Master Thesis

Virtual Brand Experiences: A Comparative Study of 360-Degree Images and 3D Products in VR on Immersion and Engagement

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II. Abstract

As brands race to establish a presence in the metaverse, the challenge is to create immersive experiences that truly engage consumers. However, not all virtual formats are equally effective. This study investigates the impact of different promotional formats (360-degree rotatable images versus 3D products) in a metaverse inspired virtual reality (VR) environment on brand experience, using a HelloFresh meal box as a case study. Engagement and immersion were examined as mediators in this relationship. A between-subjects experiment was conducted with 82 participants (41 per condition). The results of the parallel mediation analysis revealed no direct effect of promotion type on brand experience. However, engagement emerged as a significant mediator which positively influenced brand experience, with the 3D object condition generating higher engagement compared to the 360-degree rotatable image. In contrast, immersion did not mediate the relationship between promotion type and brand experience. Regardless of promotion type cognitive engagement had the strongest impact on brand experience, followed by behavioral engagement, and then emotional engagement. These findings add to the VR marketing literature by empirically demonstrating the role of engagement in shaping brand experience. Marketing managers should prioritize interactive 3D product models over 360-degree rotatable images, and engagement tracking should be used to improve brand experience, but not as the sole indicator. Finally, as VR marketing advances, ethical concerns such as data privacy, transparency, and the impact on vulnerable audiences, such as young people and the Black and Latinx communities, must be carefully addressed.

Keywords: Virtual reality, Metaverse, Advertising, 360-degree rotatable image, 3D object, Engagement, Immersion, Brand experience

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1 Introduction

The digital landscape is rapidly transforming, revolutionizing the ways in which consumers interact with technology and virtual environments. At the forefront of this change is the concept of the metaverse, an interconnected network of immersive virtual worlds that blend with the physical world, enabling real-time interaction and user-generated content, supported by an incentivized economic system (Bilgihan et al., 2024; Giang Barrera & Shah, 2023). Big tech organizations such as Meta, Microsoft, Apple, and Google have invested significant amounts of money in these technologies, with the industry expected to grow at a CAGR of 34.98%, reaching a total market size of $485.8 billion by 2030 (Trenker, 2023). This demonstrates a strong belief in the metaverse's ability to change the way people communicate, collaborate, consume media, and perceive reality, redefining social networking, e-commerce, education, and entertainment (Ramachandran et al., 2023; Riva & Wiederhold, 2022; Trenker, 2023).

Brands are eager to establish a presence in online virtual worlds to connect with customers, ensuring their brand remains prominent in consumers' minds and ultimately influences future purchasing decisions. Central to this is the creation of a compelling brand experience, which refers to the feelings, cognitions, and behavioral responses created by brand-related stimuli (Brakus et al., 2009). Virtual reality (VR) offers an innovative approach to creating these compelling brand experiences. The technology built into VR devices and environments provides new ways to promote products that differ from traditional methods in real life. VR environments offer greater freedom and flexibility compared to the constraints of the physical world, enabling brands to design immersive experiences that incorporate gamification techniques to encourage interaction and engagement (Bousba & Arya, 2022; Gabisch & Gwebu, 2011; Hollebeek et al., 2020; Moon & Han, 2023).

Despite the growing interest in metaverse marketing, there is still a significant knowledge gap in this field. VR technologies are relatively new and not yet widely adopted. While brands have begun experimenting with various and new virtual formats there is a lack of empirical research comparing the effectiveness of different promotional formats, with existing research providing conflicting findings (Kang et al., 2020). The current literature remains mainly conceptual, with numerous theoretical propositions about the roles of engagement and immersion in virtual environments but limited empirical validation (Dwivedi et al., 2022; Hollebeek et al., 2020).

This study aims to close these gaps by investigating how two VR promotional formats, 360-degree rotatable images and interactive 3D product models, influence brand experience, with a focus on the mediating roles of engagement and immersion. Using a between-subjects experimental design with a HelloFresh meal box as a case study, the research addresses the following research questions: (1) What is the impact of 360-degree rotatable images and 3D products within VR environments on brand experience? (2) What is the role of engagement and immersion in shaping brand experience?

Advanced visualization technologies enable varying levels of product exploration. 360-degree rotatable images allow consumers to explore the product on a 2D surface by rotating static views and zooming in and out (Debbabi et al., 2010), whereas 3D products integrate products into VR worlds in the same 3D space the user is in, allowing for true spatial interaction in which users can manipulate objects in three dimensions and replicate real-world interactions. This distinction suggests that 3D products may create deeper immersion through enhanced spatial presence and more natural interaction (Bilgihan et al., 2024), while potentially generating stronger engagement through richer sensory feedback and greater interactivity (Bilgihan et al., 2024).

For example, Wendy's worked with Meta to create "Wendyverse" a virtual environment where users can explore 3D products, play games, and order virtual food, thereby enhancing brand awareness and testing new product ideas (Meisenzahl, 2022). Despite these developments, the most common promotion type in the metaverse remain 2D low interactive formats (e.g., banners, billboards) (Sarna et al., 2023). These formats are preferred because they are less expensive to produce and easier to implement than more immersive 3D experiences like product placements.

When looking at the current landscape, it becomes clear how important the research questions are. While 2D formats dominate due to their practicality, it remains unclear how different promotional formats influence consumer behavior and brand experience in VR environments. This highlights the need for additional research into how various VR formats and content features affect consumer perceptions, engagement, and brand experience (Dwivedi et al., 2022; Eyada, 2023; Hollebeek et al., 2020).

To the best of our knowledge, no study has directly compared 360-degree rotatable images to 3D products in VR environments. Additionally, while 360-degree rotatable images exist on websites, this may be the first instance of such a format being implemented within a VR setting. This study will contribute to the academic literature by understanding of how different VR promotional formats affect consumer behavior and brand perception. Additionally, it will provide theoretical relevance by exploring the specific relationship between engagement and immersion in influencing brand experiences within VR. Third, the study aims to develop a theoretical framework that can guide future research on VR marketing, offering a structured approach to studying the interplay between VR formats, engagement, immersion, and brand experience.

From a practical standpoint, the findings of this study will be useful for marketers and brand managers looking to leverage VR technology within the metaverse. By empirically

assessing whether 360-degree rotatable images or 3D products improve brand experience more effectively, this study will provide clear guidance for strategic decision-making in digital marketing campaigns. Understanding how these VR promotional formats generate brand experiences in the metaverse that differ from real-life interactions will be critical.

Marketers can use this knowledge to create more immersive and engaging virtual experiences that resonate strongly with customers. These insights will not only optimize marketing strategies but also empower brands to differentiate their presence in the competitive virtual landscape, enhance consumer interaction, and eventually improve return on investment (ROI) by aligning digital investments with consumer preferences and behaviors in virtual environments. The ethical implications will also be touched upon providing critical insights into the responsible use of VR marketing techniques.

In conclusion, the outcome of this study not only advances academic understanding of VR promotion formats but also offer insights for practitioners aiming to capitalize on the transformative potential of the metaverse. By connecting theoretical exploration with practical application, this research highlights the role of innovative digital marketing strategies in shaping the future of consumer-brand interactions.

2. Literature Review and Hypothesis Development

2.1 Brand Experience

The significance of brand experience has been growing in marketing research as marketers view it as an essential strategy for establishing long term consumer-brand relationships. Research on consumer experiences has traditionally focused on utilitarian aspects of products and the overall category experience. However, when it comes to brand experience the focus shifts to specific stimuli associated with brands. According to Brakus et al. (2009) these stimuli include visual and design elements such as colors, shapes, typefaces, slogans, and mascots, which are integral to a brand's identity and marketing strategies (e.g., logos, packaging, advertisements, and store environments). Therefore, brand experience is defined as the subjective reactions of consumers, which include their sensations, feelings, and thoughts, as well as their behavioral responses triggered by stimuli associated with a brand's design, identity, packaging, marketing communications, and presentation environments, which collectively shape consumer interactions and perceptions across various touchpoints.

However, already in 2014 Grönroos & Gummerus (2014) argued that this definition no longer captured the changing nature of brand experience because of shifts in consumer behavior, market dynamics, and consumption contexts brought about by digitalization and co-creative interactions between consumers and brands. A multi-level perspective that takes into account micro (individual and dyadic relationships), meso (collective interactions within communities and cultural groups), and macro (broader societal and market dynamics) is required to see brand experience as an integrated phenomenon influenced by cultural practices, social norms, and institutional forces. A shift from viewing brand experience solely as a consumer-driven outcome to seeing it as a collaborative and evolving process influenced by a variety of actors and contexts.

It is important to note that brand experience differs conceptually from other brand-related constructs. Brand attitudes are a stable and unidimensional evaluation of a brand (Banytė et al., 2007; Spears & Singh, 2004), while brand experiences include specific sensations, feelings, cognitions, and behavioral responses provoked by brand-related stimuli (Brakus et al., 2009). While experiences can lead to general evaluations, such as liking a specific experience, they go beyond simple evaluative judgments of the brand.

Furthermore, brand experience differs from concepts like brand involvement and brand attachment. Brand involvement is a cognitive construct reflecting the extent to which a brand is personally relevant to consumers, involving goal-directed mental processes such as attention, memory, and information processing (Altarifi, 2021), whereas brand experience does not necessarily require motivational states and can occur regardless of consumer interest in the brand (Brakus et al., 2009). Unlike brand attachment, which is the degree of the emotional connection that binds the brand to the self characterized by affection, passion, and connection (Park et al., 2010; Thomson et al., 2005), brand experience focuses on other immediate responses triggered by brand stimuli rather than just the emotional relationships with the brand over time (Brakus et al., 2009).

Finally, brand experience should not be confused with concepts such as brand equity, brand awareness, or brand image. According to Keller (1993) brand equity refers to the value a brand adds to a product or service based on consumers' knowledge and perceptions of the brand and is shaped by both brand awareness (the ability to recall or recognize the brand) and brand image (the associations linked to the brand in consumers' memory). In contrast, brand experiences are the direct sensory, emotional, and cognitive responses triggered by brand stimuli, which are distinct from the processes involved in brand awareness and image formation.

To briefly summarize, while brand experience may involve emotional responses and could influence overall brand evaluations, its primary distinction lies in its focus on immediate, specific reactions to brand stimuli, which transcend traditional evaluative, affective, and associative constructs in branding. As mentioned earlier, brand experience is a dynamic and multifaceted process that shapes consumer perceptions and behaviors across various touchpoints. While customer satisfaction and brand loyalty are frequently cited as the primary outcomes of brand experiences, Khan & Rahman (2015) systematic literature review notes that the brand experience encompasses more than that. Brand attitude, brand credibility, brand equity, brand recall, and purchase intention have all been identified as important consequences in the literature. These outcomes are highly sought after by brands because they contribute to a brand's success and competitive advantage. By effectively targeting and enhancing the brand experience, companies can create deeper emotional connections with consumers, drive repeated purchases, and cultivate a loyal customer base, ultimately leading to sustained market growth and profitability.

2.2 Engagement

Defining engagement is complex, as found by varied perspectives across different studies and contexts. Engagement is generally understood as a multidimensional construct that encompasses the active, interactive, and co-creative participation of customers with a brand or firm, driven by cognitive, emotional, and behavioral dimensions (Brodie et al., 2011; Hollebeek et al., 2019). It extends beyond mere purchase behavior to include a customer's overall psychological state and motivational investment in brand interactions, incorporating both transactional and non-transactional activities (Kumar et al., 2010; van Doorn et al., 2010). Hookham & Nesbitt (2019) conducted a systematic review of engagement in serious games, highlighting the various perspectives on the concept and dives deeper into the constructs of behavioral, emotional, and cognitive dimensions of engagement.

One perspective links engagement with behavioral metrics like time on task or frequency of use, implying that engagement can be directly measured through observable actions (Hookham & Nesbitt, 2019). For example, some studies consider engagement in terms of the total time users spend interacting with a brand or the frequency of their interactions. This behavioral view suggests that higher engagement is reflected in greater usage and interaction with the brand.

