a proper representation of a normatively valued concept, idea, notion, etc.[4] See Table 1 for an overview of identified normative gender stereotypes, whose enforcement specifies our working hypotheses to what we call the *Good-Gender Hypothesis (Good-GH)*.

2.2.2. Dismantling stereotypes: Emancipating-Gender Hypothesis (Eman-GH)

Schönthaler et al. (2022) report that around 50 % of their participants expressed worries that engineering the genome to improve mental capacities may negatively affect social equality. Although an impressive number, it is not a universally shared concern. Indeed, there is a lively academic debate about whether genetic engineering or other techniques to create "perfect" children will reduce or increase socio-economic issues (e.g., Bostrom, 2003; Singer, 2009; Sparrow, 2007; Thomas, 2022; Van Dijke et al., 2018). The academic debate extends to the question of gender. Some scholars proposed that biotechnology could pave the way toward a "postgender future," where each person's mental and physical configuration is up to their maximized self-determination and not bound to traditional gender lines (Hughes & Dvorsky, 2008, p. 13). Achieving this ideal is explicitly meant to overcome the traditional male/female binary and mitigate resulting oppression and suffering (Thweatt-Bates, 2016). Arguably a very abstract goal, note how members of the LGBTQ+ community already use drugs to discover novel ways to express their gender identity in a non-binary fashion (Pienaar et al., 2020).

Translated to our case, this would mean that people use technology to design children meant to dismantle gender stereotypes and contribute to increased gender equality (cf. Sparrow, 2007). Societally, this strategy would attempt to reform the socially unfavorable environment by explicitly designing vanguards. Instead of adapting the child to the environment, this strategy adapts the child in a way that creates friction to adapt the environment. This is not an unrealistic goal. Gender stereotypes have been proven to be time-dependent (Eagly et al., 2020; Zehnter et al., 2018) and are sensitive to frequency information about shown behavior (Diekman & Eagly, 2000).

Arguably, this would put a significant burden on these children and introduce a profound strategic element to parents' reproductive decisions (Sparrow, 2007) that even Savulescu (2001) opposed. However, given that children are prone to adopting their parents' more egalitarian understanding of gender (Davis & Greenstein, 2009), the principle process described here is not new. For instance, male children with parents who hold gender egalitarian beliefs were more likely to also affirm them (Myers & Booth, 2002). Designing vanguard-like children may reflect the idea of using genetic engineering to create a better future where discrimination based on individual stereotype compliance is less prevalent. To-be-expected negative consequences for stereotype deviation (Rudman, Moss-Racusin, Glick, & Phelan, 2012) may be a burden parents are willing to place on their children. Targeting features crucial in preserving the current Western gender hierarchy may be particularly interesting here (see Rudman, Moss-Racusin, Glick, & Phelan, 2012). This entails high-status agentic traits which are more prescriptive for males (Rudman, Moss-Racusin, Phelan, & Nauts, 2012).

Such a strategy seems to favor positive societal consequences over individual ones. However, there is a long and recently renewed debate about the potential psychological and social adaptiveness of individual identification with typical male *and* female features (C. L. Martin, Andrews, et al., 2017; C. L. Martin, Cook, & Andrews, 2017).[5] In light of the potential benefits of this so-called *psychological androgyny* (C. L. Martin, Cook, & Andrews, 2017), those who follow this design strategy should not be seen negatively. Their actions can still aim to ensure a good life for their children. Another reason for the creation of vanguards may be a strong prospective focus. People may anticipate a more gender egalitarian future (Diekman & Eagly, 2000) and may attempt to adapt their children not to the contemporary but anticipated gender egalitarian stereotype landscape.

Assuming that contemporary stereotypes are perceived as non-favorable so that the child will be better off not adhering to them, *people can design emancipated children who, by their non-obedience to the gender stereotypes, can foster societal change and are prideful in doing so*. This derivation of our hypotheses is called the *Emancipating-Gender Hypothesis (Eman-GH)*.

2.3. Clarifying the implications and effects of Good- and Eman-GH

The following section will elaborate on psychological mechanisms that may foster adopting a strategy that orients at the Good-GH or Eman-GH. We will also discuss the consequences of these strategies, should they ever be implemented, and how people may react toward designed children.

Adopting an essentialistic perspective, males and females are conceived as natural, imperishable, biologically highly distinct categories (Haslam et al., 2000). If these categories are potentially explained by genetic factors (Dar-Nimrod & Heine, 2011), why would there be a need to interfere with processes that are assumed to occur naturally? Observing the characteristics whose allegedly distinct combination

[4] Categorizing genes and people as "good" is problematic because this implies the presence of a "bad" counterpart (Carbon, 2021). Hence, this naming refers to the logic of the stereotypes alone. Evaluation as "good" and "bad" in one context (for instance, in terms of terminal diseases) does not imply generalizability to other areas.

[5] Thanks to the anonymous reviewer for pointing out the theoretical link towrds psychological androgyny

constitutes the assumed binary categories inevitably reveals variety within the underlying distributions. Even if individuals posit a high degree of distinctiveness between the overarching categories, some individuals may be more similar to the "perfect" male or female (see Ellemers & Jetten, 2013). The suitable strategy to create a "good" representation of one category demands aligning them with the mean of the gender feature distribution or pushing individual characteristics even further beyond. Assuming genetic determinism, genetic engineering of personality and other features may be seen as a means to locate traits at the desired level and maximize differences.

Habermas (2005) pointed out that designing children may interfere with the child's self-determination if ever disclosed (see also Hendl, 2017). This is because the child has to cope with being purposefully designed and objectified (Habermas, 2005. Accordingly, biotechnological embryonic manipulations cut deeper than parenting or educational efforts (Hendl, 2017; cf. Sorgner, 2015). Yet, Resnik and Vorhaus (2006) argue that concern about parents who overwhelm their children with autonomy-constraining expectations builds upon an *assumed* profound genetic determinism rather than actual empirical evidence. They claim that related parental misconceptions can be easily adjusted to the latter. In other words, if genes are less influential than thought, the intervention is far less controversial because it is less consequential. Resnik and Vorhaus correctly emphasize the power of personal beliefs. Yet, what matters here is not the precise empirical effect of genetic engineering (something we currently can only speculate about) but the fact that by granting the engineered genes *some* influence, one can claim limited justification for one's expectations. After all, beliefs in genetic determinism are associated with more realistic heritability estimations of various traits, including personality (Willoughby et al., 2019). So, people may have a good intuition about the possibilities of the intervention. Even if attributing the majority of gender differences to environmental factors, parents may still contemplate whether they should not do everything possible to ensure that their children match their normative convictions.[6] Furthermore, empirically unjustified expectations can still influence the parent-child interaction (Browne, 2017). Even without strong determinism, children may experience strain from the requirement to psychologically make sense of the fact that the genetic information inscribed into them reflects social conventions and beliefs imposed on them *by others* (Habermas, 2005. This is how sex selection may infringe upon the child's autonomous development (Hendl, 2017).

However, possible interactions between (modified) genes and the environment render expression of the former uncertain (Resnik & Vorhaus, 2006; Sparrow, 2019). Nonetheless, peers already evaluate the child's biological makeup and scrutinize its observed gender identity and behavior regarding a potential overlap (Abreu et al., 2019; Broussard & Warner, 2019). Instead of linking the reason for the child's conduct to evident visual cues, people may also scrutinize its genetic makeup (Hendl, 2017). Even if unwarranted, people refer to genetic components as an irrevocable justification for stereotypes (Dar-Nimrod & Heine, 2011; Saguy et al., 2021). If polycausal social differences between males and females are explained by an allegedly essential and deterministic biological reality (Hoffman & Hurst, 1990), social contexts that incentivize such argumentations are reinforced (Saguy et al., 2021). Hence, while assuming an inevitable genetic determinism is probably fallacious (Resnik & Vorhaus, 2006), arguments for overcoming such reasoning in general (e.g., Resnik & Vorhaus, 2006) and for gender in particular (e.g., Saguy et al., 2021) must acknowledge the appealing psychological function of assuming a solid genetic influence when trying to understand human behavior (Dar-Nimrod & Heine, 2011).

Using genetic engineering to alter and create the genetic foundation for these "essential" differences harbors a contradiction. Any assumed (genetic) essence is usually explicitly defined as *immutable* (Dar-Nimrod & Heine, 2011; Neufeld, 2022). Because they were changed, engineered genes cannot qualify as immutable carriers for our identity and thus cannot justify related stereotypes. Yet, if linked to genetic determinism, assumed immutability may not only refer to a chemical structure but may also concern an assumed causal relationship (Dar-Nimrod & Heine, 2011): "If the [engineered] genes are present, the outcome is expected" (Dar-Nimrod & Heine, 2011, p. 802). However, we agree that seeing genetic engineering as a universal solution for social issues may stem from a biased perception of genetic influences (Dar-Nimrod & Heine, 2011). Nonetheless, we argue for the fundamental action-guiding effect of *assumed* technological capacities in interaction with what is *believed* to indicate a "perfect" woman/man. If people know that a child was designed in (dis)accordance with gender stereotypes, they are likely to respond to whether the designed human fulfills their (irrational) expectations. Gender and genetic essentialism are not meant to be philosophically sound. Instead, they are heuristic but consequential ways of explaining the variations within human gendered behavior (Dar-Nimrod & Heine, 2011; Saguy et al., 2021). Once the information is inscribed, it can serve as the basis for stereotypes, rendering everybody who lacks the respective genes or, where the genes fail to manifest in behavior, a "bad" representation of their assigned gender. This directly evokes the problematic notion of "good" and "bad" genes (see Carbon, 2021) and emphasizes the enterprise to create children whose behavior aligns with what is "naturally" expected (see Ellemers, 2018).

If successfully manipulated, the child's genetic code is shaped according to an external standard that values or disvalues particular genes. If the gender-related attitudes of parents prenatally guide their behavior (Browne, 2017; Jack, 2020), decisions in the genetic design process heavily depend on *parental* convictions about gender. The biological features do not merely inform parental expectations, but the expectations form the biological features. Similar to sex selection (Hendl, 2017) but far more radical, using genetic engineering in the way proposed in this paper may constrain the children's participation in its gender development. Even if it never leads to tangible differences, genetic engineering is the unidirectional manifestation of parental expectations before birth. In that sense, the embryo cannot enact gender because it is unable to act: Gender is enacted upon it. Thus, enacting the Good-GH attunes a part of physical reality to social norms. In opposition, Eman-GH-children's adaptation may necessitate questioning one's stereotypes and possibly attuning them to physical reality. Inscribing the specific attitude toward these gendered ideals renders the child's DNA an affirmative or dismantling embodiment of the stereotype content. Suppose the manipulated embryonic genes manifest in behavioral and psychological differences that match stereotype content. If so, Good-GH children do not only embody but also enact gender stereotypes. A self-experienced alignment between individual attributes and gender stereotypes can reinforce identification with one's gender and subsequently inform in-group perception (Tobin et al., 2010). The same experience was associated with beneficial individual outcomes but can also negatively influence opposing gender interactions (C. L. Martin, Andrews, et al., 2017). However, it may also be possible that children who reliably disconfirm stereotypes develop a more relaxed understanding of gender categories (Tobin et al., 2010). If these children become parents, their attitudes can then be transmitted within their families (Davis & Greenstein, 2009).

This hints toward an intricate relationship between self-perception, stereotypes, and child-related preferences. As one of the anonymous peer-reviewers did, one could argue that parents are more interested in designing a child that corresponds to *their* characteristics rather than being aligned with some external standards. For instance, when adopting a child, parental decisions can be influenced by the desire to pick a child of the same race as theirs (Ishizawa & Kubo, 2014). Moreover, parents are motivated to impart their personally held values to their children (Barni et al., 2017). Noteworthy parental, benevolent sexist convictions predicted the extent to which they propagated values that entailed a traditional perspective on gender relations (Barni et al.,

[6] Of course, there may be parents who are totally against the idea of genetically modifying their children.

2022). This adds to the findings that gender-relevant attitudes and self-perceptions are transmitted within a family (Antoniucci et al., 2023; Moen et al., 1997; Tenenbaum & Leaper, 2002). Possible reasons for these effects span from imitation learning over confirmation demands to genetic causes (Antoniucci et al., 2023) but should also be seen in light of the moderating influence of individual experiences and societal gender emancipation (Moen et al., 1997). In line with our working hypothesis A1, parents could elevate their qualities to a decision-guiding normative standard meant to ensure a good life. However, even if normative gender stereotypes may draw an exaggerated picture that does not necessarily correspond to how people describe themselves (Renström, 2024), parents are still confronted with the same gendered expectations as their future children. Hence, what they experience as important is not independent of societal forces. In that sense, the decision to design children with high similarity to oneself may still be influenced by stereotypes and converge with what is expected under the Good-GH or Eman-GH. Of course, there are normative frameworks other than gender to which the child can be adapted to. However, the point is that by being able to influence the children's characteristics, parents are urged to make critical decisions that align with some individual and social understanding of "right" and "wrong." The ubiquitous confrontation with the normative implications of gender (Butler, 1988; Saguy et al., 2021) makes it difficult to argue why this pivotal feature should not play at least some role when people are asked to design their perfect child.

Humans tend to generalize information about single individuals to validate and potentially change group evaluation (McIntyre et al., 2016). Eman-GH and Good-GH intuitively capitalize on this psychological phenomenon. Moreover, they are informed by a perceived present or desired future statistical norm of gender-associated features. The perceived statistical norm influences moral evaluation, so "normal" cases are perceived as more acceptable (Lindström et al., 2018; Martín et al., 2023). On a broader scale, empirical differences in performed social roles and activities are explained by assuming gender-related differences between the occupying individuals (Hoffman & Hurst, 1990). Hence, the success of both strategies may also depend on whether the intervention inclines/enables engineered individuals to enact (counter-)stereotypical roles.

However, the underlying dynamics can render once suitable alterations maladaptive (Döbler & Carbon, 2024). If the statistical norm changes, offspring created following the Good-GH may display gender-divergent features and may be more likely to experience the negative consequences initially meant to be prevented. At the same time, responding flexibly to contingent demands may be key to capitalizing upon the benefits of combining typical male and female traits (C. L. Martin, Cook, & Andrews, 2017). Designing children in a way that constricts their behavioral repertoire may yield the same maladaptive rigidity that could also characterize stereotype-conforming Good-GH children (see C. L. Martin, Cook, & Andrews, 2017). Evaluating this maladaptive genome against one that would be more adaptive could render the initial design "obsolete "(Sparrow, 2019, p. 7). According to Sparrow, this can have negative consequences for the child and demonstrates that dynamic developments put high pressure upon individuals to keep their genome 'up-to-date.' However, full support for related concerns presupposes viewing human behavior as significantly genetically predetermined (Resnik & Vorhaus, 2006).

Ascribing sufficient causality to our genes may tempt us to view engineering them as an alleged shortcut for social and individual issues (Dar-Nimrod & Heine, 2011). Following one of the proposed strategies further builds upon the action-guiding power of normative stereotypes. This may not only influence the behavior of the designing authority but also shape how children evaluate themselves and are evaluated by others. However, it is still unclear how design decisions will manifest. Having established a guiding theoretical framework, we will now address this issue by investigating whether the Good-GH or the Eman-GH dominates when people are allowed to create their perfect child.

3. The present study

Working hypothesis A1 suggests that people attune their behavior to normative convictions when designing their perfect child. Working hypothesis A2 adds that normative gender stereotypes are a critical source for these convictions. However, parents may have conflicting opinions on whether following (Good-GH) or dismantling (Eman-GH) these stereotypes is more beneficial. Because they are highly gender-specific (Koenig, 2018; Prentice & Carranza, 2002), our primary focus will concern the enactment of personality and talent-related stereotypes. For that purpose, we will empirically test whether the distribution of designed features of "perfect" children affirms or disconfirms present normative gender stereotypes.

4. Methods

4.1. Origin of the data: The exhibit

When discussing the hypothetical impact of genetic engineering, we inevitably face the problem of technological and ethical feasibility. We circumvented this issue by extracting existing data from an interactive exhibit about genetically designing perfect children, located in the "Deutsches Museum Nürnberg – Das Zukunftsmuseum."(Nuremberg, Germany - https://www.deutsches-museum.de/en/nuernberg). Across the museum, exhibits are meant to educate visitors about hypothetical future scenarios and disruptive technologies. Visitors can interactively explore the functioning of gene editing technologies like CRISPR/Cas9, be the human counterpart in a Turing test, or learn about concepts for space colonies. The museum recommends a minimum age of 12 years for visitors.

The exhibit is an interactive, physical screen in the "Body and Mind" section. The default language is German but can be switched to English. The English description of the exhibit reads: "Create your perfect child! You have €250,000 at your disposal. Weigh up which aspects are particularly important to you." (Perfect child = "Wunschkind. Literal translation: "wished-for-child"). At the introductory screen, visitors are told that "genetic scissors" (German: "Genscheren") can be used to purposefully interfere with the genome, either by removing, disabling, or altering specific genes. After starting the program, visitors can manipulate randomly preset features of their virtual child. During the whole manipulation process the child is depicted as a toddler (Fig. 1).

Although the technology is not mentioned directly, the term "genetic scissors" refers to the pop-science description of CRISPR/Cas9. Moreover, some screens educate visitors about the genetic foundation of manipulatable features. In that sense, the mechanism of the intervention was reliably communicated. Behind the exhibit is another station where visitors can learn about the biotechnological "cutting" mechanism of CRISPR/Cas9.

4.2. Procedure

The authors were not involved in the programming of the exhibit. The first possible choice concerns gender. This feature is indicated via a plush toy lion, either with the male mane or without (female). The next screen concerns a possible manipulation of skin, hair, and eye color. Hereafter, removing or adding pre-existing genetic disease dispositions is possible. Then, five alterable personality dimensions are presented and briefly described. These traits closely follow the Big-5 personality model (see Costa Jr. & McCrae, 1992). Visitors could then manipulate traits framed as talents. They were told that besides genetics, social features and parental style are important influences, so not every talent will be used later in life. Fig. 1 shows a procedural overview, additional information and how personality dimensions were described to the visitor. After the manipulation, visitors are informed about the other visitors' most frequent choices (not grouped by children's gender). Visitors then see an animation of their child growing up. They are told

that different environmental processes influence the child's character in a way not predictable by genetic engineering alone. The exhibit briefly describes the child's life, with comments on their personality, appearance satisfaction, or if their designed talents have been manifested. Completing the exhibit takes approximately 2–10 min.

All children are initiated with randomized features. Changing one feature costs a fixed amount of money, independent of the range of change. Hence, eliminating a predisposition costs the same as manifesting it, and maximizing a feature is similarly as costly as minimizing it. Gender, predispositions, appearance, personality, and talent expression are confined to pre-determined probabilities (see Fig. 1 for the assumed distributions). An extremely high or low feature expression is only possible by monetary investment. Emphasizing the prospect of designing features above the norm, manipulation possibilities of traits and talents are presented on a slider scale ranging from −100 % to 100 % (−1;+1 in the data). Visitors can always navigate backward to revert a made change.

4.3. Obtained data

Written permission to use the data was granted by the museum. The university ethics committee further approved the data analysis. The retrieved dataset comprised $N = 13{,}643$ complete engagements with the exhibit, resulting in the same number of virtual children. The date range of extracted data was June 4th, 2021, to May 11th, 2022. During this period, anyone locally present in the museum could interact with the exhibit. The exhibit does not ask for personal information about the participants. Hence, we have no sociodemographic information about the people who used it. This may also minimize social desirability effects. We cannot determine if persons who engaged with the exhibit did so only once and cannot clarify if people were genuine museum visitors or employees, etc.

There were irregularities with the first two data points, both created on June 4th, 2021. Here, the value of the virtual slider that determined the RGB-color value of skin, hair, and eye color seemed to have used a different scale. For instance, an initial slider value of −0.4 created a skin color visually similar to what was represented as −0.92 among other children. These first two children were excluded from further analysis because we cannot ensure whether the other scales were also affected.

The third and fourth children were created on June 29th, 2021, with the following data collected on July 20th, 2021. We have no information on what caused the gap in the data. There is no evidence that they were created by a different data-generating process. 3.03 % ($n = 413$) of the children showed no alteration. It is conceivable that these children reflect a non-attentive engagement with the exhibit. However, it is also possible that the alterable features were irrelevant enough for the visitors or that they genuinely did not want to genetically engineer their children. The lack of background information calls for caution but does not justify the exclusion of specific data points, apart from the irregularities mentioned. The final dataset comprises $N = 13{,}641$ virtual babies designed by an unknown number of people. The supplement features additional information about the data preparation process.

4.4. Terminology

We will refer to values randomly assigned by the exhibit as feature_N, where N stands for "natural," and those chosen by the visitors as feature_C (C = choice). If nothing was changed, feature_C is equal to feature_N.

In the default German description, openness [Offenheit], agreeableness [Verträglichkeit], and conscientiousness [Gewissenhaftigkeit] directly refer to the German translation of the respective Big 5 dimensions. Sociality [Geselligkeit] and sensibility [Sensibilität] do not have a semantic equivalent. The description of the traits suggests a close association with extraversion [Extraversion] and neuroticism [Neurotizismus]. Although not perfect representations, predictions will orient at this understanding.

The English setting of the exhibit asked to pick the child's sex. However, in the German settings, the first screen just asked to pick the *Geschlecht*, which is the translation for "sex" and "gender." In the following, we will exclusively use the term gender. Apart from preventing a potentially confusing shift in terminology, where sex becomes gender after the first screen, this is because the matter of stereotypes and parental expectations closely tie reproductive organs to gender attributions (Browne, 2017). Given that a female/male plush toy indicated the child's sex and the prevalence of normative gender stereotypes about toys (e.g., Koenig, 2018), the exhibit reflects the connection between sex selection and gender stereotypes (see Browne, 2017). Even an essentialistic argumentation that refers to genetic sex differences usually merges biological and non-biological variables, thus evoking *gender* essentialism (Browne, 2017; Dar-Nimrod & Heine, 2011). The exhibit described potential choices as male [männlich] or female [weiblich]. We will retain this wording to describe the depicted child's gender and not use the more age-appropriate boy/girl distinction.

Gender_N, as presented to the visitor on the first screen, can be *random Male* or *random Female*. Purposefully choosing a gender will result in gender_C = *Female/Male*. Visitors can also maintain the randomly initiated gender ($\text{gender}_C = \text{gender}_N$). For further differentiation, we include information about the gender selection decision. Hence, genderC is either *Male* (M), *Female* (F), *random male* (rM), or *random female* (rF). We will refer to these groups with their acronyms if not stated otherwise. If subsumed as the final gender, we will write out female/male with no further reference. We call children whose gender has been chosen deliberately *DGC* (Deliberately gendered children— M/F) and those whose gender_N was maintained *RGC* (Randomly gendered children — rM/rF).

4.5. Methodological considerations

The present study draws from existing data gathered in a field setting. Because we were not involved in the exhibit's design, we could not influence confounding variables, participant selection/engagement, exhibit programming, etc. Nonetheless, we believe that the overall setting and the data size are suitable for assessing the action-guiding power of stereotypes and the hypothesized behavioral patterns. Even if only evoked virtually, the dogma of parental care and associated benign motivations should outnumber data of visitors who do not sincerely act upon their beliefs or did not engage earnestly. Regardless of size and certainty, any reported effects must be verified in a more controlled setting.

The framing of the exhibit is believed to have overruled skepticism if the presented features are indeed linked to genetic variation. Visitors were further left to believe that their manipulations would reliably change the features of their virtual child. Only after completing the exhibit were they told about the possible influence of environmental factors. Hence, assessing the motivating function of stereotypes is possible by analyzing the visitor's declaration of intention, i.e., the manipulations they hoped to manifest in their "perfect" child.

Starting at 18 months of age, humans increasingly obtain gender stereotype knowledge (Miller et al., 2006). So, we can reasonably assume that visitors had at least some stereotype knowledge.

4.6. Predictions

Both hypotheses predict a discernible effect of the chosen gender on the feature_C distribution. Moreover, pre- and proscriptions should manifest in increased likeness to increase or decrease feature values. Table 1 contains respective predictions and exemplary literature references. Predictions were based on linking manipulatable features to the literature. While physically appearing in concurrence with one's assigned gender is among the most dominant stereotypes (Koenig, 2018), we refrained from assessing these factors due to the limited manipulation possibilities of the exhibit in this regard. The supplement

Table 1
Predictions.

