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THEORY AND HYPOTHESIS

Human Enhancement Without Organizational Knowledge and by Organizational Order

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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

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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

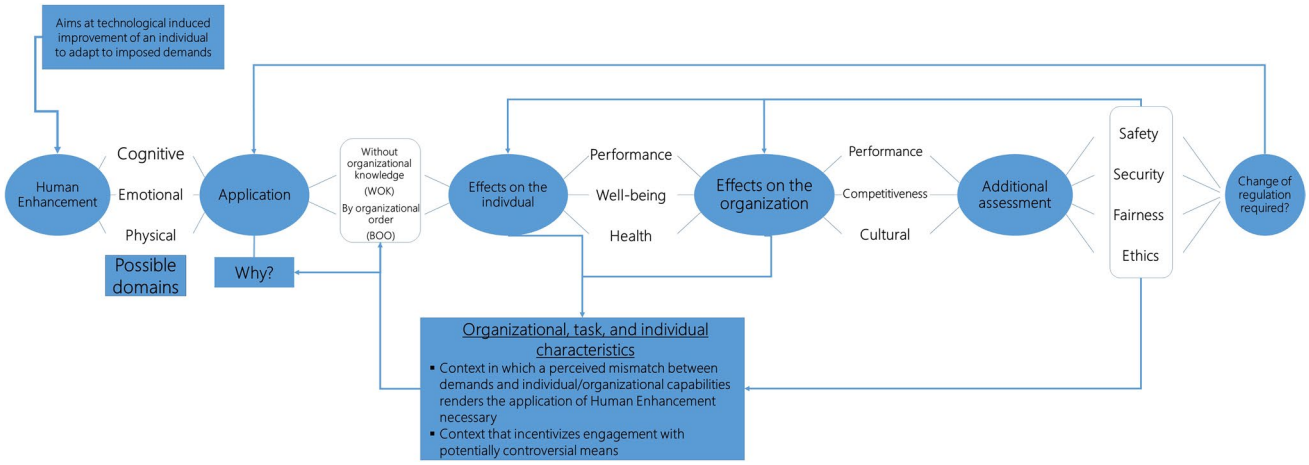

Fig. 1 Summary of the thoughts presented here. Note: this framework is far from being exhaustive but is motivated to make a thought-provoking starting point

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.

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CCC: conceptualization, supervision
HS: conceptualization, writing original draft

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Declarations

Competing Interests The authors declare no competing interests.

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