Another perspective emphasizes the emotional or affective aspects of engagement. Some definitions focus on the affective state of the user, describing engagement as a pleasurable experience that requires no effort to continue (Hookham & Nesbitt, 2019). This view aligns engagement with emotional responses such as enjoyment, fun, and intrinsic motivation. This links to flow theory which describes engagement as a state of complete absorption and deep enjoyment in an activity, where users lose track of time and feel intrinsically motivated to continue (Csikszentmihalyi, 1990).

While Hookham & Nesbitt (2019) suggest a cognitive component to engagement, it is not extensively detailed in their review. However, further clarity on the cognitive dimension of engagement can be found in literature. Mills et al. (2013) mentions that the cognitive components of engagement include attention, concentration, and the use of learning strategies. Dubovi (2022) explores cognitive engagement specifically in the context of learning with VR, defining the cognitive dimension of engagement as psychological investment. This encompasses users' mental orientation, cognitive efforts during interactions, and the thoughts or focus aroused.

(Hollebeek et al., 2020) mentions in their conceptual paper which focuses on VR worlds, the same types of engagement with the addition of social engagement, influencing the quality of user’s brand relationships after their VR experience. In this study, engagement is

specifically defined as users' cognitive, emotional, and behavioral interactions with brand-related products within the VR environment, focusing on products rather than the entire virtual world. This conceptualization emphasizes product interactions made possible by promotion formats such as 360-degree rotatable images and 3D products. This includes cognitive engagement, where users invest mental effort in exploring and understanding VR products; emotional engagement, reflecting the feelings and bonds formed during product interaction; and behavioral engagement, demonstrated by the time and effort dedicated to these interactions. This framework ensures that engagement is measured within the context of brand interactions in the VR environment, rather than in a general VR context.

2.3 Immersion

The term immersion is still used inconsistently in a variety of research contexts related to the study of interactive media, gaming, and virtual reality. When it comes to defining immersion, there appear to be two viewpoints. One perspective is that immersion is characterized as a subjective mental state where the other perspective argues that immersion is an objective technological attribute.

From the technological perspective, immersion refers to how effectively computer displays can create a comprehensive, vivid illusion of reality (Slater & Wilbur, 1997). Immersion is often described objectively with the assumption that subjective immersion will naturally follow (Hudson et al., 2019). This involves minimizing physical reality, engaging multiple senses, encompassing the user's environment, and providing high resolution and accuracy (Slater & Wilbur, 1997). Thus, factors like frame rate and display resolution are crucial in determining the level of immersion experienced in VR (Bowman & McMahan, 2007).

The psychological point of view describes immersion as a multifaceted subjective experience. It is a subjective mental state where the user feels isolated from the real world and feels deeply engaged within an immersive environment (Radianti et al., 2020; Slater & Wilbur, 1997; Suh & Prophet, 2018). It requires both physical and mental participation (Carù & Cova, 2006). Pine and Gilmore (1999) add that immersion entails being "in" a real or virtual experience. It means feeling completely connected to and part of the world around you, both in terms of where you are and the present moment. Jennett et al. (2008) states that “immersion involves a lack of awareness of time, a loss of awareness of the real world, involvement and a sense of being in the task environment”. This perspective highlights the experiential aspect of being enveloped in and interacting with a simulated reality, focusing more on the user's perception and experience rather than technological specifications.

Immersion is related to, but different from the concept of presence. Presence is when users feel like they are in a real place, even though they are in a virtual environment created by technology. The feeling of “being there” is connected to presence as well, but immersion is broader than presence (Hudson et al., 2019). The perceived level of immersion varies per individual and is minimally influenced by technological attributes (Radianti et al., 2020).

According to Csikszentmihalyi (1990), immersion is associated with the idea of "flow," a state in which participants experience a heightened state of immersion in which they become unaware of their surroundings and perceive time in a different way. Jennett et al. (2008) mentions that flow is different from immersion in that it occurs during a brief, specific period of immersion, whereas immersion can be experienced in varying levels. Furthermore, flow is always associated with positive emotional valence, but immersion does not necessarily have this (Hudson et al., 2019).

Research in gaming interfaces and virtual worlds identifies several factors that enhance immersion. These include the realism and interactivity of the virtual environment, ease of use of the technological interface, player identification with the environment, player identification with their avatar (e.g. personalizing avatar), enjoyment, and social interactions (Hudson et al., 2019; Waltemate et al., 2018).

In the context of this literature review, immersion is characterized as a multifaceted subjective experience. It represents the mental state where users feel deeply involved and psychologically transported within an immersive environment where individuals may feel detached from their everyday surroundings and fully connected to the simulated environment.

2.4 360-Degree Rotatable Images and 3D Objects in VR Environments

In this thesis, "promotion type" refers to specific advertising formats being 360-degree rotatable images or 3D objects in virtual reality environments. These formats demonstrate the practical application of advertising. Although this study focuses on these formats, it is necessary to place them within the larger theoretical framework of advertising and promotion to understand their role in modern marketing strategies.

Advertising encompasses a wide range of paid brand-initiated communication strategies aimed to persuade people to take action (Dahlen & Rosengren, 2016; Patrick & Hagtvedt, 2011), whereas promotions often include specific activities or campaigns designed to attract consumer attention and influence perceptions (Raghubir et al., 2004). Online retailers are increasingly using multisensory virtual product presentations to portray product features and performance capabilities more accurately to fulfill the needs of shoppers (Kim et al., 2020; Mishra et al., 2021). Traditionally, product features are presented through pictures and text. However, static visuals and textual information often fall short of providing the rich sensory experiences that online shoppers desire (Jiang & Benbasat, 2007). As a result, online

retailers and firms are experimenting and using 3D image display tools to simplify the consumer decision making process, leading to increased consumer engagement and purchase intention (Mishra et al., 2021).

360-degree rotatable images enhance product exploration by allowing interactive manipulation of product visuals using a mouse on PCs or a finger on touch devices like smartphones. Users can rotate, pinch, and zoom in on these images, enabling a comprehensive examination of the product from multiple angles (Kim et al., 2020). Such visualization satisfies the consumer's need to view and handle the product, providing a level of detail and engagement comparable to the product's physical interaction (Debbabi et al., 2010). A unique aspect of this study is the testing of 360-degree rotatable image within the metaverse on a 2D surface such as a billboard. This approach merges the detailed product viewing capabilities of 360-degree images with the contextual richness of VR environments, but on a traditional 2D interface. The practical benefits of this promotion type include being easier to implement in VR environments, being less expensive, taking less time to create, and making VR more accessible to users who are new to the technology by providing a familiar interaction method within the immersive VR context.

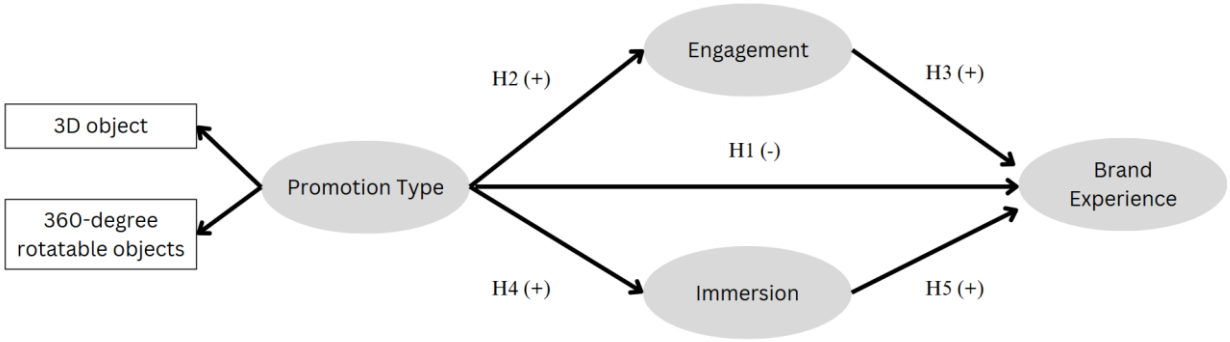
Another way of displaying products is having them as 3D objects in VR environments. To interact with virtual environments users, wear a Virtual Reality head mounted display (HMD) over their eyes which immerses the user in a computer-generated environment (Bai et al., 2021). Examples of HMDs include the HTC Vive and the Oculus Rift. In VR user’s use their hands or controllers to pick up and move 3D virtual objects which allows for a range of manipulations. Fundamental VR interaction include navigation, selection, rotation, translation, scaling, and slicing, mirroring real-world actions (Nanjappan et al., 2018). The key difference between the 360-degree rotatable image compared to 3D objects is that users can interact with the object in the same 3-dimensional space the user is

currently in. This allows for a broader range of manipulation allowing users to explore the product in a more detailed and dynamic manner.

While both promotion types enhance product visualization, they differ fundamentally in their interactive capabilities. These differences suggest that each format engage users and immerse them in distinct ways, shaping brand experience through separate pathways. Figure 1 depicts the conceptual framework of this study, illustrating the relationships among promotion type, engagement, immersion, and brand experience which will be explained in the following sections.

Figure 1

Conceptual Framework of Promotion Type (3D vs 360-Degree Rotatable Image), Engagement, Immersion, and Brand Experience



2.5 Effect of Promotion Type on Brand Experience

Drawing on theories and phenomena such as the novelty effect and heuristic processing can help explain the direct effect promotion types have on brand experience without relying on deeper mechanisms such as engagement or immersion. We also acknowledge that other frameworks may also contribute to this understanding.

Novelty plays a crucial role in capturing attention, especially in advertising where consumers are constantly bombarded with familiar messages. Encountering a new promotional format, such as a 360-degree rotatable image or a 3D object in VR, can create a sense of surprise that immediately draws attention and triggers emotional responses (Cox & Yetter, 2022; Schomaker & Meeter, 2015). While 3D objects are commonly used in VR contexts, 360-degree rotatable images in VR have yet to be adopted, making it a particularly novel stimulus. This initial reaction can shape consumers' impressions of a brand even before they engage more deeply with the content.

Research shows that novel stimuli activate the brain's emotional and memory centres, which enhances perception and action, boosts motivation, encourages exploratory behavior, and improves learning (Schomaker & Meeter, 2015). Cox & Yetter (2022) also note that novelty causes surprise when there is a mismatch between user expectations and reality, resulting in a positive reaction, particularly among first-time users. However, novelty can cause disorientation, leaving people feeling overwhelmed or distracted delaying their ability to fully engage (Cox & Yetter, 2022). This means that using novel formats can help brands cut through the noise, delivering a more vivid and memorable experience that sticks with consumers. However, if disorientation is not effectively managed, it can prevent users from fully engaging, potentially dampening the benefits of surprise. Even if users spend little time

interacting with the content, their initial surprise and emotional reaction can have a long-term impact on how they perceive the brand.

Another relevant concept is heuristic processing which is a quick, low-effort processing that is likely to be used when time and personal resources like motivation, interest, attention, and working memory capacity are limited (Forgas, 2017). When emotions are used as a mental shortcut to make decisions, the affect-as-information model suggests that people's mood will influence their judgments (Forgas, 2017). For example, if someone is in a positive mood, they are more likely to view things more favorably. While 3D objects may require more systematic processing due to their complexity, 360-degree rotatable images provide a simpler form of interaction, allowing users to rely on emotion-driven, heuristic responses for faster brand evaluations.

Thus, the following hypothesis was made based on the theories discussed above suggest that promotion types have a direct effect on brand experience.

H1: The use of 3D objects in VR environments will result in a lower direct effect on brand experience compared to 360-degree rotatable images in VR environments

2.6 Mediating Role of Engagement

Both promotion types contribute to consumer engagement and brand experience, but they do so in different ways. Engagement in VR contexts is often conceptualized as a multi-dimensional construct encompassing cognitive, affective, and behavioral aspects (Brodie et al., 2011; Hollebeek et al., 2019). The level of interaction by 360-degree images and 3D objects influences how users engage with a brand's virtual presence and in turn shapes their brand experience.

