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Enhancing virtual reality experiences in grocery retailing: the impact of audio priming on spatial presence and retailer outcomes

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ABSTRACT

As omnichannel retail strategies increasingly blend virtual and physical experiences, retailers are recognizing the significant potential of virtual reality (VR). Considering the crucial role of spatial presence in determining the quality of VR experiences, this study explores novel ways to increase spatial presence, particularly for virtual tours as a digital in-store technology in grocery retail. Given a lack of research on priming in the context of VR, the goal of this study is to examine the impact of audio priming on spatial presence. Additionally, we explore the relationship between spatial presence and perceived enjoyment, as well as between perceived enjoyment and key pre-economic variables relevant to grocery retailers. The hypotheses are developed based on theoretical backgrounds in VR, spatial presence, fluency theory, and priming. To test our hypotheses, we conducted a one-factor between-subjects experiment involving 60 participants divided into one control and two treatment groups. Before participating in a virtual farm tour, each treatment group was exposed to a distinct audio priming stimulus focusing either on farm ambiance or VR technology. The results show significant differences in spatial presence among the groups. While priming participants on VR technology enhanced spatial presence, priming them on farm ambiance had no effect. Technology priming prevents consumers from experiencing a technology shock by familiarizing them with the technological aspects of the VR experience, increasing processing fluency. In contrast, ambiance priming relies on consumers' pre-existing associations, which may not align with the actual VR experience, disrupting processing fluency. Furthermore, the results show that the increased spatial presence results in greater perceived enjoyment, which ultimately leads to an increased recommendation intention and attitude toward the retailer. Therein, this study highlights the potential of integrating audio priming in VR applications, specifically advocating for its strategic use in grocery retail settings to enhance consumer experiences in omnichannel environments.

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Introduction

As omnichannel retail strategies increasingly blend virtual and physical experiences, retailers around the world are recognizing the significant potential of virtual reality (VR) and are progressively investing capital to take advantage of advancements in this field (Yoo et al. 2023). Whether it is the Swedish furniture retailer IKEA (IKEA VR), the Chinese e-commerce giant Alibaba (Buy+), or Europe's largest consumer electronics retailer (Virtual SATURN) – they have all tested opportunities to create additional value for consumers in VR (Peukert et al. 2019). By successfully establishing virtual stores, retailers can extend their reach by allowing consumers from distant locations to visit virtually (Yoo et al. 2023). However, opportunities extend beyond the establishment of new distribution channels, encompassing novel approaches to create consumer experiences, coupled with the potential to leverage the virtual environment as a marketing instrument (Dwivedi et al. 2023; Yoo et al. 2023).

For instance, virtual tours enabled by VR technology present an opportunity for retailers to provide unique consumer experiences – whether in physical or virtual stores. Prior research has shown promising results for virtual tours as a marketing instrument, suggesting that, for example, virtual farm tours offer a viable method to engage a vast audience, irrespective of a farm's physical location (Schütz, Kurz, and Busch 2022). These tours capture the essence and presence of an in-person farm tour while minimizing the time and effort required by participants (Asani et al. 2019; Schütz, Kurz, and Busch 2022). Furthermore, in light of declining public trust in intensive animal production systems in many European countries (European Commission 2015; Krystallis et al. 2009; Weible et al. 2016), consumers without first-hand knowledge of farming operations desire a greater understanding of agricultural practices and demand transparency (Boogaard et al. 2011; Vanhonacker, WimVerbeke, and Tuyttens 2008). Providing visual insights into livestock stables through farm tours can increase transparency, improve animal welfare perceptions, and potentially stimulate a more sustainable food shopping behavior (Blokhuis et al. 2003, Schütz, Kurz, and Busch 2022; Ventura et al. 2016). Recognizing consumers' growing demand for transparency, some grocery retailers have already taken action. For example, REWE introduced live streams and VR headsets at the point of sale in 2018 in one of its supermarkets to provide visual insights into livestock stables and has continued using them since, underscoring their ongoing relevance to consumers (Kletsche 2019; Richrath 2018; Schütz, Kurz, and Busch 2022). By not utilizing this opportunity, grocery retailers miss the chance to communicate their own representation of production systems, leaving consumers exposed solely to media portrayals, which tend to shape public perception (Tonsor and Wolf 2012). A key barrier to broader implementation of virtual farm tours may be the concern among grocery retailers that visual depictions of production processes could provoke negative reactions from consumers, as the imagery might diverge from their idealized animal welfare expectations (Christoph-Schulz et al. 2018). Consequently, it is essential to ensure that virtual tours, which, unlike in-person tours, may be conducted without appropriate guidance and context, are well received by consumers. Understanding how to effectively introduce consumers to virtual farm tours is therefore critical to creating a high-quality, standalone VR experience.

The quality of a VR experience generally depends on the degree of immersion and the subsequent spatial presence. Spatial presence is a key construct in virtual reality, and researchers and practitioners are actively seeking ways to enhance it (Cummings and Bailenson 2016). So far, only one study (Cerda, AurélieFauvarque, and Del-Monte 2021, using visual priming) has explored priming's effect on spatial presence, showing that priming can indeed increase spatial presence. Given the frequent use of priming and its significant effects in other research domains (e.g. Lee and Labroo 2004; North, Sheridan, and Areni 2016), we investigate whether audio priming can enhance spatial presence during VR experiences. Audio priming generally refers to *the use of auditory stimuli to activate desired concepts in an individual's mind and influence their response to a subsequent stimulus* (Bargh and Chartrand 1999). In this study, audio priming was employed prior to a virtual farm tour to enhance how participants perceived the VR experience, using either an audio stimulus related to farm ambiance or one related to VR technology. Additionally, we aim to explore the relationship between spatial presence and perceived enjoyment, which then translates into key pre-economic variables relevant to retailers. More precisely, we seek to answer the following research questions:

(1) Does audio priming increase spatial presence?
(2) Does spatial presence increase perceived enjoyment?
(3) Does perceived enjoyment increase recommendation intention and attitude toward the retailer?

By answering these questions, this study makes several key contributions: First, it extends research on VR experiences by being the first to introduce audio priming as a novel mechanism to enhance spatial presence. Specifically, we empirically demonstrate that technology priming enhances spatial presence, whereas ambiance priming does not, and we provide a theoretical explanation for these effects by integrating fluency theory. Second, our findings establish positive relationships between spatial presence, perceived enjoyment, and key consumer responses relevant to grocery retailers, namely recommendation intention and attitude toward the retailer. Finally, we offer actionable guidance for grocery retailers on leveraging audio priming to optimize VR experiences.

