Improving simulated consumption context with Virtual Reality: a focus on participant experience

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Abstract

Context can have a significant impact on liking, emotional response and product choice, and Virtual Reality (VR) is a promising tool to evoke realistic consumption contexts in a controlled testing environment. This study compared an innovative approach – combining a 360° video and a 3D model with object tracking to an Evoked context using pictures and sound recordings to simulate a realistic consumption environment for beer (i.e. bar). This study explored consumer experience of the innovative VR design and measured their engagement with it compared to an Evoked scenario. Additionally, participants' emotional response and liking between the two contexts and the effect of including a VR training session prior to data collection were also explored. In total, 27 beer consumers participated in this study. The novel VR method that was developed for this study consisted of 360° video footage recorded in a bar with sound, which was projected around a virtual table model with an integrated questionnaire, using a pen and beer bottles attached to tracking devices. The Evoked context consisted of a picture slideshow and sound recording to simulate the exact same bar context. An interview was conducted after the VR training session to explore consumer experience of the VR design. Participant engagement was then measured after participants completed both the VR and Evoked sessions respectively. The results showed that the VR session had clear advantages in terms of participant engagement compared to the Evoked session. Audio, the time spent in VR, and realistically simulated presence of other people were identified as key elements that improved realism and immersion of the VR context, whilst low image quality and technical problems had the opposite effect. The first exposure to VR was shown to have high novelty and further impact on the emotional response to beer, which highlighted the importance of having a training/dummy session to reduce VR novelty and associated effect.

1. Introduction

In the food and beverage industry, new product development and launches are critical for a company's success. The success rate of new product launches is reported as being as low as 15% in the US (Salnikova, Baglione, & Stanton, 2019). Multiple factors can contribute to new product failures, however, questions on whether sensory and consumer testing can predict consumer decisions and purchasing behaviours have been raised by sensory and consumer scientists (de Graaf et al., 2005; Jaeger et al., 2016; Jaeger & Porcherot, 2017; Meiselman, 1992). In conventional sensory and consumer testing, great effort is made to keep external sensory signals to an absolute minimum in order to ensure internal validity, which is achieved by having individual booths with neutral coloured walls in a quiet, odourless environment with controlled temperature and humidity (Lawless & Heymann, 2010). However, this setting does not represent the real consumption situation and therefore is likely to lack predictive power on how consumers experience food and beverage in real life. Hence, the measurement of consumers' responses to food and beverage in a standard sensory lab setting is likely to have low external validity. Conducting sensory consumer studies in real life consumption environments would instead provide higher external validity but allows for less experimental control, thus reducing the ability to explain causal relationships between stimulus and response. Therefore, real life consumption environments offer lower internal validity than controlled experimental settings (Galiñanes Plaza, Delarue, & Saulais, 2018). Re-creating an appropriate consumption situation in a controlled environment provides consumers with relevant context while still allowing experimental control. In theory this approach would optimise both internal and external validity. Different methods to bring relevant context to a controlled test setting as an attempt to optimise both experimental control and ecological validity include: written scenarios (Dorado, Chaya, Tarrega, & Hort, 2016; Hein, Hamid, Jaeger, & Delahunty, 2012; Pierguidi, Spinelli, Dinnella, Prescott, & Monteleone, 2020; Spinelli et al., 2017), exposure to images (Andersen, Kraus, Ritz, & Bredie, 2019; Hersleth, Monteleone, Segtnan, & Næs, 2015), video or sound recordings (Hathaway & Simons, 2017; Liu, Hannum, & Simons, 2019)), decorating rooms to be more similar to real life environments (Holthuysen, Vrijhof, de Wijk, & Kremer, 2017), and video projection (Sester et al., 2013; Sinesio, Saba, et al., 2019). Technological developments have led to the use of video walls (Bangcuyo et al., 2015; Hannum, Forzley, Popper, & Simons, 2019; Hathaway & Simons, 2017; Worch et al., 2020; Zandstra, Kaneko, Dijksterhuis, Vennik, & De Wijk, 2020), and virtual reality (Andersen et al., 2019; Barbosa Escobar, Petit, & Velasco, 2021; Sinesio, Moneta, et al., 2019; Stelick, Penano, Riak, & Dando, 2018; Torrico et al., 2021; Wang, Meyer, Waters, & Zendle, 2020; Worch et al., 2020), to create the relevant context scenario. Virtual reality (VR) has gained great interest in sensory and consumer science as a way to immerse

individuals in a wide range of environments while maintaining experimental control (Jaeger & Porcherot, 2017). Although VR is an exciting technology, it holds several practical considerations when considering eating and drinking. When participants wear a VR headset, their eyes are constantly covered which completely cancels out participants' sight of physical reality and so the food or drink vessels cannot be seen. This poses obvious challenges for sensory testing where participants are asked to evaluate food and drink products.