360-degree rotatable images in VR environments enhance cognitive and behavioral engagement through active exploration and examination of product features from various

angles (Kim et al., 2020). The ability to control the viewing angle fosters an active information-processing experience, helping users form a more complete mental representation of the product. This cognitive engagement strengthens consumers' evaluation of brand quality and reliability (Hollebeek et al., 2020), enhancing brand trust and perceived dependability. However, while 360-degree images positively contribute to brand experience by giving consumers more control and understanding, behavioral engagement remains limited to a two-dimensional plane, limiting the depth of interaction.

In contrast, 3D objects elevate cognitive and behavioral engagement to a higher level due to their interactive nature. Manipulating 3D objects requires users to use advanced cognitive skills such as spatial awareness and problem-solving, thereby deepening cognitive engagement (Jiang & Benbasat, 2007). Users are also more motivated to interact with products due to their spatial presence and interactive capabilities (Bilgihan et al., 2024), leading to more immersive experiences that enhance brand commitment and perceived brand performance. This hands-on engagement reinforces brand experience by fostering a stronger perception of product authenticity and functionality, which can improve long-term brand trust and evaluation (Hollebeek et al., 2020).

The emotional impact of these formats also differs. While 360-degree rotatable images evoke positive responses as users experience satisfaction and excitement from exploring products comprehensively, 3D objects generate even stronger emotional responses. The tactile interactions with 3D objects create a sense of presence and realism, mimicking real-world product handling and fostering a deeper emotional connection to the brand (Bilgihan et al., 2024). This emotional connection forms favorable brand perceptions and builds emotional bonds with the brand (Debbabi et al., 2010). Moreover, the interactive nature of these experiences enhances user satisfaction and enjoyment, aligning with the principles of flow theory, where users experience deep immersion and intrinsic motivation

during interactions (Csikszentmihalyi, 1990). Emotional engagement in VR enhances affective commitment, self-connection, and passion for the brand (Hollebeek et al., 2020), which in turn strengthens brand loyalty and positive brand sentiment. Users may feel more attached to the brand as they engage physically with virtual products, reinforcing their overall brand experience (Hollebeek et al., 2020).

Thus, the following hypotheses are proposed:

H2: The use of 3D objects in VR environments will result in higher engagement compared to 360-degree rotatable images in VR environments.

H3a: Engagement with brand related products in VR environments positively influence brand experience.

H3b: The effect of the promotion type on brand experience is partially mediated by engagement.

2.7 Mediating Role of Immersion

Both promotion types influence immersion in VR environments, shaping how deeply users feel engaged with the virtual world and, in turn, impacting their brand experience. While 360-degree rotatable images enhance user experience through interactivity and ease of use of the technological interface, their impact on immersion is more limited compared to fully interactive 3D objects in VR environments. Users can achieve a moderate level of immersion by manipulating 360-degree images in VR environments, feeling involved and isolated from the real world as they focus on the detailed views of the product. However, the interaction remains within a 2D interface, which can limit the depth of the immersive experience. Nonetheless, the familiar interaction method of a 2D surface allows new VR users to feel comfortable without being overwhelmed by complex VR controls. This accessibility can enhance the initial immersion experience, making users more likely to return

and engage further. This level of immersion focuses on the user's sense of being enveloped in the virtual environment, experiencing a degree of detachment from the real world while exploring product details. Immersion helps shape brand experience by deeply involving consumers and generating strong emotional and behavioral responses to brand stimuli. Zeng et al. (2023), mentions that immersive experiences transport consumers beyond their everyday lives, fostering stronger emotional connections with brands.

In contrast, 3D objects in VR environments provide a more comprehensive and profound sense of immersion. This level of immersion is considered high as users are fully engaged in manipulating objects in a three-dimensional virtual space in the same space the user is in (Bilgihan et al., 2024). The ability to pick up, move, and manipulate 3D objects in virtual reality not only mirrors real-world actions but also empowers users with a sense of agency and control. This dynamic interaction not only enhances the sense of reality and spatial presence within the VR environment but also fosters a deeper connection to the virtual world. Users feel deeply immersed as they actively manipulate objects, influencing their surroundings and experiencing a heightened sense of presence and impact in the virtual environment. Mütterlein (2018) highlights those higher levels of immersion, often conceptualized through the lens of flow, has a direct and positive influence on satisfaction, suggesting that a deeply immersive experience can enhance consumers' overall satisfaction with a brand. Additionally, van Berlo et al. (2021) talk about how playing branded VR games increases arousal and valence which increases emotional responses towards the brand. These intensified emotional reactions increase customer engagement and brand loyalty. Thus, immersion, by facilitating a deep psychological involvement and transporting consumers into a simulated environment, improves the brand experience making it more impactful and memorable (Mütterlein, 2018; van Berlo et al., 2021; Zeng et al., 2023)

The following hypotheses are therefore proposed:

H4: The use of 3D objects in VR environments will result in higher immersion compared to 360-degree rotatable images in VR environments.

H5a: Immersion with the VR environment positively influence brand experience.

H5b: The effect of the promotion type on brand experience is partially mediated by immersion.

2.8 Conceptual Placement of Engagement and Immersion

While this study positions both immersion and engagement as parallel mediators in the relationship between promotion type and brand experience, it is important to acknowledge that immersion may act as a prerequisite condition for interaction with the promotion type to occur. As defined previously immersion is the mental state where users feel deeply involved and psychologically transported within an environment where individuals may feel detached from their everyday surroundings and fully connected to the simulated environment. If users are not immersed due to poor graphics or controls that are difficult to use, they will be less likely to interact with the promotion type, regardless of how interactive it is.

This study also recognizes that high levels of engagement can enhance immersion by making the user more invested and focused on the virtual environment, while a deeply immersive experience can foster greater engagement by making the interaction more compelling and enjoyable. By considering engagement and immersion as concurrent mediators, the model captures the complexity of user experiences in VR environments. It recognizes that both constructs simultaneously influence how users interact with and perceive promotional content, ultimately shaping the brand experience.

For the purposes of this research, immersion and engagement are treated as parallel mediators. While immersion may act as a necessary condition for engagement, this study

focuses on the independent effects of both constructs on brand experience. Future research could investigate the sequential relationship between immersion and engagement to gain further insights into the mechanisms that drive virtual brand experiences.

In summary, This study investigates the following hypotheses: (H1) The use of 3D objects in VR environments will result in a lower direct effect on brand experience compared to 360-degree rotatable images in VR environments; (H2) The use of 3D objects in VR environments will result in higher engagement compared to 360-degree rotatable images in VR environments; (H3a) Engagement with brand related products in VR environments positively influence brand experience; (H3b) The effect of the promotion type on brand experience is partially mediated by engagement; (H4) The use of 3D objects in VR environments will result in higher immersion compared to 360-degree rotatable images in VR environments; (H5a) Immersion with the VR environment positively influence brand experience. (H5b) The effect of the promotion type on brand experience is partially mediated by immersion.

3. Methodology

Two preliminary studies were conducted before the start of the main experiment. Preliminary study 1 aimed to validate the VR environment and product that would be advertised in the promotional formats, using a mixed methods approach that included a questionnaire, semi-structured interviews, and a cocreation session with five participants. Preliminary Study 2 aimed to test the experimental procedure, ensuring the VR system functions correctly, and the instructions and questionnaire items are understood as intended before the main experiment is conducted.

3.1 Preliminary Study 1

The preliminary study aimed to validate the VR environment design and recipe selection by gathering feedback from five participants (gender: three male two female, ages 20–25, culinary expertise: novice to expert). A mixed-methods approach was used, combining surveys and semi-structured interviews to assess preferences for key elements for VR worlds and recipe suitability. Figure 2 illustrates six VR loading lobbies which the participants used as initial inspiration. Key topics included navigation cues, audio design, interactive elements, and recipe characteristics. While participants agreed on core features like intuitive navigation and cohesive aesthetics, opinions diverged on autonomy, environmental density, and NPC inclusion. For recipes, culturally familiar, visually engaging dishes were preferred. The key findings are summarized in Table 1 and Table 2 respectively. Appendix A provides a more detailed explanation of Preliminary Study 1.

Figure 2

Six Pre-Existing VR Loading Lobbies in The Metaverse for Assessing Key Design Elements

Table 1

Summary of Participant Feedback on VR Environment Design

Participant Feedback	Category	Considerations for Design
Areas of Agreement	Ease of navigation and orientation	Include subtle visual cues or landmarks, clear entry/exit points for guidance.
	Sound design and audio atmosphere	Match sounds to mood and purpose, avoid overwhelming audio transitions.
	Interactive elements	Craft interactive elements that align with the environment's theme.
	Aesthetics matching	Elements placed in the VR world should match with one another (similar style)
	Clarity in advertisements/branding	Integrate brand messages subtly within the environment (e.g., banners, digital screens), not intrusively.
Areas of Disagreement	Level of User Autonomy	Implement adjustable guidance levels (free exploration vs. guided mode).
	Environmental Density (Minimalist vs. Complex)	Provide zones with varying densities, balancing minimalist vs. complex environments.
	Social Features and NPC Inclusion	Disagreement in NPC presence or not.
	Style and Realism	Some individuals preferred more realistic environments other preferred this less (low poly). It was mentioned that continuity of the level of realism should match with the environment and other assets.
	Degree and Nature of Gamification	Strategically use gamification tied to exploration, avoid overuse that distracts from the experience.
	Engagement with Branding/Advertising	There is a debate regarding whether the advertisement should have a strong presence or take a more subtle approach.

Table 2

Summary of Participant Feedback on Recipe Selection for HelloFresh Case Study

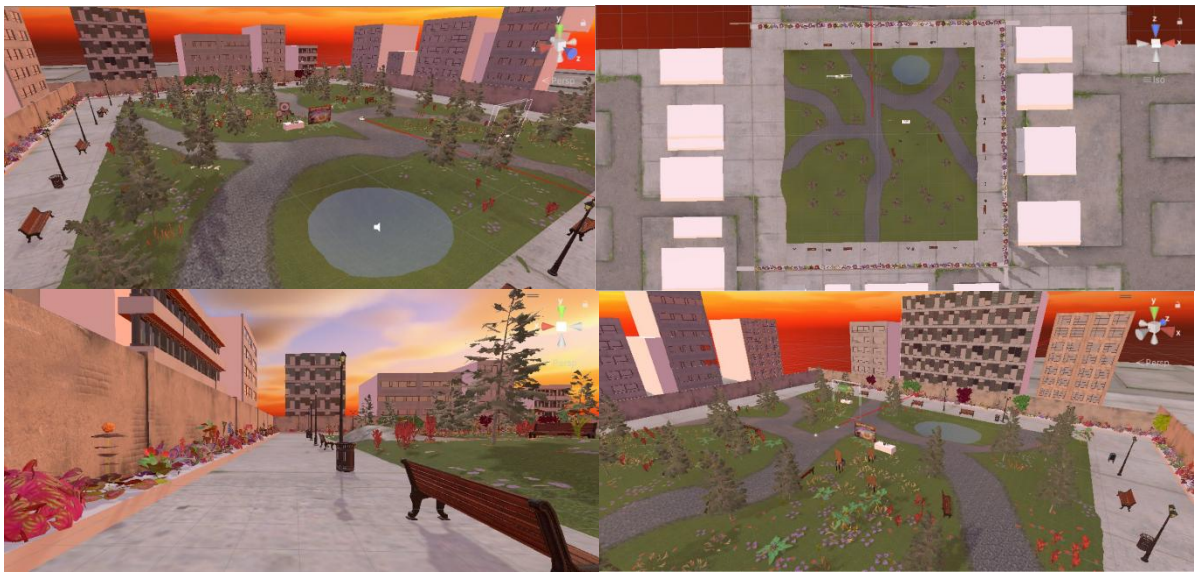
Participant Feedback	Category	Considerations for Design
General	Balance Familiarity and Novelty	Choose a recipe that resonates broadly but adds an interesting twist. For example, foreign dishes (Asian, Mexican, African cuisines were mentioned)
	Appealing Presentation	Select colorful, visually appealing dishes and have the final image of the dish present.
	Health Appeal	Incorporate health-conscious elements without alienating any demographic.
	Aligning 360-degree rotatable image with 3D object	Multiple suggestions in displaying the 360-degree rotatable image: - Having the ingredients inside the box with the image of the full dish on top - Having the ingredients displayed outside of the box while the final dish is in it A more realistic style was mentioned since both promotion types need to meet expectations of customers in the real world.

