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Customer experience, engagement, and co-creation in augmented reality retail service

增强现实零售服务中的顾客体验、参与与共创

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ABSTRACT

Retailers are increasingly using augmented reality (AR) to enhance the customer experience. This research investigates how AR service experiences contribute to customer co-creation. Two experimental studies using real AR applications and PLS-SEM provide evidence. Study 1, utilizing IKEA Place and WannaKicks, examines whether network externality enhances experience quality and whether customer autonomy influences this effect. Results show that network externality enhances experience quality, but the effect weakens at higher levels of autonomy, indicating that autonomous customers rely less on network cues. Study 2, utilizing Warby Parker and Dulux Visualizer, examines whether experience quality influences co-creation through engagement and whether the need for uniqueness moderates the engagement – co-creation relationship. Findings reveal that engagement fully mediates the effect of experience quality on co-creation, and the need for uniqueness strengthens this link for individual products, but not for shared products. The studies clarify how AR experience mechanisms and customer traits shape co-creation outcomes.

摘要

零售商将增强现实技术作为一种服务提供，用以支持顾客旅程。本研究考察在增强现实零售服务情境下，从体验到共创的路径如

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KEYWORDS
augmented reality; network externality; autonomy; experience quality; engagement; co-creation; need for uniqueness

关键词
增强现实; 网络外部性; 自主性; 体验质量; 参与; 共创; 对独特性的需要

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何形成。两项实验研究使用真实的增强现实应用程序，并采用偏最小二乘法结构方程模型进行数据分析。研究一以 IKEA Place 和 WannaKicks 为情境，检验网络外部性是否提升体验质量，以及自主性是否会改变这一关系。结果表明，网络外部性可以提升体验质量，但这种正向作用会随着自主性提高而减弱，说明高度自主的顾客在形成体验评价时对网络线索的依赖程度较低。研究二以 Warby Parker 和 Dulux Visualizer 为情境，检验体验质量是否通过参与影响共创，以及对独特性的需要是否在个体产品与共享产品情境下调节参与与共创之间的关系。结果显示，参与在体验质量与共创之间发挥完全中介作用，同时，对独特性的需要会强化个体产品情境下参与与共创之间的关系，但在共享产品情境下并不会产生类似作用。整体而言，这些研究将增强现实界定为一种受到网络外部性影响并受自主性塑造的零售服务，识别参与为将体验质量转化为共创的过程机制，并将对独特性的需要界定为影响何时以及对谁更可能发生共创的边界条件。

1. Introduction

Augmented reality (AR) is a service that retailers offer to support the customer journey. As online shopping expands (Zhang et al., 2025), many brick-and-mortar retailers are leveraging technological advances to enhance their propositions (Gauri et al., 2021; Wang & Jia, 2023). AR enables shoppers to place digital product overlays in their own spaces, which enhances evaluation before purchase (Arya et al., 2025; Aslam & Davis, 2024). IKEA Place, for example, allows users to view furniture in their homes (Hilken et al., 2022). AR adoption in retailing continues to rise (Hsu et al., 2024), with industry projections indicating growth from $2 billion in 2020 to $61.3 billion by 2031 (Algharabat et al., 2020), revealing its growing strategic importance. The present research examines how network externality (as a social signal) and autonomy (as a form of personal control) shape experience quality and co-creation through engagement in AR retail service.

Engagement and experience are key concepts in the customer journey (Brodie et al., 2011; Hollebeek et al., 2023a; Zlateva et al., 2025). Many studies report positive effects of AR on engagement and experience (e.g. Chen et al., 2024; Rafeh et al., 2024; Zeng et al., 2024); however, conflicting results remain, highlighting a notable gap in the literature. For example, while Jessen et al. (2020) view AR as an engagement – or experience-facilitating tool that will typically boost positive customer outcomes, others qualify these favorable consequences by suggesting that highly (vs. less) vivid, interactive AR tools may be more likely to engage customers (Yim et al., 2017). These conflicting findings yield an essential tension in the literature that warrants further investigation.

Despite the increasing interest in the experiential affordances of AR, such as its ability to improve product visualization, reduce uncertainty, and promote hedonic value (Hilken et al., 2017; Poushneh & Vasquez-Parraga, 2017), a critical underexplored dimension involves its social affordances. In particular, the extent to which AR-based experiences are shaped by network externality (i.e. users' perceptions of others using or benefiting from the same service) remains poorly understood in retailing. Though research on network externality in digital contexts exists (Abu Shanab et al., 2024), it is often treated as a background condition rather than a driver of core outcomes (Alimamy &

Jung, 2025). Few studies investigate its direct role in shaping experience quality, which leaves an important gap (Sheng et al., 2022; Zhang et al., 2025).

In addition, autonomy, as captured in self-determination theory (Deci & Ryan, 2000), influences how social signals are processed in immersive settings. Autonomous consumers emphasize self-endorsed choice and rely more on their own evaluations, which reduces dependence on social cues when forming experience assessments (Gagné & Deci, 2014; Sheldon et al., 1996). Hence, in Study 1, we suggest that customers displaying greater autonomy will see a more substantial effect of network externality on experience quality, given that customers hold greater capacity to make decisions independently (Sheldon et al., 1996; Sutcliffe et al., 2011). Assessment of these issues is essential, because while the impact of AR technologies on customers' engagement, experience, and/or co-creation has received prior attention (e.g. Jessen et al., 2020; McLean & Wilson, 2019; Zeng et al., 2024), acumen of the role of network externality in shaping these associations remains scant, particularly in the context of AR retail service, as therefore explored in this research.

Beyond experience formation, engagement is widely viewed as a pathway to co-creation (Hollebeek et al., 2019). Evidence within AR is growing, yet the mediating role of engagement and the conditions that strengthen it are not fully established (Abbasi et al., 2024; Chen et al., 2024). Hence, in Study 2, we explore whether experience quality fosters co-creation through engagement and whether the need for uniqueness, a prominent trait that qualifies customer participation in co-creation (Sahi et al., 2022), moderates the engagement to co-creation link across individual and shared products, extending work on trait differences (Henkel & Toporowski, 2023). Assessment of these issues is essential, because while engagement is positioned as a route to co-creation (Hollebeek et al., 2019), research in AR rarely tests the full path from experience to engagement to co-creation or specifies trait-based boundary conditions across individual and shared products, and evidence on the need for uniqueness remains limited (Sahi et al., 2022), as is therefore examined in this research.

Against this backdrop, this research draws on self-determination theory (Deci & Ryan, 2000), with a particular focus on autonomy, alongside social influence theory (Sutcliffe et al., 2011), to investigate the personal and social factors that shape experiences in AR retail service settings. Self-determination theory highlights the importance of intrinsic motivation and the perception of autonomy in fostering engagement and satisfaction (Gagné & Deci, 2014; Sheldon et al., 1996) while social influence theory explains how external elements, such as observing others' behaviors, affect perceptions and decisions through normative and informational influence (Cialdini and Goldstein, 2004; Sutcliffe et al., 2011). Hence, integrating these lenses offers insight into the contextual factors that determine the effectiveness of AR experiences in retailing, presenting a clear view of both internal and external personal influences.

To empirically test these ideas, this research conducts two experimental studies featuring real-world AR applications. In this way, two research questions (RQs) are addressed:

RQ$_1$. How does network externality influence the quality of experience, and how does autonomy impact this relationship?

RQ$_2$. What is the relationship between experience quality, engagement, and co-creation, and how is this relationship moderated by the need for uniqueness across individual and shared products?

This research makes three noteworthy contributions. First and foremost, this research clarifies how social signals, specifically network externality, interact with personal control, such as autonomy, to shape the quality of experience in immersive retail service settings. Prior research recognizes associations between network externalities and user perceptions (Abu Shanab et al., 2024; Akerlof et al., 2023) and documents autonomy effects in digital contexts (Puerta-Sierra & Puente-Díaz, 2023); yet few studies examine their joint effects on experiential outcomes in AR retail services. Much of the AR literature emphasizes technological features (Hilken et al., 2017; Yim et al., 2017) or hedonic and utilitarian outcomes (McLean & Wilson, 2019), with less attention to the social and psychological processes that shape AR experiences. The present research addresses this gap by showing that autonomy significantly moderates the association between network externality and experience quality, and importantly, in a direction contrary to the initial hypothesis. The result thus provides evidence on how social influence (Sheldon et al., 1996; Sutcliffe et al., 2011) relates to self-determination (Deci & Ryan, 2000) in immersive retail service contexts.