		Predictions under:					
		Good-Gender Hypothesis (Good-GH)			Emancipating-Gender Hypothesis (Eman-GH)		
		Predicted differences	Change	Example evidence	Predicted differences	Change	Example evidence
	Gender distribution	No preference		Balanced preference for boys and girls in Germany (Carol & Hank, 2020)	No preference		Balanced preference for boys and girls in Germany (Carol & Hank, 2020)
	Money spent on all features	No prediction	–	Too little variation in cost; inconclusive evidence regarding gender-dependent spending behavior and limited generalizability to the given context	No prediction	–	Too little variation in cost; inconclusive evidence regarding gender-dependent spending behavior and limited generalizability to the given context
	Appearance	Not in focus due to limited manipulation possibilities					
	Predispositions	Females > Males	Males are more likely to be relieved of predispositions	Parental dogma of being a good parent (Working hypothesis A1), but also male proscription not to be weak (Prentice & Carranza, 2002)	No difference		Parental dogma of being a good parent (Working hypothesis A1)
Personality	Sensibility	Females > Males	Female values increased, male values reduced	Male proscription/ female prescription to be emotional (e.g., Rudman, Moss-Racusin, Phelan, & Nauts, 2012)	Females = Males	Female values reduced, no increase for males	Alignment of female and male stereotypes by attuning females to male stereotypes (Diekman & Eagly, 2000)
	Sociality	Females < Males	No change in female values, increase in males	Agency prescribed for males, no female proscription per se (e.g., Bosson et al., 2022)	Females = Males	More increase for females, male values maintained	Alignment of female and male stereotypes by attuning females to male stereotypes (Diekman & Eagly, 2000)
	Openness	No prediction for both		No differences in desirability found (Prentice & Carranza, 2002)	No prediction for both		No differences in desirability found (Prentice & Carranza, 2002)
	Agreeableness	Females > Males	Female values increased, male values reduced	Communality prescriptive for females (Bosson et al., 2022), males get punished for being overly agreeable (Judge et al., 2012)	Females >/= Males	Reduction for females and an increase for males	Alignment of female and male stereotypes by attuning females to male stereotypes (Diekman & Eagly, 2000), but also status neutral and thus possibly less important (Rudman, Moss-Racusin, Phelan, & Nauts, 2012)
	Conscientiousness	Females < Males	Female values maintained, increase for male values	Facets linked to traits prescribed for males, not proscribed for females (Prentice & Carranza, 2002)	Females = Males	Increase for females, no overly decrease for males	Alignment of female and male stereotypes by attuning females to male stereotypes (Diekman & Eagly, 2000)
Talents	Intelligence	Females < Males	Female values maintained, increase for male values	Male prescription to be intelligent, no female proscription (Koenig, 2018)	Females = Males	Increase for females and males	Alignment of female and male stereotypes by attuning females to male stereotypes (Diekman & Eagly, 2000)
	Sportiness	Females < Males	Female values maintained, increase for male values	Male prescription, no female proscription (Prentice & Carranza, 2002)	Females = Males	Female values increased, less importance for males	Alignment of female and male stereotypes by attuning females to male stereotypes (Diekman & Eagly, 2000)
	Creativity	Difference exists	No prediction	Creativity less important for males than females (Prentice & Carranza, 2002) but associated with male-prescribed agency (Proudfoot et al., 2015)	No difference		Alignment of female and male stereotypes by attuning females to male stereotypes (Diekman & Eagly, 2000) but unclear stereotype direction.
	Musicality	No prediction for both		Musical ability linked to being psychologically androgynous (Kemp, 1985)	No prediction for both		Musical ability linked to being psychologically androgynous (Kemp, 1985)

Note. Example reference denotes one or two references that informed our prediction-building process. A comprehensive discussion of how predictions were justified can be found in the supplement.

contains a detailed rationale about prediction justification, which is not included here due to its extensive length. The direction of predictions concerns the final gender. However, to get a more nuanced perspective on the data and prevent overgeneralization, we will evaluate each prediction also concerning whether children's randomly assigned gender was maintained or picked deliberately.

Good-GH-specific predictions were based on evidence of the existence of specific pre- and proscriptive gender stereotypes (e.g., Bosson et al., 2022; Koenig, 2018; Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, & Nauts, 2012). Predictions for the Eman-GH were mainly informed by Diekman and Eagly (2000), who assessed participants' beliefs about gender stereotypes in the future (2050 CE). Results indicated an alignment trend in stereotype content, mainly driven by females assumed to acquire male traits. This study is not ideal, as it merely measured descriptive stereotypes and reported various effects. Nonetheless, we used it for broad orientation. Still, together with cross-cultural, favorable opinions toward a more gender-equal society (International Women's Day, 2019: Global Attitudes toward Gender Equality, 2019), and the more utopian vision of so-called "postgenderism" (Hughes & Dvorsky, 2008, p. 2), the Eman-GH predicts an alignment of features.

Predictions of the Eman-GH are meant as counterparts to the Good-GH and must be understood relative to the identified stereotypes and gender comparisons. Extrapolating the propositions of Diekman and

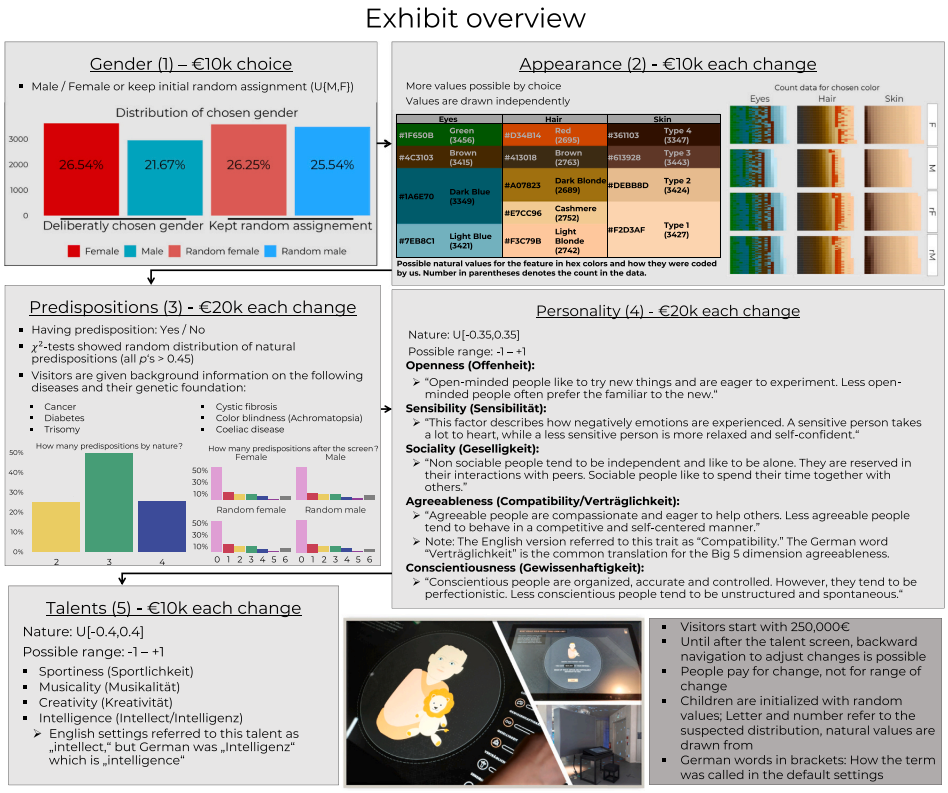


Fig. 1. Sequence of exhibit screens with additional information. Picture of the exhibit copyright: Deutsches Museum Nürnberg, Christian Illing.

Eagly (2000) about female stereotypes aligning with male ones and not vice versa, we propose the following exemplary mechanism: If the Good-GH predicts higher male values for sociality, driven by a one-sided increase due to the respective prescription, the Eman-GH predicts that a balance is driven by an attunement of female values to a level formerly only desirable for males. Eman-GH-related effects on the decision to increase or decrease a feature must be seen in the context of change and range of change. A higher likelihood to increase a feature does not tell us anything about the manifested level of $feature_C$. Hence, we must also consider the final designed values. Here, the Eman-GH predicts their manifestation in a way that counteracts stereotypes, while the Good-GH predicts their maintenance.

People may design their children in a way that does not endorse stereotypes yet reverts their content (e.g., more sensible males instead of equal levels). If results disconfirm the predictions of the Good-GH, this is not necessarily evidence of the Eman-GH.

5. Data analysis

We used the *brms* (Bürkner, 2017) package for R to calculate Bayesian regression models. Models ran for four chains with 10,000 iterations each (5000 warmup draws). Priors for predictor coefficients were uniformly set to be $N(0,1)$. Other settings retained the brms default.

For each personality and talent variable, we proceeded as follows: Employing multinomial logistic regression, we first modeled whether the chosen value differed from the randomly assigned one and in which direction the change occurred (Decreased/No Change/Increased). Chosen gender and $feature_N$ value were set as predictors. To control for budgeting effects, we included the proportion of money available on the respective screen as an additional predictor. To test possible differences, we also modeled interaction terms between the chosen gender and the other predictors.

The number of disease predispositions was modeled using an ordered logistic regression with the number of natural dispositions, the proportion of money available, and their interactions with chosen gender as predictors. Using logistic regression, we also modeled the decision to change a predisposition. Predictors were whether the disposition was present, proportion of money available, and the interactions with chosen gender.

Visual inspection of the data revealed that feature distribution did not follow a normal distribution but showed evident density bumps at the extrema (Supplement). To assess the range of change and eventually test for evidence of the dominance of one of the proposed strategies, we employed zero-one-inflated beta regression (ZOIB) to predict $feature_C$ and the proportion of money spent. Instead of just a measure of central tendency, this method allows for modeling the entire distribution of the outcome (Heiss, 2021; Kneib et al., 2023). This method also accounts for 0 s and 1 s in the data by assuming that these values do not stem from beta but from two additional logistic distributions. That way, ZOIB combines three statistical models: one beta regression and two logistic regressions. Each model consists of the shape parameter of the beta

distribution (Mean: μ – logit scale; Precision: φ – log scale) and values that describe the zero-one-inflation (zoi: logit scale; coi; logit scale). We can use the latter two to estimate the proportion of zero-one-inflated values (zoi; $\frac{0|1}{All}$;), the conditional proportion of these values being one (coi; $\frac{1}{0|1}$) and the percentage of $\frac{0}{All}$ or $\frac{1}{All}$. For a detailed explanation, we refer to two highly educative blog posts that served as primary instruction for this method and our explanation here (see Heiss, 2021; Vuorre, 2019). To suit the outcome to the beta regression, we rescaled $feature_C$ values from −1 - +1 to 0–1. For interpretability, we reverted the rescaling to the values displayed at the exhibit. Because people paid for change, not range of change, assessing $feature_C$, $gender_C$ was the single predictor for each parameter (μ, φ, zoi & coi).

Although one could interpret not changing $feature_N$ as a legitimate expression of a desired value, including this data would mean introducing purely random and computational variance to the $Feature_C$. Moreover, detailed insights into the visitors' decision-making process are impossible. Thus, we do not know if the decision to maintain $feature_N$ stems from not caring about this feature, inattention, or satisfaction. Hence, single ZOIB models for the five personality traits and four talents used only data from children whose features were modified and thus created more "actively" (Table 2). These values will be called designed values.

For the multinomial regression and ZOIB models, children with no money left when entering the respective screen were excluded ($n = 20$ for talents, $n = 0$ for all other screens).

Figs. 2 to 7 show the graphical analysis of the expected value of the posterior predictive distribution and the predictors' resulting average marginal component effect (see Heiss, 2023; McElreath, 2020). These distributions are created by building a counterfactual dataset with selected predictor values, feeding it into the fitted model, drawing from the resulting posterior, and then calculating the average of these draws (Heiss, 2022). This was done by the functions *epred_draws* and *compare_levels* from the R-package *tidybayes* (Kay, 2023). The latter calculates marginal effects by subtracting the averaged posterior draws of each group.

6. Results

Analysis of variance showed that neither initially assigned personality values nor talent values differed across $Gender_C$ or $Gender_N$ (all p's ≥ 0.16/0.25 – see Supplement).

6.1. Gender distribution

$Gender_C$ is displayed in Fig. 1 and Table 3. Deviating from our predictions, visitors displayed a preference for female children (Final gender: 47.2 % male, 52.8 % female), $\chi^2(1) = 42.45$, $p < 0.001$. Considering the uniform distribution of $gender_N$ (49.3 % rM, 50.7 % rF), $\chi^2(1) = 2.73$, $p = 0.098$, this difference was due to an imbalance within the 6576 (48.2 %) children whose gender has been deliberately chosen. (44.95 % M, 55.05 % F, $\chi^2(1) = 67.04$, $p < 0.001$). To determine the role of initiated gender on gender change, we ran a Bayesian logistic regression. The predictor was $Gender_N$, prior: $N(0,1)$. $Gender_N$ = rM predicted a change of gender, i.e., a deliberately chosen female child ($OR = 1.30$, Credible $Interval_{95\%}$ (CI): 1.20–1.41, probability of direction (pd) = 100 %).[7]

As visible in Table 3, some visitors picked the final gender their baby was already initiated with. The child's gender was displayed by a plush toy lion, either with a typical male mane (male) or without (female). The mane disappeared when visitors switched gender, which rendered the meaning of the toy visible. Still, this depiction may have led to confusion and identification difficulties. Visitors may not have understood that their choice was obsolete. Visitors may also have wrongfully assumed that the gender will be reassigned after the screen. In that case, selecting F while being assigned rF may display a safety strategy to ensure gender preference.

6.2. Disease predispositions and spent money

Results are shown in detail in the supplement. Having a predisposition was the best predictor for the decision to change (remove) it. For all gender, these effects were the strongest for diseases that may be commonly associated with severity, like cancer, cystic fibrosis, and trisomy. Across all diseases, M children were more likely to be given a predisposition than their F counterparts. This and other findings do not support the Good-GH, which predicts that males are more likely to be relieved of their predispositions due to proscribed weakness (see Prentice & Carranza, 2002).

6.3. Personality traits and talents

Fig. 2 shows the results of the multinomial logistic regression on decision probability for personality traits and talent values. Fig. 3 and Fig. 4 show the respective marginal effects. These figures allow us to assess the presence and strength of pro- and prescriptions. Fig. 5 and Fig. 6 show the expected differences in the posterior predictive distribution as predicted by the Zero-one-inflated beta regression. Fig. 7 shows the expected total proportion of extreme values. These figures are meant to display the strength of stereotypes and relative gender effects. More detailed information on all regression coefficients and figures in large resolution can be found in the supplement or the OSF. Our models reveal an effect of the chosen gender on decision probability and designed feature values. The direction, strength, and certainty of effects shifted along the lines of the gender selection process and feature.

We found a consistent negative relationship between the probability of increasing a feature and its natural values. This was often matched by a positive relationship between the probability of maintaining or decreasing features and their natural values. Decision probabilities also depended on feature and available money. Concerning the differences among female and male children whose gender had been picked deliberately (DGC), differences in decision probability never fully supported the Good-GH's predictions, except for sportiness. Within this group and other features, we, nonetheless, found evidence for the predicted proscriptive male decrease but not the female prescriptive increase (e.g., sensibility, agreeableness). Predictions of the Eman-GH were also never fully supported among the DGC. If at all, values of F children were more likely to be maintained rather than increased (except for creativity, musicality, and, to some extent intelligence). The inconclusive and relatively uncertain differences among the DGC within the decision to manipulate intelligence and conscientiousness partially contradict the predictions of both hypotheses. Decision differences between randomly gendered children (RGC) were far less pronounced but failed to support one hypothesis comprehensively. Not evident differences in the decision probability to manipulate intelligence are in line with the prediction of the Eman-GH, while some of the effects concerning sensibility manipulation cautiously point toward the direction of the Good-GH.

When comparing DGC children with their RGC-opposite-gender-counterpart, an effect of available money on the decision to maintain and increase a value became evident. At higher budgets the DGC values were more likely to be increased. This difference shifted when fewer resources were available. This suggests that not spending money on gender is correlated with other factors (e.g., inattention, general frugality) that yield fewer changes.

With respect to the expected differences in designed values, differences among the DGC supported the Good-GH concerning sportiness, creativity, sensibility, and, to a certain extent, agreeableness. No evident differences between DGC in sociality, conscientiousness, and, to some

[7] Probability of direction (pd) refers to the proportion of the coefficients posterior sharing the same algebraic sign as the median (Makowski, Ben-Shachar, Chen, & Lüdecke, 2019).

Table 2
Number and percentage of children whose values were changed.

		Female (3620)	Male (2956)	Random female (3581)	Random male (3484)	*n* in ZOIB
Personality	Agreeableness	2458 (67.90 %)	2134 (72.19 %)	2162 (60.37 %)	2112 (60.62 %)	8866
	Conscientiousness	2595 (71.69 %)	2231 (75.47 %)	2325 (64.93 %)	2218 (63.66 %)	9369
	Openness	2646 (73.09 %)	2262 (76.52 %)	2316 (64.67 %)	2260 (64.87 %)	9484
	Sensibility	2267 (62.62 %)	1983 (67.08 %)	1973 (55.10 %)	1936 (55.57 %)	8159
	Sociality	2574 (71.10 %)	2265 (76.62 %)	2245 (62.69 %)	2199 (63.12 %)	9283
Talents	Creativity	2747 (75.88 %)	2261 (76.49 %)	2465 (68.84 %)	2476 (71.07 %)	9949
	Intelligence	2865 (79.14 %)	2394 (80.99 %)	2762 (77.13 %)	2716 (77.96 %)	10,737
	Musicality	2475 (68.37 %)	2088 (70.64 %)	2216 (61.88 %)	2204 (63.26 %)	8983
	Sportiness	2780 (76.80 %)	2403 (81.29 %)	2520 (70.37 %)	2505 (71.90 %)	10,208

Note. ZOIB models that predicted differences between chosen personality and talent values only used children whose values were changed (*n* in ZOIB). Percentages refer to proportions within the gender group. ZOIB = Zero-one-inflated beta regression. Number behind gender refers to total number in data.

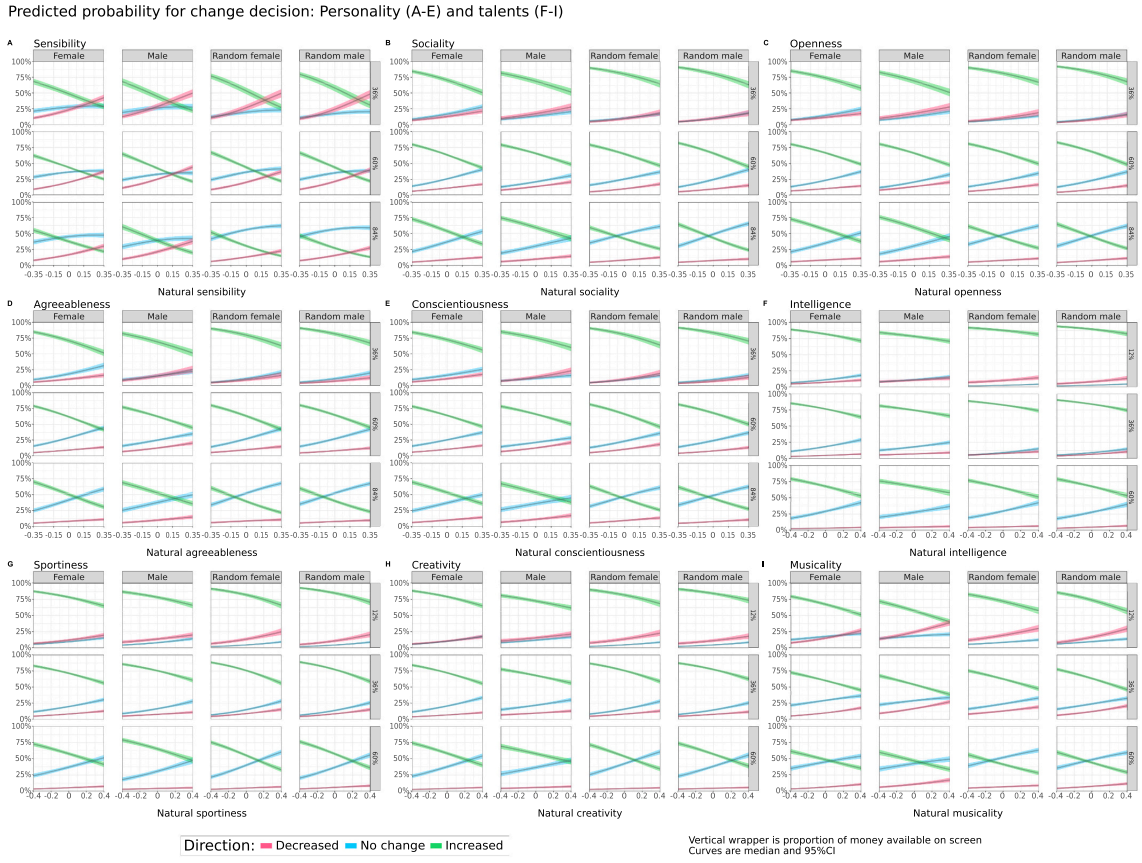


Fig. 2. Decision probability for personality traits and talents. X-axis is the natural value as randomly initiated by the exhibit. Y-axis is probability. Each colored lineribbon refers to the probability curve of the change direction (Median and 95 % credible interval). Horizontal wrappers are the chosen gender, vertical ones are exemplary proportions of money on the screen. Their values were chosen based on the data's predictor range and frequency. Model coefficients and the figure in large resolution are on the OSF. Panels indicate features.

extent, intelligence falsified the Good-GH and supported the predictions of the Eman-GH. Interestingly, differences within these features among the RGC and between rF and M children leaned toward the Good-GH. Some designed differences among RGC contradicted the Good-GH and seemed to support (sportiness) or contradict (agreeableness) the Eman-GH.

Concerning extreme values, visitors preferred feature maximization over minimization. Chosen gender again modulated these effects. The highest proportion of extreme values, in general, and minimized and maximized ones, in particular, were often found in M children.

6.4. Assessing evidence

Even the most certain differences in designed values were arguably

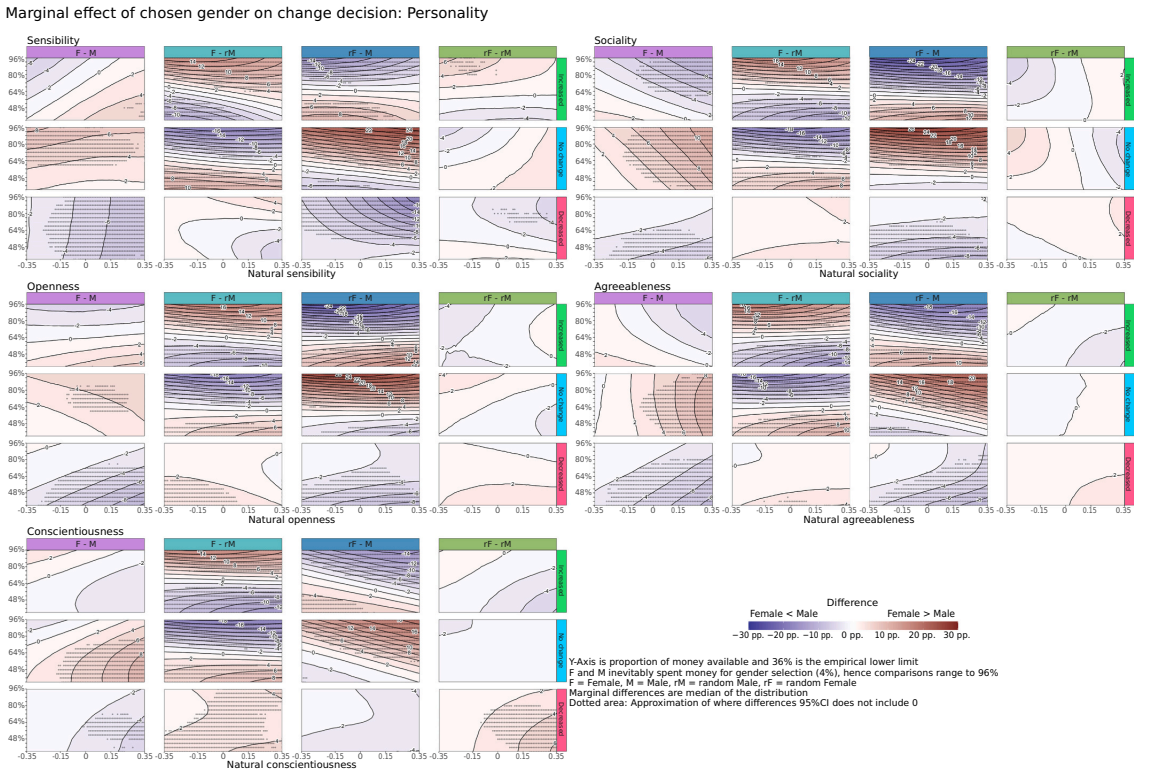


Fig. 3. Marginal effects of chosen gender on decision probability for changing personality traits (see Fig. 2). Pp. = percentage points. All comparisons, the used median, credible intervals, and additional comparisons between the same gender and the figure in large resolution can be found in the OSF. Y-axis is available money on the screen. X-axis is the natural value as randomly initiated by the exhibit. Contours and numbers within the figure are differences in decision probability for the decision (horizontal wrapper). Comparisons are made so that positive numbers (reddish) indicate a higher probability for F or rF children compared to M/rM children, while blueish contours and negative numbers indicate higher probabilities for M/rM children. For each predictor combination, several samples were drawn from the posterior. These were aggregated and examined whether the 95 % credible inverval contains zero. If not, this predictor combination is marked by a dot. This is a more conservative way to assess certainty because all other possible intervals are treated similarly although they express a different degree of certainty. Panels indicate features.

small. To better understand their meaningfulness, Bayes factors (BF) were calculated to assess evidence for a) any difference and b) predicted direction of the Good-GH over distributions that assumed no differences. The Eman-GH implies that the median and mean of the difference distribution is 0. However, the standard deviation of a respective distribution is unclear. Using the *bayestestR* package (Makowski, Ben-Shachar, & Lüdecke, 2019) and orientating at the suggested procedure (Makowski, Ben-Shachar, Chen, & Lüdecke, 2019), BF was calculated as follows: Employing different *SD*-magnitudes, we specified a so-called *Region Of Practical Equivalence* (ROPE = ± 1/2 *SD*). This is the region in which a difference is seen as trivial. We then calculated the ratio between the predicted difference distributions of our models in the area outside the ROPE and the respective area for the assumed difference Eman-GH distribution. Therefore, a BF of 3 means that the odds that the predicted distribution of differences contains a value outside ROPE is three times as large as for the Eman-GH distribution of comparison (for more detail, see Makowski, Ben-Shachar, & Lüdecke, 2019). Findings are shown in Fig. 8, where two ROPE specifications are displayed: Either symmetrically in every direction (evidence for any difference) or reflecting the Good-GH prediction. Here, ROPE ranges from infinity to one or two standard deviations in the direction of prediction. Evidence against the Good-GH does not automatically mean evidence for the Eman-GH. This would only be the case if the found difference is ~0 and, direction wise, does not oppose the hypotheses predictions (e.g., F/rM differences in intelligence).

