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# The 4C framework: Towards a holistic understanding of consumer engagement with augmented reality

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ABSTRACT

Augmented Reality (AR) is an emerging concept that impacts many disciplines, such as business, marketing, tourism, gaming, human–computer interaction, and manufacturing. Surprisingly, many scholarly and practical discussions overlook the fundamental primary factors that distinguish AR from other concepts, namely, that it involves a computing device that integrates virtual content into a consumer's perception of the real world in a specific context. The current article addresses this gap in the literature by proposing the 4C framework (based on the 4Cs: consumer, content, context, and computing device; pronounced: foresee) that highlights the importance of, and interplay among these four factors. Building on configurational theory, the framework calls for the systematic identification of additional AR-relevant factors across the 4Cs. Scholars can use this framework to systematically identify research gaps and variables of interest. Practitioners across various disciplines can employ the framework to systematically assess, communicate, and develop AR use cases.

## 1. Introduction

Augmented Reality (AR) uses a computing device to integrate contextually relevant virtual content into the consumer's perception of the physical world. Understanding and effectively developing such hybrid experiences, which consist of physical and virtual elements, has emerged as a core topic in academic research (Heller et al., 2021; Hilken et al., 2018; Rauschnabel, Babin et al., 2022; tom Dieck, Jung, & Rauschnabel, 2018) and industry (Porter and Heppelmann, 2017). Announcements from leading technology companies (e.g., Amazon, Alphabet, Apple, and Meta) and market forecasts suggest that growth will continue as AR technology matures. In the near future, AR will likely serve as a gateway to what has been touted as the "metaverse" (Dwivedi et al., 2022, 2023) or as "spatial computing" (McKinsey, 2022), and it will potentially evolve into the next generation of the Internet. Today, AR is no longer a futuristic vision. Various disciplines, such as engineering (Choi et al., 2021; Xiong et al., 2021), healthcare (Klinker et al., 2020), tourism (Loureiro et al., 2020), marketing (Jayaswal & Parida, 2023a, 2023b; Jessen et al., 2020; Tan et al., 2022), and education (Baabdullah et al., 2022; Sahin & Yilmaz, 2020; tom Dieck, Cranmer, Prim, & Bamford, 2023), are incorporating AR into their offerings.

Despite the acknowledged effectiveness of AR in general, there are instances in which certain AR solutions have either disappeared from the market (e.g., Google Glass) or are viewed as inferior to other technologies (Zanger et al., 2022). When examining individual cases, industry experts conclude that many applications simply overlay existing content on top of the physical world and fail to create experiences that take advantage of the important characteristics of AR, such as contextual

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embedding (Hilken et al., 2017; Pfaff & Spann, 2023; Von der Au et al., 2023), local presence (Rauschnabel, Felix et al., 2022), interactivity (Park & Yoo, 2020; Yim et al., 2017), immersion (Slater & Sanchez-Vives, 2016), and its ability to reduce cognitive load (Barta et al., 2023; Kao & Ruan, 2022). In other words, they suggest that many companies and vendors are eager to embrace AR without seriously considering what makes AR unique. This is not surprising, given that managers, on average, attest to a low level of knowledge in this area (Rauschnabel, Babin et al., 2022), and there is little practical or academic guidance for the development of AR use cases.

Current AR research often faces three limitations. First, AR research is frequently constrained by a reliance on general theories such as the technology acceptance model (TAM; Oyman et al., 2022) or uses and gratifications (Ibáñez-Sánchez et al., 2022), leading to a narrow understanding that overlooks the nuanced interplay of user characteristics, AR content, context, and device type. This results in fragmented insights with limited applicability to effective AR development, as seen in studies that neglect the complex interaction of these elements (Smink, 2022; von der Au et al., 2023). Second, AR studies are typically discipline-specific, focusing on particular variables, such as the utilitarian benefits of AR shopping aids (Hilken et al., 2017; Kumar, 2022; Kumar & Srivastava, 2022), without wider relevance to other AR applications. This limitation can be addressed by adopting broader frameworks, such as the technology−organization−environment (TOE) framework (Tornatzky et al., 1990), that categorize variables affecting technology adoption,[1] but such comprehensive models are scarce in AR research. Third, AR research often assumes linear variable relationships, suggesting that high-quality AR integration is universally optimal (Heller et al., 2021; Rauschnabel et al., 2019). However, different contexts and user experiences may require varying levels of integration. For instance, a clear differentiation between virtual and physical elements can be crucial in practical applications, such as engine repair using AR. This calls for a more nuanced understanding beyond linear perspectives to cater to diverse user needs and contexts.

Against this background, the current research aims to introduce a conceptual framework that overcomes these limitations by drawing on configurational theory (Fiss, 2007; Meyer et al., 1993). To address the first limitation, we focus on aspects specific to AR, in particular, that consumers experience contextually relevant virtual content through a computing device. To address the second limitation, we shift from specific domains that are only relevant for a particular type of AR (e.g., marketing or education) to AR in general. To achieve this, we present four primary characteristics of AR (consumer, content, context, and computing device) as broad categories and then discuss potential subcategories (e.g., utilitarian, hedonic, and social content). Finally, the current research addresses the third limitation by moving from the assumption of linear relationships to complex and interrelated effects based on configurational theory (Meyer et al., 1993).

The current research contributes to the AR literature in several ways. Most importantly, we present a framework that academic researchers across disciplines can use when developing AR theories or research designs. Hence, following MacInnis' (2011) classification of conceptual contributions to theory, our work provides an identification contribution (defined as introducing a new construct, procedure, framework, or theory) as well as an integration contribution (defined as providing a new holistic perspective and the creation of a new whole from different parts). Researchers can use this framework to systematically identify variables in all four categories relevant to their research. For managers and AR developers, the framework provides a structure on which AR experiences can be designed and built. In this case, the categories and subcategories describe what needs to be part of an AR experience and how those parts align.

## 2. Configurational theory as a theoretical lens

Configurational theory defines a configuration as "any multidimensional constellation of conceptually distinct characteristics that commonly occur together" (Meyer et al., 1993, p. 1175). It represents a systemic and holistic view in which specific interdependent patterns or profiles (i.e., constellations) rather than individual independent variables in isolation drive outcome variables (Delery & Doty, 1996). Hence, configurational theory implies "a clean break with the predominant linear paradigm" (Fiss, 2007, p. 1181). Whereas the classic linear paradigm treats predictor variables as competing to explain the variance in a dependent variable through the unique contribution of a specific predictor variable (e.g., X1) while holding all other predictor variables (X2, X3, and so on) constant, configurational theory focuses on how interdependent variables combine to influence a desired outcome (Fiss et al., 2013).