The majority of sensory consumer research on context has explored effects of context on liking (Delarue & Boutrolle, 2010; Liu et al., 2019; Sinesio, Saba, et al., 2019) rather than emotional response. However, context is highly relevant to consumers' emotional responses to products as reported in previous studies (Dorado, Chaya, et al., 2016; Nijman et al., 2019; Piqueras-Fiszman & Jaeger, 2014; Prescott, 2017). Emotion questionnaires have been shown to provide additional information beyond hedonic scores (Gutjar et al., 2015; Yang, Dorado, Chaya, & Hort, 2018; Yang, Shen, Foster, & Hort, 2020) and thus, have gained popularity in consumer testing in recent years (Jaeger et al., 2016; Prescott, 2017). Previous research has found that beers with different sensory properties can evoke different emotional responses (Chaya, Pacoud, Ng, Fenton, & Hort, 2015; Eaton, Chaya, Smart, & Hort, 2018; Yang et al., 2018). Interestingly, a previous study has found that simulating relevant context using VR technology has led to a first order effect, which could be due to the novelty of the technology and the task (Sinesio, Moneta, et al., 2019) .

The current paper explores innovative solutions to the design challenges and technical challenges (e.g. create a familiar context, enable drinking experience in the VR environment and create an interactive task for data collection) of simulating context in VR. Up to now, papers on the application of VR for sensory consumer research have focussed on the effect of VR on collected data. To the authors' knowledge, no papers have investigated how participants experience being exposed to VR. Thus, this study explores how participants perceived the VR experience (the perceived realism and technical challenges) and measures their engagement with it compared to an Evoked scenario. In addition, consumer responses (emotional response and liking) between contexts (VR and Evoked) were also compared. Finally the effect of including a VR training session prior to data collection to neutralise the effects of novelty on consumer response was explored.

Measuring consumers' opinions of the novel VR environment and their engagement will highlight key learnings and considerations when designing realistic consumption contexts using VR in the future. This research aims to fill a gap of knowledge by focussing on participants' experience by providing information that can guide further development and improvements in the use of VR technology for sensory consumer research. It should be noted

that the study was not designed to focus on the potential worsening of the context via use of VR but some potential downsides of the technology and associated tasks are discussed throughout.

2. Materials and Methods

This research was approved by the Faculty of Medicine & Health Sciences Research Ethics Committee of the University of Nottingham (Ethics reference number 111-1809).

2.1. Participants

A total of 27 participants (13 female and 14 male, aged 20 to 67 years) were recruited at the University of Nottingham. All participants drank beer at least once every two months and had previously visited the context on which the VR was based – the University of Nottingham's Student Union bar. Pregnant women and individuals that had any reason to refrain from drinking alcoholic beverages (including declared health, religion or addiction) were excluded from participation. Participants received an inconvenience allowance for their participation.

2.2. Beers and sample presentation

An ale and lager style beer were chosen as the sensory stimuli for this study, since they tend to have distinctive sensory profiles. Beers with a relatively low alcohol percentage (3.5% alcohol by volume (ABV) for both beers) were chosen for ethical considerations regarding the exposure of participants to alcohol. Both beers were bottled into unbranded amber 330 ml glass beer bottles at the Anheuser-Busch InBev pilot brewery at The University of Nottingham. All beers were stored at 4°C and taken out of cold storage until the time of testing (up to 5 minutes before being served). The beers were served in bottles labelled with a three-digit code and participants were instructed to drink straight from the bottle. This approach was decided upon after pre-testing with the VR equipment revealed it to be the most effective method of consumption for consumers.