As shown in Fig. 8, our results partially support the Good-GH. However, the strength of the evidence is conditional on the assumed characteristics of comparison distribution and the gender selection process. The clearest evidence for the Good-GH among all groups is found within sensibility, and the strongest evidence in terms of the Bayes factor was within F/M differences in sportiness.

7. Discussion

This study analyzed data from a museum context to evaluate potential strategies when designing a “perfect” child. It was hypothesized that people who can genetically design their perfect (virtual) child do so with benign motivations relative to present normative convictions. The dominating behavior to eliminate genetic disease disposition supports this working hypothesis A1 and the idea that a “perfect” child should live a healthy, i.e., good life (see Bondas & Eriksson, 2001).

However, normative convictions also pertain to gender-related attributes (Koenig, 2018). Against the consequential and action-guiding backdrop of normative gender stereotypes, we proposed the dominance of one of two main strategies. One comprises the attempt to enact contemporary normative gender stereotypes to minimize friction and

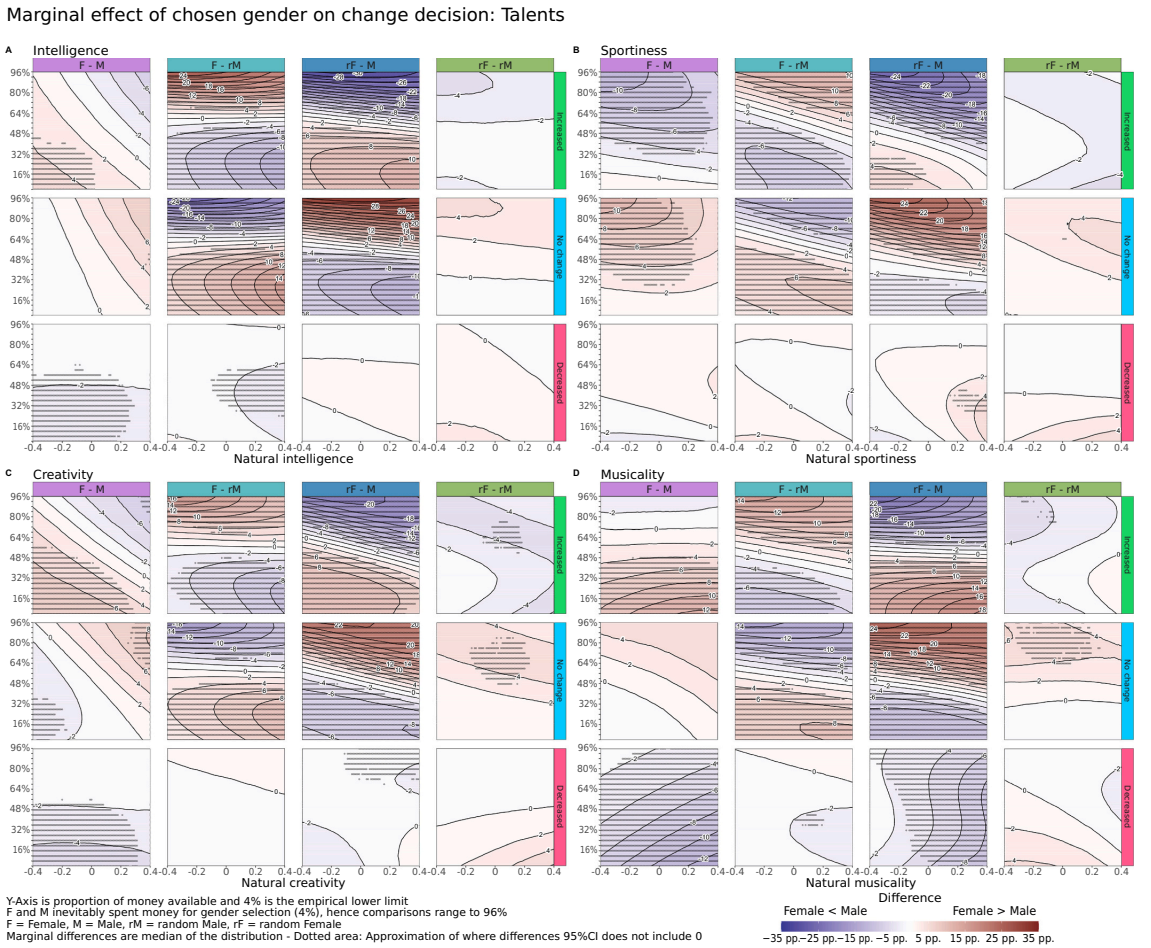


Fig. 4. Marginal effects of chosen gender on decision probability for changing talents (see Fig. 2). Pp. = percentage points. For all comparisons, the used median, credible intervals, and additional comparisons between the same gender and the figure in large resolution can be found in the OSF. Y-axis is available money on the screen. X-axis is the natural value as randomly initiated by the exhibit. Contours and numbers within the figure are differences in decision probability for the decision (horizontal wrapper). Comparisons are made so that positive numbers (reddish) indicate a higher probability for F or rF children compared to M/rM children, while blueish contours and negative numbers indicate higher probabilities for M/rM children. For each predictor combination, several samples were drawn from the posterior. These were aggregated and examined as to whether the 95 % credible inverval contains zero. If not, this predictor combination is marked by a dot. This is a more conservative way to assess certainty because all other possible intervals are treated similarly although they express a different degree of certainty. Panels indicate features.

potential negative consequences for their child (see Rudman, Moss-Racusin, Glick, & Phelan, 2012). This adapts one's child directly to the environment and creates "good boys/girls" (Good-Gender Hypothesis - Good-GH). Drawing on a study by Diekman and Eagly (2000) that showed that gender stereotypes of males and females are predicted to align in an egalitarian way and the idea that biotechnology can ease oppressive gender relations (Hughes & Dvorsky, 2008), we also suggested that people may try to adapt the environment through an adaptation of their children into a more gender egalitarian direction (Emancipating-Gender Hypothesis – Eman-GH). Although we could not assess visitors' motivation directly, their design behavior led to data patterns that partially aligned with both hypotheses' predictions. Thus, our findings suggest that people may at least partially orient on a present gender-related value structure when designing their perfect child. Evidence that differed across features was dependent on the gender selection process, i.e., designing the child deliberately as Male/Female (DGC: M/F) or maintaining the randomly assigned gender (RGC: random Male/random Female — rM/rF). However, ambiguous effects hinder a decisive interpretation. The following discussion will focus on those findings that allow for a clearer interpretation and on differences between children whose gender has been picked deliberately. This is not meant to withhold equivocalities but to provide the first step for future research in more controlled settings.

While possible values for all features ranged from −1 to 1, expected values across all features grouped at the positive side of the scale. Relative to the largest differences possible (± 2), marginal effects were small. This is not an inevitable contradiction since the Good-GH and Eman-GH predict relative rather than absolute differences. Moreover, people paid for change and not for range. Hence, there was no economic reason not to maximize a specific value. This supports the

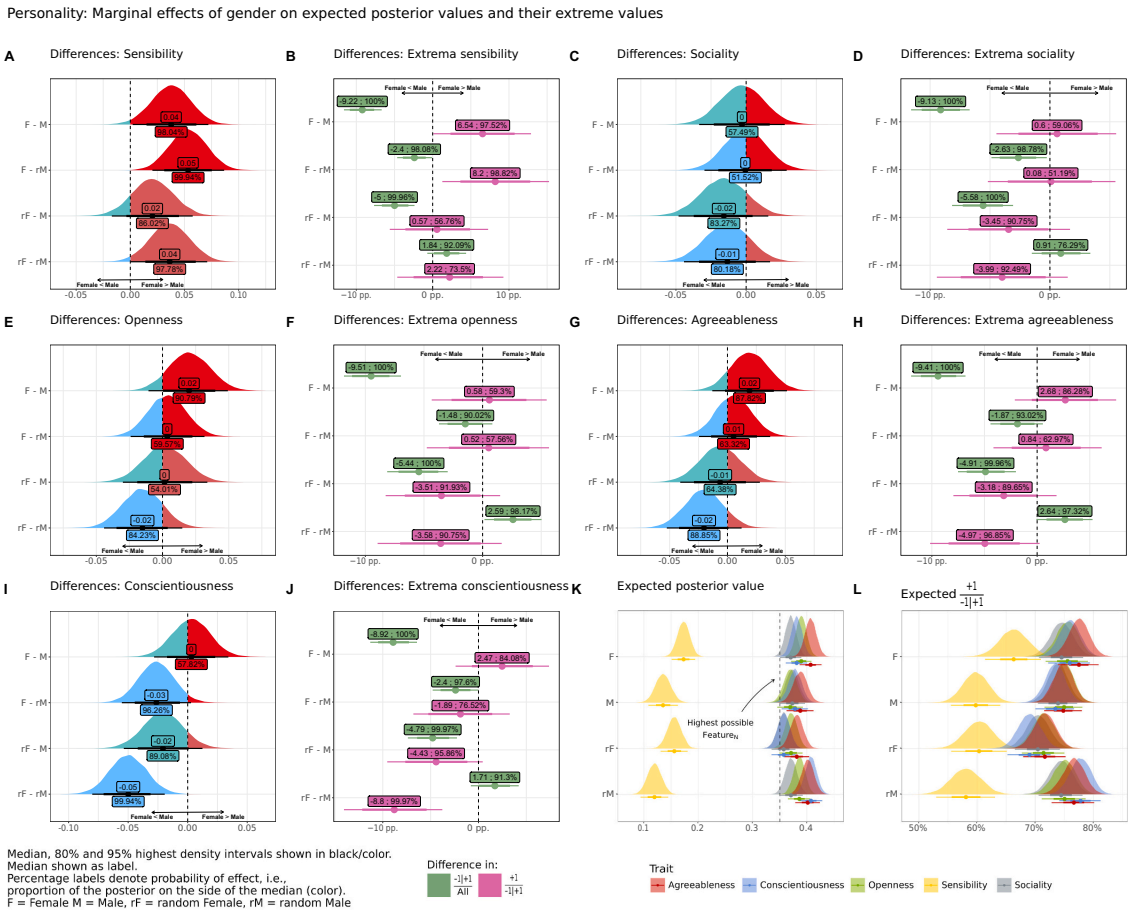


Fig. 5. X-Axis in panel A – J: Comparisons, each structured so that blueish color indicates higher values for M/rM children and reddish ones indicate higher values for F/rF children. X-axis in panels K – L refers to chosen gender. Panels entitled "Differences: [Feature]" are the marginal differences in expected posterior value across gender. Values underlying these comparisons are seen in panel K. Panels entitled "Differences: Extrema [Feature]" are marginal differences in the proportion of extreme values (Green) and conditional proportion of extreme positive ones (pink, see also panel L). All distributions show the median (dot and label in panel A - J) and 80/95 % credible intervals (thick and thin line). See the OSF for detailed comparisons and the large-resolution figure. Model coefficients are in the supplement. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

meaningfulness of identifiable differences.

Greater differences were found concerning the proportion of extreme M and F values. For instance, within designed creativity and intelligence, M children's values surpassed F ones by around ten and twelve percentage points, respectively. As noted by one of the anonymous peer-reviewers, this aligns with the so-called *variability hypothesis*. The basic idea is that the distribution of psychological characteristics among males tends to be more diverse and potentially more extreme than among females (Shields, 1982). Meta-analyses found no conclusive or strong evidence for the hypothesis concerning general creativity (Taylor et al., 2024) and intelligence (Giofrè et al., 2022). If proven effective, genetic engineering could influence any feature distribution and create a hypothesized effect that nature could not provide.

7.1. Personality: Sensibility

As predicted by the Good-GH, M children's sensibility was more likely to be decreased than those of F counterparts. However, opposing our predictions, F values were likelier to be maintained and not likelier to be increased. Nonetheless, we attribute these differences to the prescription for females to express emotions and be compassionate and the proscription for males to be emotional (e.g., Koenig, 2018; Prentice & Carranza, 2002). Consistent with general findings (e.g., Koenig, 2018), the male proscription seemed stronger than the female prescriptions. Sensibility was the only feature in which all gender differences among designed values pointed toward the predicted direction and thus provided clear support for the Good-GH.

Designed and maximized values of sensibility were the lowest of all features. This hints toward a specific devaluation of associated qualities. However, this and the findings on gender-specific effects do not mean that sensibility, in general, is seen as unfavorable (see Prentice & Carranza, 2002). While a rise in sensibility_N consistently increased the probability of decreasing it, low natural values also predicted an increase. Note that similar to gender (A. E. Martin & Mason, 2022), showing emotions is a critical aspect of being seen as human (Phillips, 2022). This may support the parental dogma hypothesis of creating favorable outcomes for their child. An overly accentuated sensibility may render the child more emotionally vulnerable, while

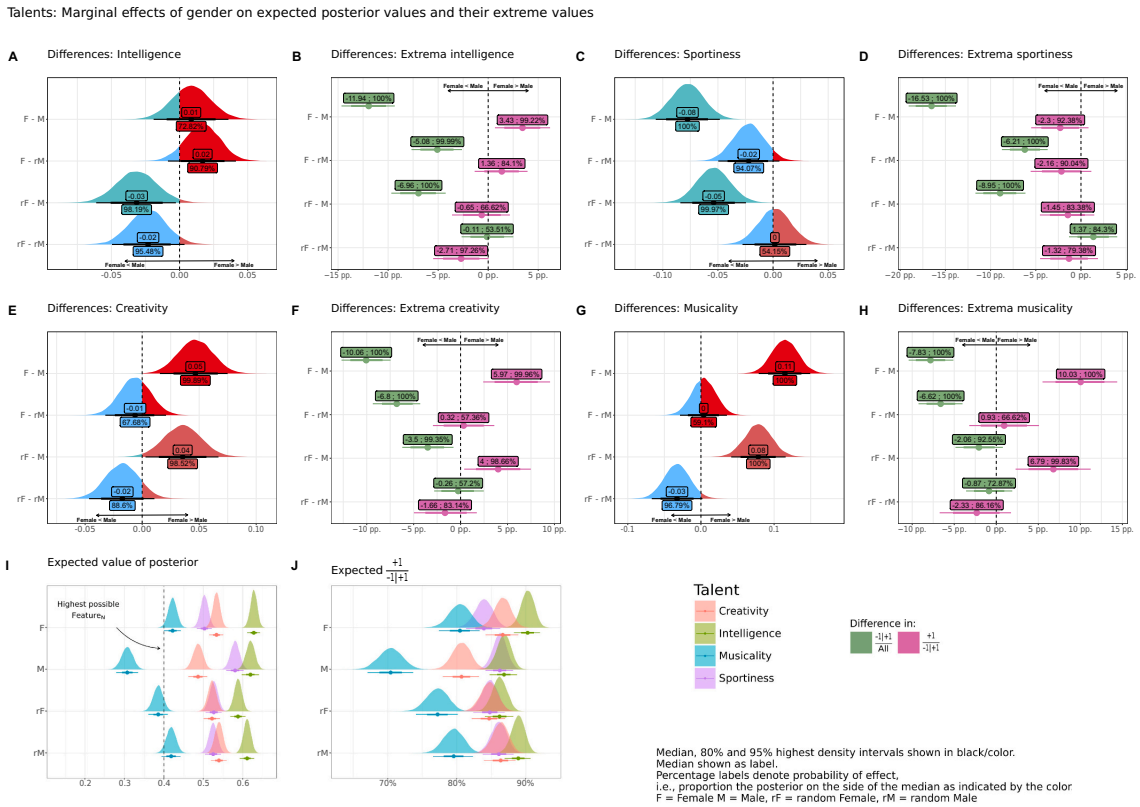


Fig. 6. X-Axis in panel A – H: Comparisons, each structured so that blueish color indicates higher values for M/rM children and reddish ones indicate higher values for F/rF children. X-axis in panels I – J refers to chosen gender. Panels entitled "Differences: [Feature]" are the marginal differences in expected posterior value across gender. Values underlying these comparisons are seen in panel I. Panels entitled "Differences: Extrema [Feature]" are marginal differences in the proportion of extreme values (Green) and conditional proportion of extreme positive ones (pink, see also panel J). All distributions show the median (dot and label in panel A - H) and 80/95 % credible intervals (thick and thin line). See the OSF for detailed comparisons and the large-resolution figure. Model coefficients are in the supplement. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

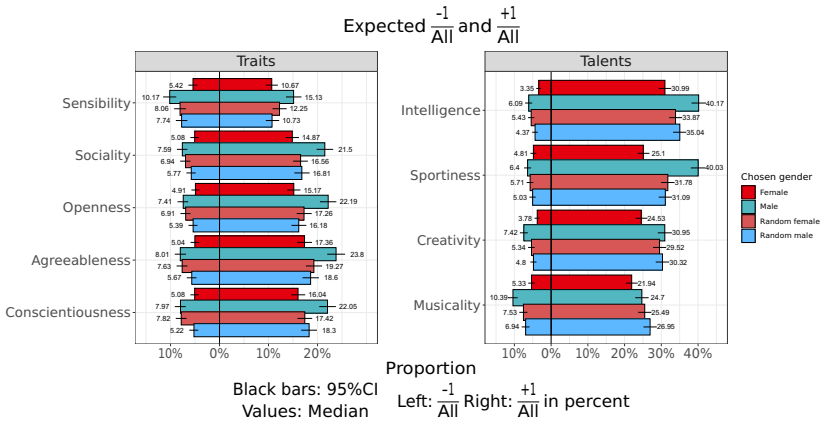


Fig. 7. Proportion of minimized (left) and maximized (right) values relative to all designed values for each feature. See OSF for detailed values and the large-resolution figure.

Table 3
Overview of frequency of natural and chosen gender.

	Natural gender		
	Random female	Random male	Overall
	(n = 6917)	(n = 6724)	(N = 13,641)
Chosen gender			
Female	1823 (26.4 %)	1797 (26.7 %)	3620 (26.5 %)
Random female	3581 (51.8 %)	0 (0 %)	3581 (26.3 %)
Male	1513 (21.9 %)	1443 (21.5 %)	2956 (21.7 %)
Random male	0 (0 %)	3484 (51.8 %)	3484 (25.5 %)
Gender changed to opposite?			
Yes	1513 (21.9 %)	1797 (26.7 %)	3310 (24.3 %)
No	5404 (78.1 %)	4927 (73.3 %)	10,331 (75.7 %)

Note. If the chosen gender is random female/male, the natural gender was maintained, and no money was spent on gender selection.

underdeveloped emotional capabilities may deprive the child of valuable experiences. Despite the many children with extreme values, the general understanding of personality traits may be positive. Still, extreme expression may be associated with more clinical phenomena like personality disorders or accentuations and are thus incompatible with a "perfect" child.

However, previous research showed that people see emotional capabilities as a key component of personal identity and are less willing to manipulate identity-constituting features within themselves or their child (Riis et al., 2008; Wagner et al., 2018). This could explain why sensibility was the trait least likely to be changed.

7.2. Personality: Sociality

We linked sociality to extraversion, agency, and the normative expectations for males to showcase assertiveness, dominance, no shyness, independence, and general agency (Bosson et al., 2022; Doey et al., 2014; Koenig, 2018; Rudman, Moss-Racusin, Phelan, & Nauts, 2012). Still, comparisons among DGC suggested little to no differences. Conditional marginal effects on decision probability partially supported a male prescription but also yielded ambiguous results inconsistent with our predictions. Found evidence favoring the Good-GH may be due to the assumed properties of the comparison distribution rather than meaningful differences. Assuming no differences aligns with what is expected under the Eman-GH and may clarify findings by Prentice and Carranza (2002), who found no gender-specific desirability differences in showing extroversion.

Apart from supporting the Eman-GH, non-evident differences among the DGC may be explained by an ambiguous understanding of "sociality." When formulating our predictions, we acknowledged that traits associated with this term could be similarly desired for males and females. However, we decided that the link to agency justifies assuming a male prescription (Supplement). Yet, psychometric facets of extraversion are named *warmth* and *positive emotions* (Costa Jr. & McCrae, 1992), qualities that can be linked to female prescriptions concerning displaying warmth, wholesomeness, and cheerfulness (Prentice & Carranza, 2002). Moreover, being overly social could undermine the male prescription of assertiveness. This would render decreasing male sociality values a sufficient strategy under the Good-GH. This would also explain

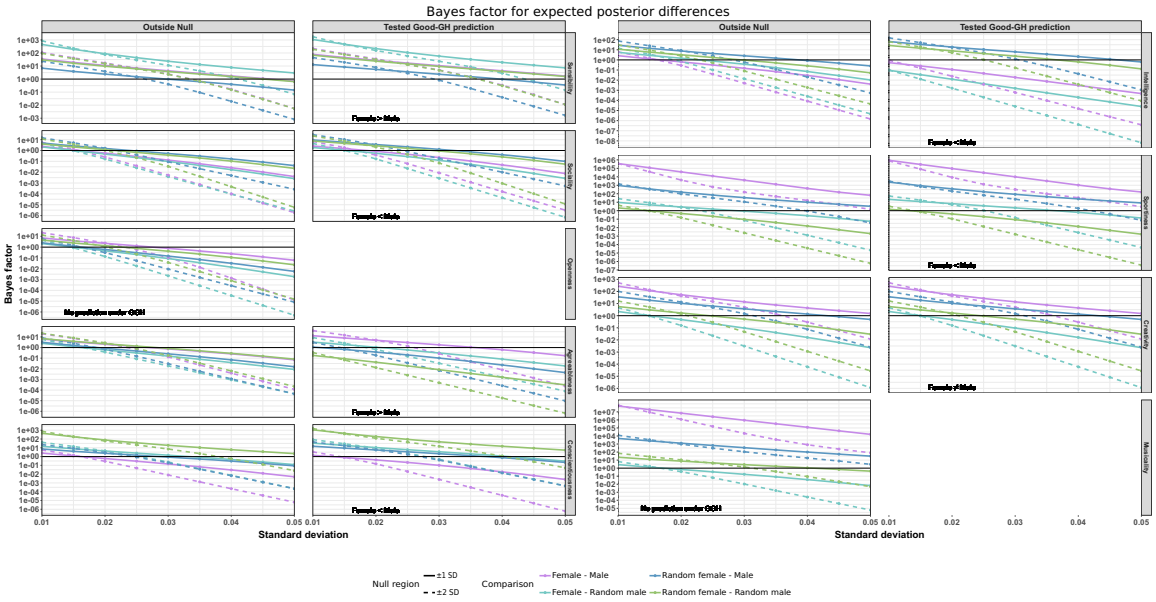


Fig. 8. Y-axis: Bayes factor (calculated on a logarithmic scale; translated for readability). X-axis: used standard deviation for comparison distribution. Comparison distribution was always N(0, SD). Between columns defined, ROPE changed and was either non-directed (Outside Null) or directed (Evidence for Good-GH prediction). In the latter case, ROPE ranged from -Inf to 1 (solid line) to 2 (dashed line) SD or − 1/2 SD to Inf, depending on predicted direction. In cases where the Good-GH did not make any predictions, we refrained from showing the same graph twice. Exception: "Creativity" to highlight that the Good-GH assumed unspecific differences. A file with all values and additional comparisons between the same gender and the figure in large resolution can be found in the supplement and the OSF. Given that a distribution of N(0,0.01) is very narrow, comparison with the predicted difference distribution still yields evidence even though the probability of effect is uncertain and small (e.g., sociality).

why M children's sociality was partially more likely to be decreased *and* increased and why the proportion of extreme values is highest among M children. More research is needed to determine how people understand "sociality" concerning normative gender stereotypes. Subsequent results could also clarify to what extent we may have over- or underweighted existing stereotypes.