Configurational theory suggests that viewing the variables determining an outcome in isolation does not effectively represent relationships in complex systems because a specific input variable may only gain meaning or become active based on the presence or absence of other variables (Fiss, 2007). For example, in management research, organizational outcomes, such as firm performance, are positive only when certain elements (e.g., structure, strategy, process, and environment) are internally harmonious and mutually reinforcing, and the same results would likely not occur if these variables were optimized in isolation (Miller, 1990). In a very simple system, one could argue that the effect of a predictor variable X1 on outcome variable Y may depend on the specific level of a second variable X2 (which in fact represents a simple moderation model). As the interdependencies among predictor variables intensify, the number of possible moderating effects quickly exceeds the number of variables in the model. This makes it difficult, or even impossible, to probe these complex relationships through classical regression.

An important building block of configurational theory is the concept of equifinality, which predicts that a system can reach the same final state through a variety of different paths (Katz & Kahn, 1978; Ketchen et al., 1993). By identifying prototypical constellations of variables, as opposed to isolated moderation effects, configurational theory differentiates itself from the classical linear paradigm. Moreover, the notion of asymmetry in configurational theory acknowledges that "variables found to be causally related in one configuration may be unrelated or even inversely related in another" (Meyer et al., 1993, p. 1178). For instance, utilitarian benefits are likely highly important for AR applications that support workers in a factory yet less relevant for AR games.

It is important to note that configurations can be derived both conceptually and empirically. Recent advances in methods—especially qualitative comparative analysis (QCA) and fuzzy-set QCA (fsQCA)—have substantially increased the attractiveness of empirically derived configurations (Kan et al., 2016; Misangyi et al., 2017) that may result in considerable advances in subsequent research, theorizing, and practice (Miller, 2018). However, given the emerging stage of AR research, we approach this area with a conceptual rather than empirical lens in an effort to derive rich and theoretically grounded constellations of AR components to inform and guide future research.

[1] Specifically, the TOE framework is a theoretical model outlining how an organization's adoption of technological innovations is influenced by technological, organizational, and environmental contexts (Baker, 2012). It provides a comprehensive lens for analyzing how internal and external factors collectively shape a company's technology adoption decisions.

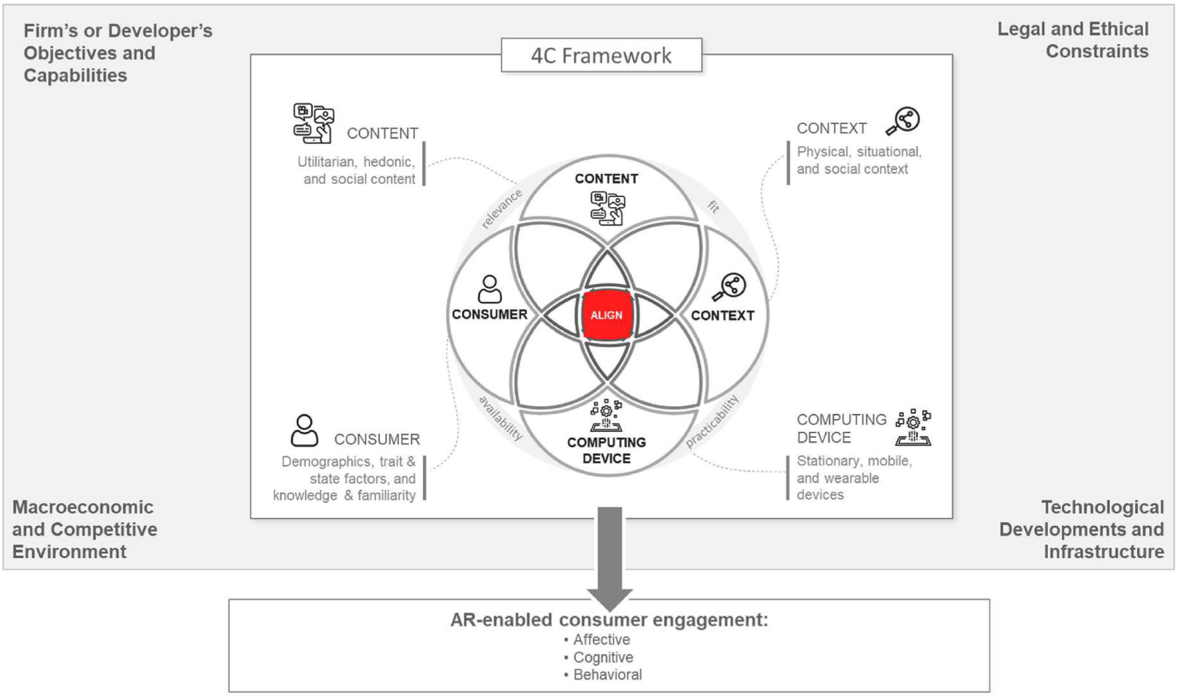


**Fig. 1.** The 4C framework for Augmented Reality.[3]

## 3. The 4C framework for augmented reality engagement

### 3.1. Consumer engagement as a focal outcome of 4C alignment

AR facilitates the integration of context-relevant virtual content into the consumer's perception of the physical world through a computing device. Our framework posits that consumers, content, context, and computing device (4Cs) are the basic categories of variables that drive consumer engagement in AR. In other words, these 4Cs (pronounce: foresee) – and their interplay – represent the variables that directly and through their interplay influence how consumers experience AR.

The extant literature has identified consumer engagement as a key variable driving customer satisfaction, loyalty, sales, and profits (Kumar & Pansari, 2016; Pansari & Kumar, 2017; Thakur, 2019). It is therefore not surprising that academic interest in consumer engagement has been steadily increasing (Alvarez-Milán et al., 2018; Hollebeek et al., 2023). In general terms, consumer engagement has been defined as an "individual-specific, motivational, and context-dependent variable emerging from two-way interactions between relevant engagement subject(s) and object(s)" (Hollebeek, 2011, p. 787). Previous research has shown that AR technology can enable consumer engagement in many different domains, such as customer relations (Jessen et al., 2020), service automation (Heller et al., 2021), education (Georgiou & Kyza, 2018), tourism (tom Dieck et al., 2018), and video gaming (Shin, 2019). However, the effects of AR experiences on consumer engagement may depend on the specific content and context of the application. For example, Christ-Brendemühl and Schaarschmidt (2022) found lower (rather than higher) engagement for consumers using an AR try-on feature (as compared to a traditional retail setting) when buying a pair of sunglasses; Zanger et al. (2022) reported similar effects for a makeup app.