The rest of this paper is organized in the following manner: The second chapter presents the theoretical background, hypotheses development, and conceptual framework. The third chapter outlines our methodological approach. The results are revealed in the fourth chapter. The fifth chapter discusses the results, highlighting their theoretical and practical significance. Lastly, the sixth chapter outlines the limitations of this study and proposes directions for future research.

Theoretical background

Virtual reality, immersion, and spatial presence

The term VR refers to *an artificial, virtual, and viewer-centered experience in which users are at least visually isolated from their physical environment in an all-encompassing three-dimensional space* (Rauschnabel et al. 2022). VR experiences are typically facilitated through VR headsets, which obscure the user's surroundings while presenting information depicting a virtual environment (Rauschnabel et al. 2022). VR headsets were originally designed for gaming and entertainment, but their usage has gradually expanded to include areas such as job training, prototyping, marketing, and tourism (Shahab, Ghazali, and Mohtar 2021). Researchers have investigated the use of VR across multiple commercial sectors, including retail (e.g. Krasonikolakis et al. 2018; Sina and Wu 2023; Vrechopoulos, Apostolou, and Koutsiouris 2009), the fashion industry (e.g. Yaoyuneyong et al. 2018), manufacturing (e.g. Berg and Vance 2017), tourism (e.g. H. Lee et al. 2019; Wei, Qi, and Zhang 2019), and healthcare (e.g. Fertleman et al. 2018).

The quality of a VR experience generally depends on the degree of immersion and the subsequent spatial presence (also referred to as physical presence in Lee 2004 or telepresence in Draper, Kaber, and Usher 1998; Rauschnabel et al. 2022), which describes *the psychological sense of 'being there' in the virtual environment* (Hartmann et al. 2016; Heeter 1992; Markowitz et al. 2018; Slater and Wilbur 1997). The terms immersion and spatial presence are often mistakenly used as synonyms. In line with numerous researchers in this field (e.g. Cummings and Bailenson 2016; Peukert et al. 2019; Schultze and Orlikowski 2010; Sharda et al. 2004; Slater and Wilbur 1997), our understanding is that immersion is not a subjective feeling, but an objective measure. Spatial presence, on the other hand, is the human perception of a virtual environment (Schultze and Orlikowski 2010). Immersion (technology), among other factors, leads to spatial presence (perception) (Cummings and Bailenson 2016; Schultze and Orlikowski 2010; Sharda et al. 2004). Both researchers and practitioners have been exploring various options to increase spatial presence (Cummings and Bailenson 2016).

Fluency theory

Processing fluency refers to *the ease with which an individual processes a stimulus* (Reber, Schwarz, and Winkielman 2004; Schwarz 2004). The core proposal of fluency theory is that the more fluently a stimulus is processed, the more positive the individual's response (Reber, Schwarz, and Winkielman 2004).

High fluency feels good to individuals for numerous reasons, including its association with progress toward successful recognition of the stimulus, error-free processing, the availability of appropriate knowledge structures to interpret the stimulus, and its signaling that the external stimulus is familiar and thus unlikely to be harmful (Carver and Scheier 1990; Derryberry and Tucker 1994; Fernandez-Duque, Baird, and Posner 2000; Ramachandran and Hirstein 1999; Schwarz 1990; Simon 1967; Vallacher et al. 1999; Zajonc 1968, 1998).

Fluency theory is particularly relevant in the context of this study, because it highlights the crucial role of ease of processing in creating engaging and effective consumer experiences. In a highly stimulated retail environment, where consumers are constantly exposed to competing stimuli, ensuring that consumer experiences are processed fluently is essential for enhancing acceptance and engagement (Im and Ha 2018; Xiao and Yii Tan 2024). If the experience is difficult to process, consumers may disengage. Moreover, when introducing a new consumer experience, such as a virtual farm tour, the extent to which consumers can effortlessly process the experience impacts its effectiveness (Jiang, Guan, and de Haaij 2020).

According to Reber, Schwarz, and Winkielman (2004) and Winkielman et al. (2012), processing fluency can be influenced by various factors, including contrast, clarity, presentation duration, prior exposure to the stimulus, and priming. Moreover, a neural experimental study by Gottfried and Dolan (2003) demonstrated that congruity between stimuli increases processing fluency, a finding later reinforced by a survey-based experiment conducted by Jiang, Guan, and de Haaij (2020) in the context of online video advertising.

Priming

Priming can be defined as *a phenomenon where exposure to one stimulus can activate desired concepts in an individual's mind to influence the response to a subsequent stimulus* (Bargh and Chartrand 1999). The concept of priming is rooted in the associative network model of memory, which posits that ideas, words, and concepts are stored in the brain in a network of interconnected nodes. When one node is activated, related nodes are also likely to be triggered, facilitating the recall or recognition of associated information. This activation process is the basis of priming. Exposure to a preliminary stimulus, also known as a prime, influences the reaction to a subsequent stimulus by activating related associations (Collins and Loftus 1975).

The lack of research on priming in the context of VR is particularly noteworthy, given that numerous studies have consistently shown the importance of priming as a concept in consumer research using various stimuli. For example, Nedungadi (1990) examined how priming consumers with brand names influences the likelihood of brand choice, Mandel and Johnson (2002) investigated how background images and colors of a web page affect consumers' product choice, and Lee and Labroo (2004) examined how conceptual and perceptual fluency affect brand evaluation. Therein, most research has focused on visual priming. However, there are also numerous studies on audio priming (e.g. North, Hargreaves, and McKendrick 1999; North, Sheridan, and Areni 2016), highlighting its potent influence on consumer behavior.

A crucial aspect of priming is its cross-modal capability. Cross-modal priming implies that a stimulus encountered through one modality can trigger related concepts or associations within an entirely distinct modality (Vallet, Brunel, and Versace 2010). For example, the color of a beverage (i.e. visual modality) can affect how sweet it is perceived to taste (i.e. gustatory modality), even if the actual flavor remains unchanged (Hoegg and Alba 2007). Similarly, Williams and Bargh (2008) discovered that individuals who briefly held a cup of hot coffee judged a target person as having a warmer (generous, caring) personality, while Liljenquist, Zhong, and Galinsky (2010) demonstrated that the scent of cleanliness can induce charitable behavior. In this respect, there is ample reason to assume that audio priming influences spatial presence.