7.3. Personality: Openness

Building on previous findings that, for example, suggested no differences in normative open-mindedness (Prentice & Carranza, 2002), none of the hypotheses yielded any prediction on openness. Differences suggest a trend toward more open F than M children, which may be driven by a male proscription.

7.4. Personality agreeableness

Partially concurring with findings on the female prescription to be communal (e.g., Bosson et al., 2022; Koenig, 2018), results suggest a trend for less agreeable M children than F children. An interpretation favoring the Good-GH is also supported by probability differences, which indicate that among DGC, M children's agreeableness was conditionally more likely to be decreased. Yet, agreeableness for F children was maintained rather than increased. Expected differences among the RGC pointed in the opposite direction and were thus inconsistent with the predictions of both hypotheses.

7.5. Personality: Conscientiousness

Linking psychometric facets of conscientiousness (e.g., being achievement focused) to male prescriptions like being ambitious (see Costa Jr. & McCrae, 1992; Rudman, Moss-Racusin, Phelan, & Nauts, 2012), our models found little evidence for the predicted male increase. Although we also found no conclusive evidence for the Eman-GH prediction that female values will be increased, the non-existing F/M differences may support the idea that female mental profiles approximate male ones (see Diekman & Eagly, 2000). However, all other gender differences seemed to support the Good-GH.

7.6. Talents: Intelligence

Only differences in designed values among the rF and rM supported the Good-GH's prediction that males ought to be more intelligent (e.g., Koenig, 2018). Found differences in decision probability and expected differences among DRC counteract the Good-GH and partially supported the Eman-GH.

Concerning intelligence, models yielded the greatest proportion of maximized children and the highest predicted values. Intelligence is often implicitly and explicitly linked to achievement and performative excellence, so associated skills are highly desirable in Western societies (Cocodia, 2014; Sternberg & Grigorenko, 2004). Although less prescriptive for females, it is desired for all gender (Prentice & Carranza, 2002). Thus, high designed intelligence may reflect Savulescu's (2001) proposition that this feature is pivotally beneficial for future children and human well-being. Nonetheless, there were some gender differences. M children showed the highest absolute proportion of maximized and minimized children. Possibly, visitors found amusement in creating a not-very-intelligent child. But it remains unclear why this was more pronounced for M than F children.

7.7. Talents: Sportiness

Besides the found evidence within designed values and decision probability for the Good-GH among DGC, Sportiness was the only feature where extreme M children were likelier to have maximized values than F ones. Moreover, expected sportiness values and the total proportion of maximized children among M matched the respective intelligence values. M children were the only group where sportiness and not intelligence was the most modified feature. Alongside effects in sensibility, differences in sportiness among the DGC provided the strongest evidence for the Good-GH. The stereotype of highly valued male and moderately valued female athleticism (Prentice & Carranza, 2002) is enforced.

7.8. Talents: Creativity

Probably driven by the decision to rather decrease M children's creativity_N and increase the values of F counterparts, the latter children were designed to be more creative. This aligns with the observation that creativity is not as important for males as it is for females (Prentice & Carranza, 2002) while challenging the notion that creativity is a male prescription due to its connotation with traits indicating agency (see Proudfoot et al., 2015). The DGC-related insight may be used to adjust the prediction of the Good-GH from unspecific differences in creativity toward the expectation that females ought to be more creative than males, which is driven by a mixture of pre- and proscriptions.

7.9. Talents: Musicality

Relative to other talents, musicality seemed devalued among M children. The overall trend of decreasing this talent at higher levels was especially pronounced for M children. Nonetheless, F children were more likely to get an increase, contributing to the evident differences in expected value. Neither Good-GH nor Eman-GH made any predictions regarding musicality. Recent evidence suggests that being musical is equally desired for men and women (Hudson & Ghani, 2024). Yet, our findings may hint toward the presence of normative gender stereotypes and urge further inquiry if musicality is as psychologically androgynous as suggested (see Kemp, 1985).

7.10. Critically evaluating Eman-GH and Good-GH for future research

The setting from which we extracted our data constrains the certainty with which we can generally affirm or discard our hypotheses. Due to ambiguous findings and differences contradicting both hypotheses, we now critically revisit our predictions and modeling choices and make suggestions for future research in more controlled settings.

Since our findings are limited in mapping individual motivation, explanations and motivational concerns other than those suggested by the Good-GH and Eman-GH must be considered. Our working hypothesis A1 should be a good starting point for deriving gender-unrelated normative reference frames that can influence design behavior.

Assuming that differences emerged based on gender, we hypothesized that our predictions would hold regardless of the gender selection process. Yet, differences among the children whose randomly assigned gender was retained often pointed in the opposite direction than differences among children with deliberately chosen gender (e.g., creativity, musicality, intelligence, openness). The former differences were often more uncertain, less pronounced but sometimes supported an opposite hypothesis. Files on the OSF feature marginal effects between M and rM as well as F and rF. Found differences within the same final gender suggest that the gender selection process played a greater role than initially hypothesized and emphasize the need for further research concerning the salience of gender in the design process.

The deliberate choice for one over the other gender prevents identification difficulties and may render associated stereotypes more available. From a Good-GH perspective, this may explain why gender differences were more pronounced among DGC than RGCs. One could further argue that the deliberate decision for one gender indicates a particular emphasis on gender in general. In this case, the following design process may orient more toward a gender-specific value structure than if gender is randomly assigned. Recall how desired child qualities

can shift after sex revelation (Imhoff & Hoffmann, 2023). This may suggest that people who opted for deliberate gender choice may design a perfect *gendered* child. In contrast, people who retain the random assignment may be more concerned about a perfect child regardless of gender. However, although differences among RGC were small and sometimes relatively uncertain, they often tended toward higher values for rM children. Future study settings could address this issue by shifting the gender selection process to the end of the procedure or eliminating it altogether. Additionally, information on the importance or prevalence of stereotypes may also be manipulated.

The study by Imhoff and Hoffmann (2023) did not show a relevant shift in mothers' attitudes following the revelation of their child's sex. The authors discuss this by referring to research on gender-dependent stereotype strength influencing the evaluation of fathers. However, they point out that there was no interaction effect on preferred qualities with gender attitudes in general. Nonetheless, we should contemplate the possible influence of the visitor's gender, age, and psychometric traits (e.g., essentialistic beliefs, self-concept, stereotype endorsement, attitudes toward genetic engineering, and personality). Since we have no information about the visitors, we cannot confirm whether personal characteristics yielded more pronounced enforcement or dismantling of stereotypes. Hence, we must postpone any related inquiry to future research.

One anonymous peer-reviewer noted that the initial instruction to "Create your perfect child!" could have been understood as a request for designing a perfect child in terms of what is *generally* and not individually associated with this term. However, a task-reminding question heading all screens of the exhibit read: "What would your perfect child look like?" ["Wie sieht dein Wunschkind aus?"]. The German word "Wunschkind" can be translated as "wished-for-child" and has a strong individual connotation. When designing a general "perfect" child, values should align with whatever feature expression is generally desired. This may yield no differences and thus yield results as predicted by the Eman-GH. Even if stereotypes conjoin both reference frames, future study designs may explicitly vary individualization of the instruction (e.g., personal, societal, other's "perfect" child). Here, one could also manipulate information about the expected societal and evolutionary consequences of one's decision. This could elucidate what societal costs people are willing to bear to ensure the benefit of their child and clarify the moral intricacies of our hypotheses. Researchers could vary the type of cost, e.g., highlighting a maladaptive effect upon genetic or social diversity. To investigate the scope people consider in their decision-making process, consequences may be communicated to occur differently on various scales, such as family, country, or humanity as a whole. Besides focusing on the decisions within the design process, the decision to conduct or reject genetic engineering should also be in focus. The motivations mentioned are likely to influence both decisions.

Abstracting from the concrete motivation of the visitors, we must critically ask if the notion of a gender-egalitarian future propagated by the Eman-GH manifests in the decision to nullify any differences. This inquiry should also question the assumed mechanisms regarding decision probability and the idea that females align with males (see Diekman & Eagly, 2000). We must also ask if desiring or anticipating a "post-gender future" (Hughes & Dvorsky, 2008) is so prevalent that it can outweigh other design strategies. We suggested that traits that are linked to the current gender hierarchy, i.e., those related to agency and high status (Rudman, Moss-Racusin, Glick, & Phelan, 2012; Rudman, Moss-Racusin, Phelan, & Nauts, 2012) may be an important target for manipulation following the Eman-GH. The uncertain differences in sociality, intelligence, and conscientiousness among DGC support this idea. This interpretation demands further inquiry and is challenged by the finding that among RGC, differences in intelligence and conscientiousness support the Good-GH. These differences also contradict the interpretation that among RGC, Eman-GH-associated processes are at work, while DGC children are designed in closer accordance with what the Good-GH. Future research could explicitly prime participants with a related goal (maintaining or overcoming stereotypes) and investigate the design outcomes. Reflecting the reality of gender, additional variations could inform people that their child's gender identity may not match the one assigned at birth or will be interpreted fluently by their offspring during different phases of their life. In line with previous findings (e.g., C. L. Martin, Andrews, et al., 2017), designers may also be informed about the potential benefits of a less strict interpretation of gender identity.

Effect sizes by Koenig (2018) suggest that the female prescription for communality is stronger than the male proscriptions to be emotional or showcase weakness. However, our findings provide more evidence for the enforcement of the latter. This is more in line with recent evidence that acting according to existing pre- and proscriptions is seen as more important for males than females (Bosson et al., 2022). Another possible explanation could be that the wording of the exhibit suggested a strong association between sensibility and traits that are proscriptive for males, while features like agreeableness may not have been directly linked to the female communality prescription. This comprehension-hypothesis could also explain the strong differences in sportiness but fails to account for the non-existing differences in intelligence. Because we were not involved in the exhibit's programming, we had to attune our predictions to the pre-defined setting instead of tailoring the study setting to our hypotheses in the most effective way. Even if the hypotheses' general mechanisms are untouched by this, description and selection of manipulatable features in future research should orient heavily on the existing literature to ensure that they match the common understanding of what is expected by males and females. Related efforts should also explore domains that we could not address. Given their relative strength and emphasis on the female body shape (Koenig, 2018), normative expectations regarding gendered appearance should be put in focus. This would allow us to compare designed children with prevailing beauty stereotypes (see Little, 1998).

Apart from group differences, gender and feature-related variation in stereotype strength and importance (Koenig, 2018; Prentice & Carranza, 2002) may have influenced feature manifestation within the same gender. For simplicity reasons and because every feature expression cost the same, we did not consider intra-gender stereotype variation when formulating our predictions. Interpreting designed values related to stereotype strength, approximation of designed sportiness, and intelligence in M children is in line with other studies (e.g., Hudson & Ghani, 2024; Prentice & Carranza, 2002). Although theoretically and methodologically defensible, not including data from people who retained natural value when comparing differences may have resulted in some nuances in the data not being considered. Hypotheses were tested on a macro-scale, which may neglect micro-scale effects. Future research should focus on identifying and comparing sub-groups within children. This may be done using clustering methods like latent profile analysis. Another possibility that would also address stereotype strength would be employing methods that model the feature variance within single children. This way, we could get a more individualized understanding and address the suggested benefits of modest stereotype divergences (Prentice & Carranza, 2002) and psychological androgyny (C. L. Martin, Cook, & Andrews, 2017). Testing the enforcement of pre- and proscriptions may be easier if values are pre-set instead of randomly assigned.

Our suggestions could be addressed in quantitative and qualitative studies. Besides an empirical approach, scholars and the public should comprehensively discuss the potential societal impacts of the Good-GH and Eman-GH. Even if concluding that the phenomena we discussed here are technologically infeasible, this can create insights into how social conventions manifest into physical reality and elucidate the desirability of such processes.

8. Limitations

The most evident limitation is the absence of any information (e.g.,

socio-demographic data, psychometrical, attention checks) about the visitors who engaged with the exhibit. The exhibit was not designed as a psychological experiment. Owing to the ecological setting, we neither know if every child is linked to exactly one visitor nor the average number of children single visitors created. The gamified characteristic of the exhibit in the museum may be a double-edged sword. It inclines engagement but can lead to a shallower, non-earnest, or inattentive engagement with the exhibit. Being primarily fun-orientated or wanting to explore multiple design possibilities are additional factors that may have influenced how people engaged with the exhibit.

The exhibit's programming may not be aligned with how humans make decisions or how economic choices commonly occur (e.g., paying for change, not range of change). Preselection of traits and talents may have influenced how normative stereotypes could be expressed and hindered the certainty of formulated predictions. Effects were often small and ambiguous. Even if predictions did not reflect the found role of the gender selection process, we consider this particular falsification of our hypotheses as an important insight for future research.

There may be various sources of selection bias concerning the composition of people who interact with the exhibit. Although the museum is open to international visitors, we cannot exclude the possibility of a German/Western bias. This extends to many studies we cited when formulating our hypotheses and predictions. Still, gender stereotypes cross-culturally align on the dimensions of prescriptive female community and male agency (Bosson et al., 2022; Kosakowska-Berezecka et al., 2022). An additional source of bias concerns the socio-demographic variables of museum visitors (e.g., Kirchberg, 1996), which further confines generalizability.

Selection bias can also stem from local behavior within the museum. People may not have engaged with the exhibit due to being inattentive, distracted, uninterested, bored, and other currently unknown variables. At the level of individual attitudes, uses other than therapeutic ones increase the reluctance to use genetic engineering (e.g., Marteau et al., 1995; Rabino, 2003; Scheufele et al., 2017). Those who reject the notion of designing a perfect child and are generally skeptical of genetic engineering may not appear in the data because they do not engage with or finish the exhibit. Even if we interpret children who were not modified as being related to such an attitude, our findings only elucidate the prioritization process *after* affirming the intervention. They can neither address the public attitude toward human genetic engineering per se nor how this attitude is justified.

Chosen skin color was not included in our models. Given the recent evidence on the relationship between normative gender stereotypes and ethnicity (Hudson & Ghani, 2024), modeling a respective interaction could explain additional variance. This also pertains to stereotype differences based on the target's sexual preferences, ethnicity, and gender (Hudson & Ghani, 2024). Although the former was not communicated to visitors, future research should explore these interactions. This could also elucidate the role of stereotypes beyond the traditional hetero-normative male/female boundaries.

The exhibit imposed a traditional male-female binarity of sex and gender onto the visitors. This distinction made it possible to link and analyze the data relative to previous research on normative gender stereotypes but undercuts the rich psychological and medical debate on the accuracy of this binary understanding and its genetic basis (e.g., Hyde et al., 2019). In contexts where gender is conceptualized as more diverse, the generalizability of our analysis is limited. This also pertains to the beliefs of the visitors about the accuracy of gender as binary.

9. Conclusion

We presented a comprehensive theoretical discussion on the relationship between biotechnology and action-guiding stereotypes. We further pointed out potential consequences and behavioral strategies that emerge from this relationship. Our results support the idea that people will genetically engineer their children according to good intentions. They also provide evidence for the hypothesis that genetic engineering will be embedded into a given socio-material context in which contemporary normative gender stereotypes influence the task of designing a "perfect child." Revealed evidence supports the possibility that this may happen by strategically imposing the respective content on offspring to minimize potential negative consequences of stereotype violation. At the same time, findings also support the idea that people may use transformative biotechnology to dismantle stereotypes. Although being an initial step into a promising field, evident limitations within the data-generating setting and the absence of psychometric data hinder a definitive conclusion regarding these hypotheses' extent and precise character. Further research in more controlled settings and additional theoretical work are needed.

The fact that some of our results could be considered controversial underscores the importance of educational facilities like the one we obtained the data from. Not only because people are given a learning opportunity but also because policy decisions can be mutually informed by the scientific analysis of data gathered within these more informal settings. Even if discarding the widespread feasibility of targeted human genetic engineering, our findings contribute to the present corpus on normative gender stereotypes and elucidate their action-guiding effect. How people *would* use genetic engineering provides crucial insights into the enactment of gender and the role attributed to biotechnology in the gendered performance.

Following the action-guiding rules of normative gender stereotypes can self-fulfillingly lead to the empirical manifestation of their content (Ellemers, 2018), which then solidifies the belief in the presence of some gender "essence" (Butler, 1988). This was highlighted concerning gender-specific adaptations of the environment (Saguy et al., 2021; Sutfin et al., 2008), but may also apply to more controversial adaptations of children. Positive correlations between self- and external ratings with descriptive stereotypes suggest partial veracity of gender stereotypes about personality (Löckenhoff et al., 2014). Under the presumption of technological feasibility, our findings provide initial evidence that genetic engineering of children could solidify this correlation and extend it to other qualities. However, gender stereotypes could also be unverified by the biotechnological alteration and societal reception of genetic reality. In both cases, the alleged imperishable essence of our identity is subjected to deliberate manipulation. Thus, genetic engineering has the potential to technologically enforce the essentialist notion of gender while also dismantling its foundation.

CRediT authorship contribution statement

NAD: Conceptualization; Hypotheses; Data analysis; Figure preparation; Writing original draft; Writing revision **CCC:** Conceptualization; Supervision; Writing - Review & Editing.

Ethics statement

This study was reviewed and approved by the Ethics Committee of the University of Bamberg, Germany (Dossier number 2023–07/31).

Funding

No funding involved.

Declaration of competing interest

The authors have no competing interest to declare.

Acknowledgments

We thank the *Deutsches Museum Nürnberg – Das Zukunftsmuseum* for their open-minded and helpful cooperation. Many thanks to Jasmin Della Guardia for helping prepare the dataset. Special thanks to Dr.

Alexander "Sasha" Pastukhov for methodological advice and Don Watson and Marlene Compton for their proofreading. NAD wants to thank Thomas Kollmann and Jonah Lutz for their philosophical input and Dorothee Busch for her emotional support. Many thanks to the anonymous reviewers for their constructive and valuable feedback.

Appendix A. Supplementary data

The supplement contains additional information about the data and its preparation. Further resources are files with the model coefficients and detailed information about the marginal effects. It can also be found at the OSF: https://osf.io/5g3rf/ – DOI 10.17605/OSF.IO/5G3RF. There, we also provide access to all figures. Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2025.104748.

Data availability

Given the agreement of our cooperation partner, data will be made available upon reasonable request. This decision was made due to ongoing research and data sharing policy of the museum. After our projects have finished, data is likely to be made public. Requests for validation of published findings or those under review will always be accepted for this purpose alone. Permission to analyze the presented data was kindly granted by the *Deutsches Museum Nürnberg – Das Zukunftsmuseum*, Nuremberg, Germany.

References

Abrejo, F. G., Shaikh, B. T., & Rizvi, N. (2009). 'And they kill me, only because I am a girl'…a review of sex-selective abortions in South Asia. *The European Journal of Contraception & Reproductive Health Care, 14*(1), 10–16. https://doi.org/10.1080/13625180802518231

Abreu, R. L., Rosenkrantz, D. E., Ryser-Oatman, J. T., Rostosky, S. S., & Riggle, E. D. B. (2019). Parental reactions to transgender and gender diverse children: A literature review. *Journal of GLBT Family Studies, 15*(5), 461–485. https://doi.org/10.1080/1550428X.2019.1656132

Alanko, K., Santtila, P., Salo, B., Jern, P., Johansson, A., & Sandnabba, N. K. (2011). Testing causal models of the relationship between childhood gender atypical behaviour and parent–child relationship. *British Journal of Developmental Psychology, 29*(2), 214–233. https://doi.org/10.1348/2044-835X.002004

Antoniucci, C., Portengen, C., & Endendijk, J. J. (2023). Like parent, like child: General and specific associations between Parents' and Children's binary gender identity in a gender egalitarian context. *Sex Roles, 88*(5–6), 225–239. https://doi.org/10.1007/s11199-023-01356-y

Banazadeh, M., Abiri, A., Poortaheri, M. M., Asnaashari, L., Langarizadeh, M. A., & Forootanfar, H. (2024). Unexplored power of CRISPR-Cas9 in neuroscience, a multi-OMICs review. *International Journal of Biological Macromolecules, 263*, Article 130413. https://doi.org/10.1016/j.ijbiomac.2024.130413

Barni, D., Fiorilli, C., Romano, L., Zagrean, I., Alfieri, S., & Russo, C. (2022). Gender prejudice within the family: The relation between Parents' sexism and their socialization values. *Frontiers in Psychology, 13*, Article 846016. https://doi.org/10.3389/fpsyg.2022.846016

Barni, D., Ranieri, S., Donato, S., Tagliabue, S., & Scabini, E. (2017). Personal and family sources of Parents' socialization values: A multilevel study. *Avances En Psicología Latinoamericana, 35*(1), 9. https://doi.org/10.12804/revistas.urosario.edu.co/apl/a.3468

Blondeel, K., Vasconcelos, S., García-Moreno, C., Stephenson, R., Temmerman, M., & Toskin, I. (2018). Violence motivated by perception of sexual orientation and gender identity: A systematic review. *Bulletin of the World Health Organization, 96*(1), 29–41. https://doi.org/10.2471/BLT.17.197251

Bondas, T., & Eriksson, K. (2001). Women's lived experiences of pregnancy: A tapestry of joy and suffering. *Qualitative Health Research, 11*(6), 824–840. https://doi.org/10.1177/104973201129119415

Bosson, J. K., Wilkerson, M., Kosakowska-Berezecka, N., Jurek, P., & Olech, M. (2022). Harder won and easier lost? Testing the double standard in gender rules in 62 countries. *Sex Roles, 87*(1–2), 1–19. https://doi.org/10.1007/s11199-022-01297-y

Bostrom, N. (2003). Human genetic enhancements: A transhumanist perspective. *The Journal of Value Inquiry, 37*(4), 493–506.

Broussard, K. A., & Warner, R. H. (2019). Gender nonconformity is perceived differently for cisgender and transgender targets. *Sex Roles, 80*(7–8), 409–428. https://doi.org/10.1007/s11199-018-0947-z

Browne, T. K. (2017). Why parents should not be told the sex of their fetus. *Journal of Medical Ethics, 43*(1), 5–10. https://doi.org/10.1136/medethics-2015-102989

Buchanan, A. E. (2011). *Beyond humanity?: The ethics of biomedical enhancement.* Press: Oxford Univ.

Bürkner, P.-C. (2017). Brms: An R package for bayesian multilevel models using Stan. *Journal of Statistical Software, 80*(1). https://doi.org/10.18637/jss.v080.i01

Butler, J. (1988). Performative acts and gender constitution: An essay in phenomenology and feminist theory. *Theatre Journal, 40*(4), 519–531.

Butnor, A., & MacKenzie, M. (2022). Enactivism and gender performativity. In K. Maitra & J. McWeeny (Eds.), Feminist philosophy of mind (1st ed., pp. 190-C10.P77). Oxford University PressNew York. doi:https://doi.org/10.1093/oso/9780190867614.003.0011.