2.3. VR Bar Development

Participants were asked to wear a VR headset (HTC Vive, HTC Corporation, Taiwan) which was connected to a gaming-specification computer running a custom application built using the Unity game engine (Unity Technology, United States), to mimic the bar experience while performing beer evaluation. The VR headset also has integrated headphones which allows sound application in the VR experience.

As familiarity and situational appropriateness have shown to affect how consumers perceive the beer product (Giacalone et al., 2015). This study aimed to simulate an existing bar environment that all participants were familiar with (The Student Union Bar at the University

of Nottingham). This simulated bar VR environment was presented as a combination of 360° background content with 3D foreground content. This combination aimed to provide a recognisably realistic and high-fidelity bar environment via the video content, but to complement this with an immersive foreground space that afforded interaction with 3D objects and furniture via a stereoscopic perspective. To create a realistic 360° representation of an existing bar, a twenty minute video recording with directional sound was captured using a 360° camera (RICOH THETA V, The Ricoh Company, Japan). The camera was positioned in the centre of a seating area in the bar and recorded people behaving as they normally would in the bar.

The foreground of the VR experience included interactive features that were modelled and presented in 3D but that mirrored the physical setup in the room. These modelled features include a table, three chairs and floor, as well as two beer bottles, a line scale and a marker pen. The virtual table, chairs and floor were designed to match the interior of the Student Union Bar shown in the 360° video and to have similar dimensions as the physical chair and table at which the participant was seated throughout the session. Three tracking devices (HTC Vive Object VR Trackers, HTC Corporation, Taiwan) were used, of which two were attached to glass bottles in which the beer was presented, as shown in Figure 1. A third tracking device was attached to a marker pen that was used to complete the questionnaire in the VR environment. The tracking devices allowed any movements that were made with the physical beer bottles and the pen to be matched by their computer-modelled counterparts in the VR, allowing participants to manipulate and importantly drink from the bottles based on their virtual presentation. Other than the position of their viewpoint, and through the manipulation of and interaction with the physical objects and their virtual counterparts, the participant is not embodied in the VR environment. Instead they must rely on proprioception to grasp the relevant objects at the beginning of each interaction. This trade-off arose primarily from the choice of VR hardware which, while it affords attaching tracking devices to arbitrary objects and provides their position and orientation in the environment, it does not support the tracking and reproduction of the participant's pose.

Three-digit codes were displayed on the virtual model of the beer bottles (Figure 2). Instructions and questions appeared one-by-one on the surface of the virtual table and a line scale was depicted across the virtual table in front of the participant (Figure 2). Participants could give intensity ratings by holding the pen over the virtual line scale. The marking of the line scale was fed back to the participant by showing a number that would appear just above the scale and that corresponded with the given score (Figure 2). To confirm their score and trigger the next question, participants held the pen over a virtual beer coaster marked with 'OK' that was depicted on the virtual table centrally above the line scale. The flow of the

questionnaire and a one-minute break between the two beer samples was controlled by the researcher who followed the progress of the questionnaire on the PC screen.

Figure 1: *Representation of the VR condition during which the participant is wearing a VR headset and moves a tracked beer bottle while a second tracked beer bottle and marker pen are placed on the table.*