Hypotheses development and conceptual framework

To answer our research questions, we derive hypotheses based on the previous theoretical considerations and the extant body of literature. Fluency theory suggests that priming can increase processing fluency, leading to a more positive response to the stimulus due to the sense of familiarity it creates (Reber, Schwarz, and Winkielman 2004). Audio priming can shape consumers' understanding of an environment and create an association between what they hear and what they expect to experience (Bolivar, Cohen, and Fentress 1994; Gaver 1993; North, Hargreaves, and McKendrick 1999). In the context of a VR experience, providing an audio prime that resonates with the upcoming visual content should increase consumers' sense of familiarity, leading to an elevated spatial presence (Cerda, AurélieFauvarque, and Del-Monte 2021; Sjölie 2012). This alignment between auditory and visual stimuli could be particularly impactful if the audio provides context prior to the experience, effectively setting the stage for what is to come (Cerda, AurélieFauvarque, and Del-Monte 2021; Lombard and Ditton 1997). Regarding virtual farm tours, we hypothesize there are two possible contexts for audio priming to potentially enhance consumers' spatial presence: the ambiance of a farm and the technology behind the VR experience. These specific types of audio priming were chosen based on a qualitative study by Schütz, Kurz, and Busch (2022), in which participants were interviewed after partaking in a virtual farm tour. The rationale for each type of priming is explicated in the development of the respective hypotheses.

To prepare participants for a farm-themed VR experience, it might be helpful to introduce them to the ambiance of a real farm. Prior qualitative research by Schütz, Kurz, and Busch (2022) found that consumers from urban areas, who may have never visited a farm or seen the inside of a stable, perceived virtual farm tours as an accessible way to gain such experiences. However, transitioning, for instance, from the inside of a supermarket in a city center to a virtual farm environment may feel abrupt and unfamiliar for these consumers. Ambiance priming can help bridge this gap by familiarizing participants with the sensory aspects of a farm before the VR experience begins, making the transition smoother and reducing potential confusion, disorientation, or unfamiliarity (Cerda, AurélieFauvarque, and Del-Monte 2021; Sjölie 2012), thereby increasing processing fluency. Therefore, we hypothesize that audio priming consumers on farm ambiance has a positive effect on their spatial presence during virtual farm tours (**H_{1a}**). In a similar vein, priming consumers on the technology behind the VR experience could serve as a way to enhance their spatial presence. Prior qualitative research by Schütz, Kurz, and Busch (2022) found that consumers who participated in virtual farm tours reported unfamiliarity with the VR experience – including a feeling of disorientation – as a key barrier to implementation at the point of sale. This suggests that processing the virtual environment may be challenging, especially for first-time users but also for those with prior experience, potentially leading to a technology shock that reduces spatial presence. Technology priming can address this issue by providing consumers with an explanation of what to expect and familiarizing them with the technological aspects of the VR experience, such as the specifics of the VR headset or the mechanics behind a 360-degree video. This preparation helps them become more comfortable with the VR medium itself and experience a smoother transition from the real world to the virtual farm tour, mitigating potential confusion, disorientation, or unfamiliarity (Cerda, AurélieFauvarque, and Del-Monte 2021; Sjölie 2012), thereby increasing processing fluency. Thus, we hypothesize that audio priming consumers on VR technology has a positive effect on their spatial presence during virtual farm tours (**H_{1b}**).

Beyond the impact of audio priming on spatial presence, it is important to understand how spatial presence impacts perceived enjoyment, which then translates into key pre-economic variables relevant to retailers. Perceived enjoyment, in the context of VR experiences, can be defined as *a positive affective response to a VR experience in its own right, apart from any anticipated consequences* (Davis, Bagozzi, and Warshaw 1992; Vorderer, Klimmt, and Ritterfeld 2004). Theoretical considerations from previous

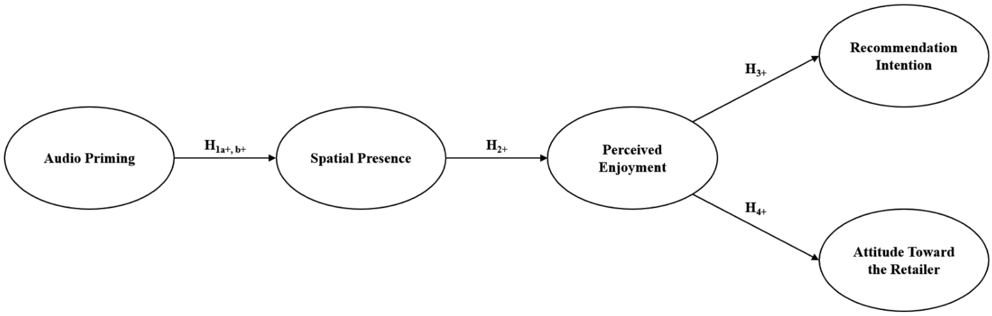

Figure 1. Conceptual framework.

research suggest that spatial presence within a virtual environment leads to higher perceived enjoyment (Heeter 1995; Lombard and Ditton 1997; Tamborini and Skalski 2006). Furthermore, numerous empirical studies have shown a positive correlation between spatial presence and perceived enjoyment (Nah, Eschenbrenner, and DeWester 2011; Peukert et al. 2019; Sylaiou et al. 2010). In line with previous research, we thus hypothesize that spatial presence has a positive effect on perceived enjoyment (**H_2**).

Recommendation intention in the context of this study can be defined as *a consumer's intention to recommend the virtual farm tour to a friend or colleague* (Ajzen 1991). Intentions are generally considered the best predictor of behavior if requisite opportunities and resources are available (Ajzen 1991). In marketing practice, a key metric among companies developed by Reichheld (2003) is the net-promoter score (NPS). The NPS assesses customer loyalty by asking respondents how likely they are to recommend a company to others, classifying them into promoters and detractors based on their responses, and calculating the ratio of promoters to detractors, essentially measuring recommendation intention at the customer base level. In general, consumers like to recommend enjoyable experiences to others, because they seek approval and positive recognition (Hennig-Thurau et al. 2004). Furthermore, prior empirical research suggests a positive relationship between perceived enjoyment and recommendation intention (Yousaf et al. 2021). Thus, we hypothesize that perceived enjoyment has a positive effect on recommendation intention (**H_3**).