Next, this research demonstrates that engagement fully mediates the relationship between experience quality and co-creation in retail environments that utilize AR, and this holds true across both individual and shared product scenarios. Earlier research links AR to engagement (Ganesan & Kumar, 2024; Jessen et al., 2020) and connects engagement to co-creation behavior applications (Hollebeek et al., 2019; Rather et al., 2019), yet these elements are rarely modeled together with real data. To our knowledge, no prior work simultaneously models experience quality, engagement, and co-creation within a single framework using real-world AR implementations. Moreover, conceptualizing engagement as a second-order formative construct, with vigor, dedication, and absorption as dimensions, allows a more precise assessment of its mediating role. Our findings show that experience quality does not directly lead to co-creation; instead, it operates through engagement, which sharpens the understanding of the engagement-to-value process in immersive retail service contexts.

Last but not least, this research highlights the need for uniqueness as a boundary condition that helps explain when and for whom engagement translates into co-creation, particularly how this relationship differs across product categories (individual vs. shared). While the need for uniqueness has previously been associated with various consumer preferences (Henkel & Toporowski, 2023; Tian et al., 2001), its moderating influence on the engagement – co-creation relationship remains unexamined in AR retail service contexts. Much of the existing literature treats co-creation as a uniform outcome, often overlooking how product context can influence this dynamic. Our findings show that the engagement – co-creation connection is significantly stronger among consumers with high need for uniqueness, but only for individual products (e.g. eyewear), not shared ones (e.g. paint). This contingency challenges the assumption of universal co-creation effects (López et al., 2017), advances current discussions on the distinction between personalized and communal value creation (Middleton et al., 2021), and provides guidance for tailoring AR experiences to meet distinct needs.

2. Literature review

2.1. Co-creation, network externality, and autonomy

Co-creation of value is foundational to service-dominant (S-D) logic, which views value as formed through the participation of actors in service systems rather than being delivered unilaterally (Vargo & Lusch, 2016). In this view, value emerges from interactive, joint, collaborative, and personalized brand-related activities that integrate resources among actors, producing perceived value through engagement in context (Hollebeek et al., 2019; Rather et al., 2022).

Network externality operates as a social signal that shapes experience, engagement, and willingness to co-create value, such that when more peers use and benefit from the same network, perceived usefulness, compatibility, and opportunity for interaction rise, which can raise the value a focal actor derives by joining and participating, for example, through richer communication with friends and family (Kijima & Arai, 2016; So et al., 2024). The explicit treatment of network externality within an S-D logic perspective remains limited; however, the linkage is natural in AR retail services, where shared visualizations and interactions enable resource integration across actors (Abu Shanab et al., 2024).

Autonomy, as a form of personal control captured via self-determination theory (Deci & Ryan, 2000), shapes how actors evaluate and enact co-creation. Autonomy supports internalization and self-endorsed action (Deci & Ryan, 2000; Gagné & Deci, 2014), which tends to heighten perceived value from interactions that allow meaningful choice, pacing, and exploration, as in the context of AR, where users select scenes, place and manipulate objects, and involve others on their own terms (Puerta-Sierra & Puente-Díaz, 2023), which can raise perceived co-created value when autonomy is high.

These arguments position network externality as a social signal that can enhance experience and, in turn, stimulate engagement, while autonomy, as a form of personal control, can alter the strength of this effect. Therefore, the AR retail service context offers a suitable setting to examine how social adoption and personal control combine to shape experience, engagement, and co-creation.

2.2. Experience quality

Experience quality is a central construct in service and retail marketing, particularly in technology-mediated settings that aim for immersive and differentiated experiences. It reflects an overall assessment formed across functional, emotional, and social dimensions along the purchase path (Chang & Horng, 2010; Pentina et al., 2022). Frameworks differ in emphasis yet converge on this holistic view. For instance, Klaus and Maklan (2012) identify product experience, outcome focus, and emotional reassurance, while Kuppelwieser and Klaus (2021) extend the evaluation to encompass brand, provider, and post-purchase stages. Related work emphasizes the significance of emotional and psychological factors in service contexts, where affective responses frequently influence evaluations (Rather & Hollebeek, 2021).

AR retail service intensifies these drivers. Features that heighten sensory engagement can reduce uncertainty and raise perceived realism, thereby improving experience quality (Chen et al., 2024; Hilken et al., 2018). Personalization and interactivity enable users to

place and manipulate products, which can foster trust, enhance feelings of psychological ownership, and increase satisfaction when the experience aligns with user goals (Ganesan & Kumar, 2024; Hilken et al., 2022). These effects are not solely technological. Social inputs also matter. Network externality and user-generated cues such as reviews and visible usage provide social proof that signals popularity and reliability, thereby reinforcing perceived quality in context (Abu Shanab et al., 2024; Zeng et al., 2024).

Treating experience quality as a distinct construct is, therefore, important in AR retail service, since evaluations arise from the joint presence of technological attributes and social signals rather than from interface features alone. This research advances that view by examining how network externality, as a social signal, and autonomy, as a form of personal control, shape experience quality in immersive retail service settings, which sets the stage for testing how engagement converts experience into co-creation.

2.3. Engagement

Engagement refers to the cognitive, emotional, and behavioral resources that consumers invest in interactions with a focal object (Hollebeek et al., 2019), such as an AR retail platform. The concept has become a key corporate metric over the past decades (Weiger et al., 2025). Three hallmarks define its core meaning.

First, engagement is an interactive process that centers on the dynamics of person-object interaction. This inherent interactivity distinguishes engagement from related constructs, such as involvement or commitment, which are important markers of relationships but do not capture the ongoing dynamics of interaction itself (Hollebeek et al., 2023b).

Second, engagement is typically modeled as multidimensional. Most work operationalizes cognitive, emotional, and behavioral facets (Honora et al., 2024), with a recent review indicating that the large majority of scales adopt a multidimensional structure, while only a small minority use a single dimension (Hollebeek et al., 2023b). In this vein, the present research models engagement as a second-order formative construct with vigor, dedication, and absorption as dimensions, which captures intensity and persistence in AR tasks more directly than a purely facet-based approach.

Third, engagement can take positive or negative forms (Hollebeek et al., 2023a). The literature has largely examined positive, firm-supporting engagement rather than negative, firm-opposing expressions (De Oliveira Santini et al., 2020), which guides the present focus on positive engagement in AR retail service.

Context matters in AR retail service. Technologies that heighten interactivity, playfulness, and personalization can raise cognitive attention and emotional connection, thereby deepening engagement beyond simple product handling (Alimamy & Jung, 2025; Ganesan & Kumar, 2024; McLean & Wilson, 2019). Service environment features, such as visual aesthetics, perceived authenticity, and interaction design, also shape engagement by influencing perceived realism and ease of action, which, in turn, affect absorption and enthusiasm (Shahid Satar et al., 2025). Individual differences further condition these effects, with traits such as the need for uniqueness and openness to innovation shaping the level and form of engagement that consumers are willing to invest (Henkel & Toporowski, 2023). These foundations, in turn, position engagement as the mechanism that converts experience quality into co-creation in AR retail service.

3. Hypothesis development

We outline the proposed hypotheses for empirical testing in the model shown in Figure 1.

3.1. Effect of network externality on experience quality

Network externality posits that the perceived value of a product or service increases as more people use it, because adoption by others signals its usefulness, compatibility, and potential payoff (Katz & Shapiro, 1985). In AR retail services, visible adoption and peer feedback function as social signals that provide normative and informational cues, shaping judgments of relevance, ease, enjoyment, and trust (Cialdini & Goldstein, 2004; Pantano & Servidio, 2012; Poushneh, 2018). As consumers explore AR features alongside observable usage, peer affirmation and shared interactions can enhance perceived realism and reduce uncertainty, thereby strengthening overall evaluations of the encounter as an experience. Accordingly:

H_1. Network externality is positively associated with experience quality in AR retail service.

3.2. Moderating role of autonomy

Autonomy, a core component of self-determination theory, reflects self-endorsed choice and voluntary action, which in turn increase intrinsic motivation and satisfaction (Deci & Ryan, 2000; Gagné & Deci, 2014). Consumers who feel autonomous tend to appraise encounters more favorably because they perceive control over options, pacing, and outcomes (Sheldon et al., 1996).