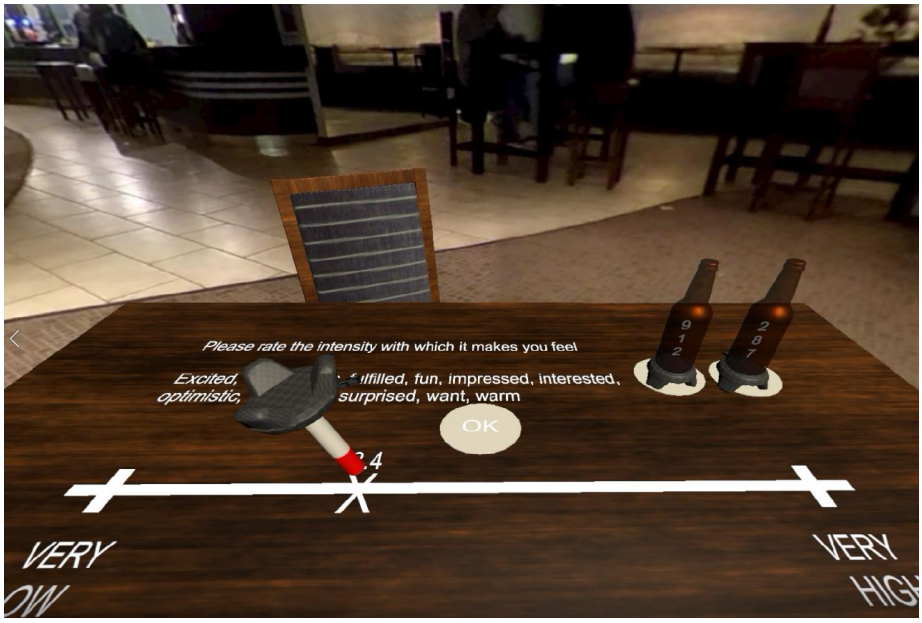

Figure 2: *Representation of participants' view in VR condition. Participant uses the marker pen to mark the line scale that is depicted on the table. Instructions, 'OK' beer coaster and the two beer samples are also visible on the table and around the table the 360° video of the bar is playing.*

2.4. Procedure

Participants were invited to attend three sessions – VR training session, VR session and Evoked session which were at least one week apart. The VR Training session always preceded the VR session but the order of the VR session and Evoked session was balanced across participants. Both VR training and VR session were conducted with one participant at a time, whereas the Evoked session was conducted with maximum 10 participants at a time.

2.4.1. VR training session

The VR training session comprised of three parts. During the first part, participants familiarised themselves with the VR environment. They were asked to put the VR headset on, look around the bar, practice scoring the emotion questionnaire using the pen and line scales that appeared on the table, and practice drinking from an empty beer bottle and then a bottle filled with water. During this time, participants' ears were not covered by headphones, which allows communication with researcher. Once participants felt comfortable with the environment, they were given a short break with the VR headset was taken off. The second part included the actual testing procedure, where participants were asked to read a pre-context written scenario to help set the scene as to why they were sitting by themselves at the table in the bar (*"Think of one of your friends that you would meet up with in a bar. Imagine having agreed to meet this friend in a bar in the late afternoon. You arrive a bit early and your friend just texted that he/she is running late, so you decide to go ahead and have a beer while you wait."*). Once participants had read the pre-context written scenario, they were asked to put the VR headset back on, including the headphones to allow the sound of the bar to be heard and start the experiment by consuming both beer samples monadically and rating their emotional response and liking using the interactive questionnaire in the VR environment. After they evaluated both beers, an interview session was held to understand participants' experience with the VR environment, which is described in section 2.5.2.

2.4.2. VR session

At the beginning of the VR session, participants were reminded of the instructions given during the VR training session. After reading the pre-context written scenario, participants were assisted by the researcher to put on the VR headset with integrated headphones. Each participant was exposed to the VR environment for one minute before they were served the beer samples. Then participants started to evaluate the beer and complete the interactive questionnaire for emotional response and liking, as described in the VR training session. The presentation order of the two beers was balanced and randomised. Although a full bottle of beer was given to give the participant a more realistic feeling of holding a freshly opened bottle, participants were instructed to only consume around 200ml of each beer due to ethical

considerations. A sticker with 3-digit code on the bottle was used as an indication to mark the line of 200ml, and when reaching the marked line, participants were reminded by a message on the virtual table which was controlled by experimenter. Context exposure ended after the participant completed the task for both beers. The researcher helped the participant to remove the VR headset and finally participants were asked to fill out the engagement questionnaire on a tablet device (9.7" Apple iPad Air A1474, Apple Inc., US) as described in section 2.5.3.

2.4.3. Evoked session

The Evoked session was set up in the standard sensory booths at the Sensory Science Centre, University of Nottingham. The same pre-context written scenario as presented in the VR session was also used. After participants had read the pre-context written scenario, they were instructed to put in a set of earphones and start a video on the tablet device that played a picture slideshow and audio recordings taken in the same bar that the VR context was based. As shown in Figure 3, while participants were watching the video, they were served with the beer samples monadically and asked to rate how the beer made them feel using the same emotion questionnaire, and how much they liked the beer on a desktop computer in the sensory booth using Compusense Cloud (Compusense, Canada). Participants were briefed at the beginning of the session that they had to stop drinking when the remainder of the beer in the bottle had reached the top of the sticker (which the marked a consumed volume of 200ml). Once they had evaluated both beers, participants were asked to complete the engagement questionnaire.