The current research uses the term "consumer" in a broad sense for any type of person engaging in AR consumption (i.e., use), including customers, employees, gamers, tourists, students, etc. Furthermore, the extant literature suggests different conceptualizations of consumer engagement, which include engagement as a psychological state (e.g., Brodie et al., 2011), behavioral manifestation (Kumar et al., 2019), or both (Alvarez-Milán et al., 2018; Hollebeek et al., 2019; Wirtz et al., 2013). Following the latter conceptualization, we define engagement as a combination of affective, cognitive, and behavioral manifestations. Thus, simply clicking on an app would—based on our definition—reflect a very low level of engagement.[2]

Fig. 1 shows how the 4Cs relate to AR-enabled consumer engagement and the objectives of a firm or developer. Following the logic of configurational theory, and in particular equifinality (Katz & Kahn, 1978; Ketchen et al., 1993), engagement should be very high once relevant factors from the 4Cs are aligned. The thick line circumscribing the 4Cs indicates a more practical approach; for instance, when designing an AR experience for consumers, the device used must be accessible to the target consumers (e.g., smartphones are readily available, but many consumers do not have access to virtual mirrors). Likewise, content needs to be specifically relevant to consumers (at least in a given context), indicating the need for a fit between the different components of the framework. For example, presenting a virtual couch on campus (vs. in one's living room) results in a low fit between the content and context (von der Au et al., 2023). As another example, the context and the computing device need to harmonize in terms of practicability

[2] Additionally, consumer engagement is fundamentally different from the user-engagement view that is predominant in the human–computer interaction (HCI) literature, where a simple interaction between an individual and a technology is often called engagement. Meaningful consumer engagement with a service provider's offering (i.e., a tangible good or service) needs to be managerially relevant by exceeding simple interactions with a set of technologies. For example, consider an individual scrolling through a social media feed (e.g., Instagram, TikTok, or Snap Chat). This activity, per definition, refers to a consumer interacting with technology. However, such an activity may be rather mundane and far from being engaging with the content or the content provider (Heller et al., 2021).

[3] Because the external factors listed in the corners of Fig. 1 are exogenous to the 4C framework, commenting in more detail on these factors is beyond the scope of the current research. However, future research may investigate how these external factors interact with the 4Cs in the practice of AR. Note: Icons used in Fig. 1 are taken from flaticon.com

(e.g., a handheld device would not be a good fit in dangerous situations where a user needs both hands free). Finally, the 4Cs are subject to external factors, including (but not limited to) a firm's or developer's objectives (e.g., a marketer increasing brand awareness or a museum educating visitors) and capabilities (e.g., budgets and market knowledge), macroeconomic and competitive environments (e.g., competitors' activities), and technological developments (e.g., battery efficiency or tracking technology) and infrastructure (e.g., high-speed mobile Internet).

## 3.2. Consumers

### 3.2.1. Demographics

We propose that demographic variables (such as age, gender, income, and education level, among others) represent a category of variables relevant to the *consumer* element of AR. The 4C framework proposes interrelations between demographic factors and other framework categories. For instance, different age groups and genders may prefer different types of AR content. Income can serve as an enabling or limiting factor to the adoption of specific *computing devices.* Likewise, social class can determine social *contexts* (e.g., specific work environments). However, the extant AR research has mostly treated demographic variables as control variables (e.g., Holdack et al., 2022; Rauschnabel et al., 2015). Hence, we argue that there is the potential to assign demographic factors a more active role in AR research and in the design of applications.

### 3.2.2. Trait and state factors

A consumer's personality is determined by biological, cognitive, affective, social, and interpersonal factors (Caprara & Cervone, 2000). Personality measures are primarily trait variables that are more stable over time than attitudes. Among the most comprehensive conceptualizations of personality are the "Big 5" personality traits, which consist of openness to experience, conscientiousness, extraversion, agreeableness, and emotional stability (John & Srivastava, 2001)—often discussed using the acronym OCEAN. These five factors have proven to be very stable when measured at different points in time for the same individual (Cobb-Clark & Schurer, 2012). Each of these broad dimensions incorporates sub-dimensions that represent more nuanced measures of personality. Research has shown that personality traits influence a variety of attitudes and behaviors, including preferences and perceptions, in the context of AR. For example, Rauschnabel et al. (2015) demonstrated that elevated levels of openness to experience and low levels of neuroticism correlate with higher levels of awareness about AR computing devices. Furthermore, their study illustrates that consumers exhibiting high levels of openness assess AR technology with an emphasis on functional outcomes. In contrast, extraverted individuals likely evaluate AR by focusing on its capacity to influence social aspects. Tabacchi et al. (2017) found that early adopters of the AR game Pokémon Go were introverted, with high levels of agreeability and conscientiousness. In the context of the 4C framework, we argue that personality traits can determine preferences within all four categories. For example, neurotic or introverted consumers may prefer content that supports interpersonal communication, whereas extraverts gravitate toward thrilling experiences. With regard to computing devices, extraverts might be more open to wearing cutting-edge and ambivalently stylish AR glasses in public, whereas introverts may prefer to use AR on "standard" smartphone devices. Likewise, introverts may prefer more private usage contexts where they are not observed by others, whereas extraverts could enjoy the attention of other individuals around them and cherish using AR in public.

Compound traits build upon basic personality factors and represent a second level in the personality hierarchy (Mowen, 2000). Metaphorically speaking, personality factors would be like different atoms from the periodic table, and compound factors would then be molecules (Credé et al., 2016). Compound factors are heavily influenced by an individual's social environment and culture (i.e., contextual factors). For instance, low levels of neuroticism combined with elevated levels of extraversion represent optimism, whereas low levels of neuroticism combined with high levels of extraversion and openness characterize thrill seeking (Hough et al., 2015). We posit that optimism and thrill seeking are examples of compound factors that can determine specific preferences for the content, context, and computing device. For example, thrill seekers would likely be more attracted to AR action games in a public setting.

### 3.2.3. Knowledge and familiarity

Adopting an innovation typically begins with awareness (i.e., knowing that an innovation exists) and how-to knowledge (i.e., specific knowledge regarding the proper use of an innovation) (Rogers, 2003). Human knowledge is stored in a semantic network structure in which pieces of information (nodes) are linked to other nodes (Anderson, 1981). These nodes can be objects, brands, attributes, or any entity that individuals have stored in their memory, including general ideas of what AR is or knowledge about specific AR use cases. Whenever a specific node is activated, associations between other nodes are also activated and "come to mind." Among more experienced AR users, more nodes become activated at the thought of AR, and more relevant knowledge is accessible to them. Therefore, individuals with high levels of usage experience would typically rely less on external cues, such as facilitating conditions (Alba & Hutchinson, 1987; Venkatesh et al., 2012), and they could experience AR more naturally. Based on these insights, we expect experienced users (due to their relevant network of nodes) to evaluate AR more positively, especially since they have more realistic expectations of AR capabilities. We also suggest that experienced AR users will have more positive attitudes toward AR in general (Rauschnabel, 2021; Schein and Rauschnabel, 2023), which may create a virtuous cycle leading to additional knowledge and familiarity through frequent use.