3.2 Materials

Research was conducted with the Oculus Quest 2 VR headset on a Lenovo laptop with an Intel Core i7-10750H, a NVIDIA GeForce GTX 1660 Ti graphics card, and 16GB of ram to ensure smooth rendering and interaction in the virtual environment. A test room measuring a minimum of 3m x 3m with no obstacles was used to allow participants to move safely and freely. The VR environment was created using the Unity game engine, keeping the insights gained from Preliminary Study 1 in mind (see Table 1). Unity version 2022.3.53f1 was used since this is a stable version which will not be influenced by updates whereas newer version could be affected by it. Urban audio was added such as cars driving by and people talking will be more prominent when on the sidewalk where inside the park nature audio such as wind and birds will be played. Figure 3 shows several still snapshots of the environment. Furthermore, as soon as the experiment begins an instruction screen will be presented with a forced exposure of 10 seconds. Once this is over the participant clicks on a trigger button and the instruction screen disappears.

Figure 3

Several Still Snapshots of the VR Environment



Next, the scene was duplicated for the two promotional content conditions. The 2 promotional formats are placed in the same location in the VR environment to control for other variables. The 360-degree rotatable image will be placed on a billboard at eye height which allows the participant to conveniently interact with it while keeping it visible (see Figure 4). To encourage participants to interact with the billboard once the controller hovers over it, laser will appear out of the controller and the controller will vibrate acting as a peripheral cue. In contrast, the 3D object promotion type will be placed on a stand at waist level so that the participant can conveniently interact with it (see Figure 5). The HelloFresh box is in a fixed position while the ingredients inside are interactive and can be removed from the box.

Figure 4

The 360-Degree Rotatable Image Promotion Type of the HelloFresh Food Box in the VR Environment.

Figure 5

The 3D Product Promotion Type of the HelloFresh Food Box in the VR Environment.

The recipe of bibimbap was chosen based on the feedback from Table 2 from pretest 1. For the creation of the ingredients of the Hellofresh box the modeling tool of Blender was used where the assets of the zucchini, carrot, ginger and eggs were found from open sources. The assets of mushrooms, soya sauce, sesame oil, siracha, white wine vinegar, jasmine rice, and spring onion were created by the researcher through the help of various YouTube tutorials.

Finally, an additional interactive element of a hit the target mini game was implemented to distract from the promotion type and to simulate the current condition of the metaverse environments (see Figure 6).

Figure 6

Still Snapshots of the Potion Throwing Game Interactable.

3.3 Preliminary Study 2

Before conducting the main experiment, a second preliminary study was conducted with five participants who did not take part in the final sample. This was done to evaluate and refine the experimental procedure, ensuring that the VR system functioned correctly, that the instructions were clear, and that the questionnaire items were understood as intended. During the preliminary study, participants went through the entire experimental procedure, which was identical to the main experiment. This included the wearing and calibration of the headset, briefing, exploring and interacting with the VR environment, and filling out the questionnaire. Observations were conducted by the researcher to identify areas where participants might struggle, and these were noted down. Feedback was gathered after each participant completed the entire experiment, with a focus on several key aspects.

First, the technical functionality of the VR system was assessed by the researcher observing participants as they used the headset, controllers, and calibration process, ensuring that each component operated smoothly without glitches or interruptions. Second, the clarity of the instructions was evaluated. Participants were asked to follow the instructions provided during the briefing and throughout the VR experience. The researcher asked if participants could easily follow the instructions or if they required additional clarification. Third, the interaction with the VR environment was observed. Participants' ability to navigate the virtual environment and interact with objects within the VR experience was evaluated. The researcher noted any difficulties participants experienced. Finally, the understanding of the questionnaire items was assessed. The researcher requested feedback from participants on the clarity of the questions ensuring that the items were understood as intended. Any ambiguous questions were refined to improve the reliability and validity of the final data set.

The second preliminary study revealed that allowing participants to explore freely often led to missed interactions with the promotion type, and inexperienced users struggled with the controls. To address this a structured task list was introduced: first, exploring the environment without interacting with any objects; then, a potion-throwing game to familiarize participants with the controls; and finally, interaction with the promotional content. Next, several scale items were refined for clarity. For example, “This brand results in bodily experiences” was expanded to “This brand provides experiences that I can feel in my body (e.g., movement, touch, or sensory reactions).” Additionally, “speak” was replaced with “interact” in one item to better suit Dutch-speaking participants. Interaction controls were also standardized. While the trigger button worked for the billboard, it was inconsistent for the HelloFresh box and potion-throwing game. Now, both trigger buttons function the same across all interactions. Overall, these refinements enhanced the experimental setup, ensuring a smoother and more reliable experience for participants in the main study.

3.4 Experiment

3.4.1 Participants

A total of 82 participants were recruited, with 41 participants assigned to each condition (360-degree rotatable image and 3D object). Most of the sample consisted of university students from the University of Twente, recruited through a combination of convenience sampling (including close connections and randomly approached individuals at the university) and the SONA system, the university's test subject pool. The randomization of participants across the condition of promotion type (Condition 360 and Condition 3D) was checked for the variables; age, gender, experience with VR, and gaming experience. Table 3 summarizes the demographics and statistical tests used to confirm successful randomization across conditions.

Table 3

Participant Demographics and Randomization Check

Variable	Condition 360 (n = 41)	Condition 3D (n = 41)	Test Statistic	p-value
Age (M)	23.73	22.61	$t(76.01) = 1.72$	0.09
Gender (Male/Female)	29/12	26/15	$X^2(1) = 0.22$	0.64
Education (High School/HBO/Bachelor/ Master/ MBO)	14/7/14/4/2	17/7/9/7/1	$X^2(4) = 2.53$	0.64
VR Experience (Low/Medium/High)	9/30/2	9/32/0	$X^2(2) = 2.06$	0.36
Gaming Experience (Low/Medium/High)	8/20/13	11/20/10	$X^2(2) = 0.86$	0.65

Note: Welch's Two-Sample t-test was conducted for age, and Chi-Squared tests were used for gender, education *VR experience, and gaming experience.*

3.4.2 Procedure

This study will investigate how two promotion formats 360-degree rotatable image and 3D products in VR environments impact engagement, immersion, and brand experience using a between-subjects design. In this experimental setup, participants will be randomly assigned and equally distributed between the conditions of a 360-degree rotatable image or the 3D object in VR.

Firstly, the participants will be briefed about the study indicating that it is about investigating VR environments and what the role of engagement and immersion are. However, this is not the true nature of the study but done so to prevent response biases in the answers. Before participating a consent form will be filled out by the participants which indicates how the data will be handled, anonymized, and explains the risks involved (i.e. motion sickness) where after the experiment will commence.

Participants will be given a VR headset and instructed to put it on, with the researcher adjusting as necessary to ensure clear vision and that the headset does not fall off their head. They will then be given controllers, allowing them to interact with the VR system. The researcher will then load one of two conditions. Once they are loaded into the condition, they will be presented with a screen which states the following:

“Welcome to the Metaverse! Explore and interact freely with the virtual environment around you. When you are ready to conclude your exploration, please notify the researcher to proceed to the next steps. Press the trigger button on your controller to begin. (this window can only be closed after 10 seconds)”

Once the participants have pressed the trigger button to make the message disappear, they will be given three sequential tasks within the VR environment told by the researcher. The first task being that they will have the opportunity to freely explore the environment without interacting with any objects. Once they feel content with their exploration, they will

inform the researcher to proceed to the next task. In the second task, participants will engage in a potion-throwing game, throwing potions at specified targets. They may continue this activity until they are satisfied with their interaction at which point they will notify the researcher and proceed to the final task. The final task is that the participant will head to the HelloFresh box promotion and are instructed to explore and interact with this. Just like the previous steps, once the participant feels content with their interaction, they will indicate this to the researcher. The researcher will then stop the simulation in unity which will conclude the VR part of the experiment.

The participant will then take off their VR headset and will be presented with a questionnaire via laptop which they will have to fill in regarding the dimensions of immersion, emotional engagement, cognitive engagement, and brand experience. Behavioral engagement will be measured through behavior logs running in Unity.

3.4.3 Measures

Participants were asked to interact with the VR environment and complete a questionnaire addressing the following dimensions:

To evaluate participants' perceptions of brand experience within the VR environment, the Brand Experience Scale from Brakus et al. (2009) was used. This scale consisted of 12 items, including statements like, “This brand makes a strong impression on my visual sense or other senses.” Responses were provided on a 7-point Likert scale ranging from 1 (Strongly disagree) to 7 (Strongly agree), instead of the original 5-point scale. Cronbach’s Alpha was 0.86.

Next, emotional and cognitive engagement was evaluated using adapted subscales from the Consumer Brand Engagement (CBE) framework by Hollebeek et al. (2014), originally developed for social media contexts. Emotional engagement was assessed using four statements, such as “I felt positive emotions while interacting with the HelloFresh

promotional content.” Participants rated their agreement on a 7-point Likert scale ranging from 1 (Strongly disagree) to 7 (Strongly agree). Cronbach’s Alpha was 0.86. Cognitive engagement was measured using three items, such as “Interacting with the HelloFresh promotional content made me think about the product.” Responses were collected on the same 7-point Likert scale. Cronbach’s Alpha was 0.82.

Behavioral engagement was objectively measured through digital logs recorded during the VR experiment capturing real-time interactions with the promotional content where three key metrics were measured. Times Touched quantified the frequency of direct interactions with promotional items (e.g., selecting/deselecting a billboard in the 360-degree rotatable image condition or grabbing/releasing a 3D HelloFresh object). Area of Interest (AOI) assessed visual attention by tracking how long participants focused on predefined promotional zones (e.g., the surface of the billboard in the 360-degree rotatable image condition or the HelloFresh ingredients, recipe and cardboard box in the 3D object condition). A gaze-based system, simulated using a head-mounted 'laser pointer' that aligned with the participant's head direction, recorded dwell time whenever the pointer landed on a predefined AOI. Total Time reflected the total duration of the VR environment, calculated from the time participants entered the virtual world until the researcher manually ended the session.

To measure immersion, an adapted version of the immersion scale from Jennett et al. (2008) was used. This scale consisted of eight items, including statements such as, “I was interested in seeing how the VR environment's events would progress.” Participants rated their level of agreement on a 7-point Likert scale ranging from 1 (Strongly disagree) to 7 (Strongly agree), instead of the original 5-point scale. The immersion scale showed a low Cronbach’s Alpha score of 0.46. to address this additional analysis was conducted and the items “I was in suspense about whether I would perform well or not in the VR environment,”

"I was unaware of what was happening around me," and "The VR environment was challenging" were removed due to their low item-total correlations. This resulted in an improved Cronbach's Alpha of 0.68.

Finally, demographic data were collected for age, gender, educational level, gaming experience and VR experience. Age was recorded as a continuous variable, while gender was categorized as male, female, non-binary, other, or prefer not to say. Educational level was categorized into groups ranging from high school, bachelor, master, and PhD. Gaming experience was categorized into three groups being, "I play video games regularly", "I play video games occasionally", and "I do not play video games". VR experience was also categorized into three groups being, "I use VR regularly", "I have used VR a few times", and "I have never used VR before."