In AR retail service, network externality supplies social signals through visible adoption and peer-generated content. Highly autonomous users convert those signals into diagnostic information rather than succumbing to social pressure, selecting credible cues, filtering out noise, and aligning their attention with their goals, which increases the

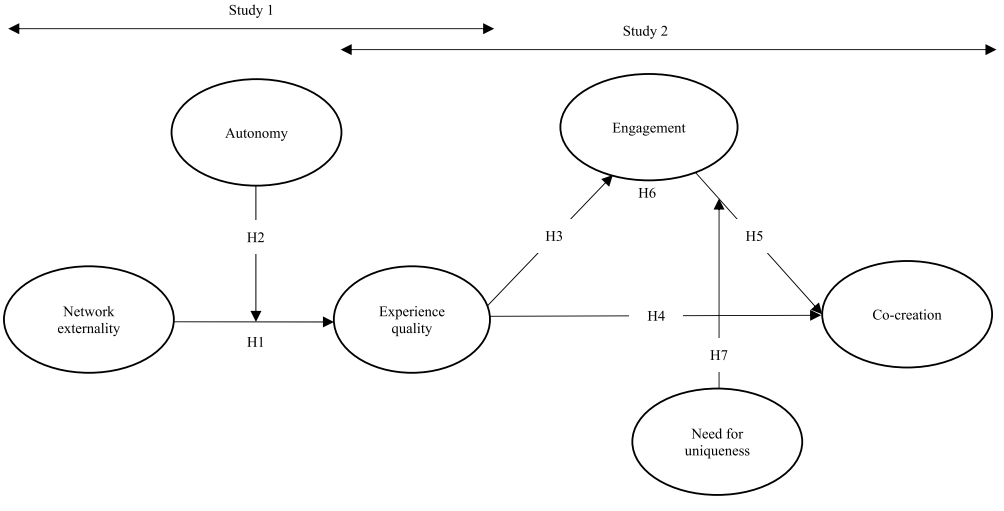

Figure 1. Research model.

likelihood that network externality improves experience quality (Akerlof et al., 2023; Cialdini and Goldstein, 2004). Less autonomous users may follow the crowd without the same depth of appraisal, which can limit the extent to which network externality lifts experience quality. Evidence that autonomy strengthens self-regulated evaluation supports this expectation (Sheng et al., 2022). As such, autonomy should change the strength of the association between network externality and experience quality, with a stronger effect expected when autonomy is higher.

H_2. Autonomy positively moderates the relationship between network externality and experience quality in AR retail service, such that the effect of network externality on experience quality is stronger when autonomy is higher.

3.3. Effect of experience quality on engagement

Retailers invest in enhancing the quality of the experience because stronger experiences signal usefulness, enjoyment, and low effort, which encourages consumers to allocate attention and effort to the interaction (Hu et al., 2025; Lemon & Verhoef, 2016). When experience quality is high, consumers feel comfortable, perceive value, and continue committing cognitive, emotional, and behavioral resources to the platform, which reflects engagement as ongoing investment rather than a one-off response (Jeganathan & Szymkowiak, 2025).

In AR retail service, vivid and sensory-rich features heighten presence and diagnosticity, which strengthens approach motivation and deepens participation, or in other words, engagement (Aitamurto et al., 2020). Positive encounters in digital retail also stimulate contributions, such as social sharing and reviews, which are visible behaviors that express engagement and help sustain it over time (Nikhashemi et al., 2021). These arguments, in turn, support a positive relationship between experience quality and engagement in AR retail services.

H_3. Experience quality is positively associated with engagement in AR retail service.

3.4. Effect of experience quality on co-creation

Co-creation reflects active participation in creating value alongside firms through personalized, collaborative, or experiential interactions, consistent with S-D logic (Vargo & Lusch, 2016) and engagement research (Hollebeek et al., 2019). Within AR retail service, co-creation may take the form of virtual try-ons, content sharing, product customization, and feedback that informs future offerings. Experience quality and engagement serve as primary drivers of these behaviors, with experience quality setting the motivational and evaluative platform on which engagement and subsequent contributions are built (Hollebeek et al., 2019; Woratschek et al., 2020).

A high-quality experience strengthens intentions to invest resources because consumers perceive higher payoff from continued participation, a stronger fit with goals, and clearer benefits from joint action. Indeed, evidence from AR shows that vivid, interactive, and personalized simulations raise perceived control and satisfaction, thereby encouraging voluntary contribution to the service process (Aslam & Davis, 2024; Hilken et al., 2018). Emotional trust and psychological ownership also rise when users can manipulate objects and see realistic outcomes in their own spaces (Hilken et al., 2022), which further

motivates co-creative actions such as sharing content, writing reviews, or refining product choices through feedback loops (Woratschek et al., 2020). Consequently, a positive association is expected between experience quality and co-creation in AR retail services.

H_4. Experience quality is positively associated with co-creation in AR retail service.

3.5. Effect of engagement on co-creation

Engagement channels cognitive attention, emotional connection, and behavioral effort toward a focal object in service (Hollebeek et al., 2019; Rather et al., 2019), positioning it as a direct driver of co-creation in AR retail services. As consumers become more engaged, they tend to undertake proactive contributions such as co-ideation, content sharing, and peer advising, which extend the firm's value creation activities into user spaces where ideas and evaluations form in context (Alimamy & Jung, 2025; Rather, 2025; Rather et al., 2025). These actions reflect discretionary resource investment rather than passive response, which aligns engagement with co-creation both conceptually and empirically. Therefore:

H5. Engagement is positively associated with co-creation in AR retail service.

3.6. Mediating role of engagement

Beyond a direct effect, experience quality is expected to influence co-creation through engagement, providing a process-based account of how high-quality encounters translate into contributions. As overall assessments of an AR encounter increase, consumers tend to allocate more cognitive, emotional, and behavioral resources to the interaction, which in turn enhances engagement with the AR platform and its features (Rafeh et al., 2024; Shahid Satar et al., 2025). Higher engagement, in turn, is associated with co-creation because greater resource investment supports activities such as co-ideation, content sharing, peer advising, and feedback that shapes offerings over time (Alimamy & Jung, 2025; Alimamy & Nadeem, 2021). Empirical support for this pathway is growing. Rafeh et al. (2024) show that engagement mediates the link between perceived advertising value and protective behavior while Rumokoy and Frank (2025) report that task – technology fit, and user engagement jointly influence AR-driven value outcomes. These findings position engagement as the conduit between experience quality and downstream behaviors in digital service settings. Thus:

H_6. Engagement mediates the relationship between experience quality and co-creation in AR retail service.

3.7. The moderating role of need for uniqueness

The need for uniqueness represents a persistent drive to stand apart from others through distinctive consumption choices that signal difference and individuality (Tian et al., 2001). Consumers with a high need for uniqueness tend to avoid conformity and prefer rare, unconventional, or highly customized offerings, which they use to communicate self-image and distinct identity (Henkel & Toporowski, 2023; Kauppinen-Räisänen et al.,

2018). Identity expression anchors this tendency, as consumers select options that project a self that is meaningfully different from the norm (López et al., 2017).

A stronger need for uniqueness should change how engagement translates into co-creation in AR retail service. Highly engaged users invest attention, emotion, and effort in the experience, and those with a strong need for uniqueness are especially likely to convert that investment into co-creative acts such as co-ideation, content sharing, and advising because these behaviors signal identity and differentiation to relevant audiences (Lindsey-Hall et al., 2021; Rodrigues et al., 2024). AR capabilities make this translation feasible in practice, since customization, personalization, and exploratory freedom permit visible self-expression through object selection, placement, and refinement in one's own space (Aslam & Davis, 2024; Hilken et al., 2022).

Product context qualifies this moderation. Individual products such as clothing and eyewear carry high symbolic value and afford clearer avenues for personal signaling, thus engagement is more likely to translate into co-creation when the need for uniqueness is strong (Jebarajakirthy & Das, 2021; Pentina et al., 2022). Shared products, such as furniture and wall paint, tend to diffuse ownership and expression across users and settings, which limits identity signaling and reduces the payoff from distinctive contributions; thus, moderation is likely weak or absent in those contexts (Hamilton et al., 2021). This pattern aligns with self-congruity reasoning (Sirgy, 2018), where consumers intensify brand-related actions when the product allows expression of the desired self, and they conserve effort when the product constrains personal signaling. Therefore:

> **H_7.** The need for uniqueness positively moderates the relationship between engagement and co-creation in AR retail services, such that the relationship is stronger for individual products but not observed for shared products.

4. Overview of studies

Two studies using AR applications were designed to test the hypotheses. Each study employed two AR applications, with one representing an individual product and the other representing a shared product. Study 1 tested H_1 and H_2. Study 2 tested H_3 through H_7. Responses for both studies were collected through CloudResearch Prolific with participants from the United States. The studies were conducted sequentially, with full details presented in the respective sections for Study 1 and Study 2.