However, familiarity and knowledge—as well as related constructs such as involvement and interest—also impact the other categories of variables driving consumer engagement. For instance, consumers high in knowledge and experience with AR will likely have different expectations of content (including usability) than consumers with less experience. Specifically, we expect that generic content may lead to positive effects for less experienced consumers and be perceived as uninteresting by experts in a given area.

## 3.3. Content

The 4C framework proposes that three different AR content dimensions (utilitarian, hedonic, and social) influence AR-enabled consumer engagement. For all types of AR content, we follow the convention that content is merged with the physical world in real time and relates to a specific location, object, task, or even person (Rauschnabel, Felix et al., 2022). While AR content is primarily visual—in other words, digital information that the consumer can see—AR content can also address other senses, including sound, smell, touch, and taste if the AR computing device allows these functionalities (Gatter et al., 2022; Zhu et al., 2020). Thus, AR content can be multisensory and is not restricted to visual perception, even though this is currently the primary distinguishing feature of AR when compared to other sensory-enabling technologies (Petit et al., 2019). Importantly, AR content can be multidimensional and incorporate more than one of the three content dimensions. For example, many AR applications on social media project entertaining elements (e.g., spiders) on a user's face. Such filters tend to have little utilitarian value but provide a hedonic as well as a social experience because they can be consumed with others.

### 3.3.1. Utilitarian content

While AR is often associated with entertainment and hedonic experiences, prior research has shown that AR can generate important utilitarian benefits for consumers (Hilken et al., 2017). For instance, prior research has shown that enhanced product information is an important reason for consumers when they are considering trying out an AR application (Nugroho & Wang, 2023). AR-generated utilitarian benefits influence consumers' attitudes toward a brand and other managerially relevant outcome variables (Qin et al., 2021; Rauschnabel et al., 2019). For example, current smartphone-based AR applications from retailers, such as Target and IKEA, allow consumers to integrate virtual furniture into their physical living spaces before making a purchase decision, leading to positive app evaluations (Rauschnabel et al., 2019). This can be extended to include cosmetic products (e.g., lipstick, eyeliner, etc.), fashion items (e.g., shoes, apparel, jewelry), interior design (e.g., home office equipment, wall color), and food (e.g., a preview of a restaurant's menu). Utilitarian filters allow consumers to virtually "try" a product and experience its characteristics by interacting with its virtual counterpart in various ways. These utilitarian filters facilitate additional, context-relevant information about a product and thus drive decision comfort and consumer confidence (Heller et al., 2019a; Heller et al., 2019b; Hilken et al., 2020; Qin et al., 2021). However, it is important to note that the digital content that replaces a physical product needs to look realistic and as close to its physical counterpart as possible for it to achieve its intended purpose (Rauschnabel, Felix et al., 2022).

#### 3.3.2. Hedonic content

Hedonic AR content is designed to entertain (Ibáñez-Sánchez et al., 2022; Vieira et al., 2022), and the use of AR in a retail or service context enhances customer experiences by driving hedonic perceptions (Hilken et al., 2017; Javornik et al., 2022). Hedonic AR content can, for instance, include a branded AR background in a social media post, a brand mascot, or a fun feature in the customer's environment. For example, the Dutch bank ING developed an AR holographic avatar that claps each time a customer successfully finalizes a transaction on a mobile phone. Similarly, social media channels, such as Snapchat, include various entertainment-based AR filters. AR applied to gaming is perhaps the most widely known application of this technology. Pokémon Go burst onto cultural consciousness in 2016, but it was simply the latest in a long line of AR gaming applications extending back more than a decade (Kumparak, 2017; Rauschnabel et al., 2017). Robo Raid (for Microsoft Hololens) and First Encounters (launched with Meta Quest 3) are two games in which gamers shoot virtual enemies that hide in the gamer's actual environment (e.g., behind furniture). Gaming and gamification in other domains, including education and performance evaluation, are broad and potentially fruitful areas of development.

#### 3.3.3. Social content

Social content is designed to allow users to maintain existing or create new social relationships. Originally, social content was theoretically rooted in situated cognition theory (for a summary, see Hilken et al., 2017), which posits that individuals naturally follow a tendency to share their everyday experiences with family, friends, and peers. This is especially relevant in a business or service context, where experiences are inevitably social. For example, in an offline (i.e., brick-and-mortar) context, consumers often shop together and share experiences with each other. Similarly, in online contexts, consumers reach out to peers to receive reviews and experiences that inform a future product or service purchase. For example, consumers often share pictures or videos of products they consider buying with friends. Furthermore, AR content can be shared with peers by exchanging screenshots or videos of an AR experience. Hence, consumers rely not only on cues from their direct physical surroundings but also on social peers when contemplating a purchase (Chylinski et al., 2020). This social component is crucial for AR, as consumer decision-making and value perceptions often depend on social input (Carrozzi et al., 2019). While the social dimension may not be fully within the control of the designer of an AR application, "social" does not strictly refer to interactions between individuals and their avatars. Applications are increasingly using artificial intelligence to generate a perception of ersatz sociality, which constitutes an easy and painless substitute for social relationships with real people (Sheldon et al., 2011). For example, interacting with a "bot" (a non-playable character [NPC] in a game context) in AR applications will become increasingly indistinguishable from interacting with other humans.

**Table 1**
Content Positioning examples.

| Content positioning dimensions | Examples of manifest features managers can use to address this dimension | Example (low) | Example (high) |
|---|---|---|---|
| Utilitarian | User-friendliness, display complex information better/ easier than other media | AR art display | AR product visualizer |
| Hedonic | Gamification, entertaining content, user friendliness | AR product manual | AR face-filters on social media |
| Social | Allow users to experience content together; multiuser AR; social media connection; allow users to communicate with other users of the app. | AR navigation system | Multi-user AR game |

Together, as shown in Table 1, the utilitarian, hedonic, and social dimensions of AR content comprise the full AR content experience. Depending on the needs of the consumer and the experience that the retailer or service provider wants to enhance with AR, all three dimensions need not be present. For example, the IKEA app visualizes furniture products in the context of consumers' physical surroundings at home, and it is primarily utilitarian. However, some consumers might also perceive it as entertaining (hedonic) and/or use the app's feature to send pictures of the augmented living room to friends. In contrast, an AR application low in utilitarian content dimensions could be an AR art display. This type of application would allow users to see digital art installations as part of their real-world environment. While it may enrich the aesthetic experience by allowing users to visualize art in various settings, it serves little utilitarian function beyond entertainment and visual enjoyment. Similarly, AR face filters on social media platforms, such as Instagram, Snapchat, and TikTok, primarily represent hedonic content that can also be shared with other users for entertainment. Thus, varied personalities and consumption contexts may trigger how specific AR content is perceived.