After the experiment had been concluded participants will be fully debriefed on the true purpose of the experiment, which focuses on how 3D objects and 360-degree rotatable images in VR environments influence brand experience, rather than general engagement and immersion on user experiences. They will be informed about which scenario they were assigned to. Deception was required to reduce response bias and ensure more authentic responses to the VR environment. Finally, participants will be thanked for their participation and asked if they have any further feedback, comments, or questions about the study and their experience. They will then reconfirm that they still want to participate in the study.

3.5 Data Analysis Plan

Data was cleaned by excluding incomplete surveys, those who did not see the promotion type, and those who did not consent after the debriefing. To ensure the validity of the regression and mediation analyses the data was tested against the assumptions of linearity, homoscedasticity, independence, normality, and multicollinearity (Poole & O'Farrell, 1971).

Linearity was assessed through pairwise scatterplots and a correlation matrix, which revealed moderate relationships between core constructs. The area of interest (AOI) was excluded from further analysis due to inconsistent tracking. Homoscedasticity and independence were confirmed via residual plots, which revealed no systematic bias or clustering. Normality was confirmed by residual histograms and Q-Q plots, where both of showed a normal distribution. Finally, the variance inflation factor (VIF) values for all predictors were less than five indicating that multicollinearity was unlikely. The dichotomous promotion type variable was omitted from regression analyses due to scaling incompatibility. These tests confirmed the data's suitability for the proposed analyses. The results of this can be seen in Appendix F.

To enable accurate comparison across variables with different measurement scales, standardized scores were created for each variable. The variables immersion, emotional engagement, cognitive engagement, and brand experience were all measured using the same 7-point Likert scale. Behavioral engagement consists of total time (measured in seconds) and the number of times selected (a count). Z-scores were calculated to account for these differences in measurement scales for the above-mentioned variables. An overall engagement metric was created by combining behavioral, cognitive, and emotional engagement.

Following this, a double parallel mediation analysis was carried out using JASP, with the promotion type condition of the 360-degree rotatable image serving as the reference

category and the 3D object as the comparison to test the hypotheses. Engagement and immersion were included as parallel mediators, with brand experience as the dependent variable. To test H1, the direct effect of promotion type on brand experience (c'-path) was examined using regression analysis. H2 to H5 were tested by assessing the indirect effects, which involved two steps. First, examining the effect of promotion type on engagement and immersion (a-paths), and then testing how engagement and immersion influenced brand experience (b-paths). The confidence intervals for all path coefficients and indirect effects were calculated using bootstrapping with 1000 resamples.

Two additional analyses were conducted to gain deeper insights into these relationships, possibly assisting marketing managers in determining which types of engagement should be prioritized to improve brand experience. The first was to determine which subcomponent of overall engagement; behavioral, cognitive, and emotional, had the greatest impact on brand experience. A multiple linear regression analysis was performed with brand experience as the dependent variable and the three engagement subcomponents as predictors. The second analysis, a correlation matrix, explained these relationships by demonstrating how each engagement dimension is related to specific brand experience dimensions. For example, whether emotional engagement drives affective brand experience more than sensory experience.

With data preparation and assumption checks completed we now proceed to the analysis results.

4. Results

4.1 Main Findings

The manipulation of the promotion type was successful. To ensure that participants were aware of the promotion type, they were asked, "Did you notice the HelloFresh promotion?" The findings revealed that all participants (100%) answered "yes," The following sections present the test results for each hypothesis.

Data was first analysed in relation to H1: The use of 3D objects in VR environments will result in a lower direct effect on brand experience compared to 360-degree rotatable images in VR environments. The path analysis showed that the effect of promotion type on brand experience was positive however not significant ($\beta = 0.075$, $SE = 0.112$, $p = 0.505$, 95% CI [-0.155, 0.310]). This suggests that promotion type does not have a direct effect on brand experience, and Hypothesis H1 was not supported.

Following this we tested H2: The use of 3D objects in VR environments will result in higher engagement compared to 360-degree rotatable images in VR environments. The analysis showed that the effect of the 3D object on overall engagement was significant ($\beta = 0.292$, $SE = 0.120$, $p = 0.015$, 95% CI [0.051, 0.524]), confirming that engagement was higher in the 3D condition. This supports Hypothesis H2.

We then tested H3a: Engagement with brand-related products in VR environments positively influences brand experience. The path analysis for the effect of engagement on brand experience was significant ($\beta = 0.551$, $SE = 0.100$, $p < 0.001$, 95% CI [0.332, 0.792]). This finding supports Hypothesis H3a, indicating that higher engagement leads to a better brand experience.

Next, we investigated H3b: The effect of promotion type on brand experience is mediated by engagement. The analysis revealed that the indirect effect of promotion type on

brand experience through overall engagement was significant (β = 0.161, SE = 0.072, p = 0.026, 95% CI [0.026, 0.346]). Thus, Hypothesis H3b is supported.

H4: The use of 3D objects in VR environments will result in higher immersion compared to 360-degree rotatable images in VR environments. The effect of promotion type on immersion was positive, but not significant (β = 0.030, SE = 0.150, p = 0.843, CI [-0.272, 0.331]), revealing that 3D objects did not result in higher immersion compared to 360-degree rotatable images. Therefore, Hypothesis H4 was rejected.

H5a: Immersion in VR environments positively influence the overall brand experience. The analysis of the direct effect of immersion on brand experience showed a positive, but non-significant, effect (β = 0.138, SE = 0.080, p = 0.084 CI [-0.042, 0.329]. Thus, Hypothesis H5a was not supported.

Even though H4 and H5a were rejected indicating no mediation takes place, we investigated H5b: Immersion mediates the effect of promotion type on brand experience. However, the indirect effect of promotion type on brand experience through immersion was non-significant (β = 0.004, SE = 0.021, p = 0.844, 95% CI [-0.044, 0.067]). This means that no mediation takes place via immersion and therefore hypothesis H5b is not supported.

In addition, the total direct and total indirect effects we examined of promotion type on brand experience. This revealed that promotion type had a total direct effect on brand experience that was not significant, while the total indirect effect was significant (see Table 6) These findings suggest that the effect of promotion type on brand experience is mediated by one or more indirect pathways rather than occurring directly.

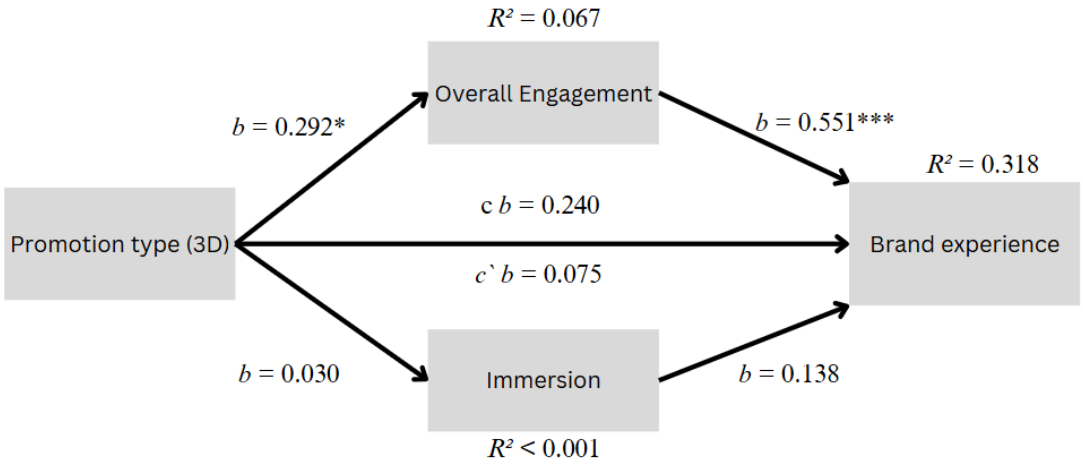
Furthermore, the model explained 31.8% of the variance in brand experience (R^2 = 0.318), indicating a substantial role for engagement. However, promotion type accounted for

only 6.7% of the variance in overall engagement ($R^2 = 0.067$). Lastly, the model did not significantly explain immersion ($R^2 < 0.001$).

The complete analysis results are presented in three tables: Table 4 reports the direct path coefficients, Table 5 shows both direct and indirect effects, and Table 6 presents the total effects. Figure 7 provides a visual summary of these key findings

Figure 7

Final Model for the Mediating Effect of Overall Engagement and Immersion on Brand Experience.



*Note: Path coefficients are displayed in the figure. Statistical significance is indicated as follows: * p < .05, *** p < .001.*

Table 4

Path Coefficients for Mediation Analysis Predicting Brand Experience

							95% Confidence Interval	
			Estimate	Std. Error	z-value	p	Lower	Upper
Promotion Type (3D)	→	Brand Experience	0.075	0.112	0.667	0.505	-0.155	0.310
Overall Engagement	→	Brand Experience	**0.551*** **	0.100	5.517	< .001	0.332	0.792
Immersion	→	Brand Experience	0.138	0.080	1.726	0.084	-0.042	0.329
Promotion Type (3D)	→	Overall Engagement	**0.292***	0.120	2.430	0.015	0.051	0.524
Promotion Type (3D)	→	Immersion	0.030	0.150	0.198	0.843	-0.272	0.331

Note: Confidence intervals are percentile bootstrapped. Standard errors, *z* -values and *p* -values are based on the delta method. * $p < .05$, *** $p < .001$.

Table 5

Direct and Indirect Effects of Condition Type on Brand Experience

										95% Confidence Interval	
					Condition Type	Estimate	Std. Error	z-value	p	Lower	Upper
Condition Type	→	Brand Experience			3D Object	0.075	0.112	0.667	0.505	-0.155	0.310
Condition Type	→	Overall Engagement	→	Brand Experience	3D Object	**0.161***	0.072	2.224	0.026	0.026	0.346
Condition Type	→	Immersion	→	Brand Experience	3D Object	0.004	0.021	0.197	0.844	-0.044	0.067

Note: Confidence intervals are percentile bootstrapped. Standard errors, z -values and p -values are based on the delta method. * $p < .05$. R^2 values: Brand Experience = 0.318, Overall Engagement = 0.067, Immersion = 4.790×10^{-4}.

Table 6

Total Effects of Condition Type on Brand Experience

									95% Confidence Interval	
				Condition Type	Estimate	Std. Error	z-value	p	Lower	Upper
Total	Condition Type	→	Brand Experience	3D Object	0.240	0.129	1.862	0.063	-0.021	0.513
Total indirect	Condition Type	→	Brand Experience	3D Object	**0.165***	0.075	2.191	0.028	0.006	0.369

Note: Confidence intervals are percentile bootstrapped. Standard errors, z -values and p -values are based on the delta method. * $p < .05$.

4.2 Additional Analyses

To determine which engagement subcomponents most strongly influence brand experience a regression analysis was conducted followed by a correlation matrix. The regression model explained a significant proportion of variance in brand experience (see Table 7), while an ANOVA analysis revealed that the overall model was significant (see Table 8). The results revealed that all three engagement subcomponents significantly predicted brand experience, with cognitive engagement showing the strongest positive effect (β_{cog} = 0.476, t = 5.150, p < .001, 95% CI [0.212, 0.479], followed by behavioral engagement (β_{beh} = 0.223, t = 2.480, p = .015, 95% CI [0.031, 0.285]), and emotional engagement exhibiting a smaller but still significant effect (β_{emo} = 0.189, t = 2.022, p = .047, 95% CI [0.002, 0.273]).

Table 10 presents correlations between engagement dimensions and brand experience dimensions. Cognitive engagement showed positive associations across all brand experience dimensions, with intellectual experience having the lowest value. Emotional engagement was most strongly related to affective and sensory brand experience. Behavioral engagement showed consistent but moderately positive associations with all brand experience dimensions expect for affective experience being the lowest.