5. Study 1

5.1. Design

Study 1 examines the relationship between network externality and experience quality (H1) and how autonomy moderates this relationship in individual versus shared product contexts (H_2). Participants were asked to download and use the IKEA Place app, an AR-based furniture app that allows users to overlay furniture onto their physical space, view pricing, read reviews, adjust colors, and share product-related content through social media or WhatsApp for a period of 15 min. We replicated the study with the WannaKicks AR app to further support the findings. In the replication, participants downloaded and used the WannaKicks app, an AR-based footwear app that allows

users to browse and virtually try on footwear, read product information, and share it with others.

To verify interaction with the assigned app, participants answered app-specific questions (e.g. What features are included in the WannaKicks/IKEA Place app?). Participants who failed to answer this attention check or answered it incorrectly were removed from the dataset. The remaining participants indicated whether they had previously used AR platforms and specified which ones they had used. They received USD 1 at the start of the survey. To ensure sample representativeness, data collection used the CloudResearch Prolific platform, which has been documented to yield high-quality data (Alimamy & Nadeem, 2021).

We collected 340 responses for the IKEA Place app, of which 49 were removed due to issues such as incomplete surveys, resulting in 291 responses for analysis. For the WannaKicks app, we collected 331 responses, of which 45 were eliminated, yielding 286 responses for analysis. Both samples showed comparable characteristics in terms of age and gender. For the IKEA Place app, 56% of respondents were male, with an average age of 35.5 years, and 44% were female, with an average age of 35.6 years. For the WannaKicks app, 59% of respondents were male, with an average age of 36.2 years, and 41% were female, with an average age of 36.0 years.

5.2. Measures

Well-established scales were drawn from the literature. In Study 1, network externality was measured using three items adapted from Wei and Lu (2014). A sample item reads: 'Many friends use the 'XX' AR app.' Autonomy was measured using three items adapted from Sheldon et al. (1996). A sample item reads: 'I am able to choose freely what I want to do in the 'XX' AR app.' Experience quality was measured using five items adapted from Trivedi (2019). A sample item reads: 'My experience with the 'XX' AR app is excellent.' For an overview of the adopted measures, see Table 1.

5.3. Analytical technique

We employed partial least squares structural equation modeling (PLS-SEM) to analyze the data. This approach provides a practical means of assessing complex theoretical relationships and is suitable when knowledge of these relationships is still evolving. PLS-SEM can handle modest sample sizes and non-normal data more effectively than covariance-based structural equation modeling (CB-SEM) (Abu Elsamen et al., 2025), which supports its use in this study.

PLS-SEM offers several advantages aligned with our objectives. First, this research focuses on predicting experience quality, engagement, and co-creation behavior in AR retail services, which aligns with the prediction orientation of PLS-SEM (Hair et al., 2017). Related guidance also recommends PLS-SEM for research that emphasizes prediction and theory development (Hair et al., 2019). Second, the complexity of the research model, including mediation and moderation paths and latent constructs with relatively few items, favors PLS-SEM over CB-SEM because it accommodates smaller samples and departures from normality (Lim, 2025; Rigdon et al., 2017). Prior work notes these features

Table 1. Measurement model statistics for Study 1.

Construct and item	IKEA Place: Shared product		WannaKicks: Individual product	
	EFA	CFA	EFA	CFA
Autonomy (AUT)	(AVE = 0.76; α = 0.84; CR = 0.90)		(AVE = 0.71; α = 0.80; CR = 0.88)	
I'm able to choose freely what I want to do in XX AR app.	0.871	0.866	0.743	0.870
I have a lot of control over my experiences in XX AR app.	0.718	0.877	0.823	0.844
While using XX AR app, my actions determined my experience with the app.	0.742	0.868	0.774	0.815
Experience quality (EQ)	(AVE = 0.66; α = 0.73; CR = 0.85)		(AVE = 0.75; α = 0.83; CR = 0.90)	
I am happy with the experience of using the XX app.	0.715	0.844	0.677	0.850
My experience with the XX AR app is excellent.	0.677	0.795	0.744	0.886
I think the total experience procedure of using the XX AR app is excellent.	0.788	0.798	0.699	0.859
Network externalities (EXT)	(AVE = 0.72; α = 0.80; CR = 0.89)		(AVE = 0.65; α = 0.92; CR = 0.92)	
Many people use XX AR app.	0.741	0.841	0.731	0.821
Many of my friends use XX AR app.	0.884	0.867	0.646	0.874
Many people in the groups which I belong to use XX AR app.	0.889	0.881	0.677	0.851

Notes: AVE = Average variance extracted. α = Cronbach's alpha. CR = Composite reliability. EFA = Exploratory factor analysis. CFA = Confirmatory factor analysis.

as strengths when models include interactions and second-order constructs (Hair et al., 2017, 2019).

5.4. Common method bias

Procedures were implemented to minimize common method bias. First, a priori, the survey randomized the order of questions across respondents (Chang et al., 2010). Second, a posteriori, Harman's single-factor test was conducted. An exploratory factor analysis indicated that the first factor accounted for 20% of the variance in the IKEA Place sample and 22% in the WannaKicks sample, both of which are well below the 50% threshold that signals serious concern (Podsakoff et al., 2003). Table 1 presents all confirmatory factor analysis loadings, ranging from 0.795–0.886, with no significant cross-loadings. Following Kock (2015), common method variance was also evaluated via full collinearity checks in SmartPLS. Variance inflation factors for the inner model remained below 3.0 in both samples, indicating low collinearity and suggesting that relationships are unlikely to be distorted by common method bias.

5.5. Measurement model

Before testing the hypotheses, the reliability and validity of the modeled constructs were assessed. First, factor loadings were examined (Table 1). Two experience quality items were removed in the IKEA Place and WannaKicks samples due to cross-loadings (EXP1, EXP2). Next, psychometric properties were assessed. The standardized root mean square residual (SRMR) values for the IKEA Place and WannaKicks models were 0.07 in both cases, below the 0.08 benchmark, indicating good model fit, whereas the Cronbach's alpha ranged from 0.73–0.92 and the composite reliability ranged from 0.85–0.92,

Table 2. Correlation matrix and heterotrait-monotrait (HTMT) ratio of correlation for Study 1.

	IKEA Place: Shared product			WannaKicks: Individual product		
Construct	Autonomy	Experience quality	Network externality	Autonomy	Experience quality	Network externality
Autonomy	**0.871**	0.834	0.563	**0.843**	0.824	0.567
Experience quality	0.716	**0.813**	0.593	0.722	**0.865**	0.706
Network externality	0.560	0.552	**0.863**	0.551	0.655	**0.849**

Notes: Bold values on the diagonal represent the square roots of average variance extracted. Values above the diagonal are heterotrait-monotrait (HTMT) ratios while values below the diagonal are correlations.

exceeding the 0.70 benchmark, indicating strong reliability (Hair et al., 2017, 2019). Convergent validity was supported, with an average variance extracted (AVE) ranging from 0.65–0.76, which exceeds the 0.50 threshold (Fornell & Larcker, 1981). Discriminant validity was examined using the Fornell and Larcker (1981) criterion, wherein the square root of each AVE exceeded the corresponding inter-construct correlations (Table 2). The heterotrait-monotrait (HTMT) ratios were less than 0.90 (Henseler et al., 2015), which supports discriminant validity.

5.6. Structural model assessment and hypothesis testing

Hypotheses were then tested. Network externality showed a significant, positive relationship with experience quality in both samples (IKEA Place: $R^2 = 0.55$, $\beta = 0.21$, $t = 4.53$, $p < 0.001$, Cohen's $f^2 = 0.66$; WannaKicks: $R^2 = 0.63$, $\beta = 0.36$, $t = 7.81$, $p < 0.001$, Cohen's $f^2 = 0.51$). No significant difference emerged between the main effects across the two samples (Figure 2). Hence, H_1 is supported.

The moderation analysis used latent variable interactions in SmartPLS *v.*4 via the product indicator approach, which models moderation with construct-level interaction terms consistent with recommended procedures (Henseler & Fassott, 2010). Autonomy negatively moderated the network externality to experience quality link in both samples (IKEA Place: $\beta = -0.093$, $t = 2.515$, $p < 0.01$, Cohen's $f^2 = 0.14$; For WannaKicks, $\beta = -0.18$, $t = 3.91$, $p < 0.001$, Cohen's $f^2 = 0.21$).