Attitude toward the retailer can be defined as *a learned predisposition to respond in a consistently favorable or unfavorable manner toward the retailer* (Ajzen 1991; MacKenzie and Lutz 1989). According to Ajzen and Fishbein (1980), an individual's attitude toward an object is determined by the multiplicative relationship between (1) the probability that the individual believes the object has a certain attribute and (2) the individual's evaluation of that attribute within the object. In our case, the object of attitude formation is the retailer. In the context of our study, individuals learn to associate a new attribute with the retailer, namely that the retailer has introduced the possibility of experiencing virtual farm tours in its stores. If this new attribute is evaluated positively (i.e. if individuals enjoy the virtual farm tour), the attitude toward the retailer will improve. Based on these considerations, we hypothesize that perceived enjoyment has a positive effect on attitude toward the retailer (**H_4**). Figure 1 illustrates our conceptual framework.

Method

Preliminary study

In preparation for our main study, we undertook a preliminary study to validate our two distinct audio priming stimuli. We developed these stimuli based on insights from literature on guided imagery. According to Dinger-Broda (2013), a guided imagery session consists of three distinct phases: 1. Induction Phase: This phase helps participants enter a relaxed state by focusing on their breathing and achieving physical relaxation, which is essential for engaging in the main phase; 2. Main Phase: This phase delivers the desired stimulus, which in our study involved either the farm ambiance or the VR technology priming; 3. Return Phase: In this phase, participants are gently brought back to a wakeful, alert state through deep breathing and movement. The stimuli, articulated in German, were matched in length both in written format and spoken duration (Farm ambiance: 1364 characters, 2 minutes and 18 seconds (Group 1); VR technology: 1361 characters, 2 minutes and 17 seconds (Group 2); for the full stimuli, refer to the Appendix). Our objective was to ascertain consistent voice quality and general attitude toward the audio content across both stimuli.

To conduct our preliminary study, we developed an online survey that was distributed through the crowd working platform Clickworker (https://www.clickworker.de/). To ensure high data quality, we applied a rigorous data cleaning process. Starting with 100 completed surveys (50 for each group), we first removed participants who failed at least one of two methodologically different attention checks that were built into the survey at different stages (Aguinis, Villamor, and Ramani 2020). Second, we removed participants based on their completion time for the survey using a relative speed index of 2 as the maximum threshold (Leiner 2019). Finally, we excluded participants with the most extreme scores on the gamma factor scale of socially desirable response behavior, which indicates a tendency either to diminish negative qualities or overemphasize positive qualities (Kemper et al. 2012). This resulted in a final sample of 86 participants ($N_{G1} = 45$, $N_{G2} = 41$, $M_{age} = 41.16$, $SD_{age} = 11.66$, 65.1% male).

Perceived voice quality was measured with a seven-point semantic differential scale ranging from −3 to 3, developed by Nieboer, de Graaf, and Schutte (1988). Likewise, attitude toward the audio content was measured with a seven-point semantic differential scale ranging from −3 to 3, adapted from Donthu (1998). A Welch's unequal variances t-test confirmed that there were no significant differences between the two groups in terms of perceived voice quality (M_{G1}=.30, SD_{G1}=.75, M_{G2}=.19, SD_{G2}=.68, $t = .708$, $p = .481$) or attitude toward the audio content (M_{G1}=.42, $SD_{G1} = 1.07$, M_{G2}=.25, SD_{G2}=.82, $t = .816$, $p = .417$).

Main study

Upon entering the research facility, participants were briefed about the study's procedure. They were then familiarized with the VR headset, with explanations of its operation and functionality. Participants then completed a pre-questionnaire covering socio-demographics, previous experience with VR headsets, measured on a five-point scale ('Do you have experience using VR headsets?', 1=none, 5=very much), and farm tours, assessed with a binary scale ('Have you ever participated in a farm tour?', 0=no, 1=yes). The questionnaire also included the gamma factor scale of socially desirable response behavior (Kemper et al. 2012), measured on a five-point Likert scale (1=does not apply at all, 5=fully applies), the short version of the Positive and Negative Affect Schedule (PANAS) developed by Mackinnon et al. (1999), measured using a five-point Likert scale (1=not at all, 5=very much), and the Spontaneous Use of Imagery Scale (SUIS) developed by Reisberg, Pearson, and Kosslyn (2003), measured on a five-point Likert scale (1=never applicable, 5=always fully applicable).

Subsequently, participants in the experimental groups received their designated audio priming stimulus. For procedural consistency, the control group was provided with basic audio instructions. However, since the control group did not receive a priming stimulus, the induction and return phases outlined in the previous chapter were not applicable (for the full instructions, refer to the Appendix). All audio was delivered to participants via Bluetooth-connected Apple AirPods, set to a consistent volume level of 8. Participants then started the virtual farm tour, which was the same for all groups. They began by standing in front of a barn. Using the VR headsets' eye-tracking technology, they were able to enter the barn by focusing on the door. Participants then watched a 360-degree video of the barn from three different perspectives. After the video, they found themselves outside the barn again. The virtual farm tour was facilitated using the Pico G2 4K VR headset.

According to Rauschnabel et al. (2022), VR applications can generally be positioned on a continuum based on spatial presence, ranging from atomistic (low spatial presence) to holistic (high spatial presence). The position along the continuum is influenced by several factors, including the degrees of freedom (DoF), where a key differentiation is commonly drawn between 3 DoF and 6 DoF. VR headsets with 3 DoF offer an experience characterized by rotational tracking. This feature allows users to look around by turning their head in any direction, while their position within the virtual environment remains static. On the other hand, VR headsets with 6 DoF offer a richer experience by incorporating both rotational and translational tracking. This dual tracking capability allows users to move or walk around in the virtual space and turn their heads in any direction (Pan and Hamilton 2018). The Pico G2 4K VR headset, which was utilized to display the 360-degree video in our study, featured 3 DoF.