Table 7

Model Summary for Multiple Linear Regression Predicting Brand Experience

Model	R	R^2	Adjusted R^2	RMSE
M_0	0.000	0.000	0.000	0.620
M_1	0.619	0.383	0.359	0.496

Note: M_1 includes Cognitive Engagement, Emotional Engagement, Behavioral Engagement

Table 8

ANOVA Results for Multiple Linear Regression Model Predicting Brand Experience

Model		Sum of Squares	df	Mean Square	F	p
M_1	Regression	11.912	3	3.971	16.135	< .001
	Residual	19.194	78	0.246		
	Total	31.106	81			

Note: M_1 includes Cognitive Engagement, Emotional Engagement, Behavioral Engagement

Table 9

Regression Coefficients for Multiple Linear Regression Predicting Brand Experience

Model		Unstandardized	Standard Error	Standardized	t	p	95% CI	
							Lower	Upper
M_0	(Intercept)	-1.471×10^{-16}	0.068		-2.150×10^{-15}	1.000	-0.136	0.136
M_1	(Intercept)	-2.362×10^{-16}	0.055		-4.311×10^{-15}	1.000	-0.109	0.109
	Cognitive Engagement	0.345	0.067	0.476	5.150	< 0.001	0.212	0.479
	Emotional Engagement	0.138	0.068	0.189	2.022	0.047	0.002	0.273
	Behavioral Engagement	0.158	0.064	0.223	2.480	0.015	0.031	0.285

Table 10

Correlation Matrix Mapping Engagement to Brand Experience Relationships Dimensions

	Brand Experience Sensory	Brand Experience Affective	Brand Experience Behavioral	Brand Experience Intellectual
Behavioral Engagement	0.25	0.13	0.22	0.22
Cognitive Engagement	0.48	0.42	0.41	0.32
Emotional Engagement	0.36	0.40	0.15	0.16

5. Discussion and Conclusions

This study aimed to answer the following research questions: (1) How do 360-degree rotatable images and 3D products within VR environments influence brand experience, and (2) What role do engagement and immersion play in shaping brand experience? This was done through a randomized between-subjects experiment with 82 participants. This study addressed a gap in the literature by empirically testing the effects of VR promotional formats, moving beyond the mostly conceptual focus of previous research in VR advertising. To the best of our knowledge this is the first study to develop and test an interactive VR billboard offering a new advertising format in this field.

The findings indicate that promotion type did not have a direct effect on brand experience. However, engagement fully mediated this relationship, meaning that the effect of 3D objects and 360-degree rotatable images on brand experience operated entirely through engagement. In contrast, immersion was not a significant mediator, nor did it significantly differ between promotion types. These results suggest that engagement, rather than immersion, is the key mechanism through which interactivity in VR promotions enhances brand experience. The following sections will discuss these findings in detail, examining their theoretical, practical, and ethical implications.

5.1 Findings and Theoretical Implications

5.1.1 The Role of Novelty in Brand Experience and Engagement

The findings revealed that the promotion type had a positive but insignificant direct effect on brand experience, which contradicts our hypothesis that 3D objects in VR environments would result in a lower direct effect on brand experience compared to 360-degree rotatable images. While Cox & Yetter (2022) suggest that disorientation in VR environments could reduce the positive impact it has on brand experience, this explanation

seems unlikely since participants were given sufficient time to familiarize themselves with the controls and environment before interacting with a promotion type. A more plausible explanation is that prolonged exposure could reduce the immediate impact of novelty, allowing participants to process the content more deeply rather than relying on quick heuristic judgments. While previous research indicates that novel stimuli capture attention and provoke initial emotional responses (Cox & Yetter, 2022; Schomaker & Meeter, 2015), this effect may be short-lived especially in experimental settings where participants are exposed to the promotion type for an extended period. Therefore, novelty may serve as an entry point to engagement by capturing initial attention and stimulating cognitive, emotional, and behavioral engagement, thereby shaping brand experience via this deeper mechanism.

5.1.2 Mediating Role of Engagement

It was proposed that the use of 3D objects in VR environments led to significantly higher levels of engagement compared to 360-degree rotatable images which was the case. For the 360-degree rotatable image the interactive visual exploration of the HelloFresh box by rotating the image was sufficient to engage users as supported by previous research. The ability to manipulate the product view enabled users to evaluate features and benefits, which increased cognitive engagement, while the sense of control generated positive emotional responses (Kim et al., 2020). However, behavioral engagement was restricted to rotation, reducing the depth of interaction. In contrast, the manipulation of the 3D object HelloFresh box allowed for participants to activate their spatial awareness which required their cognitive engagement (Jiang & Benbasat, 2007). For behavioral engagement, it enabled full spatial manipulation rather than being limited to a 2D plane like the 360-degree rotatable image. Furthermore, having more control over the 3D object increased user agency by allowing participants to explore it from any angle, manipulate its position, and interact with it more naturally. This increased autonomy most likely contributed to a stronger sense of

engagement. Emotionally, the more lifelike interaction may have elicited stronger emotional responses compared to the relatively static experience of rotating a 2D image (Bilgihan et al., 2024). This difference in interactivity explains why 3D objects generated higher overall engagement compared to 360-degree rotatable images.

Furthermore, the direct effect of engagement on brand experience was significant and positive, reinforcing the idea that higher engagement leads to more favorable brand experiences. This finding is supported by Violante et al. (2019), who examined how VR environments influence consumer engagement in the context of supermarkets. Their study found that VR's interactive qualities can enhance cognitive, affective, and behavioral engagement by creating a more memorable and emotionally resonant consumer experience. This aligns with the conceptual framework suggested by Hollebeek et al. (2020), which highlights the role of cognitive, emotional, behavioral, and social engagement in shaping brand relationship quality. Their work emphasizes that engagement creates stronger brand connections by enhancing consumer commitment, intimacy, and self-connection within immersive VR experiences, ultimately influencing brand experience.

The additional analyses revealed complementary insights into the role of engagement in shaping brand experience. The regression analysis revealed that cognitive engagement is the most influential subcomponent of engagement in shaping overall brand experience, followed by behavioral engagement and emotional engagement. However, the correlation matrix tells a more complex story when examining its relationship to specific brand experience dimensions. Cognitive engagement has a strong impact across all brand experience dimensions, with the weakest association appearing in intellectual experience. Emotional engagement, while less influential overall, emerges as particularly important for affective experiences in addition to cognitive engagement. Behavioral engagement maintains

consistent but moderate correlations across most dimensions, showing its weakest connection to affective experiences.

These findings highlight the need to consider both the dominant role of cognitive engagement and the specialized contributions of emotional and behavioral components when designing VR brand experiences. While cognitive engagement appears to be the most influential factor of brand experience, these findings should be considered with caution. As mentioned before novelty can act as a cue to capture attention and stimulate all engagement dimensions, thereby indirectly influencing brand experience (Cox & Yetter, 2022; Schomaker & Meeter, 2015). Furthermore, research on the topic of consumer behavior suggest that emotional and subconscious systems are primary drivers. Dijksterhuis et al. (2005) argues that many consumer decisions are influenced by subtle environmental cues rather than conscious processing, suggesting that emotional and subconscious processes may have a greater impact on brand experience than is captured here. For example, the VR environment can trigger emotional responses that exist below conscious awareness, which self-reported measures may not fully capture. Heath & Feldwick (2008) critique the overuse of the information processing model, highlighting that emotional and sensory cues often have a stronger influence on brand perception than rational messages. Therefore, the smaller effect of emotional engagement in this study may stem from the limitations of self-reported measures in capturing subconscious responses.

Additionally, engagement fully mediated this relationship, rather than partially, as previously proposed. This complete mediation suggests that the benefits of 3D objects over 360-degree images operate entirely through engagement, with no direct pathway between promotional format and brand experience. The finding highlights engagement as the critical mechanism through which VR interactivity shapes brand perceptions.

5.1.3 Role of Immersion on Brand Experience

The results of this study revealed that immersion did not mediate the effect of promotion type on brand experience, nor did 3D objects result in significantly higher immersion compared to 360-degree rotatable. Additionally, while immersion had a positive effect on brand experience it was not statistically significant. These findings contradict previous research indicating that immersion is an important driver of brand experience in VR environments (Mütterlein, 2018; van Berlo et al., 2021; Zeng et al., 2023). Below, we explore potential explanations for these unexpected results.

One plausible explanation is that the overall VR experience was sufficiently immersive, overpowering any additional immersion provided by the promotion types (360-degree rotatable images vs. 3D objects). The small effect size for H4a suggests that the interaction with the promotion type did not meaningfully contribute to immersion beyond what the VR environment already provided. If the VR environment was already very immersive, manipulating a 360-degree image or a 3D object may have had little impact. This could explain why 3D objects, despite their higher interactivity, did not result in significantly higher immersion compared to 360-degree images.

Another possibility for the insignificant results is the immersion measurement scale's reliability. The initial Cronbach's alpha of 0.48 indicated low reliability, leading to the removal of several ambiguous items to improve scale consistency. While this increased the reliability to 0.68, the scale still fell short of the conventional threshold of 0.70, indicating that the immersion measurement was not completely robust.

The removed items, such as "I was unaware of what was happening around me" and "the VR environment was challenging," were most likely misinterpreted by participants or did not directly capture the core dimensions of immersion. Since these items were ambiguous

it is possible that other items in the scale also had similar issues which may have contributed to the scale's low reliability, even after improvements.

This could explain why immersion did not mediate the effect of promotion type on brand experience or significantly influence brand experience. With a more reliable and validated scale, the effect of immersion might have reached significance, particularly given its marginal p-value.

5.2 Implications for Marketing Management

The study's findings provide actionable insights for brand managers and marketing professionals looking to improve the brand experience using VR technologies. Engagement is found to be the primary driver of brand experience, making it an important focus for VR campaigns. Specifically, they should prioritize the creation of 3D object models to display their products rather than 360-degree rotatable images as it allows for greater interactivity and product exploration. 3D objects should be designed to maximize user control allowing users to manipulate objects that mimic real world product use. Specifically targeting cognitive engagement leads to overall improvements in brand experience. Therefore, incorporating gamification elements like challenges, rewards, or interactive play can help to increase user engagement and create a more memorable brand experience.

Given the strong link between engagement and brand experience, tracking engagement can provide useful insights into the effectiveness of VR campaigns aimed at improving brand experience. Managers must carefully select metrics to monitor the various dimensions of engagement that align with the business goals of brand experience. Current developments in this field are the tracking of user behavioral engagement through walking patterns to regions of interest where they can map out and later assess the layout of VR environments (Vasic et al., 2024). Another study discovered that involuntary body gestures

can detect cognitive arousal and indicate high attention, suggesting that physiological signals like involuntary foot movements can be used to reliably measure cognitive and emotional engagement in VR (Elvitigala et al., 2022). Furthermore, there are currently VR headsets which use eye tracking to measure cognitive effort through fixation duration and pupil dilation, and emotions through fixation duration and saccade rate (Adhanom et al., 2023). While these tracking methods offer valuable insights into engagement, they should be viewed as complementary measures. They provide deeper behavioral and physiological data that can enhance traditional engagement metrics but may not always align directly with business-oriented key performance indicators. However, the use of such tracking technologies must be balanced with ethical considerations, ensuring user privacy and transparency in data collection.

Even though this study did not find immersion to be a significant mediator other studies suggest that immersion is a foundational element for creating engaging VR interactions and enhancing brand experiences. Immersion, as a subjective mental state and a technological attribute, builds a sense of presence and emotional engagement, both of which are necessary for meaningful interactions and impactful brand (Mütterlein, 2018; van Berlo et al., 2021; Zeng et al., 2023). Therefore, when developing VR experiences, managers should ensure that the environment is realistic and immersive enough to support the promotional content, but do not rely on immersion alone to create a positive brand experience.