***Figure 3**: Representation of Evoked condition during which participants were exposed to sound recordings and picture of the bar via a Tablet and completed the questionnaire on the PC.*

2.5. Participant responses – Interviews, engagement and emotional responses

2.5.1. Emotional response and liking

Participant's self-reported emotional response elicited by beer was measured using a previously developed beer-specific emotion lexicon (Dorado, Chaya, et al., 2016; Eaton, Chaya, Smart, & Hort, 2019) consisting of ten emotion categories (*shocked, bored, content, excited, nostalgic, disconfirmed, disgusted, tame/safe, underwhelmed* and *curious*). Each of the ten emotion categories was presented together with the associated terms and participants were asked to indicate the extent to which they were experiencing the emotions associated with those descriptors by giving an intensity rating on continuous line scales, anchored from 'very low' to 'very high' at 5% and 95% of the scale. The order of the emotion categories was randomised over participants and sessions. After evaluating emotional response, participants were asked to rate overall liking on a continuous line scale, anchored at 5% and 95% with 'dislike extremely' and 'like extremely'.

For each beer, emotional response and liking were measured after participants had drunk approximately 200 ml of the beer, indicated by the location of a sticker with the 3-digit code on the bottle. A one-minute break was enforced between the two beer samples.

2.5.2. Interviews

The objective of the interviews was to gain an in depth understanding of how participants experienced and reacted to the VR environment. The interviews focussed specifically on collecting participants' feedback on the realism of the design elements of the VR simulation and the novel approaches that were used to overcome technical challenges in VR. The researchers asked pre-determined questions covering three key elements (Table 1) that were based on literature and pre-tests with the VR experience, including first reaction, perceived realism of VR bar design (this includes environment, realism, distraction, and social context) and technical challenges (this includes drinking beer in VR, questionnaire, and comfort). In addition to the scripted questions, the researcher asked probing questions following the participant's answers to explore additional themes that came up, and to encourage participants to further explain their answers. Questions from the interview script were not asked if the topic was already covered by the answers to previous questions. Both video and audio recordings were captured during the interview to help researchers to transcribe the interview. All participants gave written consent to be audio recorded, and 25 out of 27 participants gave written consent to be video recorded.

***Table 1**: Interview script*

Theme	**Sub-theme**	**Interview questions**
First Reaction	First reaction:	How was that/what did you think? How did the experience make you feel?
Perceived Realism of VR Bar design	Environment:	What did you think about the environment you were in? Can you describe the environment? (Did you recognize the bar?) Would this be a setting that you would encounter in your real life?
	Realism:	What made the environment realistic/not realistic? What did you think about objects/furniture/sound/people/not seeing yourself
	Distraction:	Would you say you felt distracted from the task by the environment? What was distracting?
	Social context	Was the written scenario realistic? Would this scenario be applicable to you? What did you think about having people around you?
Technical Challenge	Drinking beer in VR:	Were you drinking the beers as you normally would in a bar? Can you describe your experience with drinking the beer? Did you feel reluctant to drink from the VR bottle?
	Questionnaire:	What did you think of the questionnaire? What did you think about the way you were answering the questions?
	Comfort:	Was there anything about the VR experience that made you feel uncomfortable? Was the headset comfortable? Did you experience any dizziness or motion sickness?

2.6. Engagement questionnaire

The engagement questionnaire was an adaptation of the questionnaire used by Bangcuyo et al. (2015) and consisted of 20 items that were aimed to measure participants' experience with regards to specific statements comprising of their eight dimensions of engagement, as shown in Table 2. Usability, environmental aesthetics, novelty, involvement and immersion dimensions were measured on a seven-point Likert scale (coded -3 to +3) instead of 5-point Likert scale in Bangcuyo et al. (2015)'s study to increase discrimination and keep consistency with other dimensions. Sensory awareness, distraction and realism, in addition to two items related to participants' comfort based on findings from (Andersen et al., 2019), and one statement related to difficulties with drinking the beer, were added to the questionnaire and rated using a 7-point categorical scale ranging from 1 (not at all) to 7 (very much).