Concluding the virtual farm tour, a short audio snippet informed participants that their virtual journey had ended, instructing them to remove the VR headset. Immediately afterward, participants received the post-questionnaire, which again included the short version of the PANAS developed by Mackinnon et al. (1999), as well as the variables from our conceptual framework. Spatial presence was measured using the Spatial Presence Experience Scale (SPES) developed by Hartmann et al. (2016), which models spatial presence as a reflective-reflective higher-order construct (Sarstedt et al. 2019) consisting of two dimensions, measured with four items per dimension: self-location (SPES-SL) and possible actions (SPES-PA). Both dimensions were assessed on a five-point Likert scale (1=fully disagree, 5=fully agree). To measure attitude toward the retailer, participants were asked to imagine that EDEKA, Germany's largest grocery retailer by market share, introduced the possibility of experiencing virtual farm tours in its stores. Participants were then asked to rate their attitude toward EDEKA on a seven-point semantic differential scale ranging from −3 to 3, using three items developed by Muehling (1987) and

Table 1. Descriptive statistics.

	Group 1 (Priming: Farm ambiance, *N* = 19)		Group 2 (Priming: VR technology, *N* = 18)		Group 3 (Control, *N* = 20)	
Variable	M	SD	M	SD	M	SD
SPES-SL	3.20	1.15	3.79	.65	3.25	1.07
SPES-PA	2.61	1.01	3.10	.95	2.39	.92
Perceived Enjoyment	4.11	.94	4.17	.71	4.15	.81
Recommendation Intention	7.16	2.41	6.44	2.50	5.60	2.85
Attitude Toward the Retailer	5.33	1.38	5.98	.75	6.05	1.04
Prior experience with VR headsets	1.63	1.01	1.50	.79	1.80	.95
Prior experience with farm tours	.53	.51	.56	.51	.35	.49
SUIS	3.91	.94	3.80	.81	3.58	.86
Age	24.05	8.20	23.44	7.33	26.10	10.49

M=Mean, SD=Standard deviation.

MacKenzie and Lutz (1989). Perceived enjoyment was measured with a single item using a five-point Likert scale (1=not at all, 5=very much), and recommendation intention was assessed with a single item on a ten-point Likert scale (1=very unlikely, 10=very likely). Once the participants had completed the study, they were compensated with €10.

Sample

We recruited a total of 60 participants who provided their informed consent prior to the commencement of the study. They had either normal or corrected vision and confirmed their overall well-being. The participants were randomly assigned to the control group, the farm ambiance priming group, or the VR technology priming group. Before conducting the subsequent analyses, we excluded participants with the most extreme scores on the gamma factor scale of socially desirable response behavior (Kemper et al. 2012). This resulted in a final sample of 57 participants ($N_{G1} = 19$, $N_{G2} = 18$, $N_{G3} = 20$, $M_{age} = 24.58$, $SD_{age} = 8.75$, 57.9% male). Of these participants, 27 indicated they had never previously participated in a farm tour, while 33 reported having no prior experience with the use of VR headsets, 14 had a little experience, 8 had moderate experience, 1 had a lot, and 1 had very much experience. Table 1 presents an overview of descriptive statistics for the three groups, displaying the variables from the conceptual framework as well as the control variables.

Results

Preliminary considerations

The hypotheses were tested via partial least squares structural equation modeling (PLS-SEM) in R (version 4.3.2) using the seminr package (version 2.3.2). We decided to use PLS-SEM because it is the recommended approach for analyzing experimental designs in structural equation models (Bagozzi, Yi, and Singh 1991). Following the approach of Hair et al. (2019), we first assess the suitability of our sample size. We then proceed to assess the measurement model and structural model. To determine the minimum sample size for a given significance level and desired statistical power, we use the inverse square root method developed by Kock and Hadaya (2018). The analysis of our main model yields a minimum significant path coefficient of .327 (see Table 4). With a significance level of .05 and a power of .8, the minimum sample size is given by:

$$n_{min} > \left(\frac{2.486}{.327}\right)^2 \cong 58$$

Given that the inverse square root method is rather conservative, in that it slightly overestimates the sample size required to render an effect significant at a given power level (Hair et al. 2021), we conclude that our sample size of $N = 57$ is adequate for the analysis.

Measurement model assessment

The first step in evaluating reflective measurement models in PLS-SEM is to examine indicator loadings (Hair et al. 2019). Indicator loadings greater than .708 are recommended, as they indicate that the construct explains more than 50 percent of the indicator's variance (Hair et al. 2019). Table 2 shows that this recommendation is met for all multi-item reflective constructs. The second step in reflective measurement model assessment involves examining internal consistency reliability, which is the extent to which indicators measuring the same construct are associated with each other (Hair et al. 2021, 2019). The most commonly used metrics in PLS-SEM are composite reliability rho_c and Cronbach's alpha (Hair et al. 2021). We use Cronbach's alpha because it is the more conservative measure (Hair et al. 2021). Table 2 shows that all Cronbach's alpha values exceed the recommended threshold of .700 (J. Hair et al. 2021; Nunnally 1978). The third step is to assess convergent validity, which is the extent to which the construct converges in order to explain the variance of its indicators (Hair et al. 2021). The most commonly used metric to assess convergent validity is the average variance extracted (AVE). Table 2 shows that all AVE meet the .500 cutoff required (Fornell and Larcker 1981; Hair et al. 2021). The fourth step is to assess discriminant validity, which is the extent to

Table 2. Measurement items.

Construct	Items	IL	CA	AVE
SPES-SL	I felt like I was actually there in the environment of the virtual farm tour.	.878	.838	.674
	It seemed as though I actually took part in the action of the virtual farm tour.	.791		
	It was as though my true location had shifted into the environment in the virtual farm tour.	.810		
	I felt as though I was physically present in the environment of the virtual farm tour.	.802		
SPES-PA	The objects in the virtual farm tour gave me the feeling that I could do things with them.	.779	.799	.622
	I had the impression that I could be active in the environment of the virtual farm tour.	.763		
	I felt like I could move around among the objects in the virtual farm tour.	.782		
	It seemed to me that I could do whatever I wanted in the environment of the virtual farm tour.	.828		
SPES	SPES-SL	.936	.835	.858
	SPES-PA	.916		
Perceived Enjoyment	How much did you enjoy the virtual farm tour?	n/a	n/a	n/a
Recommendation Intention	How likely is it that you would recommend the virtual farm tour to a friend or colleague?	n/a	n/a	n/a
Attitude Toward the Retailer	bad – good	.922	.878	.805
	negative – positive	.952		
	unpleasant – pleasant	.811		