Calabrese, C., Ding, J., Millam, B., & Barnett, G. A. (2020). The uproar over gene-edited babies: A semantic network analysis of CRISPR on twitter. *Environmental Communication, 14*(7), 954–970. https://doi.org/10.1080/17524032.2019.1699135

Carbon, C.-C. (2021). Good, bad and ugly genes? Science matters, also in terms of terminology and word usage. *Open. Psychology, 3*(47–49). https://doi.org/10.1515/psych-2020-0109

Carol, S., & Hank, K. (2020). Natives' and Immigrants' gender preferences for children in Germany. *European Journal of Population = Revue Europeenne de Demographie, 36*(2), 235–246. https://doi.org/10.1007/s10680-019-09527-y

Clemens, V., Berthold, O., Witt, A., Brähler, E., Plener, P. L., & Fegert, J. M. (2020). Childhood adversities and later attitudes towards harmful parenting behaviour including shaking in a German population-based sample. *Child Abuse Review, 29*(3), 269–281. https://doi.org/10.1002/car.2623

Cocodia, E. A. (2014). Cultural perceptions of human intelligence. *Journal of Intelligence, 2*(4), 180–196. https://doi.org/10.3390/jintelligence2040180

Costa, P. T., Jr., & McCrae, R. R. (1992). The five-factor model of personality and its relevance to personality disorders. *Journal of Personality Disorders, 6*(4), 343–359.

Cunningham, J., Goldsmith, L., & Skirton, H. (2015). The evidence base regarding the experiences of and attitudes to preimplantation genetic diagnosis in prospective parents. *Midwifery, 31*(2), 288–296. https://doi.org/10.1016/j.midw.2014.09.010

Dabb, C., Dryer, R., Brunton, R. J., Yap, K., & Roach, V. J. (2023). Paternal pregnancy-related anxiety: Systematic review of men's concerns and experiences during their partners' pregnancies. *Journal of Affective Disorders, 323*, 640–658. https://doi.org/10.1016/j.jad.2022.11.092

Dar-Nimrod, I., & Heine, S. J. (2011). Genetic essentialism: On the deceptive determinism of DNA. *Psychological Bulletin, 137*(5), 800–818. https://doi.org/10.1037/a0021860

Davis, S. N., & Greenstein, T. N. (2009). Gender ideology: Components, predictors, and consequences. *Annual Review of Sociology, 35*(1), 87–105. https://doi.org/10.1146/annurev-soc-070308-115920

Diekman, A. B., & Eagly, A. H. (2000). Stereotypes as dynamic constructs: Women and men of the past, present, and future. *Personality and Social Psychology Bulletin, 26*(10), 1171–1188. https://doi.org/10.1177/0146167200262001

Döbler, N. A., & Carbon, C.-C. (2024). Adapting ourselves, instead of the environment: An inquiry into human enhancement for function and beyond. *Integrative Psychological and Behavioral Science, 58*(2), 589–637. https://doi.org/10.1007/s12124-023-09797-6

Doey, L., Coplan, R. J., & Kingsbury, M. (2014). Bashful boys and coy girls: A review of gender differences in childhood shyness. *Sex Roles, 70*(7–8), 255–266. https://doi.org/10.1007/s11199-013-0317-9

Dubuc, S., & Coleman, D. (2007). An increase in the sex ratio of births to India-born mothers in England and Wales: Evidence for sex-selective abortion. *Population and Development Review, 33*(2), 383–400. https://doi.org/10.1111/j.1728-4457.2007.00173.x

Eagly, A. H., Nater, C., Miller, D. I., Kaufmann, M., & Sczesny, S. (2020). Gender stereotypes have changed: A cross-temporal meta-analysis of U.S. public opinion polls from 1946 to 2018. *The American Psychologist, 75*(3), 301–315. https://doi.org/10.1037/amp0000494

Ellemers, N. (2018). Gender Stereotypes. *Annual Review of Psychology, 69*, 275–298. https://doi.org/10.1146/annurev-psych-122216-011719

Ellemers, N., & Jetten, J. (2013). The many ways to be marginal in a group. *Personality and Social Psychology Review, 17*(1), 3–21. https://doi.org/10.1177/1088868312453086

Fitzgerald, W. A. (1997). Engineering perfect offspring: Devaluing children and childhood. *Hastings Constitutional Law Quarterly, 24*(4), 833–861.

Garland-Thomson, R. (2020). How we got to CRISPR: The dilemma of being human. *Perspectives in Biology and Medicine, 63*(1), 28–43. https://doi.org/10.1353/pbm.2020.0002

Giofrè, D., Allen, K., Toffalini, E., & Caviola, S. (2022). The impasse on gender differences in intelligence: A Meta-analysis on WISC batteries. *Educational Psychology Review, 34*(4), 2543–2568. https://doi.org/10.1007/s10648-022-09705-1

Habermas, J. (2005). *Die Zukunft der menschlichen Natur: Auf dem Weg zu einer liberalen Eugenik? [The future of human nature: on the road to liberal eugenics?] Erweiterte Ausgabe* (5. Auflage). Suhrkamp. (Original work published 2002).

Haslam, N., Rothschild, L., & Ernst, D. (2000). Essentialist beliefs about social categories. *British Journal of Social Psychology, 39*(1), 113–127. https://doi.org/10.1348/014466600164363

Haslam, N., & Whelan, J. (2008). Human natures: Psychological essentialism in thinking about differences between people. *Social and Personality Psychology Compass, 2*(3), 1297–1312. https://doi.org/10.1111/j.1751-9004.2008.00112.x

Heiss, A. (2021). *A guide to modeling proportions with Bayesian beta and zero-inflated beta regression models* [other]. *Socialsciences*. https://doi.org/10.59350/7p1a4-0tw75

Heiss, A. (2022, September 26). Visualizing the differences between Bayesian posterior predictions, linear predictions, and the expectation of posterior predictions. *Andrew Heiss's Blog*. https://doi.org/10.59350/xge39-emt86

Heiss, A. (2023). *The ultimate practical guide to conjoint analysis with R* [other]. *Socialsciences*. https://doi.org/10.59350/xgwjy-dyj66

Hendl, T. (2017). A feminist critique of justifications for sex selection. *Journal of Bioethical Inquiry, 14*(3), 427–438. https://doi.org/10.1007/s11673-017-9797-6

Hodgson, J., & McClaren, B. J. (2018). Parental experiences after prenatal diagnosis of fetal abnormality. *Seminars in Fetal and Neonatal Medicine, 23*(2), 150–154. https://doi.org/10.1016/j.siny.2017.11.009

Hodgson, J., Pitt, P., Metcalfe, S., Halliday, J., Menezes, M., Fisher, J., Hickerton, C., Petersen, K., & McClaren, B. (2016). Experiences of prenatal diagnosis and decision-making about termination of pregnancy: A qualitative study. *Australian and New Zealand Journal of Obstetrics and Gynaecology, 56*(6), 605–613. https://doi.org/10.1111/ajo.12501

Hoffman, C., & Hurst, N. (1990). Gender stereotypes: Perception or rationalization? *Journal of Personality and Social Psychology, 58*(2), 197–208. https://doi.org/10.1037/0022-3514.58.2.197

Hudson, S. T. J., & Ghani, A. (2024). Sexual orientation and Race Intersectionally reduce the perceived gendered nature of normative stereotypes in the United States. *Psychology of Women Quarterly, 48*(1), 56–79. https://doi.org/10.1177/03616843231187851

Hughes, J. J., & Dvorsky, G. (2008). *Postgenderism: Beyond the gender binary*. Institute for Ethics and Emerging Technologies.

Hyde, J. S., Bigler, R. S., Joel, D., Tate, C. C., & Van Anders, S. M. (2019). The future of sex and gender in psychology: Five challenges to the gender binary. *American Psychologist, 74*(2), 171–193. https://doi.org/10.1037/amp0000307

Ihde, D. (1990). *Technology and the lifeworld: From garden to earth*. Indiana University Press.

Imhoff, R., & Hoffmann, L. (2023). Prenatal sex role stereotypes: Gendered expectations and perceptions of (expectant) parents. *Archives of Sexual Behavior, 52*(3), 1095–1104. https://doi.org/10.1007/s10508-023-02584-9

International women's day 2019: *Global attitudes towards gender equality*. (2019). Ipsos; The Global Instititue for Women's leadership; King's College London. https://www.kcl.ac.uk/giwl/assets/iwd-giwl-main.pdf.

Ishizawa, H., & Kubo, K. (2014). Factors affecting adoption decisions: Child and parental characteristics. *Journal of Family Issues, 35*(5), 627–653. https://doi.org/10.1177/0192513X13514408

Jack, A. (2020). The gender reveal party: A new means of performing parenthood and reifying gender under capitalism. *International Journal of Child, Youth and Family Studies, 11*(2), 82–93. https://doi.org/10.18357/ijcyfs112202019520

Jackson, E. F., Bussey, K., & Myers, E. (2021). Encouraging gender conformity or sanctioning nonconformity? Felt pressure from parents, peers, and the self. *Journal of Youth and Adolescence, 50*(4), 613–627. https://doi.org/10.1007/s10964-020-01387-8

Jedwab, A., Vears, D. F., Tse, C., & Gyngell, C. (2020). Genetics experience impacts attitudes towards germline gene editing: A survey of over 1500 members of the public. *Journal of Human Genetics, 65*(12), 1055–1065. https://doi.org/10.1038/s10038-020-0810-2

Judge, T. A., Livingston, B. A., & Hurst, C. (2012). Do nice guys—And gals—Really finish last? The joint effects of sex and agreeableness on income. *Journal of Personality and Social Psychology, 102*(2), 390–407. https://doi.org/10.1037/a0026021

Kane, E. W. (2006). "No way my boys are going to be like that!": Parents' responses to Children's gender nonconformity. *Gender & Society, 20*(2), 149–176. https://doi.org/10.1177/0891243205284276

Kay, M. (2023). *Tidybayes: Tidy data and Geoms for Bayesian models (version v3.0.6)*. [Computer software]. Zenodo. https://doi.org/10.5281/ZENODO.1308151

Keller, J. (2005). In genes we trust: The biological component of psychological essentialism and its relationship to mechanisms of motivated social cognition. *Journal of Personality and Social Psychology, 88*(4), 686–702. https://doi.org/10.1037/0022-3514.88.4.686

Kemp, A. E. (1985). Psychological androgyny in musicians. *Bulletin of the Council for Research in Music Education, 85*, 102–108.

Khalaf, K., Janowicz, K., Dyszkiewicz-Konwińska, M., Hutchings, G., Dompe, C., Moncrieff, L., … Kempisty, B. (2020). CRISPR/CAS9 in cancer immunotherapy: Animal models and human clinical trials. *Genes, 11*(8). https://doi.org/10.3390/genes11080921

Kirchberg, V. (1996). Museum visitors and non-visitors in Germany: A representative survey. *Poetics, 24*(2–4), 239–258. https://doi.org/10.1016/S0304-422X(96)00007-1

Kneib, T., Silbersdorff, A., & Säfken, B. (2023). Rage against the mean – A review of distributional regression approaches. *Econometrics and Statistics, 26*, 99–123. https://doi.org/10.1016/j.ecosta.2021.07.006

Koenig, A. M. (2018). Comparing prescriptive and descriptive gender stereotypes about children, adults, and the elderly. *Frontiers in Psychology, 9*, 1086. https://doi.org/10.3389/fpsyg.2018.01086

Kosakowska-Berezecka, N., Bosson, J. K., Jurek, P., Besta, T., Olech, M., Vandello, J. A., … Zadkowska, M. (2022). Gendered self-views across 62 countries: A test of competing models. *Social Psychological and Personality Science, 194855062211296*. https://doi.org/10.1177/19485506221129687

Lindström, B., Jangard, S., Selbing, I., & Olsson, A. (2018). The role of a "common is moral" heuristic in the stability and change of moral norms. *Journal of Experimental Psychology: General, 147*(2), 228–242. https://doi.org/10.1037/xge0000365

Little, M. O. (1998). Cosmetic surgery, suspect norms, and the ethics of complicity. In E. Parens (Ed.), *Enhancing human traits: Ethical and social implications* (pp. 162–176). Georgetown University Press.

Löckenhoff, C. E., Chan, W., McCrae, R. R., Fruyt, F., Jussim, L., Bolle, M., … Terracciano, A. (2014). Gender stereotypes of personality. *Journal of Cross-Cultural Psychology, 45*(5), 675–694. https://doi.org/10.1177/0022022113520075

Makowski, D., Ben-Shachar, M., & Lüdecke, D. (2019). bayestestR: Describing effects and their uncertainty, existence and significance within the Bayesian framework. *Journal of Open Source Software, 4*(40), 1541. https://doi.org/10.21105/joss.01541

Makowski, D., Ben-Shachar, M. S., Chen, S. H. A., & Lüdecke, D. (2019). Indices of effect existence and significance in the Bayesian framework. *Frontiers in Psychology, 10*, 2767. https://doi.org/10.3389/fpsyg.2019.02767

Marks, J. L., Lam, C. B., & McHale, S. M. (2009). Family patterns of gender role attitudes. *Sex Roles, 61*(3–4), 221–234. https://doi.org/10.1007/s11199-009-9619-3

Marteau, T., Michie, S., Drake, H., & Bobrow, M. (1995). Public attitudes towards the selection of desirable characteristics in children. *Journal of Medical Genetics, 32*(10), 796–798. https://doi.org/10.1136/jmg.32.10.796

Martin, A. E., & Mason, M. F. (2022). What does it mean to be (seen as) human? The importance of gender in humanization. *Journal of Personality and Social Psychology, 123*(2), 292–315. https://doi.org/10.1037/pspa0000293

Martin, C. L., Andrews, N. C. Z., England, D. E., Zosuls, K., & Ruble, D. N. (2017). A dual identity approach for conceptualizing and measuring Children's gender identity. *Child Development, 88*(1), 167–182. https://doi.org/10.1111/cdev.12568

Martin, C. L., Cook, R. E., & Andrews, N. C. Z. (2017). Reviving androgyny: A modern day perspective on flexibility of gender identity and behavior. *Sex Roles, 76*(9–10), 592–603. https://doi.org/10.1007/s11199-016-0602-5

Martín, D., Rueda, J., Earp, B. D., & Hannikainen, I. R. (2023). Normality and the treatment-enhancement distinction. *Neuroethics, 16*(2), 13. https://doi.org/10.1007/s12152-023-09519-0

McElreath, R. (2020). *Statistical rethinking: A Bayesian course with examples in R and Stan* (2nd ed.). CRC Press.

McIntyre, K., Paolini, S., & Hewstone, M. (2016). Changing people's views of outgroups through individual-to-group generalisation: Meta-analytic reviews and theoretical considerations. *European Review of Social Psychology, 27*(1), 63–115. https://doi.org/10.1080/10463283.2016.1201893

Meyer, M., & Gelman, S. A. (2016). Gender essentialism in children and parents: Implications for the development of gender stereotyping and gender-typed preferences. *Sex Roles, 75*(9–10), 409–421. https://doi.org/10.1007/s11199-016-0646-6

Miller, C. F., Trautner, H. M., & Ruble, D. N. (2006). The role of gender stereotypes in children's preferences and behavior. In L. Balter, & C. S. Tamis-LeMonda (Eds.), *Child psychology: A handbook of contemporary issues* (2nd ed., pp. 293–324). Psychology Press.

Moen, P., Erickson, M. A., & Dempster-McClain, D. (1997). Their Mother's daughters? The intergenerational transmission of gender attitudes in a world of changing roles. *Journal of Marriage and the Family, 59*(2), 281. https://doi.org/10.2307/353470

Moss-Racusin, C. A., Phelan, J. E., & Rudman, L. A. (2010). When men break the gender rules: Status incongruity and backlash against modest men. *Psychology of Men & Masculinity, 11*(2), 140–151. https://doi.org/10.1037/a0018093

Myers, S. M., & Booth, A. (2002). Forerunners of change in nontraditional gender ideology. *Social Psychology Quarterly, 65*(1), 18. https://doi.org/10.2307/3090166

Neufeld, E. (2022). Psychological essentialism and the structure of concepts. *Philosophy. Compass, 17*(5). https://doi.org/10.1111/phc3.12823

Nürnberger, M., Nerb, J., Schmitz, F., Keller, J., & Sütterlin, S. (2016). Implicit gender stereotypes and essentialist beliefs predict preservice Teachers' tracking recommendations. *The Journal of Experimental Education, 84*(1), 152–174. https://doi.org/10.1080/00220973.2015.1027807

Padden, C., & Humphries, J. (2020). Who Goes first? Deaf people and CRISPR germline editing. *Perspectives in Biology and Medicine, 63*(1), 54–65. https://doi.org/10.1353/pbm.2020.0004

Pew Research Center. (2016). U.S. public wary of biomedical technologies to 'enhance' Human Abilities. https://www.pewresearch.org/science/2016/07/26/u-s-public-wary-of-biomedical-technologies-to-enhance-human-abilities/#:~:text=For%20example%2C%2047%25%20of%20Americans,results%20in%20physical%20abilities%20%E2%80%9Cfar.

Phillips, B. (2022). "They're not true humans:" beliefs about moral character drive denials of humanity. *Cognitive Science, 46*(2), Article e13089. https://doi.org/10.1111/cogs.13089

Pienaar, K., Murphy, D. A., Race, K., & Lea, T. (2020). Drugs as technologies of the self: Enhancement and transformation in LGBTQ cultures. *International Journal of Drug Policy, 78*, Article 102673. https://doi.org/10.1016/j.drugpo.2020.102673

Powell, R. (2012). The evolutionary biological implications of human genetic engineering. *Journal of Medicine and Philosophy, 37*(3), 204–225. https://doi.org/10.1093/jmp/jhq004

Powell, R. (2015). In genes we trust: Germline engineering, eugenics, and the future of the human genome. *The Journal of Medicine and Philosophy, 40*(6), 669–695. https://doi.org/10.1093/jmp/jhv025

Prentice, D. A., & Carranza, E. (2002). What women and men should be, Shouldn't be, are allowed to be, and don't have to be: The contents of prescriptive gender stereotypes. *Psychology of Women Quarterly, 26*(4), 269–281. https://doi.org/10.1111/1471-6402.t01-1-00066

President''s Council on Bioethics. (2003). *Beyond therapy: Biotechnology and the pursuit of happiness*.

Proudfoot, D., Kay, A. C., & Koval, C. Z. (2015). A gender Bias in the attribution of creativity. *Psychological Science, 26*(11), 1751–1761. https://doi.org/10.1177/0956797615598739

Rabino, I. (2003). Gene therapy: Ethical issues. *Theoretical Medicine and Bioethics, 24*(1), 31–58. https://doi.org/10.1023/a:1022967623162

Redman, M., King, A., Watson, C., & King, D. (2016). What is CRISPR/Cas9? *Archives of disease in childhood. Education and Practice Edition, 101*(4), 213–215. https://doi.org/10.1136/archdischild-2016-310459

Renström, E. A. (2024). Differences between prescriptive and proscriptive gender stereotypes and gendered self-evaluations in Sweden. *Scandinavian Journal of Psychology, 65*(3), 511–520. https://doi.org/10.1111/sjop.12995
Resnik, D. B., & Vorhaus, D. B. (2006). Genetic modification and genetic determinism. *Philosophy, Ethics, and Humanities in Medicine, 1*, 9. https://doi.org/10.1186/1747-5341-1-9
Riis, J., Simmons, J. P., & Goodwin, G. P. (2008). Preferences for enhancement pharmaceuticals: The reluctance to enhance fundamental traits. *Journal of Consumer Research, 35*(3), 495–508. https://doi.org/10.1086/588746
Rudman, L. A., Moss-Racusin, C. A., Glick, P., & Phelan, J. E. (2012). Reactions to vanguards: Advances in backlash theory. In P. G. Devine, & E. A. Plant (Eds.), *Advances in experimental social psychology* (pp. 167–227). Elsevier. https://doi.org/10.1016/B978-0-12-394286-9.00004-4.
Rudman, L. A., Moss-Racusin, C. A., Phelan, J. E., & Nauts, S. (2012). Status incongruity and backlash effects: Defending the gender hierarchy motivates prejudice against female leaders. *Journal of Experimental Social Psychology, 48*(1), 165–179. https://doi.org/10.1016/j.jesp.2011.10.008
Saguy, T., Reifen-Tagar, M., & Joel, D. (2021). The gender-binary cycle: The perpetual relations between a biological-essentialist view of gender, gender ideology, and gender-labelling and sorting. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 376*(1822), 20200141. https://doi.org/10.1098/rstb.2020.0141
Sanchez, D. T., & Crocker, J. (2005). How Investment in Gender Ideals Affects Well-Being: The role of external contingencies of self-worth. *Psychology of Women Quarterly, 29*(1), 63–77. https://doi.org/10.1111/j.1471-6402.2005.00169.x
Sattler, S., Mehlkop, G., Bahr, V., & Betsch, C. (2021). Why parents misuse prescription drugs to enhance the cognitive performance of healthy children: The influence of peers and social media. *Journal of Drug Issues, 51*(3), 461–482. https://doi.org/10.1177/0022042621994547
Savulescu, J. (2001). Procreative beneficence: Why we should select the best children. *Bioethics, 15*(5/6), 413–426.
Savulescu, J. (2005). New breeds of humans: The moral obligation to enhance. *Reproductive Biomedicine Online, 10*, 36–39. https://doi.org/10.1016/S1472-6483(10)62202-X
Scheufele, D. A., Xenos, M. A., Howell, E. L., Rose, K. M., Brossard, D., & Hardy, B. W. (2017). U.S. attitudes on human genome editing. *Science* (New York, N.Y.), Vol. 357 (6351), 553–554. doi:https://doi.org/10.1126/science.aan3708.
Schönthaler, E. M. D., Hofer, G., Grinschgl, S., & Neubauer, A. C. (2022). Super-men and wonder-women: The relationship between the acceptance of self-enhancement, personality, and values. *Journal of Cognitive Enhancement*. https://doi.org/10.1007/s41465-022-00244-9
Sharp, R. R., McGowan, M. L., Verma, J. A., Landy, D. C., McAdoo, S., Carson, S. A., … McCullough, L. B. (2010). Moral attitudes and beliefs among couples pursuing PGD for sex selection. *Reproductive Biomedicine Online, 21*(7), 838–847. https://doi.org/10.1016/j.rbmo.2010.09.009
Shields, S. A. (1982). The variability hypothesis: The history of a biological model of sex differences in intelligence. *Signs: Journal of Women in Culture and Society, 7*(4), 769–797. https://doi.org/10.1086/493921
Singer, P. (2009). Parental choice and human improvement. In J. Savulescu, & N. Bostrom (Eds.), *Human enhancement* (pp. 277–289). Oxford University Press.
Snure Beckman, E., Deuitch, N., Michie, M., Allyse, M. A., Riggan, K. A., & Ormond, K. E. (2019). Attitudes toward hypothetical uses of gene-editing Technologies in Parents of people with autosomal aneuploidies. *The CRISPR Journal, 2*(5), 324–330. https://doi.org/10.1089/crispr.2019.0021
Sorgner, S. L. (2015). The future of education: Genetic enhancement and Metahumanities. *Journal of Evolution and Technology, 25*(1), 31–48.
Sparrow, R. (2007). Procreative beneficence, obligations, and eugenics. *Genomics, Society and Policy, 3*(3), 43–59.
Sparrow, R. (2019). Yesterday's child: How gene editing for enhancement will produce obsolescence-and why it matters. *The American Journal of Bioethics, 19*(7), 6–15. https://doi.org/10.1080/15265161.2019.1618943
Sternberg, R. J., & Grigorenko, E. L. (2004). Intelligence and culture: How culture shapes what intelligence means, and the implications for a science of well–being. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 359*(1449), 1427–1434. https://doi.org/10.1098/rstb.2004.1514
Stotzer, R. L. (2009). Violence against transgender people: A review of United States data. *Aggression and Violent Behavior, 14*(3), 170–179. https://doi.org/10.1016/j.avb.2009.01.006
Sutfin, E. L., Fulcher, M., Bowles, R. P., & Patterson, C. J. (2008). How lesbian and heterosexual parents convey attitudes about gender to their children: The role of gendered environments. *Sex Roles, 58*(7–8), 501–513. https://doi.org/10.1007/s11199-007-9368-0
Tang-Péronard, J. L., & Heitmann, B. L. (2008). Stigmatization of obese children and adolescents, the importance of gender. *Obesity Reviews, 9*(6), 522–534. https://doi.org/10.1111/j.1467-789X.2008.00509.x
Taylor, C. L., Said-Metwaly, S., Camarda, A., & Barbot, B. (2024). Gender differences and variability in creative ability: A systematic review and meta-analysis of the greater male variability hypothesis in creativity. *Journal of Personality and Social Psychology, 126*(6), 1161–1179. https://doi.org/10.1037/pspp0000484
Tenenbaum, H. R., & Leaper, C. (2002). Are parents' gender schemas related to their children's gender-related cognitions? *A meta-analysis. Developmental Psychology, 38*(4), 615–630. https://doi.org/10.1037/0012-1649.38.4.615
Thomas, A. (2022). Transhumanism and advanced capitalism: Elitist logics and dangerous implications. In P. Jorion (Ed.), *Humanism and its discontents* (pp. 151–180). Springer International Publishing.
Thweatt-Bates, J. (2016). *Cyborg selves: A theological anthropology of the posthuman*. Routledge (Original work published 2012).
Tobin, D. D., Menon, M., Menon, M., Spatta, B. C., Hodges, E. V. E., & Perry, D. G. (2010). The intrapsychics of gender: A model of self-socialization. *Psychological Review, 117*(2), 601–622. https://doi.org/10.1037/a0018936
Van Dijke, I., Bosch, L., Bredenoord, A. L., Cornel, M., Repping, S., & Hendriks, S. (2018). The ethics of clinical applications of germline genome modification: A systematic review of reasons. *Human Reproduction, 33*(9), 1777–1796. https://doi.org/10.1093/humrep/dey257
Verbeek, P.-P. (2011). *Moralizing technology: Understanding and designing the morality of things*. University of Chicago Press.
Vuorre, M. (2019, February 18). How to analyze visual analog (slider) scale data? https://mvuorre.github.io/posts/2019-02-18-analyze-analog-scale-ratings-with-zero-one-inflated-beta-models/.
Wagner, K., Maslen, H., Oakley, J., & Savulescu, J. (2018). Would you be willing to zap your child's brain? Public perspectives on parental responsibilities and the ethics of enhancing children with transcranial direct current stimulation. *AJOB Empirical Bioethics, 9*(1), 29–38. https://doi.org/10.1080/23294515.2018.1424268
Weaver, M. S., October, T., Feudtner, C., & Hinds, P. S. (2020). "Good-parent beliefs": Research, concept, and clinical practice. *Pediatrics, 145*(6). https://doi.org/10.1542/peds.2019-4018
Weisgram, E. S., & Bruun, S. T. (2018). Predictors of gender-typed toy purchases by prospective parents and mothers: The roles of childhood experiences and gender attitudes. *Sex Roles, 79*(5–6), 342–357. https://doi.org/10.1007/s11199-018-0928-2
Willoughby, E. A., Love, A. C., McGue, M., Iacono, W. G., Quigley, J., & Lee, J. J. (2019). Free will, determinism, and intuitive judgments about the heritability of behavior. *Behavior Genetics, 49*(2), 136–153. https://doi.org/10.1007/s10519-018-9931-1
Wilson, S. G. (2014). Enhancement and identity: A social psychological perspective. In S. J. Thompson (Ed.), *Global issues and ethical considerations in human enhancement technologies* (pp. 241–256). IGI Global. https://doi.org/10.4018/978-1-4666-6010-6.
Zehnter, M. K., Olsen, J., & Kirchler, E. (2018). Obituaries of female and male leaders from 1974 to 2016 suggest change in descriptive but stability of prescriptive gender stereotypes. *Frontiers in Psychology, 9*. https://doi.org/10.3389/fpsyg.2018.02286

Supplementary

For better visibility, all figures are also shared at the c

https://osf.io/5g3rf/ – DOI 10.17605/OSF.IO/5G3RF.