### 3.4. Context

The context in which AR content is consumed is an often-overlooked factor that drives consumer engagement. Physical, situational, and social contexts can have substantial effects on AR outcomes. As all value creation is contextual (Heller et al., 2021), the impact of context cannot be overstated.

#### 3.4.1. Physical context

The registration of augmented content in the surrounding physical world is one of the key issues driving perception and engagement in AR (von der Au et al., 2023; Zhu et al., 2015). Integrating augmented content with physical content is a limiting factor, as less sophisticated AR technology often struggles with identifying floors, dealing with uneven lighting conditions, and defining adequate spatial anchors. Legacy AR applications and hardware have struggled with comprehending, mapping, and rendering physical surroundings, and contextual factors impact how fluently virtual content is integrated with the real world, as perceived by the user (Peddie, 2017). Future technological developments (such as spatial computing or pervasive AR) can potentially address issues with the registration of physical and augmented content, as this will positively impact consumer experience and user engagement along with perceptions of quality.

Scholz and Duffy (2018) argue that the AR experience is not limited to the device, but it also includes a user's "domestic space" (p. 12). Because consumers perceive the physical environment jointly with the augmented information, consumers can create an augmented physical environment that resembles a dream world of fairy tales, dragons, art, and wild animals that only they can see (Rauschnabel, 2018). When consumers process information about their physical context (e.g., one's family room), it can activate mental representations associated specifically with the physical context (e.g., family). By adding virtual elements through AR to the physical context (e.g., AR family photos attached to walls), consumers cognitively combine and integrate these information schemes with each other (Anderson, 1981).

The degree to which virtual content cognitively and logically fits into the physical environment impacts the consumer's processing effort. Because individuals often form judgments based on "the ease with which instances or associations come to mind," congruent data will likely be processed more favorably (Tversky & Kahneman, 1973, p. 208). These insights reveal several potential paths to consumer engagement through the physical context. First, a high logical fit between virtual elements and the physical environment typically leads to high processing fluency (Lee & Labroo, 2004), which in turn should increase AR-enabled consumer engagement. Second, virtual content that is incongruent with or challenging to integrate into the physical environment (such as dragons and other non-existing creatures, as discussed in Rauschnabel et al.'s [2018] study) may lead to disfluency in information processing. However, as evidenced by Alter (2013), disfluency can produce positive outcomes when it prompts consumers to process information more carefully and deeply. For example, an emerging stream of AR research has shown that new and unexpected information may drive consumer engagement through novelty and awe (Hilken et al., 2017). Third, as shown by von der Au et al. (2023), a matching context (e.g., experiencing a couch in one's living room vs. on a university campus) can increase plausibility perceptions with positive downstream consequences (e.g., purchase intentions of the couch). However, since there are often similar "real" (i.e., physical) products in a matching context, consumers can compare them and will likely recognize that the virtual products presented through AR applications are artificial, as reflected by lower levels of local presence (von der Au et al., 2023). Likewise, Pfaff and Spann, (2023) showed that messy (vs. clean) physical environments can have detrimental effects on an AR experience.

#### 3.4.2. Situational context

Prior research has consistently shown that the situational context influences the individual jointly with many other factors (Conway, 2001). Situational context has been theorized to drive behaviors following an encounter along three dimensions: pleasure, arousal, and dominance (Mehrabian & Russell, 1974). Situational factors are temporal cognitive states or emotions that influence the perception of AR and thus alter engagement, and they affect AR processing at any given time within a given context. Unlike demographic or personality variables (cf. section 3.2), which are inherently more stable, situational factors can change within seconds.

For example, when using AR in a hectic or stressful situation (i.e., under high arousal and low dominance), consumers' expectations about the information they receive through AR will most likely differ when compared to more laid-back (i.e., low arousal and high pleasure) situations (cf. Hoffmann et al., 2022). For instance, when playing a game, browsing a brand's products through an AR app, or consuming AR content about a potential holiday destination, users may not have specific expectations of either the content or how it is presented. Thus, downloading and installing an app or investing time in understanding how an app works may not be a limiting factor in this situational context. In contrast, when AR is used to support decision-making in real time (e.g., deciding on whether to buy a product or not), consumers search for relevant content under time pressure. Thus, consumers may not be able or willing to install and learn a new AR app, and a simpler form of AR displayed using a web browser (web AR) might be preferred in this context.

#### 3.4.3. Social context

Finally, the social context dimension also impacts AR engagement. It is important to understand how consumers interact with each other through and around AR technology (Carrozzi et al., 2019). Several studies have shown that AR impacts not only the consumer but also others surrounding the consumer (i.e., bystanders). For example, Rauschnabel et al. (2019) showed that potential threats to other people's privacy decrease the acceptance of AR technology because certain AR applications are capable of recognizing and tracking the faces of individuals. In addition, Rauschnabel (2018) showed that gratifications driving the usage intention of AR differ between public and private contexts. This implies that people are seeking different benefits when using AR alone versus when surrounded by other people. In fact, there are two dimensions of social context that matter in AR. Co-presence involves interacting with an AR application at the same time as others, and this requires persistent AR information. That is, AR information must persist temporally and spatially to allow others to interact with the material (Bachras et al., 2019). The other social context dimension involves co-experience in which other users can not only perceive the same information simultaneously but can also interactively alter, co-create, and share the AR experience at the same time (Battarbee & Koskinen, 2008).

Complicating the social context factor is the fact that it may become increasingly difficult for consumers to differentiate between interacting with others persons (or their potentially photorealistic avatars) and interacting with an NPC. Artificial intelligence (Huang & Rust, 2021) and machine learning (Volkmar et al., 2022) are being increasingly deployed across disciplines, and are expected to have a substantial impact also on AR.

### 3.5. Computing devices

The computing device on which an AR is presented to consumers impacts its perception and effectiveness. For instance, handheld devices prevent consumers from experiencing AR content hands-free (which can negatively impact the overall experience), and a wearable AR device may not allow consumers to augment themselves as they can with a stationary virtual mirror. The ubiquity and availability of a device (e.g., smartphones vs. AR smart glasses) can restrict usage among certain consumer groups. The type of device also influences how consumers process AR experiences. For example, ergonomic factors may impact how consumers experience AR content in wearable devices, whereas these factors are usually less important for stationary devices. Several different types of devices can employ AR content with different benefits and limitations. Drawing on prior research (Grubert et al., 2017; Rauschnabel, 2018), we classify computing devices as stationary, mobile, or wearable (Table 2).