IL=Indicator Loading, CA=Cronbach's Alpha, AVE=Average Variance Extracted.

which a construct is empirically distinct from other constructs in the structural model (Hair et al. 2021). The most commonly used metrics in PLS-SEM are the Fornell-Larcker criterion (Fornell and Larcker 1981) and the heterotrait-monotrait ratio (HTMT) of correlations (Henseler, Ringle, and Sarstedt 2015). Table 3 shows that the square roots of the AVE exceed the interconstruct correlations, indicating discriminant validity according to the Fornell-Larcker criterion (Fornell and Larcker 1981). Furthermore, our results also indicate discriminant validity according to the HTMT criterion, given there are no HTMT values above .850 (Hair et al. 2021). In line with Sarstedt et al. (2019), we do not consider discriminant validity between the higher order construct SPES and its lower order dimensions SPES-SL and SPES-PA, as a violation of discriminant validity between these constructs is expected.

Structural model assessment

Prior to the evaluation of the structural model, we calculated the variance inflation factors (VIF) for all predictor constructs. Given there are no VIF values above 5, we conclude that multicollinearity does not pose a problem in this study.

To examine the impact of audio priming on SPES, the structural model includes two dummy variables, one for each treatment group, with the control group as the reference group. Thus, the corresponding bootstrapped path coefficients represent the differences in SPES means between each treatment group and the control group. In line with Bagozzi, Yi, and Singh (1991), we use γ to denote these coefficients, while using β for the others.

To assess the structural model, we ran a bootstrapping analysis with 10,000 resamples. The results (Table 4, Model 1) show that priming participants on farm ambiance (Group 1)

Table 3. Fornell-larcker criterion.

#	Construct	AVE	Correlations/Square Roots of AVE					
			1	2	3	4	5	6
1	SPES-SL	.674	**.821**					
2	SPES-PA	.622	.716	**.788**				
3	SPES	.858	–	–	**.926**			
4	Perceived Enjoyment	n/a	.508	.398	.493	**n/a**		
5	Recommendation Intention	n/a	.419	.485	.486	.408	**n/a**	
6	Attitude Toward the Retailer	.878	.315	.197	.281	.382	.348	**.897**

AVE=Average Variance Extracted.

Table 4. PLS-SEM results.

Hypothesis	Path	Model 1	Model 2
Hypothesized paths:			
H_{1a}	Group 1 (Priming: Farm ambiance) → SPES	.035 (.177)	.009 (.139)
H_{1b}	Group 2 (Priming: VR technology) → SPES	.327 (.138) **	.299 (.118) **
H_2	SPES → Perceived Enjoyment	.502 (.110) ***	.497 (.107) ***
H_3	Perceived Enjoyment → Recommendation Intention	.407 (.118) ***	.407 (.118) ***
H_4	Perceived Enjoyment → Attitude Toward the Retailer	.385 (.154) **	.385 (.154) **
Control variables:			
–	Prior experience with VR headsets → SPES	–	−.234 (.157)
–	Prior experience with farm tours → SPES	–	−.075 (.122)
–	SUIS → SPES	–	.291 (.134) **
–	Age → SPES	–	.232 (.130) *

R^2_{SPES} = 9.4% (Model 1), R^2_{SPES} = 33.8% (Model 2), $R^2_{Perceived\ Enjoyment}$ = 24.3%, $R^2_{Recommendation\ Intention}$ = 16.7%, $R^2_{Attitude\ Toward\ the\ Retailer}$ = 14.6%, *$p < .1$, **$p < .05$, ***$p < .01$, Bootstrapped path coefficients with standard errors in parentheses.

had no significant effect on SPES relative to the control group (γ = .035, confidence interval$_{95\%}$ [–.312, .383], $p > .1$, H_{1a}). However, priming them on VR technology significantly increased SPES (γ = .327, confidence interval$_{95\%}$ [.038, .574], $p < .05$, H_{1b}).With regards to H_2, we find that SPES significantly increased perceived enjoyment (β = .502, confidence interval$_{95\%}$ [.269, .688], $p < .01$, H_2). Regarding H_3 and H_4, the results show that perceived enjoyment significantly increased both recommendation intention (β = .407, confidence interval$_{95\%}$ [.160, .619], $p < .01$, H_3) and attitude toward the retailer (β = .385, confidence interval$_{95\%}$ [.100, .659], $p < .05$, H_4). To account for potential other factors influencing SPES, we control for the participants' prior experience with VR headsets, their prior experience with farm tours, their everyday use of mental imagery (SUIS), and their age. The results (Table 4, Model 2) show that all hypothesized effects remain significant. We found no significant differences in positive or negative affect before and after the intervention between the three groups, as indicated by the PANAS.

Common method bias

Our study design minimizes the likelihood of common method bias (CMB) occurring ex ante by incorporating multiple temporal and methodological separations throughout the data collection process (i.e. pre-questionnaire, audio stimuli, virtual farm tour, post-questionnaire) (Podsakoff, MacKenzie, and Podsakoff 2012; Viswanathan and Kayande 2012). To evaluate the potential threat of CMB ex post, we applied Harman's single-factor test, the most widely used technique for detecting CMB in business research (F. Kock, Berbekova, and Assaf 2021). According to this test, CMB is indicated when an unrotated exploratory factor analysis reveals a single factor that accounts for more than 50% of the variance (F. Kock, Berbekova, and Assaf 2021). In our study, the first factor accounted for only 28.8% of the variance, indicating no statistical evidence of CMB.

Discussion and implications

The purpose of this study was to determine whether audio priming can enhance consumers' spatial presence and whether spatial presence subsequently increases their perceived enjoyment during VR experiences, which then translates into key pre-economic variables relevant to retailers. Therein, our research provides valuable insights for both researchers and practitioners.