Data preparation

Sliders in the interface of the exhibit allow for percentage values without any decimal places. They ranged from -100% to +100%. A value of +21% on a slider should translate into a 0.21 in the dataset. This was not always the case. The data comprised values with more than two decimal places. To evaluate if any value was changed (Boolean: TRUE/FALSE), we had to compare $feature_N$ with $feature_C$. However, differences after the second decimal place may yield a TRUE, but they are not displayed on screen and thus are not meaningful or intended by the visitor. Hence, we rounded every number to the second decimal place. Money spent was not originally present in the data. Knowing how much each modification costs, we reconstructed the amount spent by comparing each $feature_n$ with $feature_c$. If there was a change, we subtracted the respective amount from the start capital. Before the rounding procedure, value comparison sometimes resulted in an identified "change" of < 0.01 and, thus, a subtraction of money. This led to some visitors allegedly spending more than the initial €250,000, which is impossible. The correctness of the data preparation was assessed by examining if people spent more than the starting capital of 250k. When using the standard *round* function of Base-R, there were still some children with more money spent than possible. We identified the problem within the round function. The base version renders -0.185 to -0.18. Only when we rounded respective numbers up (-0.185 to -0.19), there was no child whose spending exceeded € 250,000. We used the function *round2* from the package "webexercise" (Barr & DeBruine, 2023) for this operation.

Method

As the uniform distribution of the random values for each feature reaches from -0.35 to +0.35 (Personality), respectively -0.4 to + 0.4 (Talents), any value beyond can only be reached by investing money into change.

The Data

Money spend

Each visitor starts with 250,000€ to spend virtually. Costs of each modification can be seen in Figure 1 in the manuscript. People pay for $Feature_N$ change, regardless of direction or range of change.

Looks

Hair, skin, and eye color were randomly assigned. Hex codes for the possible natural values are shown in Figure 1 (Manuscript). The exhibit chose between these values unconditionally and randomly. As displayed in the same figure, color choice was limited and oriented at “natural” human hair, eye, and skin color.

Predisposition

The exhibit tells visitors about randomly assigned disease predispositions (Figure 1 - Manuscript). If prevalent, visitors are told that the disease has a higher chance of manifesting. Visitors can choose to remove or add a disposition.

χ^2-tests showed that across chosen gender, single dispositions were equally distributed.

- Diabetes $\chi^2(3) = 2.09$, $p = 0.55$
- Cancer $\chi^2(3) = 1.73$, $p = 0.63$
- Trisomy $\chi^2(3) = 1.38$, $p = 0.71$
- Cystic fibrosis $\chi^2(3) = 0.91$, $p = 0.82$
- Color blindness/Achromatopsia/ $\chi^2(3) = 2.59$, $p = 0.46$
- Coeliac disease $\chi^2(3) = 1.00$, $p = 0.80$

χ^2-tests within the chosen gender were statistically not significant. However, some borderline cases were present. In the case of trisomy, 51% of random Female (rF) children had the disposition $\chi^2(1) =$

3.2, p = 0.07, for diabetes, 52% of female (F) children had the disposition, $\chi^2(1) = 3.47$, p = 0.06. All other differences, *p > .10*.

Predictions

When formulating our predictions, we encountered the problem that the features in the exhibit did not always semantically match the terms used in the empirical research on gender stereotypes. Here, participants usually rate a set of terms on their gender specific desirability. We will refer to these terms and elaborate on their potential semantic link to the manipulatable features in the exhibit. When directly referring to the wording used in the studies, we will italicize the terms to make the association more clear.

Gender distribution

Research indicates variation in preferences for children's gender across state borders and ethnicities (Carol & Hank, 2020; Fuse, 2010). Germans shows a slight preference for no specific gender distribution (Hank & Kohler, 2000, 2003). If they prefer a gender then usually in a way that yields an equal distribution (Hank & Kohler, 2003).

According to the GOOD-GH, the prospect of foreseeable discrimination against one gender leads to the choice of the other. For instance, visitors may choose the male gender because they do not want their female child to deal with structural discrimination at the workplace (e.g., Stamarski & Son Hing, 2015) in the future, which cannot be compensated through manipulation of other features. The EMAN-GH is twofold here. On one hand, an equal distribution of sex is conceivable since both gender are subjected to prescriptive stereotypes. On the other hand, designers may identify a stronger need to dismantle stereotypes for one group and thus explicitly choose this gender. These contemplations should also influence gender preference in natural contraception. But as mentioned above, there is no clear preference for one gender over the other.

Since we have no information about the visitor's socio-demographic characteristics and do not know if they already have any children whose distribution could be influencing, we adopt a more

presumption sparse prediction for the GOOD-GH. Here, we assume that the dataset will not reveal any clear preferences for one over the other gender. We also do not expect any increased change rates, i.e., if the child is initiated being male, it will not more often be changed to be female and vice versa. Under EMAN-GH, gender preference may be cut both ways, depending on the identified need of vanguards. As both males and females are subjected to normative gender stereotypes (Bosson et al., 2022; Koenig, 2018; Prentice & Carranza, 2002), and both gender experience negative consequences for stereotype-deviating behavior (Moss-Racusin et al., 2010; Rudman, Moss-Racusin, Glick, et al., 2012), gender preference may not be a fundamental issue, especially if certain traits are meant to be compensated. Note, however, that visitors have no information about the features they can influence at that point of the exhibit, except its gender. Thus, the EMAN-GH also does not assume gender preferences.

Total money spend

Is there any difference in how much families spend on boys vs. girls? Data regarding this question appears sparse. Kornrich and Furstenberg (2013) found that in 2006 and 2007, American parents in families where all children were girls spent more money on their children than those where children were all boys. Another study showed that while there may be some area and income-specific gender effects, American parents do not overall spend more money on girls than on boys (Hao & Yeung, 2015). Arguments concerning investing in education either proclaim a focus on the gender that is most likely to achieve success, i.e., boys, or the need for a compensatory focus on girls (Raley & Bianchi, 2006). Since participants can influence a range of features, these findings may not generalize well to the total amount spent at the exhibit.

Still, we may see differences in certain features and feature groups. These are tantamount to a gender-dependent higher change rate in this feature. There are also many different possibilities for spending the money. A higher amount spent means more conducted modifications but does not indicate the direction of the manipulation nor its range. Moreover, change of features often costs the same. The exact amount spent does not mean that the same features were modified.

We refrain from formulating any explicit hypotheses on differences in money spent depending on the chosen gender and will conduct any analysis in an explorative way. Reasons for that are the little variation in cost, including equality between features we will formulate predictions on and those who do not, the overall distorted financial representation, the lack of comparable findings specific to Germany, and the absence of any background information on the visitors. Furthermore, under the specific hypotheses, there are different ways to achieve one's goal. Visitors acting according to the EMAN-GH and determined to preserve normative gender stereotypes could either increase sensibility for their female child or decrease it for males. Both manipulations would cost the same and leave no differentiation in money spent.

Looks

One could argue for a normative focus on women's *appearance* (Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). The exhibit, however, did only provide limited appearance manipulation options. While there are prescriptive stereotypes for gender-distinct appearance (Koenig, 2018), we are unaware of stereotypes that link, e.g., a specific eye color to a particular gender. Due to the limited manipulation options and more prominent normative stereotypes in the other parameters, we will only provide a brief descriptive overview of the look variables.

Analyzing the data along the lines of color distribution and associated racial stereotypes is an interesting topic for further research but is outside the scope of this paper.

Predispositions

A proscription exists for males to not be *weak* (Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). One could reasonably argue that this generalizes well to the existence of predispositions. These are, by definition, not assured to manifest, so not removing them cannot be understood as designing a child will a potentially fatal disease. Still, a somewhat cynical prediction of the GOOD-GH would be that males are more likely than females to be relieved of their predispositions, yielding more dispositions for females. Considering the thoughts mentioned above on how it is rather unlikely that one will create a "bad" child to enact a normative gender difference,

the GOOD-GH does not predict that visitors will make their female children more vulnerable. So, any potential difference refers to a different prioritization of health conditional on the chosen gender. Given that diseases may differ in perceived severity, GOOD-GH would expect this effect to be more pronounced in conditions not associated with high lethality or other severe impairments. This is because the other diseases may be perceived as so bad that a predisposition will be removed regardless of normative stereotypes. Diseases like coeliac disease may be of less priority to be removed for females but are still a threat to the gender stereotype of males and are, thus, more likely to be eradicated.

EMAN-GH would suspect equal prioritization and, thus, no differences based on gender.

Personality

Forming our predictions, we oriented at the descriptions of the Big 5 dimensions and their facets as described by Costa Jr. and McCrea (1992). We are referring to this conceptualization when talking about facets. Linking personality to the normative gender stereotypes, we evaluated semantic content and grouping of attributes that were rated for their gender-specific typicality and desirability, for example, in Koenig (2018) and Prentice and Carranza (2002).

Sensibility*:* We orientated at the broader dimension of Neuroticism. Males ought not to show signs of being *weak* and thus not vulnerable (Rudman, Moss-Racusin, Glick, et al., 2012). Moreover, they should not be overly *emotional* and are urged to display *high self-esteem* (Koenig, 2018; Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). While Koenig (2018) only found that males ought not to be *emotional*, other findings indicate that females are expected to *express emotions* (Prentice & Carranza, 2002) or be *emotional* (Rudman, Moss-Racusin, Phelan et al., 2012). Moreover, female *melodramatic* behavior is evaluated more leniently (Prentice & Carranza, 2002). According to the GOOD-GH, we expect that female children, relative to their male counterparts, are designed with more sensibility. This may be due to changes in females towards higher values (prescription) and changes in males towards lower values (proscription)

Given the EMAN-GH, one could argue for a sensibility alignment to challenge normative gender stereotypes. In their study on the changing stereotypes, Diekman and Eagly (2000) showed that although stereotypes are expected to change in an imagined future, this development is mainly because females are expected to increasingly acquire personality traits that are descriptively assigned to males (e.g., being *dominant*, *aggressive*). It was also expected that this development comprises the partial decline of feminine personality traits in females (e.g., being *sensitive* or *affectionate*). Effects also showed that stereotypes for females were more malleable than for males. Hence, an equivalence in sensibility would provide support for the EMAN-GH. However, given the reported findings, we expect that this will include the direction that women are designed to be less sensitive rather than male's sensibility being increased.

Sociality: Here, we orientated at the broader dimension of Extraversion. Prentice and Carranza (2002) showed that being *extroverted* was perceived as more descriptive but not more prescriptive for males. Facets of extraversion are *warmth* and *positive emotions* (Costa Jr. & McCrae, 1992). Here, prescriptions for women exist (being *warm*, *wholesome*, and *cheerful*) (Koenig, 2018; Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). Other facets, however, are *assertiveness*, *activity*, and *gregariousness* (Costa Jr. & McCrae, 1992). Being *assertive*, *dominant*, and overall *agentic* are strong prescriptions for males (Bosson et al., 2022; Koenig, 2018; Rudman, Moss-Racusin, Phelan, et al., 2012), but rather not important for women (Prentice & Carranza, 2002). *Agentic* and *assertive* behavior is also associated with high status (Rudman, Moss-Racusin, Phelan, et al., 2012). If associated with being dominant, agentic behavior can result in negative consequences for women (Rudman, Moss-Racusin, Glick, et al., 2012; Rudman, Moss-Racusin, Phelan, et al., 2012). Males face more negative consequences for being shy (Doey et al., 2014). Men are also expected to be more *self-reliant*, but women shall be more *flirtatious* and are less expected to have a *sense of humor* (Prentice & Carranza, 2002), traits that may be associated with sociality. Low values of this trait were explicitly framed by the exhibit as leading to more independence and enjoyment of aloneness (Figure 1 in manuscript). Note the prescription for males to be more *independent* (Koenig,

2018). Yet, Koenig grouped traits under this label that suggest interpreting it as a reflection of self-reliance (e.g., *self-reliant*, *ambitious*, and *independent*), not so much a preference to be alone.

If explicitly presented as Extraversion, desirability differences in associated facets suggest a tend toward a contemporary masculine prescription based on the more agentic behaviors and traits associated with it. Considering that the exhibit framed the trait as sociality, our predictions hold, albeit with less certainty. Hence, under the GOOD-GH, we expect relatively higher values for males than females, driven by males being increasingly designed to be more social (prescription to be more agentic, shyness proscription). However, females are not expected to be changed more to the negative (no proscription to be agentic).

Considering the findings of Diekman and Eagly (2000) that future females are expected to acquire more male traits, the EMAN-GH would predict an alignment, with females increasingly changing toward higher values and male values being maintained.

***Openness*:** Prentice and Carranza (2002) found no difference in gender-specific desirability for being *open-minded*, although this trait was more ascribed to females. Conservative vs. liberal values can describe openness (Costa Jr. & McCrae, 1992). Viewed through the lens of associated sexual values (Allen & Walter, 2018), the proscription for females to not be *promiscuous* (Prentice & Carranza, 2002) or *sexually active* (Koenig, 2018), combined with the prescription or forbearance for males to show sexual activity (Koenig, 2018; Prentice & Carranza, 2002), may lead to the prediction that males shall be more open than females. However, a reduction to sexual activity alone is non-justified. Males are not expected to be as *creative* as women (Prentice & Carranza, 2002), which denotes another way to understand openness (Costa Jr. & McCrae, 1992).

These findings are somewhat mixed, and their link to the overall facet is unclear, so we cannot clearly identify a normative gender stereotype for the general dimension of openness. Therefore, neither GOOD-GH nor EMAN-GH specify any hypotheses on gender-specific differences.

Agreeableness: Being agreeable strongly confers to being *communal*, which is a strong description and prescription for females (Bosson et al., 2022; Koenig, 2018; Rudman, Moss-Racusin, Phelan, et

al., 2012). Associated characteristics may be being *cooperative*, which is not expected to have high values in men (Prentice & Carranza, 2002). Men ought also to be more *competitive* (Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012), a trait that is not expected of women (Prentice & Carranza, 2002). There is evidence for the explicit prescription for women to be *agreeable* (Prentice & Carranza, 2002). High agreeableness values also lead to economic punishment, an effect stronger for males than females (Judge et al., 2012).

Given the solid prescriptive nature of being communal for females the GOOD-GH predicts higher values in this trait for female children. This effect is likely driven by changing female traits to higher values (prescription). Although there is no explicit proscription to be not agreeable for males, desired traits for males, like assertiveness and penalizing agreeable males, may lead to a likelier reduction of this trait in male children.

Across the last decades, being communal was identified as a strong descriptive demarcation for females and males, so that some studies even report an increase in this stereotype for females (Eagly et al., 2020), while others assert differences to be relatively stable (Haines et al., 2016; Moya Morales & Moya Garófano, 2021; Zehnter et al., 2018). Imagining the year 2050, people expect females to acquire more male traits while female personality traits (e.g., being *nurturing*) move to the background (Diekman & Eagly, 2000). There is evidence that being communal is less tied to the contemporary gender hierarchy, where males have higher status than females because expectations of being communal are rather neutral in status (Rudman, Moss-Racusin, Glick, et al., 2012; Rudman, Moss-Racusin, Phelan, et al., 2012). So even if one is attempted to challenge gender stereotypes by designing a vanguard child and acting according to the EMAN-GH, agreeableness, and related communality may not be the main target. One could also aim at equipping a potential vanguard with a good sense of competitiveness to make challenging stereotypes easier. Moreover, one may aim to counteract the descriptive deficit in male communality. The EMAN-GH would predict that females are not made overly agreeable due to the status neutrality of associated features. Due to the same reasons, this feature may not be a target for manipulation among male children. This may either yield

no differences or simply reduce its magnitude. Both outcomes may be driven by an adjustment for an alleged deficit in males and the tendency to reduce agreeableness for women to make them more assertive. The difference would then be constituted by the magnitude of change.

Conscientiousness: The exhibit framed high conscientiousness with the tendency to be overly perfectionistic. This trait is not desirable for one over the other gender (Prentice & Carranza, 2002). Yet, a facet of conscientiousness is *competence* (Costa Jr. & McCrae, 1992). Being *competent* is prescriptive for males (Rudman, Moss-Racusin, Phelan, et al., 2012) and not as important for females (Prentice & Carranza, 2002). Descriptively, women are perceived as increasingly more competent (Eagly et al., 2020). However, another study showed that the perceived level of competence does not change for women but decreases for men (Zehnter et al., 2018). Striving for achievement is also a facet of conscientiousness (Costa Jr. & McCrae, 1992). Being *ambitious*, *agentic*, and *career-orientated* is prescriptive for males (Bosson et al., 2022; Koenig, 2018; Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). This and the facet of self-discipline also relates to the prescription for males to be more *independent*, *disciplined*, and *self-reliant*, with the latter not really expected from women (Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). There is also a proscription for females to not be overly *controlling* (Prentice & Carranza, 2002; Rudman, Moss-Racusin, Phelan, et al., 2012). The facet of *deliberation* (Costa Jr. & McCrae, 1992) may relate to traits like being *rational*, which has been shown to be prescriptive for males but less important for females (Prentice & Carranza, 2002).

Traits associated with conscientiousness are not only perceived as more typical for males but also associated with high status (Rudman, Moss-Racusin, Phelan, et al., 2012). Hence, they are a suitable target for enacting and challenging the Western gender hierarchy (Rudman, Moss-Racusin, Phelan, et al., 2012).

Overall, the GOOD-GH expects males to have higher values in conscientiousness, probably driven by the tendency to increase this level for male children but not to overly decrease or increase it for female ones.

In the study by Diekman and Eagly (2000) on stereotypes in the future, features associated with conscientiousness can best be described as cognitive masculine dimensions (e.g., *analytical*, *good at reasoning*). Still, some facets may also appear in cognitive features commonly assigned to females (e.g., being *imaginative, creative, artistic*). Overall, Diekman and Eagly (2000) showed that male cognitive traits are assumed to increase in females while being rather stable in males. This effect was stronger than the assumed increase in feminine cognitive traits in males and females. The EMAN-GH predicts an alignment in conscientiousness, mainly driven by an increase in female children but no deliberate decrease in male children. This once again reflects the assumed development of females increasingly acquiring favorable male traits.

Talents

Intelligence: There is evidence for the prescription that males shall be *intelligent* (Koenig, 2018; Rudman, Moss-Racusin, Phelan, et al., 2012), while it is not as much expected for women (Prentice & Carranza, 2002). Park et al. (2015) showed that males deem smarter women as more attractive, but when confronted with such this preference was not affirmed. GOOD-GH predicts that higher values for male children are driven by males being designed to be more intelligent rather than decreasing intelligence for women.

Interestingly, women are described as being more *intelligent* (Prentice & Carranza, 2002), a perception that is also visible when comparing gender stereotypes across time (Eagly et al., 2020). Nevertheless, the male cognitive dimensions, as described by Diekman and Eagly (2000), comprise skills (e.g., being *analytical*, *good at problem-solving*) that may be associated with intelligence and are highly valued in Western societies (Cocodia, 2014). Projecting the alleged trend of women acquiring these skills, resulting in a more egalitarian future society, EMAN-GH predicts the alignment of intelligence values, driven by similar positive changes for males and females. The latter effect stems from the general valuation of this feature.

Musicality: Koenig (2018) showed the prescription for females to engage with *feminine interests,* namely *arts* or *languages*. Still, the evidence for a musicality gender bias seems to be sparse.

Activities like piano playing or opera attendance are perceived as more female than male. However, these differences were rather small and opposed to the finding that music listening is rather perceived as masculine (Zinkhan et al., 2004). It has also been argued that successful musical performance is characterized by conjoined male and female qualities (Kemp, 1985).

We are not able to identify a clear, prescriptive notion of musicality. Hence, neither GOOD-GH nor EMAN-GH predict any differences in musicality.

Sportiness: Men shall be more *athletic*, a trait that is less important for women (Prentice & Carranza, 2002). Albeit female athleticism is on the rise, there is a tendency to associate different sports with maleness (the exception being aesthetic-focused disciplines like dance) (Plaza et al., 2017). Activities that include physical or competitive activity are more described as male than female (Zinkhan et al., 2004). Primarily understood as raw, undefined physical capability, being sporty gets a subtle male undertone. We must further recognize the strong focus on males in organized sports activity and its reception (Hardin et al., 2006). Hence, GOOD-GH cautiously predicts higher values for males than females, mainly due to an increase in sportiness in males while female values are maintained.

Besides predicted alignments in cognitive and personality-related domains, Diekman and Eagly (2000) revealed that their participants also somewhat expected females to become more physically similar to males. The related traits comprised being *muscular* or *physically strong*. To counter stereotypes, females may be designed with increased sportiness, while under the EMAN-GH, the male prescription becomes less important. Therefore, EMAN-GH predicts equal values in sportiness, mainly caused by putting more emphasis on this trait in females and less in males.

***Creativity*:** Diekman and Eagly (2000) labeled being *creative* as primarily a female cognitive feature. Being *creative* is not as important for men as for women (Prentice & Carranza, 2002). However, creativity is substantially associated with agentic-related features (Proudfoot et al., 2015), which are prescriptive for males *agentic* (Bosson et al., 2022; Koenig, 2018). With these mixed results, GOOD-GH cannot reliably predict a direction of differences, but only that there may be one. On the contrary, EMAN-GH would be more consistent with no existing difference.