Including autonomy increased the explained variance in experience quality. For the IKEA Place sample, R^2 increased from 0.22–0.55. For the WannaKicks sample, R^2 increased

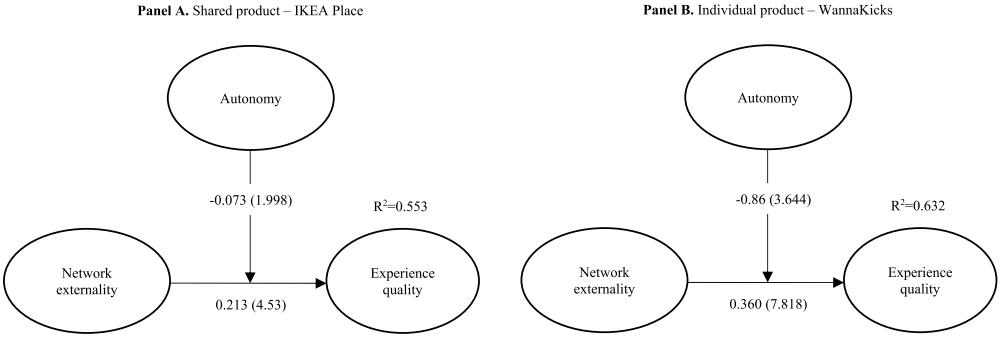

Figure 2. Results of Study 1.

from 0.34–0.63. These changes indicate a meaningful moderation effect, wherein the relationship between network externality and experience quality is weaker when autonomy is higher, opposite to H_2.

6. Study 2

6.1. Overview

Study 2 examines the impact of experience quality on engagement (H_3) and co-creation (H_4), as well as the impact of engagement on co-creation (H_5). The study also examines the mediating role of engagement in the relationship between experience quality and co-creation (H6) and the moderating role of the need for uniqueness on the relationship between engagement and co-creation (H_7).

As in Study 1, Study 2 used CloudResearch Prolific to recruit participants. Participants were again directed to use two AR apps: the Dulux Visualizer app, which permits users to project Dulux paint colors onto a wall as a shared product, and the Warby Parker app, which allows users to personalize and virtually try on eyewear as an individual product. As in Study 1, participants in Study 2 were instructed to interact with each app for 15 min to explore its functions. Manipulation checks confirmed that the Dulux Visualizer app as a shared product and the Warby Parker app was perceived as an individual product.

Participants completed the survey in exchange for a small reward. We collected 157 responses for Dulux Visualizer, of which 10 were eliminated, resulting in 147 usable responses. In contrast, 149 responses were obtained for Warby Parker, of which eight were removed, yielding 141 usable responses. Both samples exhibited comparable characteristics in terms of age and gender. For the Dulux Visualizer sample, 42% of participants were male, with an average age of 40.5 years, and 58% were female, with an average age of 40.7 years. For the Warby Parker sample, 60% were male with an average age of 36.5 years, and 40% were female with an average age of 34.8 years.

6.2. Measures

Well-established measures were again adopted. To gauge the quality of experience, the same measures were used as in Study 1. Five items measured co-creation, adapted from Ramaswamy and Ozcan (2016). A sample item reads, 'I will likely share corporate posts, for example, product information or news, through the 'XX' AR app.'

Engagement was conceptualized as a second-order formative construct comprising three first-order reflective dimensions: vigor, dedication, and absorption. This structure is grounded in a conceptualization originally developed in the organizational behavior context, namely employee engagement, with supporting evidence in Bakker et al. (2014) and Schaufeli et al. (2002), and subsequent applications to consumer or customer engagement in Dwivedi (2015), Patterson et al. (2006), and Rabbanee et al. (2021). This reflective – formative hierarchical component model (HCM) is appropriate because the three dimensions are not assumed to be manifestations of a single underlying latent factor but rather form engagement collectively (Becker et al., 2012; Hair et al., 2019). In other words, changes in any one component, for example, increased vigor, alter the overall level of engagement, which supports a formative specification at the higher-order level.

Each first-order construct was measured using reflective items adapted from Schaufeli et al. (2006) and tailored to the context of consumer–brand interaction. Vigor captured energy and mental resilience, dedication reflected enthusiasm and a sense of significance, and absorption assessed the degree to which users became immersed in the AR experience.

Each first-order construct was measured using reflective items adapted from Schaufeli et al. (2006), tailored to the consumer – brand interaction context. For vigor, items captured energy and mental resilience during AR interaction. Dedication reflected enthusiasm and a sense of significance, while absorption assessed the degree to which customers became immersed in the AR experience. This operationalization, in turn, captures the multifaceted nature of engagement in AR-enabled retail environments, where engagement manifests through energetic involvement, emotional investment, and immersive interaction. Adopting a formative higher-order structure acknowledges the theoretical position that these elements coalesce to form engagement, rather than merely reflecting it interchangeably.

6.3. Common method bias

Similar procedures to Study 1 were adopted to assess common method bias for Study 2. First, Harman's single-factor test was conducted. The exploratory factor analysis indicated that the first factor accounted for 29% of the variance in the Dulux Visualizer sample and 30% in the Warby Parker sample, which is well under the 50% threshold (Podsakoff et al., 2003). Table 3 shows that the confirmatory factor analysis loadings ranged from 0.770–0.920 for the Dulux Visualizer sample and from 0.865–0.937 for the Warby Parker sample, with no significant cross-loadings. Finally, a random dependent variable was introduced in SmartPLS to assess common method bias, and the resulting variance inflation factors for the inner model of all modeled constructs were less than 3.0 in both samples (Kock, 2015).

6.4. Measurement model

All confirmatory factor analysis loadings exceeded 0.80 except for one experience quality item in the Dulux Visualizer sample, which loaded at 0.770, and no evidence of cross-loadings was observed (Table 3). Cronbach's alpha and composite reliability values exceeded 0.70, affirming reliability, while average variance extracted values were greater than 0.50, supporting convergent validity (Hair et al., 2017, 2019). Discriminant validity was confirmed by verifying that the square roots of the average variance extracted values exceeded the corresponding inter-construct correlations (Fornell & Larcker, 1981) (Table 4). The heterotrait-monotrait ratio of correlations remained below 0.90 in both samples, which further supports discriminant validity (Henseler et al., 2015).

In line with Sarstedt et al.'s (2014) two-stage procedure, engagement was modeled as a second-order reflective – formative construct. Indicator weights and their *t*-values were computed for both samples. Only dedication and vigor showed significant weights, while absorption did not. Following guidance to inspect outer loadings when weights are non-significant, the loading for absorption was 0.90, and absorption was, therefore, retained (Sarstedt et al., 2014). A permutation multi-group analysis then

Table 3. Measurement model statistics for Study 2.

Construct and item	Dulux Visualizer: Shared product		Warby Parker: Individual product	
	EFA	CFA	EFA	CFA
Experience quality (EQ)	(AVE = 0.82; α = 0.84; CR = 0.90)		(AVE = 0.82; α = 0.90; CR = 0.94)	
I am happy with the experience of using the XX AR app.	0.871	0.770	0.843	0.905
My experience with the XX AR app is excellent.	0.904	0.917	0.872	0.908
I think the total experience procedure of using the XX AR app is excellent.	0.846	0.916	0.833	0.931
Need for uniqueness (NFU)	(AVE = 0.82; α = 0.89; CR = 0.93)		(AVE = 0.85; α = 0.91; CR = 0.94)	
I actively seek to develop my personal uniqueness by buying special products.	0.842	0.896	0.850	0.916
Having an eye for products that are interesting and unusual assists me in establishing a distinctive image.	0.858	0.906	0.855	0.913
Often when buying merchandise, an important goal is to find something that communicates my uniqueness.	0.844	0.920	0.881	0.937
Co-creation (COC)	(AVE = 0.74; α = 0.91; CR = 0.93)		(AVE = 0.82; α = 0.94; CR = 0.96)	
I will likely share corporate posts (e.g. product information or news) through the XX AR app.	0.887	0.863	0.892	0.912
I will likely upload product-related videos, audio, pictures, or images of my favorite brand through the XX AR app.	0.885	0.862	0.871	0.920
I will likely recommend my favorite (product, e.g. shoe) to my contacts through the XX AR app	0.711	0.807	0.701	0.865
I will likely join events organized through the XX AR app.	0.832	0.900	0.716	0.928
I will likely share my own shopping experiences through the XX AR app.	0.766	0.855	0.791	0.895
Engagement: Vigor (VIG)	(AVE = 0.79; α = 0.91; CR = 0.94)		(AVE = 0.86; α = 0.94; CR = 0.96)	
I feel strong and vigorous when I am using the XX AR app.	0.713	0.902	0.746	0.934
I feel very mentally resilient when I am using the XX AR app.	0.755	0.925	0.782	0.947
I will persevere when using the XX AR app, even if things do not go well.	0.881	0.875	0.803	0.913
I try my hardest to perform well when using the XX AR app.	0.830	0.839	0.730	0.907
Engagement: Dedication (DED)	(AVE = 0.75; α = 0.89; CR = 0.92)		(AVE = 0.87; α = 0.95; CR = 0.97)	
The XX AR app inspires me.	0.857	0.794	0.713	0.933
I find the XX AR app is full of meaning and purpose.	0.712	0.867	0.756	0.944
I am excited when using the XX AR app.	0.764	0.919	0.626	0.907
I am proud to use the XX AR app.	0.723	0.866	0.762	0.951
Engagement: Absorption (ABS)	(AVE = 0.81; α = 0.89; CR = 0.93)		(AVE = 0.86; α = 0.92; CR = 0.94)	
Time flies when I am using the XX AR app.	0.867	0.868	0.788	0.923
Using the XX AR app is so absorbing that I forget about everything else.	0.828	0.915	0.759	0.916
I am really immersed when using the XX AR app.	0.736	0.913	0.738	0.945

