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ORIGINAL EMPIRICAL RESEARCH

Unpacking augmentation quality and local presence: Factors that drive effective augmented reality marketing

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Abstract
Augmented reality (AR) integrates virtual content into consumers' physical environment. Although research suggests that consumers' perceptions of augmentation quality—the perceived merge of the virtual and real world—affect relevant consumer variables, the literature has not developed a comprehensive measure that adequately captures the construct nor integrated it meaningfully with theory-relevant outcomes. Grounded theory and standard scale development procedures are applied to understand what comprises perceptions of augmentation quality and how to measure it to distinguish low- from high-quality AR-marketing attempts. The findings suggest that quality perceptions in AR consist of a second-order factor, augmentation quality, represented by three first-order factors (design, interaction, and embedding quality). In addition, this research demonstrates that high augmentation quality creates a sense of local presence, i.e., the *sensation* that the augmented object experienced with AR is real and present to the consumer. The research then theoretically integrates these factors into a more comprehensive model, tying it firmly into the nomological net. In particular, augmentation quality—mediated by local presence—affects utilitarian and hedonic outcomes as well as behavioral actions. Managerial implications for understanding and using AR marketing are presented.

Keywords Augmented reality · Augmentation quality · Local presence · Scale development · Shopping experience

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Introduction

As the morning sun streams through her window, Liz indulges in her daily online browsing ritual. Today, her quest is for the perfect pair of sunglasses. A website catches her eye, promising an "AR" shopping experience—a virtual try-before-you-buy. Intrigued, she holds her smartphone in front of her face. The phone becomes a "virtual mirror" and depicts her face with digitally displayed sunglasses in real-time. With each virtual try-on, Liz enthusiastically evaluates how each pair of sunglasses complements her facial features and reflects her persona. At this moment, Liz embodies the modern consumer, immersed in this innovative experience presented by augmented reality (AR) that merges virtual objects with physical environments, offering a "metamodern customer experience" (Plangger et al., 2022).

The vignette illustrates AR marketing's potential. As AR technology grows more sophisticated, marketers are increasingly intrigued by its ability to enhance customer experiences in engaging and useful ways (Fritz et al., 2023). Existing research demonstrates AR's impact on key marketing constructs, including in-store experiences, purchase intentions, customer creativity, and positive word-of-mouth behavior (e.g., Fritz et al., 2023; Hoffmann et al., 2022; Jessen et al., 2020). Clearly, AR represents a potentially powerful marketing tool (Plangger et al., 2022; Wedel et al., 2020) and managers face increasing pressure to keep up with AR technologies (De Keyser & Van Vaerenbergh, 2024).

However, AR experiences are not always value-enhancing. Imagine that the AR application described above only partially displayed the sunglasses, or the sunglasses were out of scale, appearing too small or too large. The core benefit of AR marketing is enabling consumers to see objects in their intended environment (Elder & Krishna, 2022; Kumar et al., 2024; Schmitt, 2019). Thus, a positive AR outcome depends strongly on the quality of integration of virtual content into one's real world (e.g., Hilken et al., 2017; Rauschnabel et al., 2024). Research has yet to adequately conceptualize or operationalize precisely what perceptions of "augmentation quality" are, how consumers experience augmentation quality, and what makes augmentation quality relevant. In this context, three important issues are addressed in this paper.

First, no study systematically specifies what a high-quality AR experience entails or how it is experienced. One objective of this research is to provide a detailed conceptualization of how consumers perceive the ability of AR apps to augment their physical environment, and to elucidate the consumer AR experience. Here, we show that consumers evaluate the quality of virtual elements displayed in their physical environment based on three perceptual, tangible qualities: *design quality*, *interaction quality*, and *embedding quality*. These three factors manifest a second-order factor that we call *augmentation quality*, i.e., consumers' perception of the technical qualities of an AR experience. The higher the perceived augmentation quality, the stronger the sense of *local presence*, an abstract variable capturing the sensation that virtual objects experienced with AR are real and present. Thus, the research contributes to the literature by offering a definition of AR quality that is AR-specific and not adopted from other domains.

Second, the literature lacks a scale to measure AR marketing quality. A second objective is providing a scale specific to AR for assessing its quality. Previously, researchers borrowed measures from other media (e.g., Hilken et al., 2017; Smink et al., 2020), often virtual reality (VR). However, VR and AR are quite different. One of the primary differences being that AR does not transfer one to another reality (Wedel et al., 2020). The measurement scale introduced and validated here consists of AR-specific indicators and factors that consumers use to evaluate perceived augmentation quality and the sensation of local presence, the virtual object seemingly transported to them as a result. A second contribution is a practical scale to assess AR quality.

Third, the process by which augmentation quality affects relevant marketing outcomes is not well understood. A third objective of this research is to provide theoretical justification and empirical evidence for the important role of augmentation quality in explaining managerially relevant outcomes, including information value and hedonic benefits, purchase intentions, intention to reuse AR, and behaviors associated with its usage. While several studies compare the effects of AR with non-AR product presentations (e.g., Hilken et al., 2017; Rauschnabel et al., 2024), this paper emphasizes that AR does not equate with improved customer experiences; rather, the outcome of deploying AR depends on the degree of augmentation quality. In addition, previous AR research focuses on retailer or app-related outcomes (e.g., purchase intentions). However, the effects of AR on different outcome variables need to be distinguished. The framework illustrates how AR marketing creates value directly through experience and by helping consumers understand what products are right for them, leading to sales. Our model proposes that local presence mediates the effects of augmentation quality on relevant outcome variables, that is, augmentation quality drives positive marketing outcomes substantially to the extent that consumers feel that the virtual object is actually real and present. Thus, a third contribution lies in tying AR marketing into a meaningful nomological net.

The remainder of the paper presents five studies. The first four studies conceptualize, explore, identify, and validate quality perceptions in AR and its measurement. These four studies address the first and second research objectives and involve qualitative research (Studies 1 and 2) and quantitative research (Study 3, $N = 350$ and Study 4, $N = 320$). In Study 5 ($N = 175$), we incorporate the constructs of augmentation quality and local presence into a theory-based framework and demonstrate its effects, thereby addressing the third research objective. Overall, this research provides insights into how combining the real and virtual worlds helps create value for marketers and their customers. Above contributions to the literature, the results provide practical managerial advice.

Prior research

Augmented reality

AR has been defined in numerous ways, typically in reference to the augmentation of the real world with computer-generated content, interactively and in real-time (Azuma, 2001; Rauschnabel et al., 2022b). One of the most widely accepted definitions is from Azuma et al. (2001), emphasizing the co-existence of the virtual and actual in the same space; the definition also depicts the embeddedness of AR in real-time and the technology's interactive character. Here, we highlight the literature and identify practically and theoretically relevant issues needing further research.

The integration of digital content into a user's physical environment is AR's unique feature and distinguishes it from other media, such as VR, video, TV, or newspapers (e.g., Wedel et al., 2020). Because users still see and experience their physical environment in an AR application, they are not isolated from the real world; rather, the real environment and virtual content merge into a hybrid, "phygital" experience (Kumar et al., 2024; Tan et al., 2022). Thus, AR represents a different experience than does VR. With VR, users find themselves virtually in an entirely artificial environment (Hennig-Thurau et al., 2023). Hardware devices, such as Apple Vision Pro, Meta Quest 3, or Microsoft HoloLens, can be used for both AR and VR. However, consumers can also experience AR via smartphones or tablets.

Two primary modes of interaction exist with AR: on-body AR and in-room AR. On-body AR refers to AR experiences that augment the user's body with virtual content, typically through a "virtual mirror." Snapchat filters are a typical example of on-body AR (Flavián et al., 2019). Further, L'Oréal ("Makeup Genius") and the spectacles retailer Mister Spex (on their website) provide on-body AR solutions that allow consumers to experience their products as if they were wearing them. In-room AR allows users to place virtual products in their physical environment, as seen in applications like IKEA Place, where users can visualize virtual furniture in their own rooms, or Dulux Visualizer, where users can "paint" their walls in different colors. Both forms of AR have significant implications for marketing by enabling consumers to assess fit and style before making a purchase and creating a personalized and immersive experience (Flavián et al., 2019; Kumar et al., 2024).

Numerous brands, including Amazon, IKEA, Nike, Sephora, and VW, have deployed AR to potentially improve and enrich customer experiences. Despite great managerial potential and interest, surveys among managers still indicate that a lack of knowledge of AR, including understanding what contributes to a "good" AR experience, remains a major concern when considering investments in the technology (Plangger et al., 2022; Rauschnabel et al., 2022a). In this respect, AR shares commonality with other innovations in the digital economy that remain understudied (Sorescu & Schreier, 2021).