Theoretical implications

Currently, leading retailers are considering how to adapt their strategies to compete in the virtual future (Peukert et al. 2019; Yoo et al. 2023). It is likely that VR headsets will be the preferred way to experience virtual worlds, as 3D interactions are more intuitive to consumers than 2D ones (Ball 2022; Hennig-Thurau et al. 2022). Given the importance of spatial presence in improving VR experiences across various research domains (e.g. Blascovich et al. 2002; Hartmann et al. 2016; Heeter 1992; Jin 2010; Markowitz et al. 2018; Slater and Wilbur 1997), approaches that increase spatial presence are of great interest to retailers. Previous research suggests that consumers who experience a greater spatial presence in virtual retail stores choose a larger variety of products and are less pricesensitive (Meißner et al. 2020). Furthermore, prior studies on VR have associated higher media richness with an improved shopping experience and increased purchase intentions (Moes and van Vliet 2017). Extending these findings, our results show that audio priming can be a simple and cost-effective approach to significantly increase consumers' spatial presence during VR experiences. The increased spatial presence results in greater perceived enjoyment, which ultimately leads to an increased recommendation intention and attitude toward the retailer. Consequently, we advocate the integration of audio priming in various VR applications, such as video games or simulations, but also particularly in retail for virtual tours in physical or virtual stores. We specifically recommend employing audio priming to acquaint consumers with the technology underlying the VR experience. Processing the virtual environment may be challenging, especially for first-time users but also for those with prior experience, potentially leading to a technology shock that reduces spatial presence. Technology priming mitigates this issue by providing consumers with an explanation of what to expect and familiarizing them with the technological aspects of the VR experience, such as the mechanics behind a 360-degree video. We propose that this approach enhances processing fluency by increasing consumers' awareness of the technological aspects of the virtual environment. By understanding the underlying VR technology, consumers are able to anticipate the experience more accurately, making it easier to process, which leads to a more positive response due to the familiarity it creates (Reber, Schwarz, and Winkielman 2004) and subsequently an elevated spatial presence (Cerda, AurélieFauvarque, and Del-Monte 2021; Sjölie 2012). Conversely, priming consumers on the content's context, such as farm ambiance in our study, does not increase spatial presence and is thus not recommended. A possible general explanation is that contextual priming triggers associations related to the specific situational context, which can either align with or contradict the priming. Specifically, we argue that farm ambiance priming is ineffective because it creates a mental image that conflicts with some participants' pre-existing, often idealized notions of what a farm should be (Christoph-Schulz et al. 2018). In contrast, technology priming is independent of the situational context and does not rely on pre-existing associations. In line with fluency theory, a mismatch between pre-existing associations and the actual experience may disrupt processing fluency, making the VR experience feel unfamiliar and, in turn, reducing spatial presence. This reasoning is further supported by expectation-confirmation theory (Oliver 1980). Priming participants on farm ambiance might excessively raise their expectations, allowing extensive scope for imagination that the actual VR experience may fail to meet, ultimately resulting in disappointment.

Managerial implications

An illustrative example of the potential of virtual tours in retail is the detailed tracking of a product's journey: from its source through its processing stages to its final placement on a retail shelf. Using this approach, retailers, and also manufacturers, could address the information gaps prevalent in the market and meet consumers' desire for greater transparency, especially regarding ethical practices in the production of animal products (Caracciolo et al. 2016), which could constitute a valuable competitive advantage. As consumers increasingly seek information about the origins of animal products sold by retailers (Boogaard et al. 2011; Vanhonacker, WimVerbeke, and Tuyttens 2008), some grocery retailers have responded by partnering with farms and actively using visual content, such as videos showcasing their partner farms, as marketing material to promote the sale of animal products and ultimately boost revenue (e.g. EDEKA's BauernLiebe marketing campaign, see Rasting 2021). These videos offer consumers a glimpse into farm operations, but virtual farm tours can take this a step further. Positioned between traditional video formats and in-person farm tours, virtual farm tours offer a unique combination of convenience and presence, delivering the advantages of both mediums (Schütz, Katharina, and Gesa 2022). In fact, even virtual farm tours have already been implemented in practice. For example, a REWE supermarket began offering visual insights into livestock stables via live streams and VR headsets at the point of sale in 2018 and has continued using them ever since, highlighting their ongoing relevance to consumers (Kletsche 2019; Richrath 2018; Schütz, Katharina, and Gesa 2022). Beyond farm partnerships, virtual tours hold even greater potential as grocery retailers increasingly integrate vertically and expand their in-house production. Many retailers produce key product categories themselves. For instance, Aldi and Lidl operate their own coffee roasteries (Giuri 2018; Sachsenröder 2022). In this regard, in-store virtual tours could be an effective tool for educating customers about sourcing, roasting processes, and quality control measures. By allowing customers to virtually experience these production sites, retailers can reinforce their commitment to transparency, strengthen brand trust, and differentiate their private-label offerings in a competitive market. Additionally, grocery retailers could utilize virtual tours to enrich the shopping experience by offering educational content, such as cooking demonstrations, food preparation tips, or sustainability insights, creating a more interactive and informative shopping process.

Regarding the implementation in retail settings, cost-effective 3 DoF VR headsets seem to be particularly advantageous. Their restricted motion range makes them suitable for novice VR users, providing a simpler user experience compared to headsets that require controllers and offer extensive interaction capabilities. Deploying advanced 6 DoF VR headsets, which require the creation of complex virtual environments, presents a greater challenge and financial burden for retailers. This is because creating intricate virtual worlds and environments requires fixed infrastructure, advanced tracking technology (Rauschnabel et al. 2022), and a heightened level of technical skill to achieve high-quality graphical realism (Pan and Hamilton 2018). Furthermore, prior research has shown that more is not always better when it comes to VR headsets. Specifically, Frank et al. (2024) found that the fidelity, defined as the degree of conformity between the visual quality and experience in VR to the same phenomena in the real world (Huang and Klippel 2020), conveyed by different VR headsets has no general effect on consumers' repatronage intentions in virtual retail stores, leading them to conclude that lower fidelity requirements could expand integration opportunities with the broader range of VR headsets already available on the market.

Limitations and future research

The results and implications of this study should be considered in light of some important limitations. First, in terms of methodology, our study is based on a German convenience sample. Additionally, our sample size of $N = 57$ is relatively small. Given the complexity and cost associated with VR headset experiments, such a sample size is common in this field of research, as suggested by a literature review from Xi and Hamari (2021), which includes experimental VR studies with sample sizes as small as $N = 16$. However, this raises questions about reproducibility. Consequently, it is imperative to replicate the findings of this study in various research contexts, across different cultures, with larger and ideally representative samples.