General considerations

It has been shown that normative gender stereotypes are contingent on the age of the evaluated person, with toddlers and seniors having the smallest number of different stereotypes (Koenig, 2018). Although the exhibit displays the child as toddler, it frames genes and the related decisions as expected to have a lasting influence on the life of the child. Hence, manipulation of toddler genes is likely done under the anticipation of beneficial effects in the future. Overall, Koenig (2018) found no examples of directional change (prescription becomes proscription). The main variation was strength and existence of normative gender stereotypes. Thus, we evaluate contemporary normative gender stereotypes as somewhat centered on adolescence.

Priors

Zero-one-inflated beta regressions:

Brms-Family = zero_one_inflated_beta()

b ~ normal(0,1)

Intercept ~ student_t(3, 0, 2.5)

Intercept_coi ~ logistic(0, 1)

Intercept_phi ~ student_t(3, 0, 2.5)

Intercept_zoi ~ logistic(0, 1)

Logistic regressions:

Brms-Family = Bernoulli()

b ~ normal(0,1)

Intercept ~ student_t(3, 0, 2.5)

Ordered logistic regression:

Brms-Family = cumulative()

b ~ normal(0,1)

Intercept ~ student_t(3, 0, 2.5)

Multinomial logistic regression:

Brms-Family = categorical()

b_muEnhanced ~ normal(0,1) (Value was increased)

b_muNoChange ~ normal(0,1) (Value was maintained)

Intercept_muEnhanced ~ student_t(3, 0, 2.5)

Intercept_muNoChange ~ student_t(3, 0, 2.5)

Results

Predispositions

Table S1. Prediction of the number of chosen disease number

Predictor	Estimate	95%CI	SE	pd
Male	0.20	-0.9 - 1.3	0.56	64.3
random Female	-1.28	-2.27 - -0.31	0.50	99.5
random Male	-1.33	-2.32 - -0.34	0.51	99.5
Natural dispositions: 3	0.20	0.04 - 0.35	0.08	99.5
Natural dispositions: 4	0.54	0.37 - 0.72	0.09	100.0
Prop. available money	3.80	2.87 - 4.73	0.48	100.0
Male x Natural dispositions: 3	0.14	-0.1 - 0.36	0.12	87.2
Male x Natural dispositions: 4	-0.13	-0.38 - 0.13	0.13	82.7
random Female x Natural dispositions: 3	0.04	-0.17 - 0.26	0.11	65.1
random Female x Natural dispositions: 4	-0.05	-0.29 - 0.19	0.12	65.3
random Male x Natural dispositions: 3	0.14	-0.08 - 0.37	0.11	89.8
random Male x Natural dispositions: 4	0.17	-0.08 - 0.41	0.13	91.1
male x Prop. available money	-0.21	-1.48 - 1.07	0.65	62.8
random Female x Prop. available money	1.27	0.19 - 2.39	0.55	99.0
random Male x Prop. available money	1.10	0 - 2.2	0.56	97.5

Note. Applied model was hierarchical logistic regression. 95%CI = 95% Credible interval. Pd = probability of direction, i.e., area of posterior distribution on the side of the median. SE = Standard error. Female/Natural dispositions: 2 = reference values

Marginal effects and coefficients for models predicting the change of predispositions can be found in the respective Excel file in the OSF.

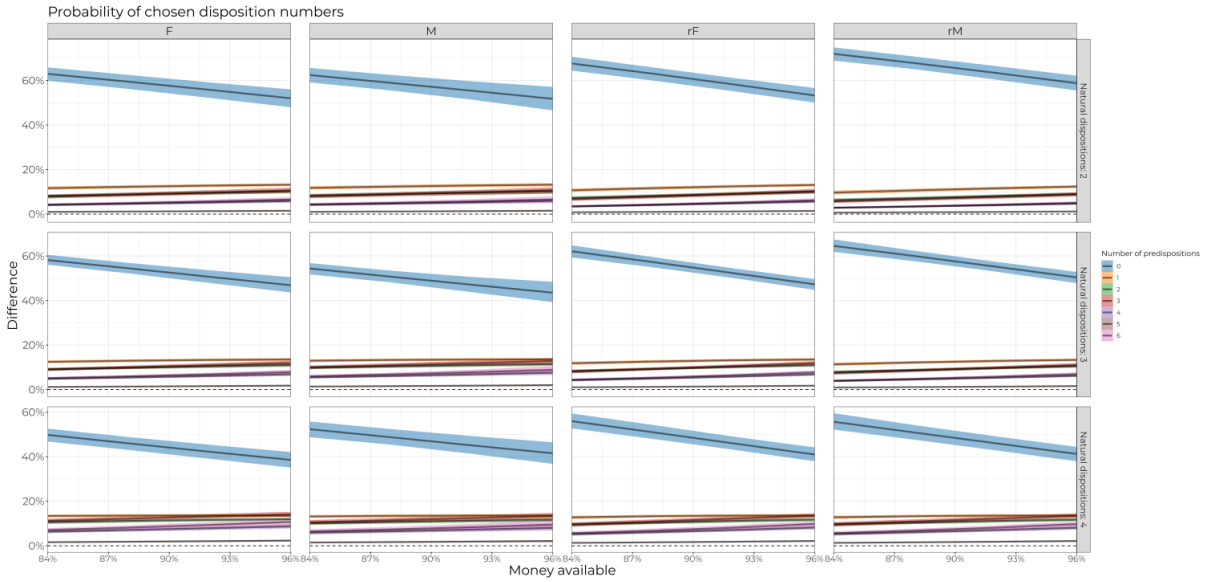


Figure S 1

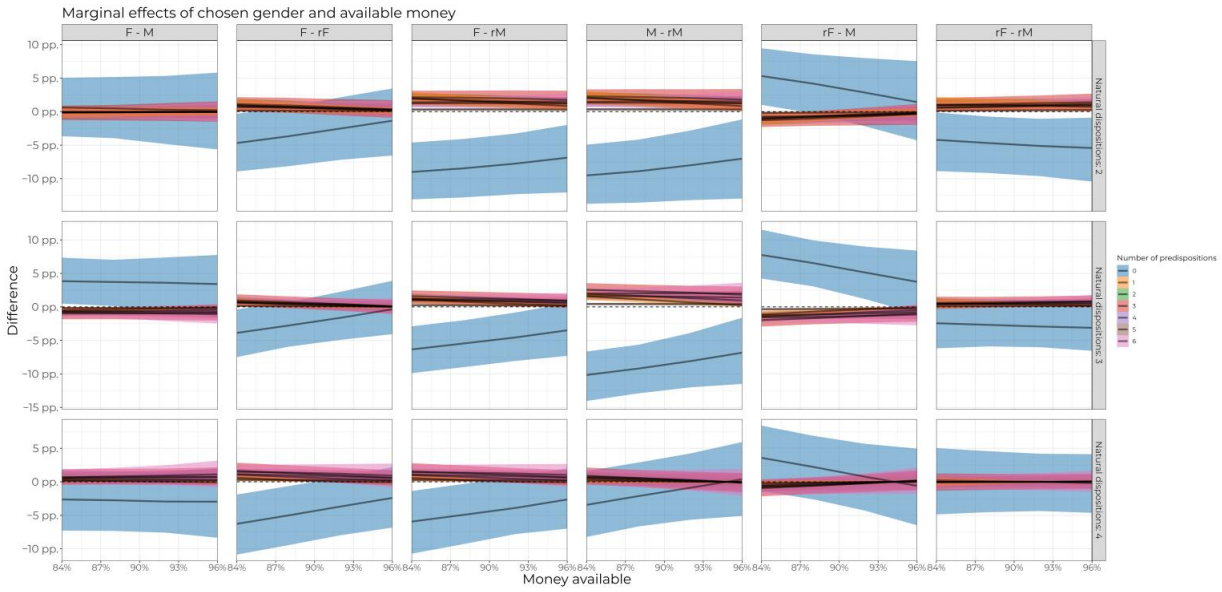


Figure S 2.

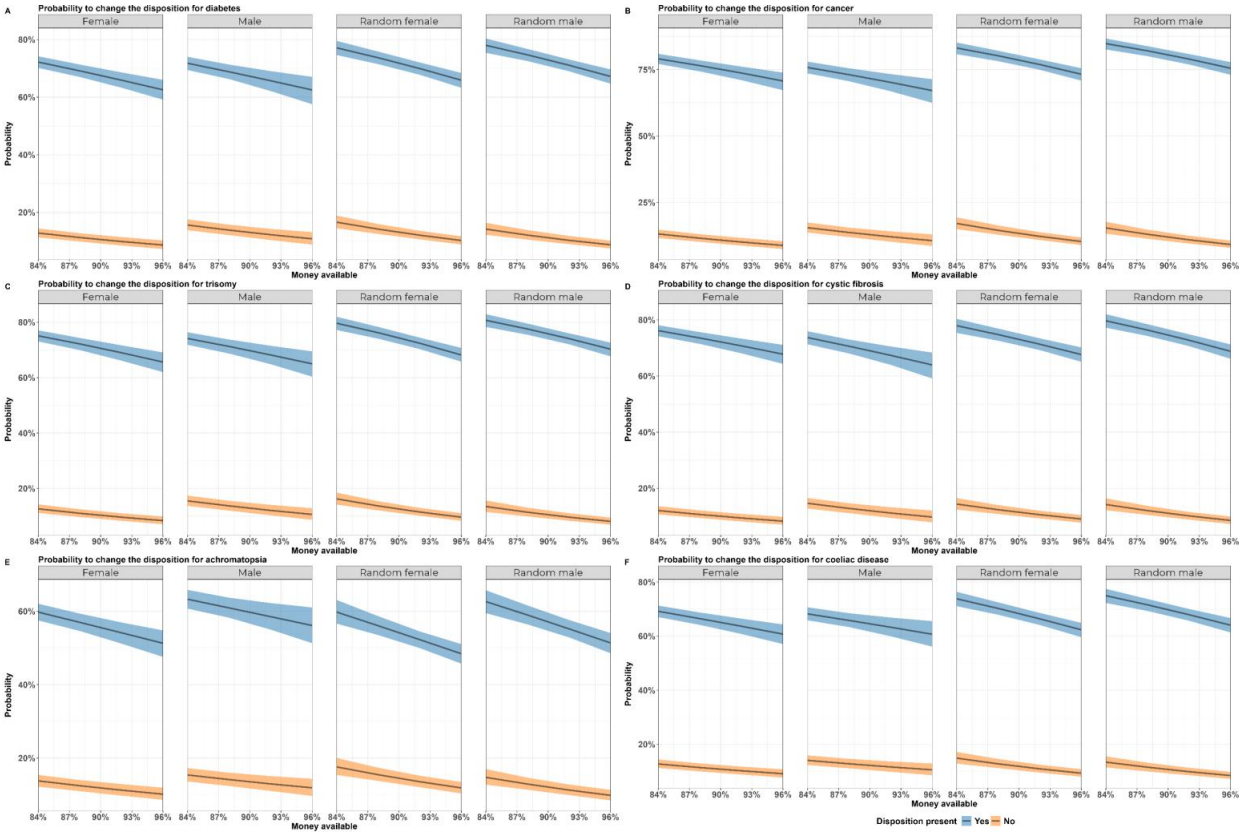

A
Probability to change the disposition for diabetes
B
Probability to change the disposition for cancer
C
Probability to change the disposition for trisomy
D
Probability to change the disposition for cystic fibrosis
E
Probability to change the disposition for achromatopsia
F
Probability to change the disposition for coeliac disease
Female
Male
Random female
Random male
Probability
Money available
84% 87% 90% 93% 96%
Disposition present Yes No

Figure S 3

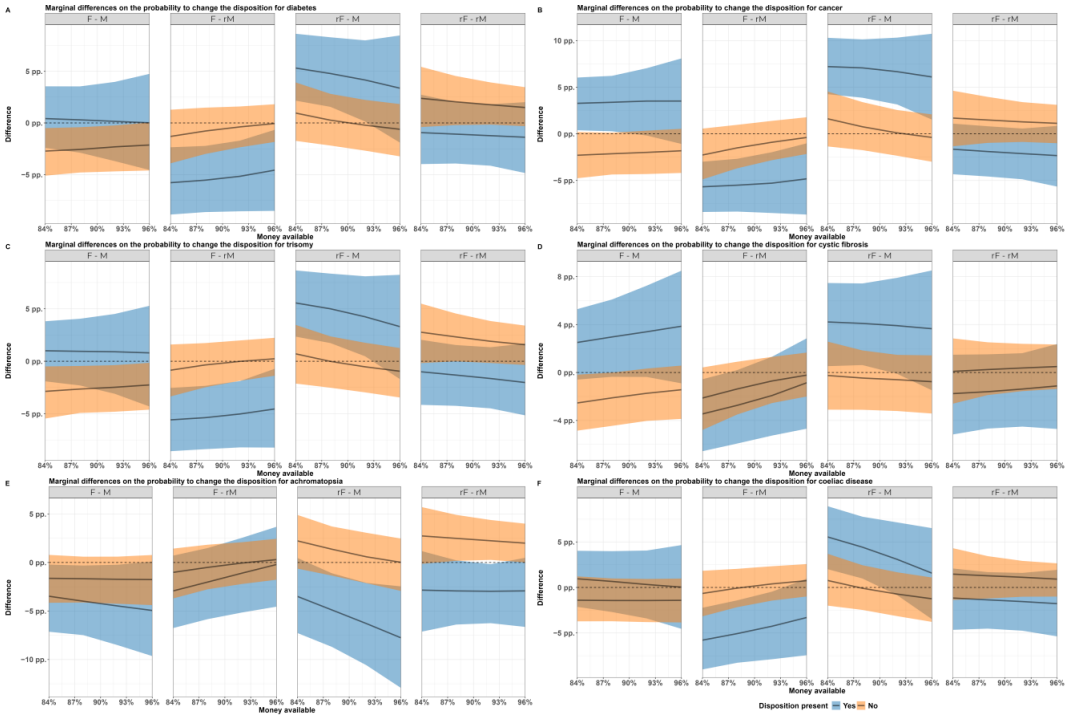

A
Marginal differences on the probability to change the disposition for diabetes
B
Marginal differences on the probability to change the disposition for cancer
C
Marginal differences on the probability to change the disposition for trisomy
D
Marginal differences on the probability to change the disposition for cystic fibrosis
E
Marginal differences on the probability to change the disposition for achromatopsia
F
Marginal differences on the probability to change the disposition for coeliac disease
F - M
F - rM
rF - M
rF - rM
Difference
Money available
Disposition present Yes No

Figure S 4

Features

Table S2. ANOVA's to determine whether the natural value is distributed equally across gender.

gender	feature	F-value	*p*-value
Choices.gender	Nature.talents.sportiness	0.53558187	0.65786936
Nature.gender	Nature.talents.sportiness	0.18710313	0.66534551
Choices.gender	Nature.talents.musicality	1.35868791	0.25341513
Nature.gender	Nature.talents.musicality	0.41295385	0.52048484
Choices.gender	Nature.talents.creativity	1.04831315	0.36985
Nature.gender	Nature.talents.creativity	4.624E-05	0.99457454
Choices.gender	Nature.talents.intelligence	0.45042419	0.71699949
Nature.gender	Nature.talents.intelligence	3.6021E-06	0.99848572
Choices.gender	Nature.personality.openness	0.8134387	0.48619762
Nature.gender	Nature.personality.openness	1.94132488	0.16354746
Choices.gender	Nature.personality.diligence	0.15200243	0.92844253
Nature.gender	Nature.personality.diligence	1.01283576	0.31424229
Choices.gender	Nature.personality.sociality	0.09573615	0.96241461
Nature.gender	Nature.personality.sociality	0.63922595	0.42400515
Choices.gender	Nature.personality.agreeableness	1.14677646	0.32862484
Nature.gender	Nature.personality.agreeableness	0.00820479	0.92782744
Choices.gender	Nature.personality.sensibility	0.25071234	0.86087592
Nature.gender	Nature.personality.sensibility	0.18231217	0.66940042

Marginal effects and coefficients for models predicting the change of features and their distribution are in the respective Microsoft Excel file.

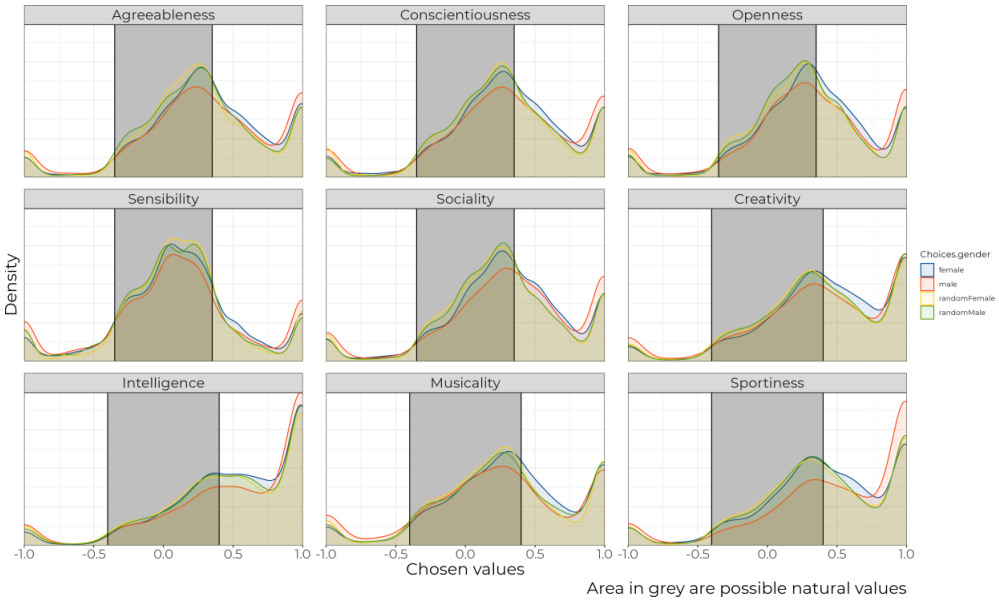


Figure S 5. Overview about the final feature distribution (all children). For distribution of values of children whose values were changed see prediction plots.

Money spent

Choosing gender costs 10,000 and will leave those who have chosen a random assignment with extra capital after the first screen. This allows for extra investments. Both groups can spend 100% of their capital. We set the proportion of total money spent as the outcome of a zero-one-inflated beta regression. The single predictor was $Gender_c$. For the interpretation of our results, note that all manipulations cost 10,000, respectively 20,000€.

Table S3. Zero-One-Inflated Beta regression on the proportion of money spent after gender selection

Chosen gender	μ	SE	CI	ϕ	SE	CI	zoi	SE	CI	coi	SE	CI
Female (Reference)	0.907	0.017	0.874 - 0.939	1.36	0.023	1.313 - 1.403	-2.54	0.06	-2.664 - -2.416	9.508	3.857	5.048 - 19.892
Male	0.102	0.025	0.053 - 0.151	0.03	0.034	-0.032 - 0.101	0.20	0.09	0.015 - 0.373	1.011	6.205	-11.075 - 14.983
Random male	-0.287	0.023	-0.090	0.11	0.033	0.042 - 0.169	0.49	0.08	0.325 - 0.649	-9.6	3.858	-19.957 - -5.126
Random female	-0.273	0.023	-0.091	0.10	0.033	0.031 - 0.159	0.41	0.09	0.242 - 0.571	-9.674	3.859	-20.015 - -5.196

Table S4. Predicted proportion spent (Expected posterior value)

Gender	Proportion spent	CI95
Female	73.33	72.67 - 74
Male	75.61	74.88 - 76.31
random Female	63.03	62.22 - 63.92
random Male	63.27	62.42 - 64.14

Note. RGC inevitably spent 4% (10.000€) less than DGC (Male/Female).
CI95: 95% Credible interval of predicted difference. The starting capital was 250.000€.

Table S5. Average marginal differences between proportion of money spent

Contrast	Difference in pp.	CI95
Female - Male	-2.28	-3.24 - -1.29
Female - random Female	10.30	9.21 - 11.37
Female - random Male	10.06	8.98 - 11.16
Male - random Male	12.33	11.2 - 13.44
random Female - Male	-12.57	-13.66 - -11.45
random Female - random Male	-0.24	-1.45 - 0.96

Note. RGC inevitably spent 4% (10.000€) less than DGC (Male/Female). CI95: 95% Credible interval of predicted difference. Pp. = percent points.

Table S6. Zero-one-inflated beta regression on chosen values of traits and talents

Chosen gender	μ	*SE*	CI95%	ϕ	*SE*	CI95%	zoi	*SE*	CI95%	coi	*SE*	CI95%
Sensibility												
F (Reference)	0.289	0.019	0.252 - 0.327	1.544	0.03	1.486 - 1.602	-1.651	0.057	-1.764 - -1.542	0.678	0.11	0.463 - 0.894
M	-0.058	0.03	-0.117 - 0.001	-0.158	0.044	-0.246 - -0.071	0.569	0.077	0.417 - 0.721	-0.281	0.143	-0.558 - 0
rF	-0.001	0.028	-0.056 - 0.053	0.136	0.044	0.048 - 0.222	0.285	0.08	0.127 - 0.442	-0.257	0.149	-0.554 - 0.038
rM	-0.069	0.029	-0.125 - -0.013	-0.058	0.044	-0.145 - 0.029	0.167	0.082	0.008 - 0.326	-0.350	0.153	-0.651 - -0.05
Sociality												
F	0.708	0.018	0.674 - 0.743	1.769	0.029	1.712 - 1.826	-1.389	0.049	-1.487 - -1.294	1.075	0.102	0.878 - 1.278
M	-0.023	0.028	-0.076 - 0.032	-0.152	0.044	-0.239 - -0.066	0.498	0.068	0.365 - 0.632	-0.033	0.135	-0.299 - 0.228
rF	0.003	0.026	-0.048 - 0.053	0.112	0.044	0.026 - 0.197	0.209	0.07	0.07 - 0.344	-0.205	0.14	-0.481 - 0.065
rM	-0.009	0.026	-0.06 - 0.042	0.052	0.044	-0.033 - 0.138	0.158	0.071	0.019 - 0.297	-0.005	0.144	-0.289 - 0.274
Openness												
F	0.752	0.017	0.719 - 0.785	1.87	0.029	1.812 - 1.927	-1.38	0.048	-1.474 - -1.286	1.128	0.101	0.933 - 1.328
M	-0.100	0.027	-0.153 - -0.048	-0.219	0.044	-0.305 - -0.134	0.514	0.067	0.383 - 0.645	-0.032	0.134	-0.299 - 0.229
rF	-0.015	0.025	-0.064 - 0.034	0.028	0.043	-0.057 - 0.112	0.237	0.068	0.102 - 0.369	-0.211	0.137	-0.477 - 0.058
rM	-0.010	0.025	-0.058 - 0.038	0.031	0.043	-0.052 - 0.116	0.089	0.07	-0.049 - 0.227	-0.028	0.144	-0.307 - 0.254
Agreeableness												
F	0.766	0.020	0.727 - 0.805	1.641	0.030	1.581 - 1.7	-1.242	0.049	-1.337 - -1.146	1.238	0.102	1.04 - 1.442
M	-0.065	0.030	-0.124 - -0.006	-0.071	0.046	-0.162 - 0.019	0.480	0.067	0.347 - 0.611	-0.148	0.136	-0.42 - 0.116
rF	-0.008	0.028	-0.062 - 0.047	0.223	0.045	0.134 - 0.312	0.243	0.07	0.106 - 0.38	-0.310	0.138	-0.582 - -0.039
rM	-0.014	0.029	-0.07 - 0.044	0.059	0.045	-0.028 - 0.148	0.105	0.071	-0.035 - 0.244	-0.050	0.147	-0.341 - 0.239
Conscientiousness												
F	0.718	0.018	0.682 - 0.753	1.727	0.029	1.67 - 1.784	-1.317	0.049	-1.414 - -1.222	1.149	0.1	0.955 - 1.348
M	-0.012	0.028	-0.068 - 0.043	-0.128	0.044	-0.213 - -0.042	0.471	0.067	0.341 - 0.599	-0.131	0.133	-0.392 - 0.13
rF	0.012	0.026	-0.039 - 0.064	0.155	0.044	0.069 - 0.239	0.232	0.068	0.099 - 0.364	-0.348	0.135	-0.614 - -0.08
rM	0.040	0.026	-0.012 - 0.091	0.142	0.043	0.057 - 0.227	0.139	0.07	0.002 - 0.277	0.106	0.146	-0.177 - 0.391
Talents												
Intelligence												
F	1.195	0.02	1.155 - 1.234	1.809	0.031	1.747 - 1.87	-0.648	0.039	-0.724 - -0.573	2.228	0.11	2.017 - 2.448
M	-0.046	0.034	-0.113 - 0.021	-0.263	0.049	-0.359 - -0.166	0.499	0.057	0.386 - 0.611	-0.341	0.141	-0.62 - -0.066
rF	-0.097	0.03	-0.155 - -0.038	-0.114	0.045	-0.203 - -0.026	0.214	0.055	0.106 - 0.323	-0.396	0.142	-0.676 - -0.12
rM	-0.09	0.03	-0.148 - -0.03	-0.102	0.046	-0.193 - -0.013	0.219	0.055	0.109 - 0.328	-0.146	0.146	-0.432 - 0.139
Sportiness												
F	0.915	0.02	0.877 - 0.954	1.696	0.030	1.637 - 1.755	-0.851	0.041	-0.932 - -0.77	1.652	0.094	1.47 - 1.838
M	0.069	0.033	0.005 - 0.133	-0.169	0.048	-0.261 - -0.074	0.709	0.058	0.594 - 0.822	0.181	0.127	-0.066 - 0.431
rF	-0.006	0.028	-0.062 - 0.049	0.132	0.045	0.042 - 0.221	0.341	0.059	0.225 - 0.457	0.064	0.13	-0.193 - 0.322
rM	-0.035	0.029	-0.092 - 0.022	0.012	0.045	-0.075 - 0.099	0.281	0.059	0.166 - 0.396	0.171	0.134	-0.092 - 0.434
Musicality												
F	0.736	0.021	0.695 - 0.776	1.546	0.031	1.485 - 1.608	-0.981	0.045	-1.07 - -0.894	1.415	0.096	1.23 - 1.607
M	-0.219	0.033	-0.284 - -0.154	-0.206	0.046	-0.297 - -0.117	0.366	0.064	0.243 - 0.493	-0.548	0.126	-0.797 - -0.303
rF	-0.1	0.031	-0.161 - -0.04	-0.029	0.046	-0.118 - 0.06	0.274	0.063	0.15 - 0.399	-0.195	0.13	-0.451 - 0.06
rM	-0.05	0.032	-0.111 - 0.012	-0.065	0.046	-0.155 - 0.025	0.313	0.063	0.19 - 0.438	-0.058	0.133	-0.317 - 0.204
Creativity												
F	0.981	0.019	0.942 - 1.018	1.736	0.031	1.676 - 1.794	-0.929	0.042	-1.012 - -0.847	1.871	0.105	1.669 - 2.08
M	-0.115	0.031	-0.176 - -0.053	-0.2	0.047	-0.292 - -0.108	0.455	0.061	0.336 - 0.573	-0.442	0.136	-0.708 - -0.176
rF	-0.060	0.029	-0.116 - -0.003	0.019	0.045	-0.069 - 0.108	0.304	0.059	0.189 - 0.421	-0.161	0.142	-0.44 - 0.118
rM	-0.041	0.028	-0.095 - 0.015	0.091	0.045	0.003 - 0.18	0.315	0.06	0.197 - 0.432	-0.027	0.144	-0.306 - 0.255

Note. Untransformed parameter estimation. μ (logit scale) and ϕ (log scale) describe the beta distribution. Zoi and coi (logit scale) describe the zero-one-inflation, respectively, the conditional one inflated part of the distribution. Interpret estimates in a linear combination with the reference category and always in conjunction. F = Female, M = Male, rF = random Female, rM = random Male. SE = standard error. Estimates are the median of respective distribution. CI95% = 95% credible interval. SE always refers to the estimate on the left of this column. Female was always the reference category.