The relevance of augmentation quality and its effects

Existing research on AR explores its impact on key consumer constructs, examining how AR content can evoke hedonic and utilitarian experiences (e.g., Hilken et al., 2017; Yim et al., 2017), inspire consumers (e.g., Rauschnabel et al., 2019), induce flow experiences (e.g., Barhorst et al., 2021; Javornik, 2016), and affect important outcomes such as brand attitude (e.g., Smink et al., 2020), intention to reuse (e.g., Daassi & Debbabi, 2021; Javornik, 2016), word of mouth (e.g., Hilken et al., 2017; Javornik, 2016), purchase intentions (e.g., Hilken et al., 2022), and in-store marketing effects (e.g., Hilken et al., 2018). Thus, previous research demonstrates that AR can positively affect various relevant consumer variables. However, not surprisingly, the literature also suggests that positive effects depend on the quality of the integration of virtual content into the real world (e.g., Hilken et al., 2017; Smink et al., 2020). Considerable research, especially from computer science and human–computer interaction fields, describes how AR makes virtual content appear as real objects. Research areas include the use of virtual lighting (Agusanto et al., 2003), shadows (Sugano et al., 2003), and real object occlusion (Breen et al., 1996), to create digital objects that appear to be physically present (Stevens & Jerrams-Smith, 2000). Furthermore, consumer research shows a growing interest in the core question of how consumers perceive the combination of virtual content within the real world and suggests that high-quality augmentation is crucial for positive AR experiences (e.g., Daassi & Debbabi, 2021). With a high-quality AR experience, consumers easily imagine products (Hilken et al., 2020, 2022), visualize alternatives (Tan et al., 2022), feel inspired (Zanger et al., 2022), experience flow (Javornik, 2016), and develop positive emotions toward both app and brand (Rauschnabel et al., 2024; Smink et al., 2020).

How prior research has conceptualized and measured augmentation quality

Prior research has taken different perspectives to conceptualize how consumers process the augmentation of the physical environment with virtual content in AR. To better understand AR marketing, we assessed the key constructs, definitions, and measures described in previous work. Below we discuss the approaches used and explain why they do not adequately represent and capture the perception of augmentation quality.

Presence and augmentation quality

Historically, presence has been defined as the degree to which a user feels present in an entirely artificial, mediated, virtual environment (Slater & Wilbur, 1997; Witmer & Singer, 1998). With theoretical and technological advances, scholars across disciplines have revised and extended their understanding of presence inconsistently and introduced new concepts, theories, and terminologies (Hartmann et al., 2015). Consequently, scholars use the term "presence" for different phenomena and subcategories; or they use different variations of the presence term to describe the same phenomena.

The term "telepresence," for instance, typically replaces the initial form of presence and represents the subjective experience of feeling "present" in a different place (Wirth et al., 2007; Witmer & Singer, 1998). With VR, the place can be an entirely artificial environment (Flavián et al., 2019; Wedel et al., 2020). Some scholars use "spatial presence" as a synonym for telepresence (e.g., Hartmann et al., 2015; Vorderer et al., 2004). Self-presence can apply to AR and VR and represents the extent to which the "virtual self is experienced as the actual self" (Aymerich-Franch et al., 2012, p. 1). Social presence describes the "sense of being with another" actual person or avatar (Biocca et al., 2003, p. 456; Hennig-Thurau et al., 2023).

Although spatial presence is more closely aligned with VR, AR researchers have pragmatically extended the concept to their domain. For instance, Hilken et al. (2017) adapted items from a scale developed by Vorderer and colleagues (2004), which was designed for "diverse media settings" (Hartmann et al., 2015, p. 4). Hilken et al. (2017) selected eight items, modified their wording for AR, and created a one-dimensional scale. Similarly, Smink et al. (2020) further adapted the spatial presence scale for their study on AR shopping apps by drawing on Hilken et al. (2017) and creating a four-item scale.

Moreover, the e-commerce literature presents a construct called "local presence" to evaluate online experiences (e.g., Verhagen et al., 2014; Vonkeman et al., 2017). There, local presence is typically defined as "the observation of an individual experiencing physical things presented online (e.g., objects, activities, persons) as actually being there with him/her in one's offline environment" (Vonkeman et al., 2017, p. 2). An example scale item of local presence is "Experiencing sunglasses on the website corresponds with my memories of experiencing sunglasses in reality" (Vonkeman et al., 2017). In the context of AR, local presence refers to the extent to which users sense AR objects as real and physically present in their own "local" physical environment. Measurement approaches for local presence, however, remain unsystematic (e.g., Rauschnabel et al., 2022b, 2024).

Realism and augmentation quality

To measure augmentation in AR-based shopping experiences, Daassi and Debbabi (2021) deploy the realism construct by drawing from the communication literature. They argue that a system is considered immersive if it offers the user a vivid illusion of reality (Slater & Wilbur, 1997). In an AR context, "perceived realism refers to whether the AR-based experience is perceived as realistic with regard to the environment augmented by the virtual products and the activities performed by the consumer" (Daassi & Debbabi, 2021, p. 8). Their study used four items from the VR literature to measure perceived realism (Schubert et al., 2001) (e.g., "my experience in the augmented environment seems consistent with my real-world experience").

Because realism refers to the perceived correspondence between a technology-mediated experience and a comparable non-mediated experience (Lombard & Jones, 2015), we argue that a realism construct is not ideal for measuring how consumers process augmentation in AR. Perceived realism deals with plausibility, typicality, and factuality, among other things (Hall, 2003). However, a situation does not necessarily have to be plausible to be perceived as a "good" augmentation. For instance, a flying dragon might be perceived as well-augmented into one's physical environment. Yet, most consumers' sense of plausibility would contribute to subsequently low realism. Thus, studying augmentation quality through the lens of realism may not fully reflect AR's use as a marketing tool.

Ad hoc approaches

Other AR studies utilize generic ad hoc conceptualizations and measures to investigate perceived augmentation, the integration of virtual content into the physical world (Javornik, 2016; Rauschnabel et al., 2019). Its definition emphasizes the visual annotations of AR technology, whereby augmentation is "proposed and specified as a unique AR feature, while its perception—perceived augmentation—is the psychological correlate of this feature" (Javornik, 2016, p. 8). The construct is measured using a five-item ad hoc scale (e.g., "I felt I could enrich X" and "the virtual objects seemed completely real"). Later, Javornik et al. (2016) employed different items to measure perceived augmentation with more "technical" wording such as "the application added virtual make up to my face," an approach that other scholars (e.g., Daassi & Debbabi, 2021) adopted and labeled as "perceived augmentation." Rauschnabel et al. (2019) defined perceived augmentation quality as "the extent to which a user perceives the augmented content as realistic" (p. 45). They measured the construct with an ad hoc scale by borrowing and adopting measures from Hilken et al. (2017), Javornik (2016), and Vorderer et al. (2004). Web Appendix 1 provides an overview of the prior definitions and measurement scales.

Overall, research consistently points to the importance of AR apps' capability to augment their physical environment, whether examined through the lens of presence, realism, or ad hoc conceptualizations. However, given that augmentation is the defining feature of AR, we argue that previous approaches lack the necessary depth to capture the complexity of AR. A detailed theoretical framework specifically tailored to AR is therefore essential to advance academic research, including the development of robust measures that enable consistent integration of augmentation constructs into future studies. Furthermore, managers can benefit from a reliable diagnostic tool to assess and improve their AR experiences.

Research objectives

Positive outcomes hinge on whether the augmentation is good. However, very little is known about what "good augmentation" means, how consumers experience it, how it can be measured, and what makes it a driver of relevant outcome variables. Inadequate measurement in previous studies may reduce their theoretical and practical value. As a result, consumers' perceptions of augmentation quality and subsequent outcomes of good or bad augmentation remain poorly understood.

Deeper theoretical insights and a validated measurement tool could support managers by highlighting crucial aspects in the graphical design of AR experiences and supporting them with a validated assessment tool for monitoring performance. In addition, it could help improve managerial knowledge of the concept and reduce the trepidation in integrating AR into marketing strategy and tactics. Based on the identified research gaps, our research has the objective to (1) conceptualize what augmentation quality is from the consumer's perspective and identify its dimensional structure, (2) provide a reliable and valid measurement scale, and (3) depict how and through what pathways augmentation quality affects managerially relevant constructs.

Understanding the perception of augmentation

In order to address RQ 1 and RQ 2, this research applies a theory-building multimethod design that follows well-accepted psychometric scale development and validation procedures (Anderson & Gerbing, 1988; Churchill, 1979). We began with a working definition for augmentation quality. Here, the perception of augmentation quality represents a consumer's overall perceptions of the goodness or badness of integration of virtual elements displayed in their real-world environment.

To flesh out this concept, we started with a literature review followed by qualitative research (Studies 1 & 2) to identify a comprehensive pool of items reflecting various expressions of augmentation quality. The second stage of the research consisted of two quantitative studies to refine (Study 3) and validate (Study 4) the constructs and relationships that constitute how consumers perceive and experience augmentation. Mindful of the overall manuscript length, further details of the scale development process not described in this section can be found in Web Appendix 2.

Studies 1 and 2: Item generation

A series of qualitative studies with consumers and experts was conducted, producing statements potentially reflecting the domain of AR quality perceptions. Study 1 focused on item generation, and Study 2 focused on reducing the gathered item pool to a "practical" size without redundancies, including initial expert validation of the proposed pool of items. Specifically, Web Appendix 2 describes how we systematically identified 199 statements and reduced them to a practical size of 31 items to move forward.