Notes: AVE = Average variance extracted. α = Cronbach's alpha. CR = Composite reliability. EFA = Exploratory factor analysis. CFA = Confirmatory factor analysis.

Table 4. Correlation matrix and heterotrait-monotrait (HTMT) ratio of correlation for Study 2.

	Dulux Visualizer: Shared product			Warby Parker: Individual product		
Construct	Co-creation	Experience quality	Need for uniqueness		Co-creation	Experience quality	Need for uniqueness
Co-creation	**0.858**	0.388	0.628	Co-creation	**0.904**	0.466	0.657
Experience quality	0.41	**0.869**	0.425	Experience quality	0.517	**0.915**	0.445
Need for uniqueness	0.619	0.367	**0.907**	Need for uniqueness	0.657	0.412	**0.922**

Notes: Bold values on the diagonal represent the square roots of average variance extracted. Values above the diagonal are heterotrait-monotrait (HTMT) ratios while values below the diagonal are correlations.

Table 5. Formative constructs statistics.

Construct	Mean difference	2.50%	97.50%	Permutation *p*-value	Variance difference	2.50%	97.50%	Permutation *p*-value
Absorption	0.009	−0.24	0.219	0.358	−0.008	−0.34	0.305	0.055
Dedication	0.005	−0.23	0.231	0.096	−0.01	−0.33	0.303	0.011
Engagement	0.007	−0.23	0.236	0.183	−0.04	−0.32	0.324	0.23
Vigor	0.006	−0.22	0.227	0.406	−0.009	−0.28	0.277	0.066

tested mean and variance differences for each higher-order indicator. Table 5 shows that the Dulux Visualizer and Warby Parker samples did not differ significantly in terms of mean or variance for absorption and vigor, whereas a significant variance difference emerged for dedication. These results, in turn, indicate partial measurement invariance for engagement.

To proceed, we employed a two-stage approach in SmartPLS. First, we extracted latent variable scores for vigor, dedication, and absorption. We then used these scores to construct the second-order formative engagement construct in a new PLS model for subsequent analyses.

6.5. Structural model

For the Dulux Visualizer sample (Figure 3 Panel A), experience quality had a significant, positive relationship with engagement [$R^2 = 0.30$, $\beta = 0.55$, $t = 8.24$, $p < 0.001$, Cohen's $f^2 = 0.12$], with a 95% bias-corrected confidence interval of [0.395, 0.660]. At the same time, engagement was significantly and positively related to co-creation [$R^2 = 0.65$, $\beta = 0.62$, $t = 10.59$, $p < 0.001$, Cohen's $f^2 = 0.62$], with a 95% bias-corrected confidence interval of [0.546, 0.803]. The total effect of experience quality on co-creation was positive and significant ($\beta = 0.36$, $t = 5.74$, $p < 0.001$), with a 95% bias-corrected confidence interval of [0.215, 0.465]. The specific indirect effect of experience quality → engagement → co-creation was positive and significant ($\beta = 0.38$, $t = 6.01$, $p < 0.001$), with a 95% bias-corrected confidence interval of [0.225, 0.494]. However, the direct relationship between experience quality and co-creation was not significant ($\beta = -0.018$, $t = 0.36$). These patterns offer a suggestive indication of full mediation for the relationship between experience quality and co-creation in this sample.

For the Warby Parker sample (Figure 3 Panel B), experience quality had a significant, positive relationship with engagement [$R^2 = 0.30$, $\beta = 0.54$, $t = 9.06$, $p < 0.001$, Cohen's $f^2 = 0.44$], with a 95% bias-corrected confidence interval of [0.403, 0.645]. Engagement was also significantly and positively related to co-creation [$R^2 = 0.56$, $\beta = 0.61$, $t = 8.63$, $p < 0.001$, Cohen's $f^2 = 0.43$], with a 95% bias-corrected confidence interval of [0.452, 0.734]. The total effect of experience quality on co-creation was positive and significant ($\beta = 0.34$, $t = 5.83$, $p < 0.001$), with a 95% bias-corrected confidence interval of [0.223, 0.443]. The specific indirect effect of experience quality → engagement → co-creation was positive and significant ($\beta = 0.34$, $t = 5.83$, $p < 0.001$), with a 95% bias-corrected confidence interval of [0.223, 0.443]. However, the direct relationship between experience quality and co-creation was not significant ($\beta = -0.06$, $t = 0.88$). These patterns also suggest full mediation. Thus, H_3, H_5, and H_6 are supported, while H4 is not.

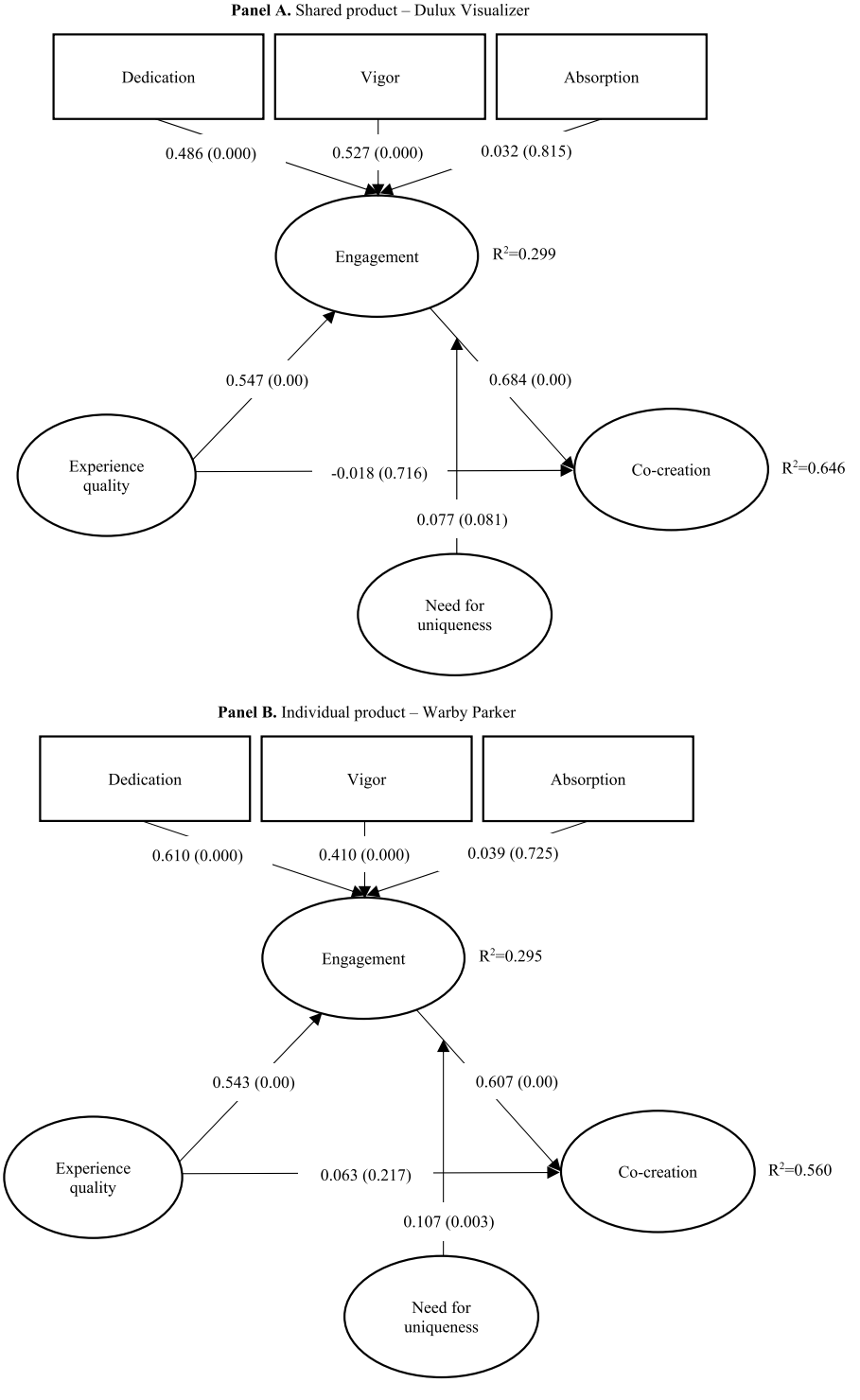

Figure 3. Results of Study 2.