There is some debate over what types of businesses are appropriate for entering the metaverse. Companies with strong R&D capabilities, expertise in change management, and the ability to protect and leverage knowledge gained from early entry are best positioned to enter the metaverse first (Gauttier et al., 2024). However, given the high uncertainty of the metaverse, being a fast follower can also be advantageous if companies can capitalize on knowledge spillovers and establish competitive differentiation through user retention,

switching costs, and network effects (Gauttier et al., 2024). Co-specialization enables legacy businesses to gradually adopt the metaverse by combining existing strengths with new technology (Benassi & Rialti, 2024). For example, a manufacturer could use VR simulations to improve factory layouts, or a retailer could combine customer data with virtual showrooms. This creates more value together than either could alone, without requiring disruptive overhauls (Benassi & Rialti, 2024). Furthermore, experience-driven industries or companies looking to create customer experiences can benefit the most, such as hospitality and tourism (Buhalis et al., 2023; Dwivedi et al., 2022), which are already at the forefront, but education, events, fashion, and food & beverage are not far behind. These are some promising opportunities, but businesses must carefully consider their strategic fit before venturing into the metaverse.

5.3 Ethical Considerations to VR Advertising

The rise of VR environments presents new opportunities for marketers to engage users through immersive and engaging experiences. Many studies focus on the business advantages VR technologies offer without addressing the ethical implications. The distinction between advertising and content becomes increasingly difficult to identify in VR settings raising ethical concerns regarding transparency, targeting, and manipulation, especially for young individuals.

While billboard ads in VR are a continuation of traditional advertising formats, 3D objects represent a more subtle and manipulative form of promotion. The issue of what constitutes an ad in VR is still unclear as highlighted by Lobov (2018). In the UK traditional media, product placements and sponsorships are regulated. However, in VR, product placements may not be classified as ads, especially if the brand has no control over the content, such as when a brand pays a VR developer to feature a product, creating regulatory

gaps. Cassidy et al. (2024) adds that increasing the level of synergy and congruence between marketing and entertainment will blur the lines between them. These objects can make it increasingly difficult for users to distinguish between authentic virtual experiences and branded content, raising ethical concerns around transparency and user awareness.

A major concern is for vulnerable groups, who will be disproportionately affected using VR in gaming. Children under the age of eight are known to be cognitively vulnerable to advertising because they lack the ability to understand its intent and frequently accept claims at face value (Shifrin et al., 2006). A systematic review of advertising's impact on young people aged six to 17 finds that it influences their attitudes across all age groups (Packer et al., 2022). Simply improving children's understanding through disclosures or media literacy programs will not protect them from the harmful effects of advertising. As a result, limiting their exposure to advertisements is likely a more effective strategy. Although regulations typically apply to children up to the age of 12, research suggests that all young people, including teenagers, could benefit from stronger protections against advertising exposure.

Marginalized communities, such as Black and Latinx populations, also face unique risks in the VR advertising landscape. Algorithmic biases can expose these groups to exploitative ads that reinforce harmful stereotypes, particularly in food and beverage marketing (Cassidy et al., 2024). These biases further complicate ethical advertising in immersive environments, where regulatory gaps leave vulnerable groups unprotected from targeted exploitation.

Roblox attempts to regulate VR ads by imposing age restrictions on static, video, and portal ads, with users who do not meet the age requirement seeing a blank filler or, in the case of the portal ad, being unable to enter the new area (Roblox, n.d.). However, existing

advertising regulations struggle to keep pace with the evolving VR landscape. Traditional guidelines focus on ensuring ads are clearly identifiable and appropriately targeted. These frameworks, created for more traditional media, do not fully address the unique challenges posed by VR's immersive and interactive nature (Dremliuga et al., 2020; Lobov, 2018).

The blurred line between content and advertising in virtual environments makes enforcement difficult, especially when user engagement is driven by seamless, native VR experiences. This is compounded by ethical concerns in VR marketing, such as user consent and data security, which can leave personal and sensitive data vulnerable to exploitation (Sheena et al., 2023). Moving forward, regulatory bodies must adapt their frameworks to account for VR-specific risks, particularly around transparency, consent, and user protection.

Ethical advertising practices must be redefined to safeguard vulnerable groups, ensuring users are aware of when they are being marketed to and how their data is being used. Open data practices and comprehensive data security measures are vital in protecting users from unauthorized access and misuse of their personal data, particularly in VR settings (Dremliuga et al., 2020; Sheena et al., 2023). Without proactive regulation, there is a growing risk that virtual reality will become an unregulated space where ethical boundaries are constantly tested, making consumers more vulnerable to manipulation and exploitation. To address these gaps, policymakers, VR developers, and marketers must engage in an urgent dialogue to ensure that ethical standards evolve alongside technological advancements.

5.4 Limitations

This study has several limitations that should be acknowledged. First, the tracking of behavioral engagement using the Area of Interest (AOI) metric was unreliable, specifically for the 360-degree rotatable image. The current method which functions similarly to a forehead-mounted laser pointer lacks precision.

Second, due to resource constraints and the way the 360-degree rotatable image was set up, participants could only rotate the image and not zoom in or out of it. This limited interaction may have constrained the depth of how participants explored the product compared to the 3D object. This may potentially narrow the gap in engagement between the two promotion types leading to a different result.

Third, recent literature in marketing has suggested to test advertising in the context where it is situated to replicating real life interaction to get unbiased data and prevent. This study has not done this in several instances. Participants were forcefully exposed to the promotion type which might not be the case. This can also be seen as forcing engagement which might reflect on the data.

Fourth, participants also had varying levels of VR experience with the minority being very experienced VR users. In real world settings most users are likely to have more experience with VR, which could mean that the results of this study are inflated.

Fifth, the use of z-scores to standardize various measurement scales introduced interpretability challenges. While z-scores allowed for the combination of different metrics in regression analyses, they draw away from the results from the original units of measurement, making it difficult to contextualize findings within the original scales.

Finally, the lack of a control group presents a significant limitation. A control group, such as a group exposed to a VR environment without promotional features or with a traditional 2D image would have provided a baseline for comparison. This would have provided a clearer understanding of the actual impact of 360-degree rotatable images and 3D products on brand experience, engagement, and immersion. Without a control group, it is difficult to determine whether the observed effects are solely due to the promotional features or are influenced by general VR environment characteristics.

While this study provides valuable insights into the impact of promotional formats on brand experience in VR environments, several limitations highlight areas for future research to further explore and refine these findings.

5.5 Future research

The lack of a control group in this study makes it difficult to distinguish the effects of promotional features from overall VR characteristics. Future research should include a control group (e.g., VR environments without promotions or with a traditional 2D image without interactions) to provide a more accurate baseline for comparison.

Recent literature emphasizes the importance of testing advertising in realistic, contextualized settings to replicate real-life interactions, specifically social interactions since this is a key component of the metaverse (Eyada, 2023; Hollebeek et al., 2020; Riva & Wiederhold, 2022). Future research could include social elements of the metaverse to better understand how social interactions influence engagement and brand experience, such as having multiple users in the same space. This study also included participants with varying levels of VR experience, which may have influenced the results. Future research should focus on experienced VR users to better reflect real-world usage and ensure the findings are generalizable to more adept audiences.

While this study focuses on the food industry with the Hello Fresh case, the application of VR technologies and the metaverse can also be applied to other sectors. Industries such as e-commerce, automotive, real estate, travel, and entertainment could all benefit from exploring how 360-degree rotatable images and 3D products influence consumer engagement and brand experience.

Finally, this study relied on self-reported measures of engagement, which may not fully capture subconscious or emotional responses. With the same research design, future

research could explore advanced methods for measuring engagement, such as eye-tracking physiological signals or walking patterns. These methods could provide more objective insights into how users engage with VR environments.

5.6 Conclusion

This study investigated the impact of 360-degree rotatable images and 3D products in VR environments on brand experience, with engagement and immersion as mediators. The findings revealed that while promotion type had no direct effect on brand experience, engagement fully mediated this relationship, with 3D objects generating significantly higher engagement than 360-degree images. Cognitive engagement was the most influential factor, followed by behavioral and emotional engagement. In contrast, immersion did not mediate the relationship, suggesting that the immersive nature of the VR environment itself overshadowed the effects of promotional formats.

These findings highlight the importance of prioritizing interactive 3D models in VR marketing campaigns to foster deeper engagement, which in turn enhances brand experience. Marketing managers need to critically consider if their current company is ready to enter the metaverse based on their technological capabilities, strategic alignment, and the potential for co-specialization to combine existing strengths with emerging opportunities. However, the study also highlights the ethical challenges of VR advertising, particularly in terms the protection of vulnerable groups. As VR evolves and is increasingly adopted by consumers, researchers, policymakers, and industry leaders must collaborate to develop ethical guidelines that strike a balance between innovation and user well-being.

This study adds to the growing body of literature on VR marketing by providing empirical evidence about the effectiveness of various promotional formats. However, it also provides new opportunities for exploration. Future studies could investigate the role of social

interactions in VR environments, refine measurement tools for immersion and engagement, and examine the long-term effects of VR advertising on consumer behavior. By addressing these gaps, we can deepen our understanding of how immersive technologies shape brand experiences and pave the way for more responsible and impactful marketing practices in the metaverse.

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V. Appendices

Appendix A: Preliminary Study 1 Design Validation for the VR Environment and Recipe Selection

The purpose of this pre-study was to validate the design considerations for the virtual reality (VR) environment and to assess the appropriateness of selected recipes. Rather than relying solely on subjective judgment for these design elements, the pre-study aimed to leverage feedback from participants to ensure a well-informed and engaging final design. A total of five participants were recruited for this pre-study. The participants were chosen to represent a diverse demographic sample, with an age range of 20 to 25 years (three males, two females) and varying levels of culinary expertise. Their experience ranged from novice (e.g., occasionally preparing simple meals) to experienced home cooks (e.g., regularly preparing meals using various cooking techniques). Recruitment was carried out using convenience sampling.

For a general overview of this pre-study, a mixed-methods approach was using various qualitative techniques to gain a comprehensive understanding of participant preferences and feedback. Participants completed a survey divided into two sections, one focusing on the VR environment and the other on recipe selection. The first and second question were answered independently by participants. The remaining questions followed a semi-structured interview format where the researcher probed participants to elaborate on their preferences and ideas. The researcher also shared their own thoughts and ideas, as well as those of other participants, to further validate and refine concepts through co-creation, which encouraged collaborative input on both sides.

The survey began by asking participants to identify the most important features or elements for creating an engaging VR loading lobby in the metaverse. This was intended to

gather their unbiased opinions on what makes a virtual space appealing. They were then asked to rank six images of existing metaverse loading lobbies, providing a comparison of their preferences and highlighting key design elements. The participants were probed to explain why they ranked each environment in such an order. Next, participants shared their thoughts on essential assets for an immersive VR loading lobby, including interactive elements like moving objects, NPCs, and background animations. They also provided input on whether the environment should have a realistic or stylized design, along with their reasoning. Shifting focus to recipe-related questions, participants were asked to identify the key characteristics of a recipe that would be suitable for the HelloFresh VR case study. Lastly, they offered feedback on how to design the 360-degree rotatable image and the 3D promotional object to ensure these formats are comparable.

The results from this included the following. In terms of the VR environment there was a strong consensus on the importance of ease of navigation. Participants mentioned the need for intuitive navigation with suggestions for visual cues such as arrows, paths, or lighting to guide users. This feedback suggests that the environment should include subtle markers or landmarks that help users orient themselves without disrupting immersion. Regarding audio, participants agreed that appropriate background audio, such as nature sounds, or theme-related music was also important. They recommended using complementary audio that fits the mood of the surrounding environment. Furthermore, participants felt that interactive elements in the environment should serve a purpose, contributing to immersion rather than being purely decorative. They expressed concerns that if the only interactive elements were the promotional content, it could lead to a biased experience. This feedback suggests that incorporating non-promotional interactions would better reflect real-world VR experiences where users engage with various elements that enhance presence and exploration while not being dominated by advertising. In terms of

aesthetics, participants suggested that the elements placed have a consistent visual style, matching and complementing one another to create a cohesive environment.