2.7. Data analysis

For interview results, all 27 participant interviews were transcribed verbatim using the NVivo software. Word-for-word transcription with minimal additional description of hand gestures was made of each interview based on the recordings. Hand gestures were only described when it is important for the understanding of spoken word. For example, when participants said 'that' and pointed towards a specific object, the transcription included a description of the object the pointing gesture was made to. For the sake of investigator triangulation, transcripts were analysed independently by two researchers following two different strategies. One researcher used the NVivo software to code the transcripts on eight pre-determined codes based on the eight sub- themes the interview focussed on (Table 1), and then summarised the content within each sub-theme. The second researcher analysed the transcripts without software and generated the key themes and subcategory lists from the transcripts which were then cross-referenced with the interview themes from Table 1. Subsequently a 'cut and paste' method was used in which relevant parts from the transcripts were 'cut' for each category and 'pasted' together to create a matrix and the content within each category was summarised.

The summaries were compared and discussed between the two researchers. Overall, the content of the themes and subcategories aligned between the separate analyses. Findings that both researchers agreed on were reported. Considering the relatively low number of participants, comments that were made by only one participant were reported if both researchers considered the comment relevant.

For the engagement questionnaire, Factor analysis was performed for both context combined, where Cronbach's alpha was used to measure internal consistency overall and for each dimension of engagement. Data for relevant items for each dimension were averaged to generate a dimension score for each test condition (VR and Evoked) for each individual participant. The total engagement score per condition was the sum of individual dimension scores (Bangcuyo et al., 2015). A mixed model two-way ANOVA with participant as random factor and test condition as fixed factor was performed for each dimension score and total engagement score.

For emotional categories and liking data, two separate mixed model three-way ANOVA with participant as random factor, test condition (VR vs Evoked, or VR training vs VR respectively) and beer type (Lager and Ale) as fixed factors were performed for all 10 emotional categories and liking rating. All data were analysed using XLSTAT version 2017 (Addinsoft, 2021).

3. Results

3.1. Consumer experiences regarding the VR bar

3.1.1. First reaction

Figure 4 shows a word cloud of the words spoken by participants directly after taking off the VR headset. The most frequently expressed term was ‘really’ which was used in combination with adjectives such as ‘good’, ‘weird’, ‘cool’ and ‘strange’ which were also expressed frequently. The use of the words ‘weird’ and ‘strange’ seems to convey novelty while ‘good’ and ‘cool’ seem to express enjoyment. This finding is in line with earlier research by Andersen et al. (2019), which showed that exposing participants to a context in VR can lead to higher levels of excitement compared to a method using a picture and the participants’ imagination. VR is a new technology that most consumers are not familiar with (Andersen et al., 2019), although the popularity of VR has increased over the last few years, the current data shows that consumers still find VR testing for food to be a novel task. While this novelty can increase engagement (Bangcuyo et al., 2015), it could also potentially impact on consumer responses.

Figure 4: *Word cloud of first few phrases participants spoke after taking off the headset, excluding stop words.*

3.1.2. Perceived realism of VR Bar design

The relevance of social context for the situation of having a drink in a bar was strongly confirmed by participants. Most participants explained that it would be unusual for them to sit in a bar by themselves and that the pre-context scenario was helpful in that it provided an explanation to why they were sitting alone: *"That [pre-context scenario] certainly helped. Because, you know, it would be a bit weird I suppose if you were just saying right, you're in a bar, you're on your own and you are basically doing nothing except drinking beer. I wouldn't do that, but I would expect to be meeting someone so that was quite useful, because it helped to sort of set the scene"*.

In general, participants felt very positive about the VR bar design. For example, when participants were asked to describe the social context element they experienced in the VR environment, most participants mentioned that people interacting in the background made the experience feel more realistic. For example, one participant said *"Quite realistic. Different groups of people, so to the left you'd see two guys, you had a couple on a date and then you had a group of friends, which was quite realistic".* Although some participants mentioned that they did feel a little 'lonely', or that they missed being able to engage in social interaction with people in the VR bar, or having a friend to talk to. As social interaction is typically an essential part of eating and drinking, the inclusion of social interaction with other people should be carefully considered within the context as it would bring additional noise in the dataset, reducing the ability to explain relationships between stimulus and response.