Model fit

Predictions are based on *n* = 1,000 *predicted_draws* of the R-package *tidybayes*. This method uses the fitted model to generate n-different datasets with the original number of used cases in the model. We then calculated the median value and 95% interval for how often a value was drawn across gender and the respective proportion, which were then plotted against the empirical data.

We have provided two figures for the proportion of money spent. The second figure rounds predicted values between 0.01 and 0.99 to multiples of 0.04. This reflects the empirical possible data of money spent more accurately.

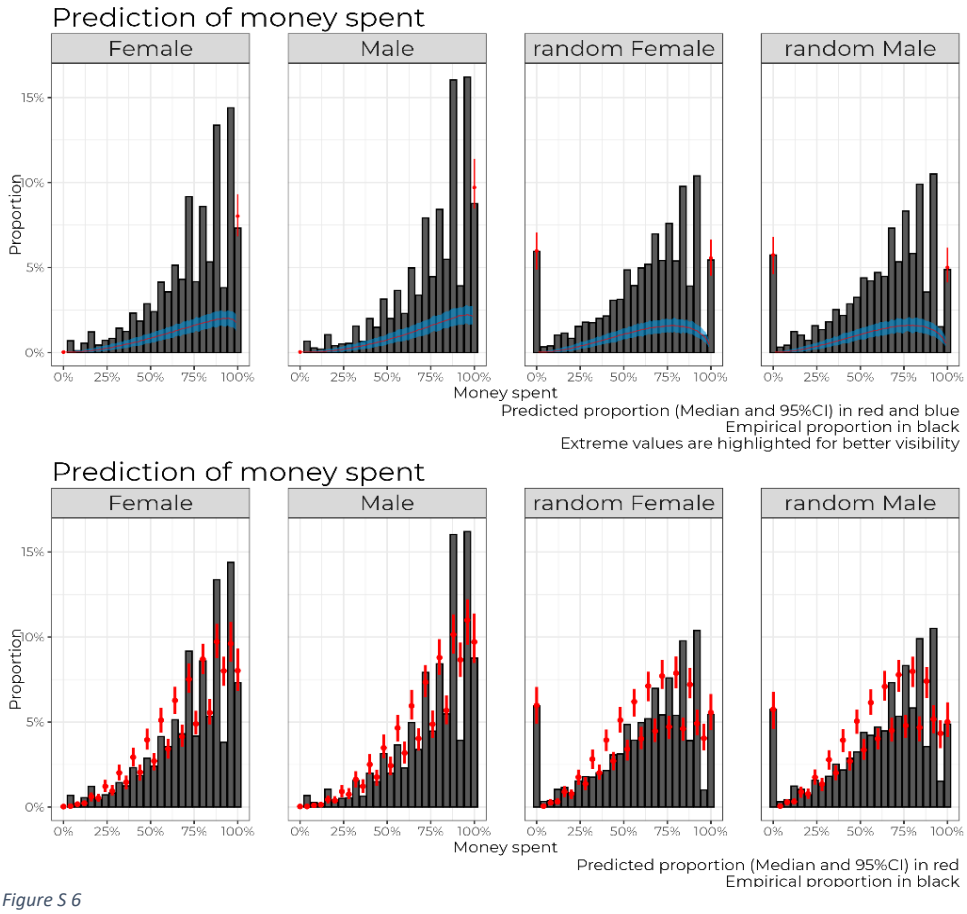


Figure S 6

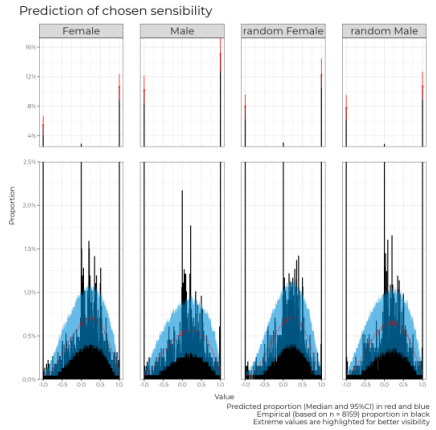


Figure S 7

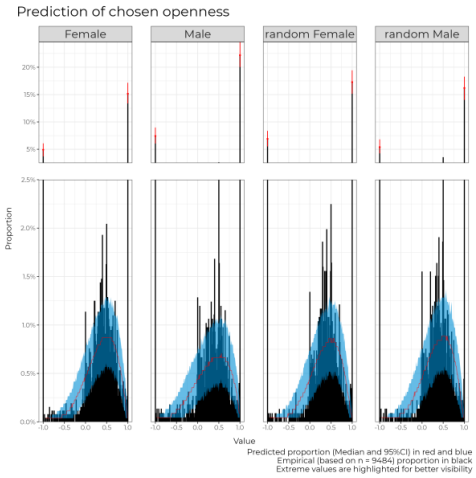


Figure S9

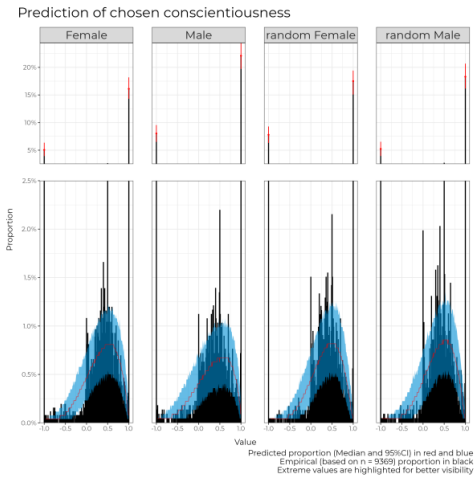


Figure S 11

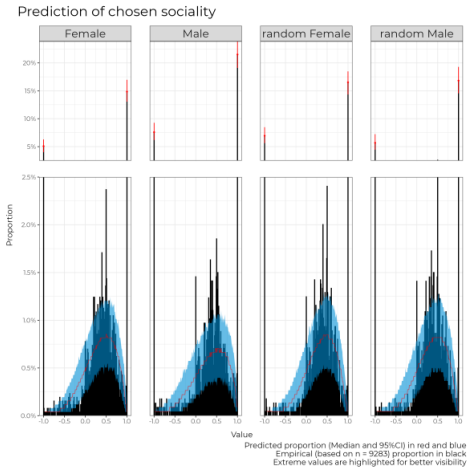


Figure S 8

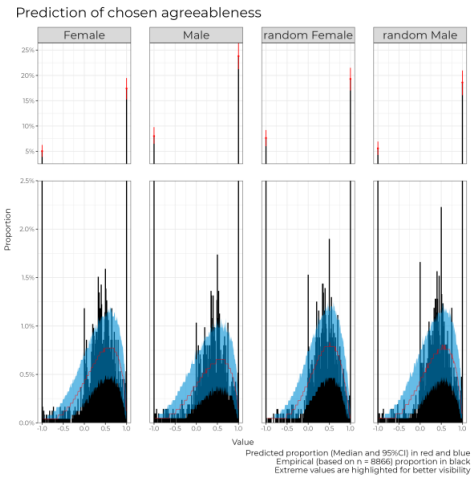


Figure S 10

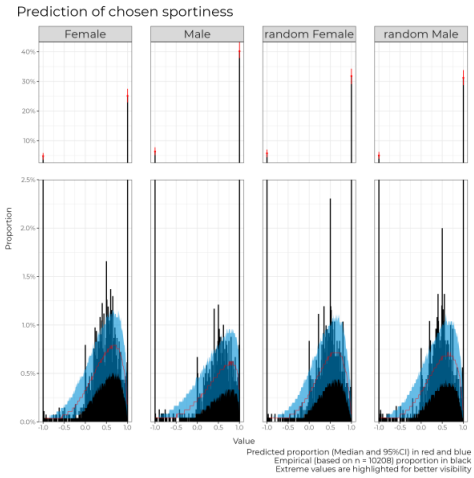


Figure S 12

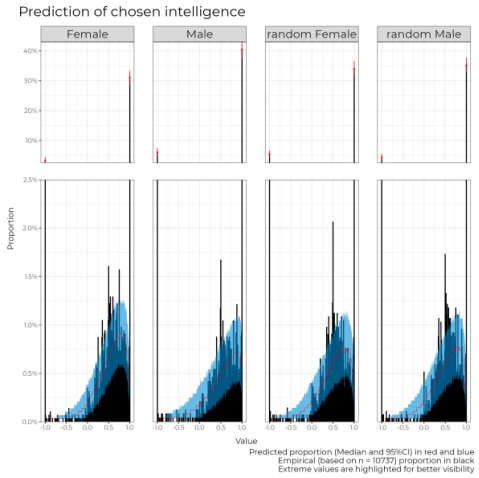


Figure S 13

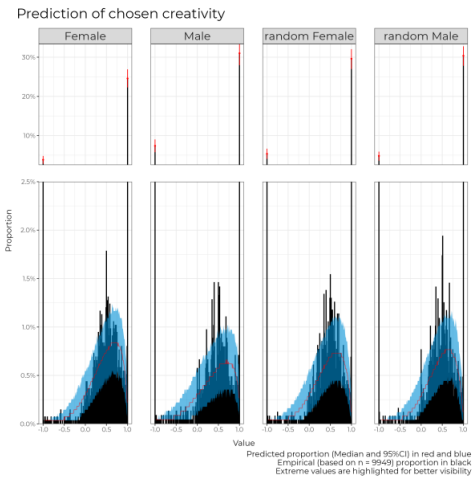


Figure S 14

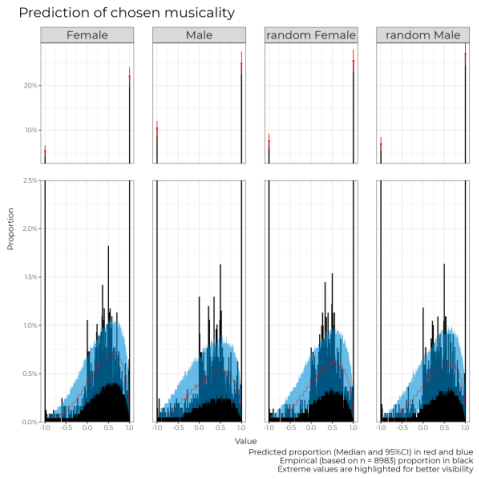


Figure S 15

All figure captions read:

Prediction proportion (Median and 95%CI) in red and blue

Empirical based on (n = [number] proportion in black

Extreme values are highlighted for better visibility

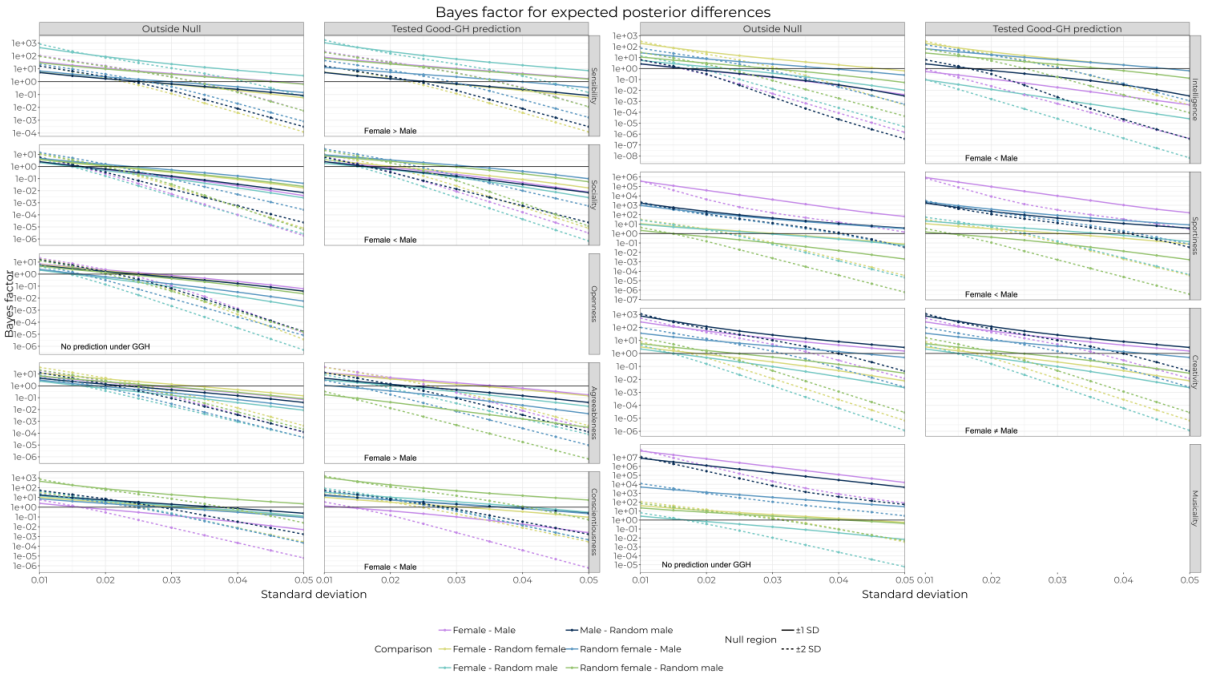


Figure S 16

Epred draws

4,000 for decision probabilities

1,000 for marginal effects in decision probabilities

20,000 for expected posterior predictive distributions and marginal effects

Different numbers were employed to minimize computation time. Especially in the models with several predictors and their interaction, generated datasets were very large.

Bayes Factor

All Bayes factor calculations are in respective Excel file.

Extreme values

All extreme value calculations are in respective Excel file. They were obtained by expected posterior draws and the respective proportion.

References

Allen, M. S., & Walter, E. E. (2018). Linking big five personality traits to sexuality and sexual health: A meta-analytic review. *Psychological Bulletin*, *144*(10), 1081–1110. https://doi.org/10.1037/bul0000157

Barr, D., & DeBruine, L. (2023). *webexercises: Create Interactive Web Exercises in "R Markdown" (Formerly 'webex')* (Version 1.1.0) [Computer software]. https://CRAN.R-project.org/package=webexercises

Bosson, J. K., Wilkerson, M., Kosakowska-Berezecka, N., Jurek, P., & Olech, M. (2022). Harder Won and Easier Lost? Testing the Double Standard in Gender Rules in 62 Countries. *Sex Roles*, *87*(1–2), 1–19. https://doi.org/10.1007/s11199-022-01297-y

Carol, S., & Hank, K. (2020). Natives' and Immigrants' Gender Preferences for Children in Germany. *European Journal of Population = Revue Europeenne de Demographie*, *36*(2), 235–246. https://doi.org/10.1007/s10680-019-09527-y

Cocodia, E. A. (2014). Cultural Perceptions of Human Intelligence. *Journal of Intelligence*, *2*(4), 180–196. https://doi.org/10.3390/jintelligence2040180

Costa Jr., P. T., & McCrae, R. R. (1992). The five-factor model of personality and its relevance to personality disorders. *Journal of Personality Disorders*, *6*(4), 343–359.

Diekman, A. B., & Eagly, A. H. (2000). Stereotypes as Dynamic Constructs: Women and Men of the Past, Present, and Future. *Personality and Social Psychology Bulletin*, *26*(10), 1171–1188. https://doi.org/10.1177/0146167200262001

Doey, L., Coplan, R. J., & Kingsbury, M. (2014). Bashful Boys and Coy Girls: A Review of Gender Differences in Childhood Shyness. *Sex Roles*, *70*(7–8), 255–266. https://doi.org/10.1007/s11199-013-0317-9

Eagly, A. H., Nater, C., Miller, D. I., Kaufmann, M., & Sczesny, S. (2020). Gender stereotypes have changed: A cross-temporal meta-analysis of U.S. public opinion polls from 1946 to 2018. *The American Psychologist*, *75*(3), 301–315. https://doi.org/10.1037/amp0000494

Fuse, K. (2010). Variations in attitudinal gender preferences for children across 50 less-developed countries. *Demographic Research*, *23*, 1031–1048. https://doi.org/10.4054/DemRes.2010.23.36

Haines, E. L., Deaux, K., & Lofaro, N. (2016). The Times They Are a-Changing … or Are They Not? A Comparison of Gender Stereotypes, 1983–2014. *Psychology of Women Quarterly*, *40*(3), 353–363. https://doi.org/10.1177/0361684316634081

Hank, K., & Kohler, H.-P. (2000). Gender Preferences for Children in Europe. *Demographic Research*, *2*. https://doi.org/10.4054/DemRes.2000.2.1

Hank, K., & Kohler, H.-P. (2003). Gender preferences for children revisited: New evidence from Germany. *Population: English Edition*, *58*, 133–144. https://doi.org/10.4054/MPIDR-WP-2002-017

Hao, L., & Yeung, W.-J. J. (2015). Parental Spending on School-Age Children: Structural Stratification and Parental Expectation. *Demography*, *52*(3), 835–860. https://doi.org/10.1007/s13524-015-0386-1

Hardin, M., Dodd, J. E., & Lauffer, K. (2006). Passing it on: The reinforcement of male hegemony in sports journalism textbooks. *Mass Communication & Society*, *9*(4), 429–446. https://doi.org/10.1207/s15327825mcs0904_3

Judge, T. A., Livingston, B. A., & Hurst, C. (2012). Do nice guys—And gals—Really finish last? The joint effects of sex and agreeableness on income. *Journal of Personality and Social Psychology*, *102*(2), 390–407. https://doi.org/10.1037/a0026021

Kemp, A. E. (1985). Psychological androgyny in musicians. *Bulletin of the Council for Research in Music Education*, *85*, 102–108.

Koenig, A. M. (2018). Comparing Prescriptive and Descriptive Gender Stereotypes About Children, Adults, and the Elderly. *Frontiers in Psychology*, *9*, 1086. https://doi.org/10.3389/fpsyg.2018.01086

Kornrich, S., & Furstenberg, F. (2013). Investing in children: Changes in parental spending on children, 1972-2007. *Demography*, *50*(1), 1–23. https://doi.org/10.1007/s13524-012-0146-4

Moss-Racusin, C. A., Phelan, J. E., & Rudman, L. A. (2010). When men break the gender rules: Status incongruity and backlash against modest men. *Psychology of Men & Masculinity*, *11*(2), 140–151. https://doi.org/10.1037/a0018093

Moya Morales, M. C., & Moya Garófano, A. (2021). Evolution of gender stereotypes in Spain: From 1985 to 2018. *Psicothema*, 53–59.

Park, L. E., Young, A. F., & Eastwick, P. W. (2015). (Psychological) Distance Makes the Heart Grow Fonder: Effects of Psychological Distance and Relative Intelligence on Men's Attraction to Women. *Personality and Social Psychology Bulletin*, *41*(11), 1459–1473. https://doi.org/10.1177/0146167215599749

Plaza, M., Boiché, J., Brunel, L., & Ruchaud, F. (2017). Sport = Male… But Not All Sports: Investigating the Gender Stereotypes of Sport Activities at the Explicit and Implicit Levels. *Sex Roles*, *76*(3–4), 202–217. https://doi.org/10.1007/s11199-016-0650-x

Prentice, D. A., & Carranza, E. (2002). What Women and Men Should Be, Shouldn't be, are Allowed to be, and don't Have to Be: The Contents of Prescriptive Gender Stereotypes. *Psychology of Women Quarterly*, *26*(4), 269–281. https://doi.org/10.1111/1471-6402.t01-1-00066

Proudfoot, D., Kay, A. C., & Koval, C. Z. (2015). A Gender Bias in the Attribution of Creativity. *Psychological Science*, *26*(11), 1751–1761. https://doi.org/10.1177/0956797615598739

Raley, S., & Bianchi, S. (2006). Sons, Daughters, and Family Processes: Does Gender of Children Matter? *Annual Review of Sociology*, *32*(1), 401–421. https://doi.org/10.1146/annurev.soc.32.061604.123106

Rudman, L. A., Moss-Racusin, C. A., Glick, P., & Phelan, J. E. (2012). Reactions to Vanguards: Advances in Backlash Theory. In P. G. Devine & E. A. Plant (Eds.), *Advances in Experimental Social Psychology* (pp. 167–227). Elsevier. https://doi.org/10.1016/B978-0-12-394286-9.00004-4

Rudman, L. A., Moss-Racusin, C. A., Phelan, J. E., & Nauts, S. (2012). Status incongruity and backlash effects: Defending the gender hierarchy motivates prejudice against female leaders. *Journal of Experimental Social Psychology*, *48*(1), 165–179. https://doi.org/10.1016/j.jesp.2011.10.008

Stamarski, C. S., & Son Hing, L. S. (2015). Gender inequalities in the workplace: The effects of organizational structures, processes, practices, and decision makers' sexism. *Frontiers in Psychology*, *6*, 1400. https://doi.org/10.3389/fpsyg.2015.01400

Zehnter, M. K., Olsen, J., & Kirchler, E. (2018). Obituaries of Female and Male Leaders From 1974 to 2016 Suggest Change in Descriptive but Stability of Prescriptive Gender Stereotypes. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.02286

Zinkhan, G., Prenshaw, P., & Scheinbaum, A. C. (2004). Sex-Typing of Leisure Activities: A Test of Two Theories. *Advances in Consumer Research*, *31*, 412–419.