Study 3: Identifying the dimensional structure of augmentation perceptions

Methodology and sample

Study 3 sought to examine the appropriateness of the 31 items surviving Studies 1 and 2. We recruited 350 respondents (50.5% female, M = 34.0 years, SD = 14.7) through customer intercepts in a German shopping mall. Participants were briefed on AR to guarantee a common understanding and then randomly assigned to one of six AR apps, including on-body AR (2x) and in-room AR applications (4x) (see Web Appendix Table 4). Participants tried the assigned AR app using a tablet computer until they had a good impression of virtual objects augmented onto the physical environment (on average, 3–5 min). Next, respondents completed a questionnaire displayed on laptops. The survey started with general questions on technologies. Respondents then provided ratings of the AR experience using the 31 items. A Likert-scale approach ranging from 1 ("I do not agree") to 7 ("I fully agree") was employed and the items were presented in a randomized order. An attention check helped ensure that participants read the items carefully.

Results

An exploratory factor analysis (EFA) approach enabled further item reduction and examined underlying dimensions using the items. Following standard scale development protocols, we eliminated items based on established criteria, including weak loading estimates (<|.50| and thus, low total communality), substantial skewness, or substantial cross-loadings (>|.45| as a second-highest loading). across different estimation and rotation specifications. The result was a refined set of 13 items (76.2% of variance explained) with still some moderate cross-loadings among four items reflecting local presence, as discussed later. We then conducted separate EFA using the nine and four items, respectively. Here, we found ideal solutions for the nine items (three factors; no cross loadings >|.30|; no factor loading <|.65|) and a stable unidimensional structure for the four items. Web

Appendix 2 provides more detail. We used prior research (as discussed in the previous section), an inspection of the items' meanings, and expert feedback (Study 2) to define and name the factors.

Three factors represent "technical" and more tangible quality perceptions of the augmentation. More specifically, the first factor captures common *design* characteristics, as exemplified by "There is a high level of detail in the design of the virtual object." The second factor includes statements such as, "The virtual object is realistically embedded in the environment," and thus, represents the quality of contextual *embedding*. Finally, the third factor represents how well the AR content reacted to *interacting with it*: "The virtual object responds in real-time." We named the three factors "design quality," "embedding quality," and "interaction quality," respectively.

In contrast to the three quality factors, the fourth factor is transcendental and more abstract. The statements loading highly on it describe the extent to which the virtual content feels as "being real or present." For instance, "I have the *feeling* that the virtual object actually exists in the real world," or, "It *seems* as if the virtual object has shifted from the device into the room." Not surprisingly, when consumers are asked what augmentation quality means to them, they may describe the technical factors that make up good augmentation quality and what consequences result, including sensations resulting from high augmentation quality. In a nutshell, the consequence represents the degree to which consumers sense or feel that the augmented object experienced with AR is truly real and present in their real-world environment—in other words, feeling "local" to them. Thus, we named this factor "*local presence*" because the content is consistent with previous conceptualizations (e.g., Chen et al., 2021; Rauschnabel et al., 2022b).

By adopting the term "local presence," we distinguish our concept from spatial presence, which historically has been used interchangeably with telepresence, a key element of VR rather than AR (Hartmann et al., 2015). Furthermore, the word "local" in "local presence" originates from the Latin word "locus," meaning "place" or "location". Over time, it evolved through the Latin adjective "localis," meaning "relating to a place." In English, "local" generally refers to something nearby or connected to a specific location, making it suitable for AR. Therefore, "local" serves as the conceptual counterpart to "tele,"[1] as discussed in Rauschnabel et al. (2022b).

Design quality, embedding quality, and interaction quality all contain content related to the perceived quality of augmentation. Thus, each being representative of perceived quality, we expect that the three factors are positively interrelated. In other words, good (bad) design facilitates good (bad) embedding and interactivity. Although each forms a unique factor at the first level of abstraction, the expectation is that they come together to represent different aspects of a second-order construct that we term *augmentation quality*. Design quality relates to how well the virtual object is visually designed, embedding quality refers to how well the integration of a virtual object into its environment is perceived, and interaction quality captures how responsive the object seems to user interactions. Together, these factors reflect the AR experience's overall effectiveness and seamlessness, or lack thereof (degree of goodness or badness).

Augmentation quality, as a higher level of abstraction than its three first-order factor indicators, drives a similarly abstract construct of local presence. By conceptualizing augmentation quality as a cause of local presence, we emphasize that the technical quality of the AR experience plays a critical role in shaping a user's rather abstract sense of presence. Importantly, augmentation quality represents a controllable variable that managers and developers can attempt to influence directly through variations in design, algorithms, and the utilization of advanced technologies. In contrast, local presence cannot be directly manipulated by these actions. Rather, the design, embeddedness, and interactivity components, functioning together as perceived quality, affect neurological processes that lead to high sensations of presence.

The neuroscience literature explores ways technologies like AR affect thoughts, feelings, and somatic responses (Hilty et al., 2020). When AR content is displayed well (design quality), behaves authentically (interaction quality), and fits naturally into its surroundings (embedding quality), it enhances the internal and external plausibility of the content; it makes the virtual content seem "real and present." Before proceeding to a confirmatory study, we reanalyzed the data using structural equation modeling to account for this relationship between augmentation quality and local presence, yielding a good model fit (see Table 2).[2] Local presence was included in the confirmatory factor analysis (CFA) to assess its status as a related but distinct concept from augmentation quality. Figure 1 presents the framework, and Table 1 summarizes the constructs, definitions, and conceptual characteristics of this model.

Returning to Liz's AR shopping experience from the introduction, we can further illustrate how augmentation quality—comprising embedding, interaction, and design

[1] The prefix "tele" in "telepresence" is derived from the Greek word "τῆλε" (tēle), meaning "far" or "at a distance." In VR, users are virtually transported to another environment, whereas in AR, the content is brought directly to the consumers within their existing environment.

[2] Treating local presence as a fourth first-order factor indicator or a single second-order factor leads mathematically to identical results; however, such a model is conceptually less consistent with the nature of the factors.

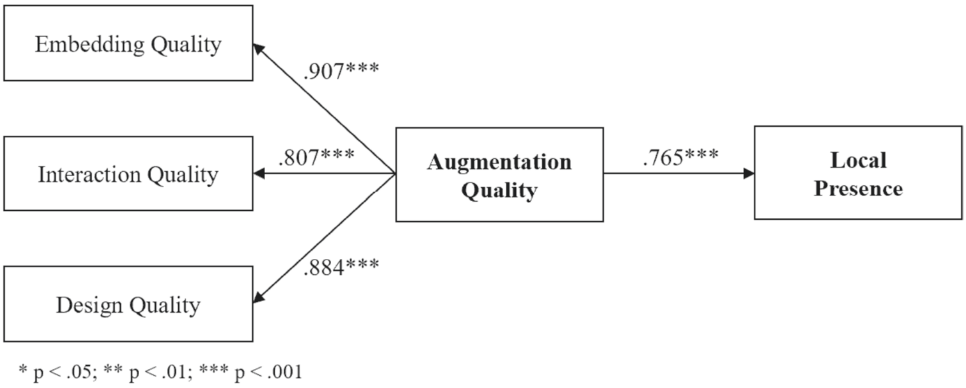

Fig. 1 The augmentation quality–local presence relationship

Table 1 Perceptions of augmentation quality: Constructs, definitions, and conceptual characteristics

Concept/Construct	Type	Definition
Augmentation Quality	Multi-dimensional construct, antecedent of local presence	Consumers' perception of the relatively tangible technical qualities of an AR experience
Embedding Quality	Component of Augmentation Quality	Consumers' perception of how well the virtual object is embedded into the physical environment
Interaction Quality	Component of Augmentation Quality	Consumers' perception of how responsive the virtual object is to user interactions
Design Quality	Component of Augmentation Quality	Consumers' perception of how well the virtual object is visually designed
Local Presence	Unidimensional construct, consequence of Augmentation Quality	The sensation that the augmented object experienced with AR is actually real and present to the consumer

All constructs are conceptualized as subjective evaluations by consumers

quality—affects local presence. When Liz looks into the screen, her virtual mirror, the sunglasses are in the right position and their size is in scale to her face demonstrating high embedding quality. As she moves her head, the sunglasses stay perfectly aligned with her face without any lag, demonstrating high interaction quality. However, the textures of the sunglasses appear flat, the reflections on the lenses look artificial, and the frame color seems overly saturated, demonstrating poor design quality. Liz struggles to see the sunglasses as an actual product rather than a digital overlay, resulting in low local presence. She sees the virtual sunglasses on her face, but they don't feel real and present.

Study 4: Justifying the dimensions of augmentation perceptions

The validation of the augmentation measures in Study 4 is purely confirmatory, given that the over-identifying constraints are known based on theory. The study deploys CFA to assess fit, convergent (AVE, internal consistency), and discriminant validity. Furthermore, this study aimed to assess the relationship between the second-order perceived augmentation quality factor and the more abstract local presence factor while including various control variables.

Methodology and sample

Study 4 employed the same survey approach as in the previous study, including AR app testing, followed by a survey including the final augmentation items and scales representing other related constructs. This time, we recruited respondents between 18 and 50 years old with the help of a commercial, ISO-certified, market research firm. Because we relied on existing AR apps, we restricted participation to panelists with an Apple mobile device as the availability of AR apps was larger for iOS devices.