The familiarity of the environment seemed to make participants feel more comfortable and relaxed, especially after a few minutes of exposure to the VR environment: *"I think it does feel like you are having a drink in a place where you would more normally have a drink in that sort of respect. And I did feel very relaxed. I think the more I got used to everything the more I relaxed. So I probably just relaxed into it the longer I was wearing the headset".*

As expected, audio appeared to increase the level of immersion. Participants mentioned that having the headphones on made it easier to forget where they were. In addition, hearing other people and noises from the bar environment was said to make the experience more realistic.

Some participants expressed being conscious of being part of an experiment and so anything that reminded them of the fact that they were not really in the bar reduced their perception of realism and sense of immersion. For example, twelve out of the 27 participants mentioned the video quality in the VR environment, which was a little blurry and not as clear as the modelled table and other objects that were closer to participants. Shooting in a low light environment proved to be a challenge, however, if many participants noticed the quality of the video, it would be worth to invest more time and effort to improve the quality of the footage.

Although many positive comments were received about the actual bar being a familiar environment, a few participants were critical of certain aspects of the VR experience in comparison to the real-life experience in the bar. For example, two participants mentioned that the bar is usually much busier and the music is much louder. This highlights that although there are benefits of creating a familiar environment for consumer testing, the environments should be as realistic as possible, since people who are familiar with them are likely to pick up on cues that are not general practice. Mimicking real-life experience is challenging as it is unique to each individual, therefore, future research should consider exploring consumer experience of a generic environment using VR technology.

During the interview, participants said they focused on the table when filling the questionnaire in the VR environment and did not feel distracted by the surrounding environment. Participants focused more on the environment around them when drinking the beer in the VR: *"…when I wasn't drinking I was focussing on the table and focussing on the lines [line scales] and things like that. I wasn't really focussing on the environment when I was doing the questionnaire. But when I was drinking the beer I was focussing more on the environment then. So I don't think I found it really distracting at all."* In general, participants perceived the VR environment as a positive experience, however, when facing technical challenges, participants could be distracted and were reminded the environment was not real, which is described in more detail in the next section (3.1.3).

3.1.3. Technical challenges

Drinking beer from the bottles while wearing the VR headset received both comments related to ease and difficulty with drinking. Several participants described how they struggled to pick up the bottles, hold the top of the bottle to their mouth and some knocked the bottle against the headset or had to lift up their head more to be able to tilt the bottle enough to drink. These difficulties were caused by technical limitations of the VR technology such as the fact that participants could not see their own arms, nor the beer in the bottle, as well as some misalignment of the physical bottle and that of the VR-model when the signal from the attached tracker is temporarily blocked. Participants described they were more careful and slower in their movements at first, before getting more confident with handling the objects after some practice – highlighting the importance of the VR training session. Some participants also described behaviour changes including holding the bottles more often in their hands with the fear of 'losing it', thus they drank the beer faster as they normally would. However, most participants reported that they got more comfortable with handling the bottles over time, which means these limitations can be improved by practice.

The method of rating emotion categories and liking using the pen and the line scale depicted on the virtual table was described by participants as a clear, easy and intuitive task. Specifically moving their arm physically in the VR environment to give ratings was positively received and participants articulated feeling more engaged with the task. Several participants said that they felt less removed from the environment while rating on the interactive questionnaire in the VR environment, and they preferred this experience over using a computer or a phone. Despite the overall positive response to the questionnaire, there were a few negative comments. One participant thought the pen was a bit heavy because of the tracking device attached to it. Some participants started out by tapping the physical table with the pen, but stopped doing that once they realised their score was registered without physical contact between the pen and the table.

Another limitation of the VR bar experience is that the participants' body is invisible. In general, participants either did not even notice or did not find it strange because they normally would not look at themselves if they were in a bar anyway. However, a few participants did mention that they felt bit odd they could not see themselves.

Most participants felt comfortable in the VR environment. One participant expressed she felt more at ease in the VR environment than in the sensory booths: *"I would have thought that I would be more uncomfortable than I was. But I felt really comfortable in it, and it sounds really stupid but it was easier, to like, daydream. When you're in a sensory booth, I find that you notice your surroundings and you don't normally daydream but with that I was sort of thinking, like I normally would"*. Even though most participants did not feel uncomfortable, a few participants did notice the feeling of the headset pressing on their face and commented that it felt quite warm to wear. In addition, one participant experienced dizziness after the headset was taken off.