6.6. Moderation analysis

To test the moderating role of need for uniqueness on the relationship between engagement and co-creation, we implemented a latent variable interaction in SmartPLS. This approach models moderation effects using construct-level interaction terms, consistent with recommended procedures (Henseler and Fassott, 2010). For the shared product (Dulux Visualizer), as expected, the moderation analysis indicates that the need for uniqueness plays no role in the engagement to co-creation relationship [$\beta = 0.077$, $t = 1.70$], with a 95% bias-corrected confidence interval of [−0.011, 0.155]. For the individual product (Warby Parker), as expected, the moderation analysis shows that need for uniqueness positively moderates the relationship between engagement and co-creation [$\beta = 0.107$, $t = 2.96$, $p < 0.003$, Cohen's $f^2 = 0.11$], with a 95% bias-corrected confidence interval [0.029, 0.172]. The conditional effect of engagement on co-creation at both low and high levels of need for uniqueness is also plotted in Figure 4. Therefore, H_7 is supported.

6.7. Measurement invariance and multi-group tests

To further test H_7, we assessed differences between coefficients across the contextual grouping variable, that is, individual versus shared products, using multi-group analysis. We applied Henseler et al.'s (2016) three-step procedure to analyze the measurement invariance of composite models (MICOM).

In step 1, configural invariance was established by ensuring equality in sample size considerations, indicators, algorithm settings, and data-analytical procedures across the two apps.

In step 2, compositional invariance was tested by comparing the original correlation with the 5th percentile using a permutation test with 5,000 permutations. The results shown in Table 6, Panel A, indicate that step 2 is satisfied, as all original correlations exceed the 5 percent quantile and are not significantly different from 1, allowing the analysis to proceed.

In step 3, composite equality was assessed by checking whether the mean and the variance of the original difference fall between the 2.5 and 97.5 percent quantiles. If both conditions are met, full invariance is observed. If one condition is met, partial invariance is observed. If neither condition is met, invariance is not observed. The results in Table 6, Panel B, show that the mean and variance values in the Dulux Visualizer sample do not

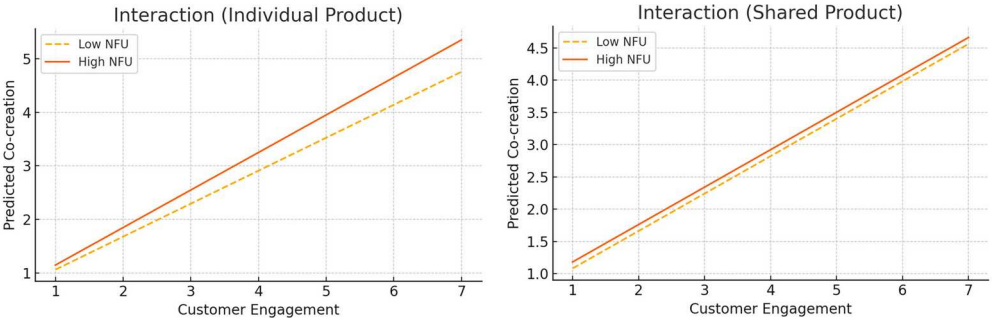

Figure 4. Interaction plot.

Table 6. Measurement invariance of composite model statistics.

Panel A. Compositional invariance			
Construct	Correlation	5.00%	*p*-value
Co-creation	1	1.000	0.605
Engagement	0.998	0.977	0.750
Experience quality	1	0.997	0.542
Need for uniqueness	1	1.000	0.774

Panel B. Composite equality								
Construct	Mean difference	2.5%	97.5%	Permutation *p*-value	Variance difference	2.5%	97.5%	Permutation *p*-value
Co-creation	−0.092	−0.229	0.212	0.420	−0.278	−0.240	0.238	0.058
Engagement	0.000	−0.221	0.234	1.000	−0.049	−0.307	0.307	0.753
Experience quality	0.517	−0.229	0.223	0.000	−0.620	−0.549	0.536	0.031
Need for uniqueness	−0.047	−0.226	0.229	0.685	−0.347	−0.385	0.354	0.066

Table 7. Cross-group differences.

Path	Coefficient difference (Dulux Visualizer vs. Warby Parker)	*p*-value
Engagement → Co-creation	−0.002	0.563
Experience quality → Co-creation	0.000	0.624
Experience quality → Engagement	0.004	0.856
Need for uniqueness × Engagement → Co-creation	−0.001	0.437

differ significantly from those in the Warby Parker sample for each modeled construct, except for experience quality, where the mean and variance differed across the two groups. Therefore, partial measurement invariance is established.

We then performed a multi-group analysis on the two datasets. The results in Table 7 show that none of the hypothesized structural paths differ significantly across groups, which indicates strong consistency of the structural model across the two samples. Although only partial measurement invariance was achieved, the consistency of structural relationships across product contexts suggests that the observed patterns are unlikely to be due to measurement artifacts.

7. Discussion, implications, limitations, and future directions

7.1. Discussion

Consumers are increasingly co-creating value with retailers through digital technologies, including via AR, which retailers provide as a value-added service. Study 1 examined the association between network externality and experience quality under the moderating influence of autonomy for individual versus shared products. Study 2 subsequently investigated the association between experience quality, engagement, and co-creation for these products under the moderating influence of the need for uniqueness.

Aligned with digital technology research (Hilken et al., 2017; McLean & Wilson, 2019; Zeng et al., 2024), the findings from Study 1 suggest that network externality is

significantly related to experience quality in both individual and shared products. An unexpected result also emerged, whereby autonomy negatively moderated this relationship. Consumers with lower autonomy reported higher experience quality, which implies that they benefit more from network externality due to stronger reliance on others. This finding contrasts with studies that frame autonomy as a universally positive driver of digital experiences (Puerta-Sierra & Puente-Díaz, 2023; Sheldon et al., 1996). The pattern also refines social influence research by indicating that highly autonomous consumers may be less receptive to peer-driven cues in AR settings, particularly when choice overload or decision fatigue is present (Hamilton et al., 2021; Iyengar & Lepper, 2000). Viewed through social influence theory (Sutcliffe et al., 2011), highly autonomous users appear more likely to dismiss network-related social cues and to favor independent judgment instead (Deci & Ryan, 2000; Sheldon et al., 1996). When they perceive high choice complexity or decision strain, they may place less value on social signals that would otherwise enhance the experiences of less autonomous consumers. Therefore, future research could examine whether autonomy primarily shapes responses to the perceived relevance or trustworthiness of network-based information (Gagné & Deci, 2014).

Study 2 builds on these results by showing that the quality of experience shapes engagement, which, in turn, drives co-creation in AR retail service settings. These relationships are moderated by the need for uniqueness, with significant moderation in the individual product context but not in the shared product context. This contrasts with research that often assumes that both social and shared consumption experiences equally stimulate engagement and co-creation across consumer groups (Brodie et al., 2011; McLean & Wilson, 2019). The findings instead reveal that for consumers high in the need for uniqueness, personalized product experiences are more effective than shared ones in fostering value co-creation. Therefore, in AR contexts, the alignment between product type and identity-related motives plays a larger role than previously recognized.