The questionnaire started with an icebreaker question about AR knowledge and defined AR to ensure a common understanding. Participants were then asked to download one of three randomly assigned AR apps (2 on-body AR, 1 in-room AR). Each participant then tried the app on their mobile device (see Web Appendix Table 4). To ensure that they had used the app, the respondents had to upload a screenshot demonstrating how they used it (those who did not were excluded from the sample). Participants then completed the questionnaire while recalling their AR experience.

In addition to the 13 augmentation-related items that were displayed to respondents in a randomized order, the survey also included measures used in previous AR research,

Table 2 Perceptions of augmentation quality: CFA and SEM (Studies 3, 4 and 5)

	Study 3	Study 4	Study 5
Global Model			
$\chi2$ (61*df*)	122.61	102.18	116.40
$\chi2$/df ratio	2.01	1.68	1.91
CFI	0.97	0.98	0.97
TLI	0.96	0.97	0.96
RMSEA	0.05	0.05	0.07
SRMR	0.05	0.04	0.05
Factor 1: Embedding Quality			
CR	*0.80*	*0.86*	*0.82*
AVE	*0.57*	*0.67*	*0.61*
The virtual object blends in with real elements	0.71	0.81	0.61
The size of the virtual object is in scale to things in the real world	0.67	0.77	0.79
The virtual object is realistically embedded in the environment	0.86	0.87	0.91
Factor 2: Interaction Quality			
CR	*0.83*	*0.84*	*0.92*
AVE	*0.63*	*0.63*	*0.80*
Interaction with the virtual object is intuitive	0.68	0.76	0.78
The virtual object responds in real-time	0.83	0.83	0.96
The virtual object moves smoothly	0.86	0.79	0.94
Factor 3: Design Quality			
CR	*0.88*	*0.87*	*0.90*
AVE	*0.71*	*0.69*	*0.75*
The design of the virtual object appears to be in high quality	0.87	0.80	0.88
There is a high level of detail in the design of the virtual object	0.83	0.84	0.90
The virtual object appears realistic from all perspectives	0.84	0.85	0.82
Higher Order Factor: Augmentation Quality			
CR	*0.92*	*0.90*	*0.84*
AVE	*0.80*	*0.75*	*0.63*
Embedding Quality	0.90	0.91	0.86
Interaction Quality	0.83	0.81	0.73
Design Quality	0.94	0.88	0.79
Factor 4: Local Presence			
CR	*0.89*	*0.93*	*0.87*
AVE	*0.66*	*0.78*	*0.62*
I perceive the virtual object as a real object	0.85	0.88	0.80
I have the feeling that the virtual object actually exists in the real world	0.85	0.88	0.74
It seems as if the virtual object has shifted from the device into the room	0.85	0.92	0.75
Everything I see in the display appears to be real	0.70	0.84	0.85
Augmentation Quality → Local Presence	**0.82**	**0.77**	**0.75**

Estimator: MLR; all factor loadings are significant (all $p < 0.001$). CFI: comparative fit index; TLI: Tucker–Lewis index; RMSEA: root mean square error of approximation; SRMR: standardized root mean square residual; the wording of the statements has been slightly adapted to reflect the product context of the study (see Appendix A & Appendix C)

such as hedonic and utilitarian benefits (Hilken et al., 2017; Rauschnabel et al., 2019), inspiration (Rauschnabel et al., 2019), and attitude (Rauschnabel et al., 2019), to assess nomological validity. Furthermore, to assess robustness in the relationship between perceived augmentation quality and local presence, we included potential alternative explanations, which are discussed later in this section. Appendix A lists the constructs and their measurement items used in this study. The CFA models were estimated using Mplus (version 8.0) and AMOS 28 for robustness. The final sample included 320 participants (53.7% female, M = 33.6 years, SD = 8.81).

Results

Fit validity Overall, the proposed model (see Fig. 1) fits the data well (Hair et al., 2017). The results for the overall model yield a χ^2-value of 102.177 with df = 61 ($p < 0.001$), a CFI = 0.98, TLI = 0.97, RMSEA = 0.05, and SRMR = 0.04, providing evidence of fit validity (see Table 2). In addition, the loading estimates and relationship between augmentation quality and local presence are all positive ($p < 0.001$) and consistent with the results from Study 3 (see Fig. 1).

Convergent and discriminant validity Convergent validity is suggested by standardized loading estimates that exceed 0.76, factor CR values above 0.84, and AVE estimates greater than 0.63. Thus, adequate convergent validity is present (Hair et al., 2017). Specifically, the second-order factor, augmentation quality, displays strong evidence of convergent validity (loadings ≥ 0.81; AVE = 0.75; CR = 0.90; see Table 2).

Discriminant validity was evidenced by comparing variance explained within and between factors (Fornell & Larcker, 1981). The lowest AVE (0.57) exceeds the highest squared correlation estimate (0.45). Further, no two factors can be combined into one and improve fit. All results suggest adequate discriminant validity (Hair et al., 2017). We compared the model fit between the four-factor solution with a one-factor (first-order) solution ($\chi2$ (65 *df*) = 562.04; CFI = 0.76; TLI = 0.70; RMSEA = 0.16; SRMR = 0.09); the four-factor solution's model fit is far better.

Robustness Several control variables were then introduced to the model predicting local presence. First, we controlled the augmentation quality–local presence relationship by AR knowledge. One could argue that consumers with higher knowledge pay more attention to details and, thus, rate local presence lower; whereas consumers new to AR might perceive the experience more "realistic" because of a feeling of awe. Next, we included imagination. A consumer with more imagination may more easily sense augmented objects as real and present in their physical environment. Furthermore, we controlled for design acumen, defined as a consumer's ability to recognize, categorize, and evaluate product designs (Bloch et al., 2003). Consumers with high design acumen are assumed to make sensory connections faster and exhibit more sophisticated preferences concerning object design (Csikszentmihalyi & Robinson, 1990). Finally, age and gender supplement the model because they represent common control variables. The results show weak effects for gender, age, and design acumen ($p < 0.05$), and non-significant effects for AR knowledge and imagination. No matter the combination of control variables, the link between augmentation quality and local presence remained stable and significant (ranging 0.75 to 0.77, see Appendix B).

Nomological validity Finally, we assessed nomological validity, which can be assumed if the constructs behave as expected in combination with related constructs (Bagozzi & Yi, 1988). Therefore, we estimated correlations between our focal constructs and theoretically related variables. Supported by prior research, we hypothesized that design quality, interaction quality, embedding quality, and local presence positively correlate with hedonic benefits (Hilken et al., 2017), utilitarian benefits (Hilken et al., 2017), inspiration (Zanger et al., 2022), and attitude toward the app (Smink et al., 2020). As indicated in the correlation table in Web Appendix Table 7, correlation estimates are consistent with theoretical expectations helping to support nomological validity.

Summary

Studies 1–4 conceptualize how consumers experience augmentation, encompassing augmentation quality and local presence. In addition, traditional scale development procedures yield valid measurement scales for augmentation quality and local presence. Analysis for nomological validity shows that the constructs behave as expected in a network of established constructs from the AR literature.

To better understand the role of perceived augmentation quality in influencing consumer behavior, we later introduce a theoretical framework that depicts how augmentation quality affects managerially relevant outcome variables, such as utilitarian and hedonic benefits, purchase intentions, and behaviors associated with its usage.

Using augmentation quality to explain behavioral outcomes

Augmentation quality and the customer experience

We draw primarily on Mental Imagery Theory (Dahl et al., 1999; Elder & Krishna, 2022) and Situated Cognition Theory (Schwarz, 2006) to explain why augmentation quality, which results in higher or lower levels of local presence as represented in the previous chapter (see Fig. 1), affects relevant outcome perceptions and behavior. The literature has used both theories to explain the effects of AR (e.g., Heller et al., 2019; Hilken et al., 2017; Jessen et al., 2020), and both theories also apply to the effects of augmentation quality, as high augmentation quality better enables AR applications to deliver the benefits they ideally can.

Seeing or imagining how a product that requires a context will look in its intended environment provides relevant information for purchase decisions (Weathers et al., 2007). Thus, enabling consumers to see objects in their intended environment is a core benefit of AR (Elder & Krishna, 2022; Kumar et al., 2024). Good AR cannot only provide consumers with an undistorted visual representation of the product in a context, but it also allows them to transform such visuals in terms of size or spatial location (Heller et al., 2019). High-quality AR can provide more detailed and accurate visualizations than a consumer's self-generated and self-transformed mental images (Hilken et al., 2022). In doing so, AR can be a source of additional and enriched information. Moreover, AR with high augmentation quality reduces consumers' effort to self-generate and self-transform mental images (Heller et al., 2019; Jessen et al., 2020). Less effort can lead to positive feelings, such as processing fluency (Heller et al., 2019), and allows consumers to explore numerous different products in a meaningful way, increasing their engagement, creativity, and anticipated satisfaction (Jessen et al., 2020). This "playground effect" (Jessen et al., 2020) should be stronger when augmentation quality is perceived to be high than when it is low because high augmentation quality provides more visual support to promote fascination and enjoyment. Drawing on Situated Cognition Theory, Hilken et al. (2017) argue that AR facilitates situated information processing (Semin & Smith, 2013). AR allows consumers to process a product embedded in their physical environment and embodied through physical action (Hilken et al., 2017). When using AR, consumers will not process the product in a decontextualized way. They will also consider their interactive experience and the feelings associated with it (Schwarz, 2004). For example, if an object is shown to scale with other objects, interacts realistically, and thus appears to be present, consumer interaction and information processing should be pleasant and fluent. Because positive product interactions (Eelen et al., 2013) and positive feelings such as processing fluency (Petrova & Cialdini, 2018; Schwarz, 2004) increase liking, augmentation quality can affect product evaluations. Thus, higher-quality AR should create a more rewarding customer experience and help promote mutually beneficial conative outcomes, including further engagement with app and product. A high-quality AR experience should be perceived as gratifying and something that a user would want to experience again (e.g., Hilken et al., 2017). Likewise, a good app experience acts as a contagion to brand and product and promotes product-related outcomes such as purchase intentions (Hilken et al., 2017; Tan et al., 2022; Yim et al., 2017).