#### 3.5.1. Stationary devices

AR content displayed on stationary devices, such as large screens in public spaces or smart mirrors in retail stores, allows for a large, first-person view, which has been described as the augmented self (Javornik et al., 2021). These devices have advantages due to their large screens and general hands-free use. They typically have a single purpose (such as providing consumers with the opportunity to try on clothing at a retail fashion store) and thus can be customized to the physical context (e.g., a specific location in a specific store) and specific consumer needs.

Stationary AR devices are typically owned and managed by organizations (e.g., in public spaces or retail stores), which impedes targeting consumers at home or in other, more private environments. In public spaces (for example, shopping malls or airports), they may have positive effects on managerially relevant downstream variables, such as attitudes and consumer engagement (Baek et al., 2018). Designed for specific purposes, they enable consumers to explore various products (e.g., fashion) in a short period of time with low effort, and thus potentially inspire them by testing products they might typically not consider.

**Table 2**
Common computing devices for augmented reality and their core characteristics.

| Characteristics | Stationary AR | Mobile AR | Wearable AR |
|---|---|---|---|
| Status of technologies as of 2023 | Established | Established. Improved tracking and mapping due to new sensors and algorithms | On the rise as an enterprise AR in the form of headsets. Still futuristic as a consumer technology |
| Examples | Smart mirrors | AR apps for smartphones and tablets, or AR accessed over a browser (web AR) | Headsets (e.g., Apple Vision Pro, Meta Quest 3, Microsoft Hololens) |
| Usage duration | Short time, only while a person is close to the device | Several minutes | Whenever a person can wear glasses |
| Functionality | Video see-through | Video see-through | Video or optical see-through |
| Technological Embodiment | Very low | Low | High |
| Advantages | Large screen. Hands-free experience (no need to hold a device). User can see him/herself. Generates attention | High prevalence of devices (e.g., smartphones). Familiarity with the system and its interaction techniques | Can be used hands-free and usually includes more and better sensors than most mobile devices |
| Disadvantages | Cannot be used in private/intimate situations. Usage is often visible to others in public spaces. Limited customization because stationary AR devices are typically owned by others (e.g., shops). Negative reactions of bystanders possible | Requires substantial user attention, such as holding the device in one hand. Users clearly see that AR content is on the screen and not in the real world. No stereoscopic 3D effects | Still an expensive early-stage technology, often struggling with technical issues. Social acceptance may still be low. No mirror function is available (e.g., difficult to alter oneself). Video-see-through solutions may be perceived as less real and induce fear among users. Optical see-through struggles to create large fields of view or high-contrast effects. |

### 3.5.2. Mobile devices

Almost all modern mobile devices, such as smartphones and tablets, contain the sensors and processing power that AR requires (such as cameras, tracking algorithms, etc.), yet most are currently employed in a rudimentary fashion. More advanced devices include specific depth sensors (e.g., time-of-flight cameras; light detection and ranging [LiDAR]) that allow tracking of the real world in more detail. Mobile devices are restricted to video-see-through AR and typically require at least one hand to hold and operate the device.

Because there is nearly 100% penetration of mobile devices in developed markets, the number of mobile AR applications is expected to increase substantially in the years to come. For marketers, mobile AR applications can complement print ads with interactive content, visualize products, or extend physical products with virtual layers. The extant literature mainly reports positive effects on managerially relevant downstream variables. For example, Poushneh and Vasquez-Parraga (2017) find that consumers using the Ray-Ban virtual mirror on their smartphones show higher levels of satisfaction and willingness to buy, as compared to consumers browsing through a traditional product website from the same company. Furthermore, a recent field study of an international cosmetics retailer showed that AR usage on the retailer's mobile app increased sales of more expensive products and less popular brands and attracted consumers who were new to the online channel (Tan et al., 2022). However, a potential disadvantage of mobile AR is that the device itself can reduce technological embodiment along with perceived local presence.[4] Specifically, see-through applications on smartphones or tablets (as compared to a self-view) may impair the experience because users can easily see real-world surroundings outside of the screen and be distracted from experiencing the augmented virtual and real content on the screen while holding the device in position.

### 3.5.3. Wearable devices

The most common forms of AR wearables are headsets, also referred to as AR smart glasses (ARSGs), mixed reality headsets, or head-mounted displays. They are worn as regular glasses and integrate virtual content into a consumer's field of view (Kalantari & Rauschnabel, 2018; Ro et al., 2018). These devices (e.g., Apple Vision Pro, Magic Leap One, and Microsoft Hololens) are specifically made for AR and include multiple cameras and depth sensors to track the physical environment. Such wearables can contain optical see-through displays that show virtual content directly in front of the consumers' eyes in such a way that they perceive it as being integrated with the real-world content (e.g., Microsoft Hololens). Alternatively, video see-through displays provide a live stream of the real world and integrate virtual content in real time (e.g., Apple Vision Pro, Meta Quest Pro, and Meta Quest 3). Because prices are still high and the devices are in an early stage of development, wearable AR devices are not yet a ubiquitous technology for consumers. However, the global AR market size was valued at USD 38.56 billion in 2022 and is expected to grow at a compound annual growth rate (CAGR) of 39.8% from 2023 to 2030, with the major share of this growth driven by AR wearables (Grand Vision Research, 2022). Furthermore, the development of AR wearables that provide an even more immersive experience for consumers, such as AR contact lenses, will without a doubt have a substantial impact on the industry.

## 4. Relationships among and interplay of the 4Cs

Drawing on configurational theory, the 4C framework places particular emphasis not just on each of the categories in isolation but on the interplay and alignment of the fundamental factors of AR. Discussing all the overlaps is beyond the scope of this article, and Table 3 presents prototypical combinations of the 4Cs that will potentially lead to either high (1A–1D) or low (2A–2D) AR-enabled consumer engagement. The main takeaway from Table 3 is that, following the premises of configurational theory (Fiss, 2007; Fiss et al., 2013; Meyer et al., 1993), the 4Cs do not maintain a linear relationship with AR-enabled consumer engagement, in which "more" of a factor will automatically contribute to an increase in engagement. Rather, several avenues can potentially lead to high consumer engagement through different combinations of the 4Cs. High levels of engagement can emerge from the alignment of these fundamental factors of AR, regardless of whether this alignment is the result of purposeful efforts by management or a serendipitous occurrence. However, there are also configurations in which such an alignment among the 4Cs is missing, resulting in low expected consumer engagement. In the remainder of this section, we provide additional insights into a selection of the 4C configurations shown in Table 3.