However, there were also areas of disagreement. In terms of user autonomy in the VR space, some participants preferred a highly autonomous experience in which they could explore at their own pace, while others preferred a more guided environment. For this experiment, an autonomous space will be created due to resource limitations that prevent implementing both options simultaneously, as well as the need to control other variables. Furthermore, opinions on the density of the environment differed; some participants preferred minimalist spaces to avoid distraction, whereas others preferred more detailed, complex environments that provided a richer experience. Striking a balance between these preferences, such as creating different zones with varying levels of density, may provide the best solution. Another area of disagreement was the inclusion of social features and NPCs. While some participants appreciated the social interaction that NPCs or avatars could provide, others felt that these characters might detract from the experience or disrupt user autonomy. No NPC will be placed as this falls outside of the scope of the study. Lastly, there were varying opinions on the style and realism of the environment. Some participants favored photorealistic visuals, while others preferred a more stylized approach.

When selecting a recipe for a VR experience it's important to focus on simplicity with dishes with known ingredients and preparation steps. Recipes that are culturally familiar, like burritos or pasta, tend to resonate with a broad audience, while colorful, visually appealing ingredients may make it more appealing for a participant to engage with it. The final dish and its ingredients should be realistically depicted in the VR content to manage user expectations with what they get outside of the VR environment. Incorporating health-conscious options, such as plant-based appeals to lifestyle preferences without excluding other diets. A balance

between novelty and familiarity is key, offering dishes that are both recognizable and intriguing with a unique twist.

Appendix B: Adapted Immersion Scale

For each statement how much do you agree or disagree with the statement.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7

1	I was interested in seeing how the VR environments events would progress.
2	I was in suspense about whether I would perform well or not in the VR environment.
3	I sometimes found myself to become so involved with the VR environment that I wanted to interact with the VR environment directly.
4	I enjoyed the graphics and imagery of the VR environment.
5	I enjoyed completing the VR environment.
6	I was unaware of what was happening around me.
7	I felt that I tried my best during the VR environment.
8	The VR environment was challenging.

Appendix C: Adapted Cognitive Engagement Scale

Please indicate the extent to which you agree or disagree with the following statements about your interaction with the promotional content (360-degree rotatable images or 3D products) in the virtual reality (VR) environment.

(Depending on the condition the following explanation was displayed)

- 360-degree rotatable image was the billboard with the HelloFresh box on it
- The 3D object is the Hello Fresh Box you interacted with underneath the stand.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7

1	Interacting with the [VR promotional content] gets me to think about HelloFresh.
2	I think about HelloFresh a lot when I interact with the [VR promotional content].
3	Interacting with this [VR promotional content] stimulates my interest in learning more about HelloFresh.

Appendix D: Adapted Emotional Engagement Scale

Please indicate the extent to which you agree or disagree with the following statements about your interaction with the promotional content (360-degree rotatable images or 3D products) in the virtual reality (VR) environment.

(Depending on the condition the following explanation was displayed)

- 360-degree rotatable image was the billboard with the HelloFresh box on it
- The 3D object is the Hello Fresh Box you interacted with underneath the stand.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7

1	I feel very positive when I interact with the [VR promotional content].
2	Interacting with the [VR promotional content] makes me happy.
3	I feel good when I interact with the [VR promotional content].
4	I’m proud to interact with the [VR promotional content].

Appendix E: Adapted Brand Experience Scale

The following statements are about the experience you just had. On a 7 point Likert scale to what extent do you agree or disagree with the following statements ranging from 1 strongly disagree to 7 strongly agree.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7

1	HelloFresh made a strong impression on my visual sense or other senses.
2	I found HelloFresh interesting in a sensory way.
3	HelloFresh did NOT appeal to my senses.
4	HelloFresh generated feelings and sentiments.
5	I did NOT have strong emotions for HelloFresh.
6	HelloFresh is an emotional brand.
7	I engaged in physical actions and behaviors when I used HelloFresh.
8	HelloFresh resulted in bodily experiences. (e.g., it engages my senses, involves physical interaction, or creates sensations such as movement or touch)
9	The HelloFresh experience was NOT action oriented.
10	I engaged in a lot of thinking when I encountered HelloFresh.
11	HelloFresh did NOT make me think.
12	HelloFresh stimulated my curiosity and problem solving.

Appendix F: Assumption checks for linear regression

Table F1

Correlation Matrix of Key Variables

Variables	Mean	Standard Deviation	Brand Experience	Immersion	Cognitive Engagement	Emotional Engagement	AOI	Total Time	Times Touched
Brand Experience	4.45	0.86	1.00						
Immersion	5.88	0.67	0.36	1.00					
Cognitive Engagement	4.67	1.27	0.53	0.03	1.00				
Emotional Engagement	5.12	0.96	0.34	0.50	0.26	1.00			
AOI	42.55	26.96	0.16	0.24	-0.16	0.03	1.00		
Total Time	305.49	80.85	0.22	0.46	-0.02	0.31	0.48	1.00	
Times Touched	16.11	9.57	0.26	0.09	0.09	-0.03	0.46	0.52	1.00

Figure F1

Pairwise Scatter Plots of Key Variables

Figure F2

Residuals vs. Fitted Values Plot for Homoscedasticity and Independence

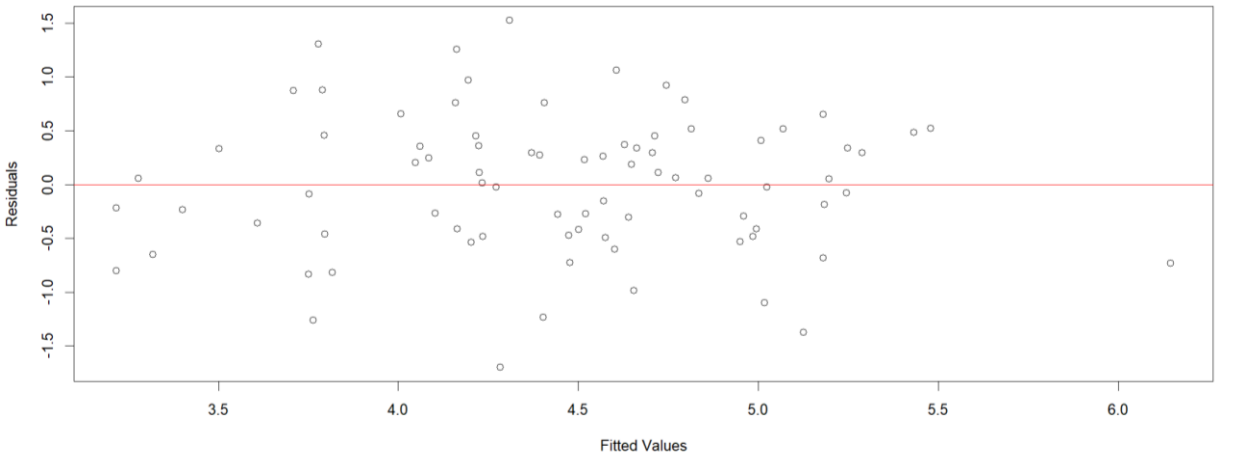

Figure F3

Histogram of Residuals for Normality Assessment

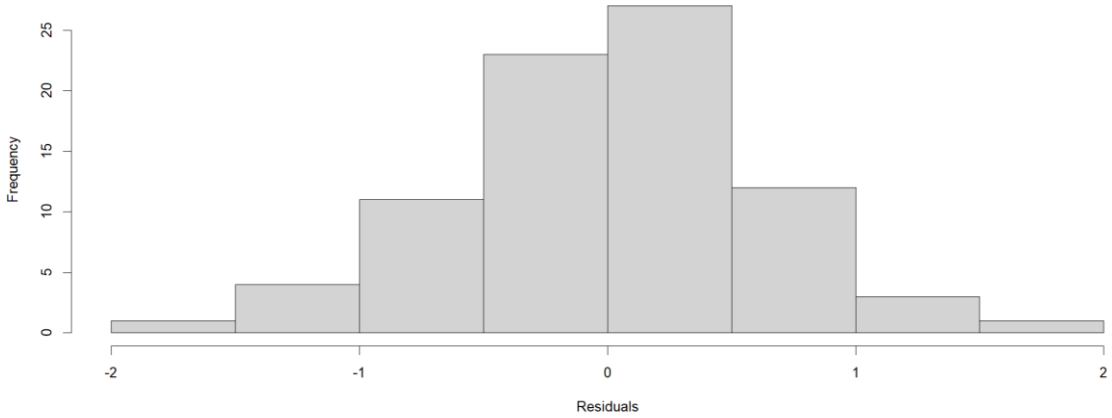

Figure F4

Q-Q Plot of Residuals for Normality Assessment

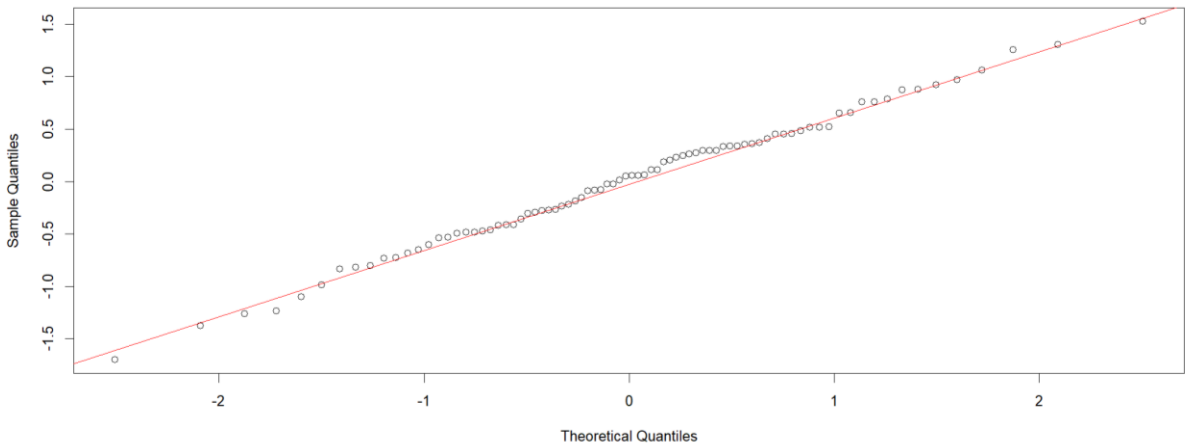

Table F2

Variance Inflation Factor (VIF) Values for Predictor Variables

Predictor	VIF
Immersion	1.59
Cognitive engagement	1.19
Emotional engagement	1.57
AOI	1.50
Total Time	2.02
Times Touched	1.68

Appendix G: Use of AI in the making of this report

AI was used on multiple occasions during the research and writing of this report. In addition to Scopus, Science Direct, Google Scholar, and Web of Science, the consensus.ai tool was used to identify additional relevant sources. Furthermore, after finding sources and scanning through their abstracts and text, Chat GPT was used to summarize large sections of scientific articles to further filter them.

ChatGPT was used as a starting point for paragraphs of the report where the input was information from scientific article(s) that I found and curated myself as being useful to the report's subject. The AI generated initial drafts based on this which I then reviewed and revised to ensure accuracy and alignment with my intended message. All outputs of ChatGPT were read and critically reviewed by me before being added to the report. All the output was also edited to some degree to make it fit my personal writing style. ChatGPT was often used as a sparing partner for ideas and points where I would provide an insight and asked it to give me counter arguments against it. Additionally, ChatGPT was used to help grade my sections as I used the master thesis criteria and the section as input where then it would provide me with recommendations for improvement.

When writing the report, I used ChatGPT and Quilbot to improve my sentence structure and fluency. Chat GPT also assisted in organizing the report's paragraph structure and sections. Quilbot was designed specifically for fluency purposes.

For the cleaning of data when using R studio, ChatGPT was used substantially for the generation of R-script to remove columns, edit column names, merge columns, and run statistical analysis.

Finally, Dalle-3 was used for the generation of the billboard used in the 3D object Hello Fresh Box and the potion throwing game billboard.