In Study 5, we focus on two key pathways through which augmentation quality, mediated by local presence, affects post-engagement outcomes. The context for Study 5 is a shopping experience involving a virtual try-on (on-body AR). As such, the value of the experience is determined by assessments of both its usefulness, or utilitarian value, and a distinct factor capturing how gratifying and enjoyable the experience is in itself, as reflected by the overall hedonic value (Babin & Krey, 2020; Babin et al., 1994). The perceptions of utilitarian and hedonic benefits motivate further approach-related behaviors and positively relate to actual purchase behavior (Babin & Attaway, 2000). The utilitarian path (the lower path in Fig. 2) is based on an app experience providing value through information that facilitates the shopping task (Babin & Krey, 2020). High augmentation quality should lead to greater utilitarian benefits through informativeness. The second path relates to immediate gratification experienced as high augmentation quality promotes a rewarding hedonic experience (Babin et al., 1994; Smink et al., 2020). Study 5 considers perceptual outcomes, intentions, and observed behaviors as dependent variables. In the following sections, we use the terms "app-related outcomes" and "product-related outcomes" as generic terms for consumer variables related to either the app or the product, since the two objects of consumer evaluation lead to different paths. The app-related outcomes considered in the study are: (a) consumers' intention to use the app again and (b) their decision to take home a card with the web address/link to the app as a proxy for actual behavior. The product-related outcomes considered in the study are: (a) consumers' intention to purchase the product they added to their shopping cart (purchase intention) and (b) their decision to receive the exact pair of sunglasses instead of Euro 100 if they won the post-study raffle (see "Methodology and Sample" for details) as a proxy for actual behavior.

Augmentation quality and app-related outcomes

High augmentation quality promotes more positive AR experiences. Likewise, varying levels of augmentation quality should correspond to the desire to reuse (or not) an AR application. In part, that correspondence is driven because the consumer is better able to learn whether a product fits their needs. Higher augmentation quality means, for example, more detailed and realistic product embeddedness, beyond other visual displays and self-generated mental images, providing the consumer with additional information about the product and its fit with real-world elements (Hilken et al., 2022). In other words, the app conveys useful information that promotes better purchase decisions (Hoffmann et al., 2022; Yim et al., 2017). The informational value should influence app-related outcomes by making the app more useful in evaluating products, that is, by increasing

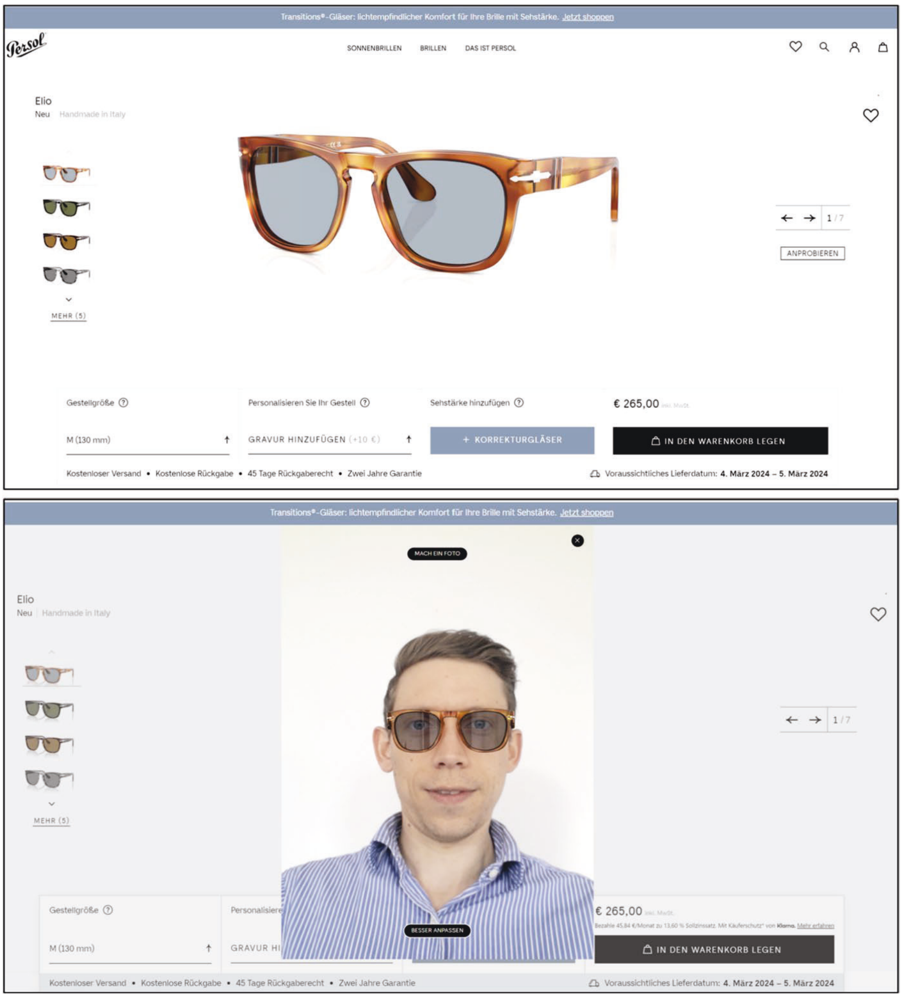

Fig. 2 Illustration of the Persol website with AR integration

consumers' certainty about their product evaluations (Heller et al., 2019; Hoffmann et al., 2022; Kowalczuk et al., 2021). Informational value is defined here as the user's perception of how helpful the information provided by the app is in evaluating a product and is theoretically related to "utilitarian value" as measured by Hilken et al. (2017). Because consumers reflect on how valid their evaluation of a product is, and in doing so consider the perceived accuracy and completeness of the information that is/was available (Rucker et al., 2014), a higher informational value should increase consumers' perceived certainty in evaluating the product (Gross et al., 1995).

In addition, higher informational value may lead consumers to believe an application provides better product evaluations. Barden and Petty (2008) show that the perception that one has thought hard about an issue increases attitude certainty. Furthermore, when augmentation quality is high, AR allows consumers to explore multiple products meaningfully, giving them more expected certainty about a choice (Jessen et al., 2020). Thus, higher informational value may make consumers feel that the application is more appropriate for evaluating products, thereby increasing attitude certainty. Attitude certainty is typically defined as how much consumers feel an attitude is correct (Gross et al., 1995; Tormala et al., 2006). Here, attitude certainty is the degree of certainty individuals have about the appropriateness of a product evaluation. The more consumers feel that an application helps them make accurate and valid judgments (Gross et al., 1995), the more they should find the application useful and the more likely they are to use it again. Taken together, we expect that augmentation quality resulting in a sense of local presence, as represented in the previous section, has a positive effect on application-related outcomes and that perceived informational value and attitude certainty mediate the effect. In Study 5, two constructs represent application-related outcomes: self-reported intention to reuse the app and an application-related behavior, accepting the offer to take home a card with a link to the app. We propose:

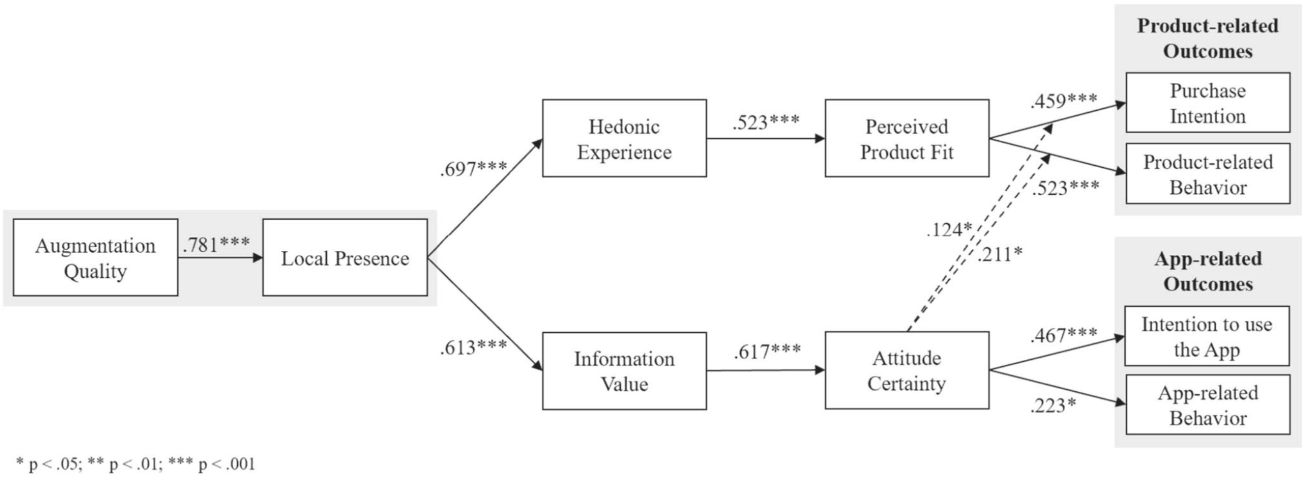

Fig. 3 Augmentation quality and its effects on important outcomes and behavior

H1a Augmentation quality has a positive effect on intention to use the app again, which is serially mediated by local presence, then in turn by perceived informational value, and attitude certainty.