Configurations 1A–1D are expected to lead to high AR-enabled consumer engagement, while configurations 2A–2D are likely to produce low engagement. In configuration 1A, the public (vs. private) context aligns well with a consumer's personality traits, the hedonic content (e.g., fashion apparel), and the AR computing device, ultimately

[4] Compare Rauschnabel, Felix et al. (2022) for a discussion of local presence in AR.

**Table 3**
Augmented reality: Prototypical configurations for the 4C dimensions.

| Configuration | Consumer | Content | Context | Computing device | Expected AR-enabled consumer engagement |
|---|---|---|---|---|---|
| 1A | Extrovert/high openness to experiences | Hedonic (fashion-oriented) | Public | Stationary AR mirror at clothing retailer | High |
| 1B | High AR knowledge/familiarity | Utilitarian (guide for decision making) | Private | Wearable | High |
| 1C | Young/extravert/open to experiences/ high AR knowledge/familiarity | Social | Public | Mobile (smartphone) | High |
| 1D | Open to experiences/high AR knowledge/familiarity | Utilitarian | Business application (e.g., assembly line) | Wearable | High |
| 2A | Introvert/low openness to experiences | Hedonic (fashion-oriented) | Public | Stationary AR mirror at clothing retailer | Low |
| 2B | Low AR knowledge/familiarity | Social | Time constraint | Wearable | Low |
| 2C | Older/low openness to experiences/ high conscientiousness | Hedonic | Business application (e.g., assembly line) | Mobile (smartphone) | Low |
| 2D | Younger/extravert/open to experiences/neurotic | Utilitarian | Physical restrictions (e.g., lack of space, insufficient lightning) | Mobile (tablet) | Low |

facilitating high engagement. In configuration 1B, virtual content shown in the glasses is informative and utilitarian, which, in combination with the other three categories, leads to high consumer engagement. In configuration 1C, high congruency among the 4Cs leads to high AR-enabled consumer engagement. Finally, in configuration 1D, the content shown in the smart glasses is instructive and informational, which aligns well with the worker's characteristics and needs, thereby producing high engagement.

In contrast, we predict comparably low AR-enabled consumer engagement for the prototypical configurations 2A–2D. In configuration 2A, the consumer using the device is introverted and has a low openness to experiences, which clashes with the hedonic content and public context of the situation, leading to low consumer engagement. Configuration 2B places a consumer under time constraints (e.g., the consumer may also need to fulfill household chores or go to work), which will likely lead to low consumer engagement driven by feelings of anger and frustration. In configuration 2C, an AR app provides content that is extremely high in hedonic stimulation, and a lack of fit among the 4Cs will lead to distraction and low consumer engagement. Lastly, configuration 2D is characterized by suboptimal space and lighting conditions, which represent situational factors that frequently impede AR apps from accurately recognizing the physical environment, resulting in misalignment among the 4Cs in this configuration, and in turn, leading to low AR-enabled consumer engagement.

These prototypical configurations demonstrate that higher levels of each category are not necessarily better. The value of each is dependent and contingent on each of the other categories in the framework. For example, consumers with a high level of AR knowledge and familiarity will likely struggle less with novel AR applications, but there are configurations of the 4Cs that can engage consumers with low levels of AR experience and knowledge. Similarly, hedonic and/or social AR content (as opposed to utilitarian AR content) can be successful for some consumer segments and fail miserably for others.

A key takeaway of our framework is that both researchers and practitioners should not focus on any of the 4Cs in isolation. Instead, prototypical configurations of the 4Cs should be explored and documented. As the complete body of AR research builds and coalesces, principles that effectuate generalizations among the 4Cs are likely to emerge. However, as the academic literature progresses to empirically link these prototypical configurations, managers should think in terms of the 4Cs as a framework rather than trying to optimize the individual elements of AR in isolation.

## 5. Discussion

The emerging AR research landscape is highly fragmented, with most studies tackling niche topics from the perspective of a single discipline. Thus, a comprehensive framework is needed to synthesize and systematically assess published research, aid in the planning and conduct of future research, guide the development of practical AR projects, and stimulate conceptualizations of AR as configurations of critical elements that must be aligned. Starting with the definition of AR, this article conceptualizes AR engagement as being driven by complex and interrelated systems dependent on the consumer, context, content, and computing device. By incorporating multiple perspectives through the lens of configurational theory, this research proposes the new 4C framework, in which four broad categories of elements drive AR. Most importantly, more emphasis on any one of these categories is not necessarily better; it is the interplay of these 4Cs that determines the level of success derived from AR initiatives. Our framework makes multiple important contributions to AR theory and practice.

### 5.1. *Theoretical contributions to augmented reality research*

The current article articulates a general framework for a holistic understanding of AR engagement. The framework makes an identification contribution (MacInnis, 2011) by outlining four categories of factors: the 4Cs, consisting of the consumer, content, context, and computing device. This interplay of the 4Cs determines the experience and perception of AR, resulting in consumer engagement. In contrast to existing frameworks, the 4C approach is not rooted in one specific theoretical domain; rather, it is grounded in a broad interdisciplinary definition of AR. Hence, the 4C framework is conceptualized at a higher level of abstraction. First, a key contention of this approach is that, depending on the study or implementation background and objectives, scholars and practitioners must identify relevant variables and their interplay across all 4Cs (and their intersections). For instance, when studying how consumers evaluate specific content in a given context, local presence (i.e., a construct that describes the degree to which consumers perceive the virtual content as being actually "here" [Rauschnabel, Felix et al., 2022]) would constitute a link between the content and physical contexts and thus be potentially relevant (Pfaff & Spann, 2023; von der Au et al., 2023). In sum, when conducting future AR research, the 4C framework can guide scholars throughout the process. For instance, by applying qualitative pre-studies, scholars might identify relevant variables for the categories that matter. Finally, when reporting research designs, relevant aspects of all four categories should be discussed and potentially controlled.

Second, this framework focuses on AR and its various sub-forms (e.g., assisted reality and mixed reality) that are distinct from concepts such as virtual reality (Rauschnabel, Felix et al., 2022). Many of the assumptions in our framework are unique to AR, especially when looking at the level of the various subcategories; however, the main ideas may also be extended to other technologies. For instance, stimulating configurational thinking in general could be relevant for understanding artificial intelligence and the Internet of Things (IoT). Furthermore, our study also contributes to technology acceptance and user experience (UX) research in general by providing new perspectives on the "recipes" for high consumer engagement. In this vein, it is important to note that many other frameworks and theories implicitly propose that specific variables are "always" relevant. For example, technology acceptance theories typically argue that utilitarian benefits directly shape user reactions. The 4C approach suggests a more nuanced approach that is dependent on each of the 4Cs and their interactions.