Indeed, the observed need for uniqueness effect is consistent with the theoretical account proposed by Tian et al. (2001), yet it diverges from AR retailing work that emphasizes the benefits of social presence and collective experiences (Hilken et al., 2017). Such studies found that AR's immersive capabilities enhanced both individual and shared experiences by providing vivid product information and enabling social interaction. Whereas the present results indicate that for consumers high in the need for uniqueness, distinctiveness rather than connectedness is the primary driver of engagement, as shared AR experiences may introduce pressures toward conformity or diminish perceived individuality, thereby reducing their motivational appeal for these consumers.

A further distinction from earlier work lies in the mediating role of engagement. In line with Hollebeek et al. (2019) and Jaakkola and Alexander (2014), the findings confirm that engagement serves as the pathway through which experience quality translates into co-creation. Unlike studies that document a direct link between experience quality and co-creation in digital retail (McColl-Kennedy et al., 2012), no such direct relationship is observed in AR retail service. Notably, positive experiences alone do not trigger co-creation unless they also generate strong cognitive, emotional, and behavioral engagement. This insight, therefore, refines extant conceptual models of AR-driven value co-creation by positioning engagement as a necessary mechanism rather than a mere outcome.

7.2. Theoretical implications

This research makes interrelated contributions to theory in AR retail service, engagement, and value co-creation.

First and foremost, this research shows how network externality and autonomy interact to qualify the quality of experiences in immersive AR retail environments. Prior work acknowledges the impact of network externality on user perceptions (Abu Shanab et al., 2024) and the role of autonomy in digital engagement (Puerta-Sierra & Puente-Díaz, 2023), yet little attention has been given to their combined effects within AR settings. The results indicate that autonomy moderates the effect of network externality in an unexpected way, which offers fresh insight into how social influence operates (Sutcliffe et al., 2011) and how self-determination processes shape evaluation (Deci & Ryan, 2000; Sheldon et al., 1996). The insight, therefore, challenges the view that autonomy consistently enhances digital experiences and highlights the situational nature of social influence in AR contexts.

Second, by establishing engagement as a full mediator between experience quality and co-creation across individual and shared products, this research advances engagement frameworks (Brodie et al., 2011; Hollebeek et al., 2020) and enriches the S-D logic (Vargo & Lusch, 2016). In contrast to studies that view engagement as a downstream outcome of positive experiences (Kumar et al., 2019; McColl-Kennedy et al., 2012), the results position engagement as the process mechanism through which experiential value is converted into co-creation. This repositioning shifts attention away from whether positive experiences will naturally lead to co-creation toward understanding how engagement is activated and sustained in AR contexts.

Third, this research contributes to a richer understanding of psychological traits and retail service behavior by incorporating the need for uniqueness as a boundary condition. The moderating effect of the need for uniqueness observed only in the individual product context supports a context-contingent role of personal traits in shaping participatory behavior in co-creation. This distinction also contributes to segmentation and personalization frameworks by showing how traits interact with product context to shape behavioral outcomes (Tian et al., 2001). The result also suggests that dispositions such as uniqueness seeking are more salient in self-expressive consumption settings, which refines the understanding of antecedents of engagement-based co-creation.

Fourth, the use of multi-group analysis and the establishment of partial measurement invariance between individual and shared product contexts add methodological rigor and advance comparative retail service research. While the quality of experience differs between contexts, the consistency of model paths across samples suggests that the core mechanism of experience through engagement holds across product categories. This supports a more generalizable process model of experience to engagement to co-creation while allowing for contextual moderation.

Last but not least, integrating a trait-based moderator, a process mediator, and a contextual factor yields a multi-layered model of value co-creation that emphasizes connections among individual, relational, and systemic dimensions of retail service experiences. The approach aligns with calls to expand value co-creation research beyond dyadic interactions to consider wider psychological and situational influences (Akaka & Vargo, 2015). It also aligns with recent developments that highlight multi-level, multi-actor

contingencies on digital platforms, where value creation stems from dynamic coordination among actors, technologies, and institutional structures (Mbanefo & Grobbelaar, 2025). Hence, by demonstrating how autonomy and the need for uniqueness influence engagement and co-creation outcomes by product type, the model positions engagement in AR retail services as inherently conditional, identity-driven, and multidimensional. This theoretical repositioning contributes to a more predictive and context-aware framework that respects psychological diversity and situational variation, which offers stronger explanatory power for future research in digital retail and service settings.

7.3. Managerial implications

This research offers actionable guidance for designing AR retail service that converts experience into engagement and co-creation.

Findings from Study 1 indicate that autonomy influences how consumers utilize social signals in response to network externality. The effect, however, runs counter to common expectations. Consumers with lower autonomy, in particular, gain more from socially rich AR features because external validation raises perceived quality and satisfaction. Real-time popularity indicators, visible usage volume, and peer endorsements should, therefore, provide reassurance when confidence or independence is low, which aligns with evidence that social presence and peer feedback elevate user experience under such conditions (Kim et al., 2024). Consumers with higher autonomy, in contrast, tend to prefer self-directed environments with minimal social interaction. Private customization modes, clear control over data visibility, adaptive recommendations that can be tuned or switched off, and step-by-step tools that preserve independence should, therefore, sustain their experience and reduce friction.

Findings from Study 2 reveal engagement as the essential bridge between experience and co-creation, as a positive AR encounter, on its own, does not guarantee advocacy, feedback, or content sharing. Managers should, therefore, design their approach explicitly to foster cognitive, emotional, and behavioral engagement. Specifically, interactive product exploration, personalized task flows, immersive narratives, gamified micro-goals, and time-bound challenges should create purposeful effort and repeated return visits, which recent work has linked to stronger engagement outcomes (Liu et al., 2020; Suh et al., 2018).

The need for uniqueness further strengthens the engagement in the co-creation pathway for individual products. Notably, consumers with a high need for uniqueness view AR as a platform for self-expression; therefore, exclusive customization options, limited digital editions, creator templates, and co-design features that produce distinctive outcomes should increase participation. Shared product contexts require a different approach because identity signaling is diluted; instead, community identity and collaboration become the primary drivers. Group design boards, neighborhood or household palettes, and team-based AR makeovers should, therefore, invite contribution without forcing conformity. Message framing should also reflect this split, wherein identity-forward, show-your-style language works for eyewear and apparel, whereas togetherness and project language suits paint and furniture.

Overall, the findings suggest that aligning AR retail service design with social signals (network externality), personal control (autonomy), psychological trait (need for

uniqueness), and context-specific motivations (individual vs. shared product) is key to realizing its potential. Offering socially rich AR experiences for low-autonomy users, providing independent design environments for high-autonomy users, and building engagement triggers that sustain participation enable service providers to enhance both experience quality and willingness to co-create. In turn, AR retail service shifts from novelty to a strategic capability that drives strong experiences, deep engagement, and active co-creation, which fosters short-term satisfaction and long-term loyalty.

7.4. Limitations and future directions

Several limitations recommend a careful reading of the findings and set a clear agenda for future research.

First and foremost, partial measurement invariance was established between individual and shared product groups, which implies that full scalar equivalence was not achieved. Multigroup comparisons remain informative yet should be interpreted with caution. The robustness of structural relationships across contexts suggests that the observed effects are unlikely to be explained solely by measurement artifacts. Future research should, therefore, endeavor to replicate these findings under full measurement invariance to reinforce cross-context conclusions, using additional checks such as configural and scalar invariance to validate equivalence.

Second, procedural remedies and statistical tests were used to minimize and detect common method bias, including Harman's single-factor test and the random dependent variable approach. Exclusive reliance on self-reported, cross-sectional data may still leave residual common method bias. Future studies should, therefore, incorporate multi-source data or employ marker variables or latent method factor techniques to more fully assess and control potential bias.

Third, future research can leverage complementary theories to explain when and why AR retail services create value. Social exchange theory can be used to assess the perceived benefits versus the costs of interacting with AR retail services, while social identity theory can be used to examine how people cultivate their identity in these settings. Additional mediational pathways also merit testing, including task – technology fit and effects on perceived product value (Rumokoy & Frank, 2025), as well as the influence of brand love on engagement (Kabadayi et al., 2023).

Last but not least, while the modeled dynamics were examined for individual products, such as eyewear and footwear, and shared products, such as furniture and paint, replication and extension across other categories, such as jewelry, cars, and toothpaste, would strengthen external validity. Beyond purchase-related dynamics, post-purchase behavior, such as word of mouth, deserves attention to cover more of the journey. The research design can also be replicated in adjacent contexts, such as fashion and textiles, to gauge boundary conditions of the process model (Alexander & Varley, 2025; Brand, 2025).

Data availability statement

Data can be made available on reasonable request.

Disclosure statement

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