H1b Augmentation quality has a positive effect on app-related behavior, which is serially mediated by local presence, then in turn by perceived informational value, and attitude certainty.

Augmentation quality and product-related outcomes

The above mechanism (see H1) describes how augmentation quality informs consumers and helps them evaluate a product. However, better information does not necessarily mean that the product will become more attractive to consumers, as more informed evaluations can also mean that consumers realize that the product is not the right choice for them. So, can high augmentation quality cause consumers to evaluate a particular product experienced through an app better than they would with low augmentation quality?

AR can reduce mental effort and deliver compelling experiences. High augmentation quality and local presence result in positive hedonic experiences (Hilken et al., 2017; Smink et al., 2020; Yim et al., 2017). Thus, when using an AR application, the more positive the hedonic experience, the more favorable users will be toward the product promoted in much the same fashion that positive feelings (Schwarz, 2004), positive product interactions (Eelen et al., 2013), and an environment's atmosphere promote increased patronage (Babin et al., 1994; Babin & Krey, 2020). Thus, high augmentation quality compared to low augmentation quality should lead to a more positive evaluation of the product and thereby increase purchase intention and product-related behavior.

With regard to product evaluation as a mediator, this study focuses on perceived product fit, defined as the degree to which consumers perceive that the product displayed in AR suits them well. When consumers evaluate a product, they evaluate both the product itself (e.g., its color and shape) and the product's fit with relevant real-world elements (e.g., what does the color and shape look like in the intended context?). We focus on perceived product fit because information about product fit is the unique and most important benefit that AR can provide (Hilken et al., 2017). We expect that high augmentation quality that leads to local presence results in a positive hedonic experience, which increases perceived product fit and thus positively affects product-related outcomes. In Study 5, two constructs will represent the product-related outcomes: self-reported purchase intention, and a product-related behavior, that is, selecting the product as a raffle prize instead of a monetary amount. We propose:

H2a Augmentation quality has a positive effect on purchase intention, which is serially mediated by local presence, and then in turn by perceived hedonic benefits, and perceived product fit.

H2b Augmentation quality has a positive effect on product-related behavior, which is serially mediated by local presence, and then in turn by perceived hedonic benefits, and perceived product fit.

Positive evaluations of product fit may positively affect product-related behavior. However, attitudes vary in how strongly they influence behavior because consumers tend to reflect on their assessments and ask themselves whether their evaluation is correct (Moreno et al., 2021; Rucker et al., 2014). As a result, attitudes held with high certainty are more likely to guide behavior than attitudes held with low certainty (Clarkson et al., 2008; Fazio & Zanna, 1978). Therefore, we expect that attitude certainty moderates the effect of perceived product fit on product-related outcomes. When consumers believe that a product will fit well in its intended context, high certainty in this assessment is more likely to lead to purchase behavior than low certainty (see Fig. 3). We propose:

H3a Attitude certainty moderates the effect of perceived product fit on purchase intention: the positive effect of perceived product fit on purchase intention increases with attitude certainty.

H3b Attitude certainty moderates the effect of perceived product fit on a product-related behavior: the positive effect of perceived product fit on the product-related behavior increases with attitude certainty.

Methodology and sample

An empty store space in the center of a large city in Germany was converted into a research lab with the necessary infrastructure (e.g., high-speed Internet, survey computers, interview spaces with privacy screens, displays, etc.). Trained research assistants randomly approached nearby pedestrians and invited them to participate in an academic research survey regarding new media. The only requirement for participation was that they did not typically avoid wearing sunglasses. As incentives, we offered candy and the opportunity to participate in a raffle.

After respondents consented to participate, the study began with some questions about familiarity with AR and the "Persol" brand. Persol is an eyewear brand in the mid-price segment that does not focus on particularly sleek or unusual designs and has integrated an AR function on its website. Persol, Inc. did not sponsor nor was the company involved in the study.

Next, respondents were asked to take an iPad and try out the “Persol” AR experience to explore sunglasses as long as they wanted to and choose the model they would most likely purchase by placing it in the app’s shopping basket (see Fig. 2). A research assistant briefed all study participants based on a predefined protocol to reduce the risk of usability issues and to guarantee that each participant received identical instructions. After the AR exposure, they returned to their interview space and continued the survey. The survey included the augmentation quality items, local presence items and items for the other variables/constructs in the model. The survey closed with demographic questions and a debriefing statement.

This study follows the same procedures and key measures (augmentation quality and local presence) as in the previous studies. Since we used a specific product category (sunglasses), we adjusted all measures to this context (see Appendix C). We also adopted existing scales for hedonic experiences (Babin et al., 1994), information value (Parker et al., 2016), product fit (von der Au et al., 2023), attitude certainty (Smith et al., 2008; Tormala et al., 2006), purchase intention (Zeithaml et al., 1996), and intention to use the app (Hanson & Yuan, 2018). The scales varied in format, which reduces concerns about common-methods variance (CMV) (Hair et al., 2017; Podsakoff et al., 2024). In addition, we used randomizations of items to minimize order bias. We also emphasized anonymity, the academic purpose of the study, and the importance of honest responses.

To complement the attitudinal and intentional items with proxies for actual purchase behavior, we asked each participant whether they would like to receive further information about the app to take home (i.e., view a summary page with a QR code or receive a printed card with this information, coded as 1, versus no, coded as 0; 25% wanted to receive further information). Every participant was eligible to win prizes from a raffle as an incentive. Respondents were told: “You now have the opportunity to choose between the sunglasses you added to your shopping cart or EUR 100 in cash as part of the competition. Which prize would you like to win?” (0 = cash, 1 = sunglasses; 42% chose sunglasses). The sunglasses’ retail prices ranged between 200 and 440 EUR. Thus, selecting the chosen model over cash indicated a convincing shopping experience. Data quality checks included an attention filter.

The final sample comprises $N = 175$ participants (60.6% female, M = 39.4 years, SD = 17.4, different backgrounds and statuses). We analyzed data using CFA and SEM procedures with Mplus 8.0, AMOS 28, and lavaan. All perceptual augmentation items and reliability coefficients are presented in Table 2.

Results

CFA Results

CFA was used again to validate the scale itself. The CFA results again provided evidence of good fit with a χ^2 of 116.4 (df = 61; $p < 0.001$), a CFI of 0.97, a TLI of 0.96, RMSEA of 0.07, and SRMR of 0.05 (Hair et al., 2017). Convergent validity is again strong, the CRs all greater than 0.83, and all AVEs greater than 0.61 (see Table 2). All

AVEs exceed squared correlation. Thus, construct validity is evident.[3]

SEM Results

First, we assessed the overall SEM model fit with all the variables from our main model. The results indicated sufficient model fit to test the hypotheses in a linear model (χ^2= 812.3, df =418; $p < 0.001$; CFI =0.91; RMSEA =0.07; SRMR =0.11). Next, we modelled the effect on the dichotomous outcome variables as non-linear logit functions.

App-related outcomes

In line with H1, we found a significant positive effect from augmentation quality to local presence (β =0.781; $p < 0.001$), from local presence to perceived informational value (β =0.613; $p < 0.001$) and from perceived informational value to attitude certainty (β =0.617; $p < 0.001$). We further found a positive effect from attitude certainty to intention to use the app (β =0.467; $p < 0.001$). We further see a positive effect from attitude certainty to application-related behavior (β =0.223; p= 0.038) Additionally, we examined mediation by estimating indirect effects from augmentation quality to the intention to use the app again (H1a), and the application-related behavior (H1b) respectively. Indirect effects are evident in that 0 is not in the 95% confidence interval (CI) of the unstandardized indirect effects (using bias-corrected CIs from 10,000 bootstrap samples; augmentation quality to intention to use the app again: b= 0.257, LCI =0.123, HCI =0.454; augmentation quality to the application-related behavior: b= 0.022, LCI =0.004, HCI =0.051; (see Web Appendix Table 8). The findings support H1a and H1b.

Product-related outcomes

In line with H2, we found a positive effect from augmentation quality to local presence (β =0.781; $p < 0.001$), from local presence to hedonic benefits (β =0.697; $p < 0.001$) and from hedonic benefits to perceived product fit (β =0.523; $p < 0.001$). We further found a positive effect from perceived product fit to purchase intention (β =0.459; $p < 0.001$), and a positive effect on the product-related behavior, that is, selecting the product as a raffle prize (β =0.523; $p < 0.001$). We examined indirect effects from augmentation quality to purchase intention (H2a), and the product-related behavior (H2b), respectively. The unstandardized indirect effect from augmentation quality to purchase intention is positive (b =0.261, LCI =0.150, HCI =0.438), as is the indirect effect from augmentation quality to product-related behavior (b =0.057, LCI =0.034, HCI =0.092; see Web Appendix Table 8). The findings support H2a and H2b.