Third, the 4C framework represents an integration contribution (MacInnis, 2011) by aligning human factors in AR with content, contextual, and technology factors that impact research across many disciplines. This can facilitate the identification of research gaps when developing theoretical models applicable to AR. Because the 4C framework has a specific emphasis on the interdependencies among the four categories, it encourages scholars to pay particular attention to these interactions. From a methodological perspective, uncovering moderators or mediators, as well as latent heterogeneity between independent variables (e.g., using latent class analysis models or similar clustering techniques; cf. Vermunt & Magidson, 2002), represents a potential avenue for future research. Likewise, case studies and qualitative work (e.g., in-depth interviews or ethnography) can compare different AR experiences and uncover patterns associated with the 4Cs. Empirical studies based on configurational theory have been successfully used in this way, as they typically use fsQCA. Specifically, this approach applies Boolean algebra to identify different equifinal "causal recipes" that drive certain outcomes (e.g., a very high level of AR engagement).

Finally, the 4C framework contributes to the AR discipline by providing a high-level theoretical framework for understanding how people engage with AR. Moving from specific constructs to categories of variables (i.e., the 4Cs) provides a starting point for scholars to identify specific variables and their interrelationships for research topics (e.g., through qualitative research). As the current research shows how crucial the interplay of the four categories is, researchers working in the field of AR should consider them holistically when designing studies—and systematically report methodological decisions along the 4Cs (Who were the respondents? Where was the study conducted? What kind of content did they experience? What computing devices were used for evaluation? And, most importantly, how might these methodological decisions affect the conclusions?).

### 5.2. Implications for the management of augmented reality

Managers have shown a keen interest in using systematic frameworks to develop ideas. For instance, the business model canvas (BMC) proposes that business models can be described and developed based on nine relevant categories, and this model has received significant attention in both business education and practice (Keane et al., 2018). Whereas the BMC is dedicated to the structuring of an overall business, the 4C framework allows managers to focus on the development and assessment of AR applications within a specific organizational context. The 4C framework suggests that AR-enabled consumer engagement is dependent on an interplay of variables from all 4C categories. For example, providing AR content that merges augmented content with the real world can trigger inspiration and other hedonic benefits (Rauschnabel et al., 2019), a flow experience (Barhorst et al., 2021), or other factors, such as purchase-decision comfort (Hilken et al., 2017). Likewise, the features of the computing device determine how well a technology can track, understand, and augment the physical environment. Finally, individual consumers may interpret content differently. For instance, an experienced user operating within a given product category may perceive product-related content as useless, whereas another user with less product knowledge might appreciate the utilitarian value provided by an AR app. Similarly, depending on the specific context (e.g., work vs. leisure), an individual consumer can perceive the same content as either interesting or boring.

It is important to note that many AR applications are launched by organizations (e.g., consumer brands, companies, NGOs, governments, destinations, bands, movies, etc.) to interact with a variety of internal and external stakeholders. This professional use of AR is broadly defined as AR marketing (Chylinski et al., 2020; Rauschnabel, Babin et al., 2022). Depending on the strategic AR business objectives of organizations (e.g., driving sales, improving brand image, generating loyalty, employer branding, or improving public relations), managers need to identify a content strategy that defines not only the AR content but also the role of the brand (e.g., a strong focus of the brand or not) and the goals of the organization. These decisions should be based on the purpose of the AR application and a careful assessment of what consumers desire or expect in the contexts in which they will encounter the AR.

The 4C framework can also guide the development of practical AR projects. Managers can adapt the framework to their specific needs and objectives (for example, by using specific sub-categories) and assess and plan their strategies by aligning the 4Cs. For instance, rather than simply asking "who is the target group," they may also want to ask "in which context will the AR project be used," "what content is appropriate for that," and "can our target groups' devices display this content or is there a need for a different presentation approach."

### 5.3. Avenues for future research

This article suggests a new framework for thinking about AR engagement in terms of four broad categories and their interplay. Future research is needed to measure many of these constructs in an AR environment. For example, metrics for the computing device may appear simple at first. That is, one may think in terms of screen size or number of pixels when considering computing devices. However, while this might be meaningful for smartphones, tablets, and computer screens, such an approach does not take into account other emerging devices providing AR experiences, such as smart glasses (headsets) or more immersive technologies.

Future research should also explore the interplay between AR-enabled consumer engagement and other forms of engagement, such as brand engagement in marketing (Hollebeek, 2011), tourist engagement in hospitality and travel research (Lin et al., 2022), and student engagement in pedagogical research (Reyes et al., 2012). The boundaries between AR-enabled consumer engagement and other forms of engagement present rich opportunities for exploration. This research should also explore the degree to which AR-enabled consumer engagement facilitates or leads to managerially relevant outcome variables, including brand commitment and purchases.

While the 4C framework focuses on AR, as mentioned above, the basic ideas and tenets outlined in our work may also apply to other forms of immersive and innovative technologies (at least to some extent). Defining when and where these tenets hold with respect to related technologies should be a fruitful sector of future research. The optimal configurations of the categories in AR may transfer to related technologies, such as VR, the metaverse, and spatial computing applications, and future research should explore these possibilities (cf. Hennig-Thurau et al., 2023). The published research on each of these tangentially related technologies is at a different stage of development, and these streams of research might inform AR research, and vice versa. For example, recent research on the metaverse has focused on the potential negative societal impacts of this technology (Dwivedi et al., 2023). Similar research could focus on negative impacts associated with any of the 4Cs, or, more importantly, negative outcomes that might result at the intersections of the 4Cs.

Finally, both AR managers and scholars alike should monitor recent advancements in AR. The AR concept is in constant flux, and technologies and approaches are evolving quickly (Heller et al., 2023; Pfeifer, Hilken, Heller, Alimamy, & Di Palma, 2023). According to the 4C framework, changes in the context, consumer groups, content, or computing device being used all impact AR engagement. Thus, the framework can guide scholars to more effectively categorize and study items that might impact future AR initiatives.

## 6. General conclusion

As we move into an era of "metaverse" or "spatial computing" where the boundaries between the physical and digital worlds are increasingly blurred, AR is emerging not just as a technological trend, but as a fundamental part of our future lives. The 4C framework can be adapted and used by scholars and managers by considering AR through a complex interplay of the 4Cs. We hope that the 4C framework will help to better understand and shape these developments.

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## CRediT authorship contribution statement

**Philipp A. Rauschnabel:** Conceptualization, Project administration, Resources, Writing - original draft, Writing - review & editing. **Reto Felix:** Conceptualization, Project administration, Writing - original draft, Writing - review & editing. **Jonas Heller:** Conceptualization, Project administration, Writing - original draft, Writing - review & editing. **Chris Hinsch:** Conceptualization, Project administration, Writing - original draft, Writing - review & editing.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

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