Second, laboratory experiments can fail to capture the complexity of real world settings and may not generalize well to field settings (Levitt and List 2007). Thus, we encourage replicating the findings of this study in more realistic field experiments that take into account, for example, distraction effects that may be present at the point of sale but not in laboratory settings. Moreover, in our laboratory experiment, participants did not have the option to skip the priming. However, in a real world setting, users may prefer to bypass the priming to start the VR experience more quickly. Thus, future research could examine whether the positive impact of audio priming on spatial presence persists when users are given the option to skip the priming at any time or presented with shorter priming stimuli.

Third, the participant demographic in our study predominantly comprised individuals with minimal to no prior experience with VR headsets (33 with none, 14 with a little, 8 with moderate, 1 with a lot,and 1 with very much). Future research would benefit from including a larger proportion of frequent VR users to examine how increased prior VR headset experience impacts the effects observed in our study. While our model accounted for prior VR headset experience as a control variable, indicating that spatial presence tended to be less pronounced among participants with greater VR headset experience, exploring this effect in more evenly distributed samples (e.g. 50% without and 50% with prior VR headset experience) would provide valuable insights into the importance of prior VR headset experience.

Fourth, another interesting avenue for future research is to explore the impact of audio priming on spatial presence using advanced 6 DoF VR headsets. Given the greater immersion provided by 6 DoF VR headsets (Pan and Hamilton 2018; Rauschnabel et al. 2022), audio priming might exert a different influence on spatial presence compared to 3 DoF VR headsets.

Fifth, a further promising avenue for future research is the inclusion of additional constructs related to the farm. Variables such as trust in farming practices, perceived authenticity of the farm, and perceived animal welfare could provide deeper insights into how consumers perceive virtual farm tours. While our study primarily focuses on the implications for grocery retailers, virtual farm tours can influence consumers' perceptions of both the farm and the retailer facilitating the experience. Some grocery retailers actively position themselves as intermediaries that ensure transparency in sourcing and production practices, showcasing farm partnerships as part of their brand image (e.g. Rasting 2021; Richrath 2018). As such, the distinction between farm-related and retailer-related perceptions may not always be clear-cut. Nevertheless, future research could further explore this differentiation by explicitly measuring farm-related outcomes alongside retailer-related outcomes to assess their relative impact. This could provide a more nuanced understanding of how virtual farm tours shape consumer attitudes toward both the farms and the retailers offering these experiences. Moreover, the absence of such farm-related variables in our model may help explain the observed mean differences in the downstream outcome variables (see Table 1). For instance, participants in the farm ambiance priming group may have generally had greater trust in farming practices or perceived animal welfare more positively during the virtual farm tour – both of which could plausibly have contributed to a higher recommendation intention.

Sixth, we argue that the effect of audio priming on spatial presence can be explained by fluency theory: Audio priming consumers on VR technology increases processing fluency, leading to a more positive response to the stimulus due to the sense of familiarity it creates, ultimately increasing spatial presence (Cerda, AurélieFauvarque, and Del-Monte 2021; Reber, Schwarz, and Winkielman 2004; Sjölie 2012). However, as we did not directly assess processing fluency or the sense of familiarity in our research, we cannot conclusively attribute the observed effect to this explanation. Therefore, alternative explanations remain plausible. Accurately measuring processing fluency and the sense of familiarity in the context of VR presents distinct challenges, highlighting opportunities for further research. One alternative explanation is that the audio priming stimulus has a sensitizing effect, aiding in the development of cognitive processes necessary for establishing spatial presence in VR environments (Wirth et al. 2007).Another explanation could be that the audio priming simply increases consumers' attention and concentration on the upcoming VR experience, thereby facilitating the conditions required for spatial presence (Draper, Kaber, and Usher 1998; Hartmann et al. 2016, Schubert, Friedmann, and Regenbrecht 2001; Wirth et al. 2007).

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Appendix

Group 1: priming (Farm ambiance)

Stand comfortably and relaxed and slowly come to rest. Feel whether you are really standing comfortably. If not, change your posture again. Now, close your eyes and pull the VR headset over your head with your eyes closed. Now, press the button on the side. Keep your eyes closed. Take a few deep breaths. Concentrate on your breathing and feel how your stomach rises and falls with each breath. Just pay attention to your breath – and to the fact that you are becoming more and more relaxed.

Imagine you have been invited to visit a farm. You are picked up, and when you get there, you are greeted by a farmer. You walk a few steps across the farmyard. You feel the slightly muddy ground under your feet and a pleasantly cool breeze on your skin. You take a deep breath. The fresh air flows through your lungs. You are now standing in front of a barn where pigs are kept. The farmer gives you an information sheet about how the pigs are kept and invites you to explore the barn at your leisure. Now open your eyes and take your time to look around. You can start your tour of the barn at any time by focusing on the barn door.

You are now standing in front of the barn again. Now, close your eyes again. The farm tour is now finished. Keep your eyes closed for a moment and take a few deep breaths. Now, remove the VR headset from your head. Open your eyes when you are ready. Be fully awake again.

Group 2: priming (VR technology)

Stand comfortably and relaxed and slowly come to rest. Feel whether you are really standing comfortably. If not, change your posture again. Now, close your eyes and pull the VR headset over your head with your eyes closed. Now, press the button on the side. Keep your eyes closed. Take a few deep breaths. Concentrate on your breathing and feel how your stomach rises and falls with each breath. Just pay attention to your breath – and to the fact that you are becoming more and more relaxed.

You are about to experience a 360-degree video. This is a video that provides a view in all directions from the camera's point of view. 360-degree videos are recorded with an omnidirectional camera to provide a sharp and detailed image – regardless of which direction the viewer is facing. For this study, a 360-degree video of a barn where pigs are kept was recorded. You are right in front of this barn. At the beginning, you are shown an information sheet about how the pigs are kept. You can take a look at the barn. Now open your eyes and look around. You can start the tour of the barn at any time by focusing on the barn door.

You are now standing in front of the barn again. Now, close your eyes again. The farm tour is now finished. Keep your eyes closed for a moment and take a few deep breaths. Now, remove the VR headset from your head. Open your eyes when you are ready. Be fully awake again.

Group 3: control

You stand in the center of the room and have enough space around you. Take a position in which you want to spend the next few minutes. Now, pull the VR headset over your head. Now, press the button on the side and look around. You can start the barn tour at any time by focusing on the barn door.

The VR experience has now concluded. You can remove the VR headset from your head.