Moderation analyses

The interaction probing procedure described by Aiken et al., (1991) was employed to assess the hypothesized moderating effect of attitude certainty on the relationship between perceived product fit and purchase intention (H3a) and product-related behavior (H3b). We modeled the interaction term between perceived product fit and attitude certainty using the latent moderated structural equations approach in Mplus, while controlling for attitude certainty's direct effect. The results indicate a significant interaction effect (β_{int}= 0.124; $p < 0.05$) of perceived product fit on purchase intention, supporting H3a. Additionally, in line with H3b, there is a significant interaction effect (β_{int}= 0.211; $p < 0.05$) of perceived product fit on the product-related behavior. Thus, the effect of perceived product fit on both purchase intention and product-related behavior increases with increasing attitude certainty. Figure 3 illustrates the results.

Discussion and conclusion

Summary

Though AR has received increased attention in marketing theory and practice, still very little is known about how consumers process and evaluate such hybrid experiences that blend virtual and physical worlds. Although previous research has suggested that a positive AR experience depends on how well AR content and the physical environment match (Hilken et al., 2017; Smink et al., 2020), conceptualizations of augmentation quality have been incomplete, imprecise, and partially misleading. Incomplete, because they have not systematically captured user perceptions of the merge of physical and digital content; imprecise, because they have not distinguished between perceptions that occur at different levels; and partially misleading, because they have incorporated constructs from other disciplines that are not AR-specific. Because augmentation quality was not appropriately conceptualized, its effects on relevant marketing variables are not well understood. This paper addresses these gaps. Using a grounded theory approach, this research develops quality perceptions in AR. First, the findings suggest that consumers evaluate augmentation quality in terms

[3] Although in the survey instrument different types of scales are used for different constructs, the augmentation quality and local presence scales are 7-point Likert scales. Thus, some statistical approaches were used to assess the potential for common method bias. Those include a check on the first eigenvalue among the 13 x 13 data matrix. It is 6.74, which accounts for 51.9% of the total variance, which is less than the 60% standard at which concerns for CMB arise based on simulation studies (Fuller et al., 2016).

of design, embedding, and interaction quality, which come together in a second-order factor. Second, this research depicts that quality perceptions in AR drive perceptions of local presence, the sensation that the augmented object experienced with AR is actually real and present. Using the scales developed in this research, this paper also demonstrates that augmentation quality determines relevant outcome variables mediated by local presence.

Going back to Liz, who we introduced at the beginning of this article and who was exploring an AR shopping app, this research shows that the more Liz perceives the augmentation quality of the app as high, the more she will feel that the object is"actually real and present,"and the more informative and enjoyable she will find the experience, increasing her intention to reuse the app and to purchase the product. This research provides multiple contributions to both academia and practice, which we discuss below.

Theoretical contributions

The research deciphers the "core" of AR from a consumer's perspective: the process of how consumers evaluate how "well" virtual content is integrated into the real world. Although researchers agree that augmentation quality is highly relevant (Javornik, 2016; Rauschnabel et al., 2024), the measurement approaches deployed previously do not show the concern that such a high degree of relevance merits. The results presented here suggest and empirically validate perceptions of augmentation quality and a model consisting of a second-order factor—*augmentation quality*—that determines a unidimensional, AR-specific presence construct: *local presence*. Studies 1 through 4 identify the constructs and their dimensional structure, and Study 5 supports the mediating role of local presence as proposed by the previous findings. Augmentation quality drives positive marketing variables to the extent virtual objects appear "actually real and present." The findings provide theoretically relevant insights into the processing of AR experiences from a consumer's perspective, and thus, can serve as a theoretical grounding for further advancements in AR marketing. For example, augmentation quality links technological AR features and new technological developments to relevant marketing outcomes. Advances in computer science have facilitated AR features such as algorithms for displaying shadows (Sugano et al., 2003) or virtual lighting (Agusanto et al., 2003). By illustrating the criteria consumers use to evaluate an AR experience, which drives local presence, augmentation quality and the framework tested here link technical qualities to consumption-relevant outcomes. As a result, the findings provide a more holistic understanding of AR.

Second, incomplete or imprecise conceptualizations have limited previous attempts at measurement. While adhoc approaches are common for new concepts and are quite pragmatic, they also represent less than the best practices for strong psychographic measurement. For instance, measuring constructs with adopted or ad hoc scales might reduce validity which can cause incorrect empirical findings and eventually lead to false theoretical conclusions. The current research contributes to the literature by providing a reliable and validated measurement scale that AR researchers in marketing and other disciplines can adopt. With 13 items in total (nine augmentation quality and four local presence items), our measures are short and can be included in future research on AR in marketing, but also in other disciplines. Augmentation quality and local presence also can be used independently.

Third, this research emphasizes augmentation quality as shaping relevant outcomes of AR experiences consistent with Mental Imagery Theory (Dahl et al., 1999; Elder & Krishna, 2022) and Situated Cognition Theory (Schwarz, 2006). The framework tested in Study 5 focuses on two key pathways for the perceptions of augmentation quality to affect post-engagement outcomes. The hedonic path relates to the pleasant, rewarding experience that high augmentation quality provides. Positive hedonic experiences enhance product evaluations, which in turn, increase purchase intention and product-related behavior. The utilitarian path is based on the fact that high augmentation quality provides value through information serving as a means to the end of better decisions. High-quality AR helps consumers to understand what products are right for them. The higher the augmentation quality, the more informed and confident the consumer is in his or her evaluation, thereby increasing app-related outcomes such as intention to use the app again. In addition, increased confidence determines whether consumers' product evaluations will trigger behavior. If consumers feel that a product will fit well in its intended context, high certainty in this assessment is more likely to lead to purchase behavior than low certainty. Further, this research considers not only behavioral intentions, but also behaviors. The app-related behavior was the decision to take information about the app home. The product-related behavior was the respondent's choice of whether they would prefer to win EUR 100 in cash or receive the product they selected with the AR app (if they were drawn), indicating a positive product evaluation. Study 5 shows that augmentation quality positively affects both behaviors and thus builds on and extends prior research (Hilken et al., 2022).

Managerial implications

As marketers work with design engineers to create effective AR apps, a key consideration is creating an experience that facilitates local presence. Augmentation quality, well-managed, can help create the sense of local presence that sets in motion positive effects on relevant marketing outcomes relate to value and behavior. Higher perceptions of augmentation quality increase consumers' product evaluations. The results suggest that consumers with a good AR experience are more likely to choose the AR-depicted product compared to a fixed amount of money. Therefore, managers' investments in AR marketing technologies produce tangible returns. The indirect effects on app-related behavior are another sign that high-quality AR experiences will drive consumer engagement. When marketers improve AR experiences, they should observe positive reactions in terms of consumer engagement analytics and conversion rates. By doing so, they can better assess the ROI on investments in AR technologies. The effects on attitude certainty suggest that consumers will become more confident in their purchase decisions if a high-quality AR experience precedes that decision. Also, the second-order nature of augmentation quality suggests that the three work together and that high design will not compensate for poor interaction quality, for example.

Likewise, managers need to assess and monitor augmentation quality for their AR applications. The developed scale provides a relatively parsimonious diagnostic tool to assess if their AR experiences are value-enhancing. In addition, marketing managers can deploy the scale to assess how their own AR apps compare with competitors' AR apps. Furthermore, the scale guides managers in the overall design and development of AR apps by helping with this question: "How can managers—or app developers—achieve a high level of perceived augmentation quality and, thus, local presence?" The assessment of AR quality can also help determine the effectiveness of virtual try-ons, gamification, and interactive product displays.

In recent years, numerous technology brands have introduced or revealed new products and software advancements in augmented reality (AR). For example, several smartphone brands are integrating advanced sensor technologies such as LIDAR, while operating systems are developing proprietary AR technology such as ARKit for iOS and ARCore for Android. There is also competition between different hardware approaches. Some headsets are based on transparent screens (e.g., Microsoft Hololens, xreal ultra, or Meta's announced Orion AR glasses), while others (e.g., Apple Vision Pro or Meta's Quest series) focus on video see-through technology, often referred to as "passthrough." A company's decision to focus on certain technologies and possibly exclude others is based on a number of factors. However, from a marketing standpoint, consumer evaluation should be the primary consideration. The results of this research could form a basis for a systematic market analysis.

Limitations and future research

The empirical studies rely heavily on data from a limited cultural and national context. Future research should address these limitations with broader and more diverse samples. Cross-cultural validation attempts of the augmentation quality and local presence factors present a fruitful avenue for future research. Here, the data represent a highly developed, western culture with relatively individualistic values and lower power distance. Future studies should include multiple samples that would include countries typical of both western and eastern culture span a spectrum of cultural values. As AR technology becomes commonplace using relatively accessible technologies, studies contrasting developed and developing nations also would be interesting. These studies could address the degree of equivalence among the scales in terms of translation and measurement invariance as different languages and cultures come into play.

Additionally, while the research considered behavioral variables (e.g., choices), AR marketing effectiveness will be measured, at least in part, by its effect on sales. Future research conducted that partner with actual retailers would provide for more direct assessment of effects on sales, price perceptions, perceived value, customer satisfaction, and word-of-mouth behavior. The impact on impulse purchasing would also be of value from both a managerial and policy standpoint. All outcomes would be particularly interesting to enhance normative recommendations concerning the use of AR.

The conceptual model proposed here should be extended to consumer-brand relationships, as high augmentation quality and the hedonic experience and informational value it creates may positively influence brand attachment, brand trust, and related constructs. Augmentation quality can affect the consumer's relationship with product brands and retailer brands when the latter provide the application. For example, future research could examine the extent to which consumers'perceptions of augmentation quality influence their perceptions of the product brand versus the retailer brand. Relatedly, this research does not explore a potential threshold at which poor augmentation quality might harm the (product or retailer) brand, suggesting that the AR application should be suspended until improvements are implemented. Since poor augmentation quality can create an annoying experience, future research could explore the emotional responses that different levels of perceived augmentation quality elicit (Romani et al., 2012). Additionally, by measuring brand perception and liking before and after the AR experience, improvements and deteriorations might be quantified and linked to specific levels of perceived augmentation quality using the scales developed in this research.

This research focused on immediate product-related behaviors and intentions, but high augmentation quality should also lead to lower return rates in online retailing and may improve customer satisfaction, which could be investigated in future research. Related to the above argument, high augmentation quality can influence product choice to the benefit of the consumer. Allowing consumers to evaluate an object in its intended environment may change their information processing. Research has shown that when consumers evaluate alternatives simultaneously, they tend to overweight easily comparable attributes, such as price or numerical technical features (Hsee, 1996; Nowlis & Simonson, 1997). Overemphasis on easily comparable attributes may not lead to the choice that brings the greatest long-term happiness and satisfaction (Hsee & Zhang, 2004). By experiencing and"playing"with the product, high-quality AR can shift the product evaluation from a joint evaluation to a more separate evaluation, increasing the influence of attributes that may be more relevant to long-term satisfaction and happiness (Hsee & Zhang, 2004), such as how the product looks in its environment. Thus, high augmentation quality may contribute to long-term satisfaction and future research may investigate the effects.

Moreover, other contexts for AR Marketing could be considered. For example, AR may enhance customers' abilities to co-creation value (Alimamy & Jung, 2024). Companies that market stoves and grills could include AR-enhanced instructional guides, so consumers become more effective as at-home chefs. AR-enhanced technology in automobiles can assist owners with parking and other aspects of car ownership. Golf equipment could be AR-enhanced to help deploy that equipment more effectively, such as assisting with the proper grip and aim. Augmentation quality could be tested in these types of contexts to examine its role in overall service quality, customer satisfaction, perceived value, and loyalty. The use of AR-enhanced images can also be an effective tool in nostalgia marketing by virtually inserting people or objects from the past into the present (Heinberg et al., 2020).

Industry forecasts indicate a future where AR content will most likely be integrated into glasses-like headsets. Existing devices such as Microsoft's HoloLens provide prototypical examples and promise a substantially better merge of real and virtual content (Flavián et al., 2019). In the end, the device by which the AR is implemented plays a role in shaping utilitarian and hedonic outcomes, both important in assessing the value derived from a customer experience. The theoretical model developed and tested here can guide research on this futuristic scenario of a "metaverse" or "spatial computing" where consumers consistently live and shop in hybrid realities.

Appendix A

Table 3 Overview of constructs and measurements of Studies 3 & 4

Construct	Items
AR Knowledge (Hinsch et al., 2020)	I know what augmented reality is I already had experience with augmented reality Overall, I am interested in the topic of augmented reality
Attitude toward the App (Rauschnabel et al., 2019)	It is a good idea to use this AR app I like using this AR app I have a positive attitude toward using this AR app
Augmentation Quality (developed in this research)	The virtual object blends in with real elements The virtual object is realistically embedded in the environment The size of the virtual object is in scale to things in the real world There is a high level of detail in the design of the virtual object The design of the virtual object appears to be in high quality The virtual object appears realistic from all perspectives Interaction with the virtual object is intuitive The virtual object responds in real-time The virtual object moves smoothly
Design Acumen (Bloch et al., 2003)	Being able to see subtle differences in product design is one skill that I have developed over time I see things in a product's design that other people tend to pass over I have the ability to imagine how a product will fit in with designs of other things I already own
Hedonic Benefits (Venkatesh et al., 2012)	Using this AR app is fun Using this AR app is enjoyable Using this AR app is very entertaining
Imagination (adapted from Goldberg, 1992)	I see myself as someone who has an active imagination I can easily visualize things
Inspiration (Rauschnabel et al., 2019)	This app has inspired me in a way This app stimulated my thinking This app gave me new ideas and views
Local Presence (developed in this research)	I perceive the virtual object as a real object I have the feeling that the virtual object actually exists in the real world It seems as if the virtual object has shifted from the tablet into the room Everything I see in the display appears to be real
Utilitarian Benefits (Venkatesh et al., 2012)	This AR app is useful This AR app is practical

The table includes the constructs used in Studies 3 and 4. The constructs are listed in alphabetical order

Appendix B

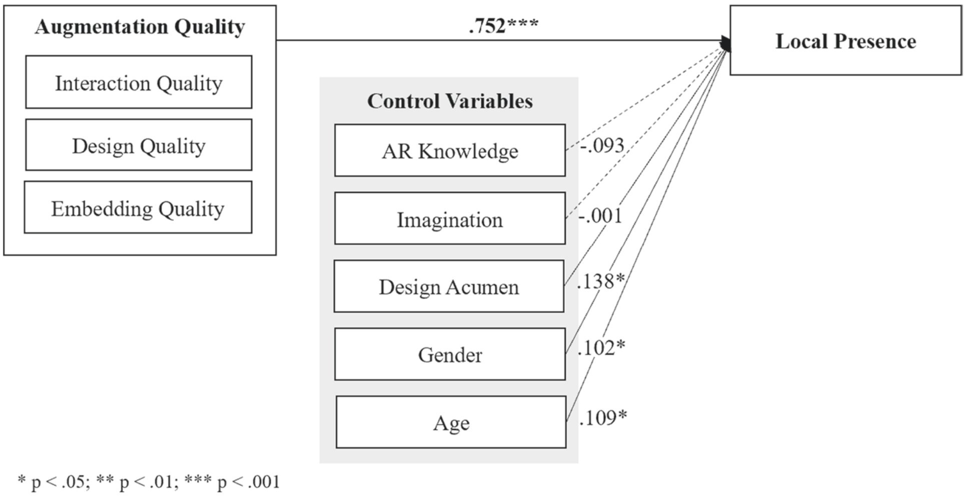

Fig. 4 The augmentation quality–local presence relationship controlled by several variables (Study 4)

Appendix C

Table 4 Overview of constructs and measurements of Study 5

Construct	Items
Attitude Certainty (adapted from Smith et al., 2008 and Tormala et al., 2006)	How confident are you with your (positive or negative) assessment of the sunglasses? How confident are you with your assessment of how well the sunglasses would look on you? How convinced are you that your judgement about the glasses is correct? How convinced are you that your judgement about how well or poorly the glasses would look on you is correct?
Augmentation Quality (developed in this research)	The sunglasses blend in with my face The sunglasses are realistically embedded in my face The size of the sunglasses is in scale to things in the real world There is a high level of detail in the design of the sunglasses The design of the sunglasses appears to be in high quality The sunglasses appear realistic from all perspectives Interaction with the sunglasses is intuitive The sunglasses respond in real-time The sunglasses move smoothly
Hedonic Experience (Babin et al., 1994)	This shopping experience was truly a joy Compared to other things I could have done, the time spent in the app was truly enjoyable I continued to use the app, not because I had to, but because I wanted to I enjoyed trying out new products
Information Value (adapted from Hilken et al., 2017)	If I wanted to buy a pair of sunglasses, …the app would help me to better evaluate the product …the app would simplify the decision-making process …I would have a good feeling about choosing the product thanks to the app
Intention to Use the App (adapted from Hanson & Yuan, 2018)	If I wanted to buy sunglasses, I would use an application with AR function
Local Presence (developed in this research)	I perceive the sunglasses as a real object I have the feeling that the sunglasses actually exist in the real world It seems as if the sunglasses have shifted from the tablet into the room Everything I see in the display appears to be real
Perceived Product Fit (von der Au et al., 2023)	The sunglasses fit me very well The sunglasses suit me very well The sunglasses suit my face very well
Purchase Intention (adapted from Zeithaml et al., 1996)	If I wanted to buy sunglasses, I would buy the sunglasses that I just put in my shopping cart

The table includes the constructs used in Study 5. The constructs are listed in alphabetical order

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Philipp A. Rauschnabel: Conceptualization, Writing – Review & Editing, Supervision, Project Administration, Methodology.

Sandra Praxmarer-Carus: Conceptualization, Writing – Review & Editing, Methodology, Supervision.

Barry J. Babin: Conceptualization, Writing – Review & Editing, Methodology, Validation.

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Declarations

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