3.2. Comparing the VR and Evoked context

3.2.1. Consumer Engagement

Cronbach's alpha was 0.94 for total engagement when including all twenty items with both contexts combined, indicating a good internal consistency of the questionnaire across both contexts. The Environmental Aesthetics, Involvement, Sensory Awareness and Realism dimensions also showed high internal consistency (Cronbach's alpha >0.8), while Immersion (0.55) and Distraction (0.48) and in particular Novelty (0.04) had relatively low internal consistency (Table 2).

***Table 2**: Mean scores ± standard errors of all items from the engagement questionnaire rated by 27 participants during the Evoked and VR session. F and p-values on context effect were obtained*

through two-way mixed model ANOVA on dimension scores using participant as random factor and context condition as fixed factor.

			VR	Evoked	Context effect (DF=1)	
	Dimension	**Item**	***M* ± *SE***	***M* ± *SE***	***F***	***p***
strongly disagree (-3) to strongly agree (+3)	1. Usability	1. The testing environment assisted in my evaluations of the beers	1.48±0.2	0±0.25	20.08	< 0.001
	2. Environmental Aesthetics	***Total Environmental Aesthetics (Cronbach's α = 0.84)***	1.8±0.15	-0.56±0.27	62.72	< 0.001
		2. The testing environment was appealing	1.74±0.17	-0.85±0.3	58.6	< 0.001
		3. The testing environment engaged my senses	1.85±0.17	-0.26±0.32	35.29	< 0.001
	3. Novelty	***Total Novelty (Cronbach's α = 0.04)***	1.61±0.21	0.33±0.2	17.06	< 0.001
		4. The testing environment incited my curiosity	2.11±0.23	-0.59±0.31	50.49	< 0.001
		5. The testing environment distracted me [R]	1.11±0.3	1.26±0.28	0.13	0.72
	4. Involvement	***Total Involvement (Cronbach's α = 0.81)***	1.9+0.17	0.01±0.21	34.47	< 0.001
		6. The testing environment was boring [R]	1.52±0.23	-0.37±0.3	18.6	< 0.001
		7. The testing environment was fun	1.93±0.27	-0.74±0.28	40.26	< 0.001
		8. I was engaged in the sensory task I performed	2.26±0.16	1.15+0.19	14.29	< 0.001
	5. Immersion	***Total Immersion (Cronbach's α = 0.55)***	1.33±0.17	-1.04±0.22	80.83	< 0.001
		9. I felt like I was in a bar	1.59±0.22	-1.74±0.28	95.12	< 0.001
		10. I lost track of time	1.07±0.24	-0.33±0.32	17.27	< 0.001
not at all (1) to very much (7)	6. Sensory awareness	***Total sensory awareness (Cronbach's α = 0.82)***	5.56±0.13	3.49±0.19	83.38	< 0.001
		11. How completely were all of your senses engaged by the testing environment?	5.48±0.15	3.41±0.26	52.2	< 0.001
		12. How much did the visual aspects of the testing environment involve you?	5.3±0.21	2.33±0.21	108.19	< 0.001
		13. How much did the auditory aspects of the testing environment involve you?	5.89±0.19	4.74±0.24	15.58	< 0.001
	7. Realism	***Total Realism (Cronbach's α = 0.83)***	5.04±0.16	2.96±0.18	74.24	<0.001
		15. How much did your experiences in the testing environment seem consistent with real-world experiences?	5.07±0.26	2.67±0.32	48.14	< 0.001
		16. How completely did you feel immersed in the testing environment?	5.19±0.21	2.7±0.2	52.24	< 0.001

		17. How involved were you in the testing environment experience?	5.37±0.19	3±0.21	93.25	< 0.001
	8. Distraction	***Total Distraction (Cronbach's α = 0.48)***	5.6±0.15	4.22±0.18	31.18	< 0.001
		18. How aware were you of events occurring in the real world around you? [R]	5.19±0.31	2.89±0.32	29.94	< 0.001
		19. How quickly did you adjust to the testing environment experience?	5.96±0.19	4.74±0.26	10.42	< 0.001
		20 How much did the testing environment interfere or distract you from performing your sensory evaluation? [R]	5.67±0.23	5.04±0.25	4.47	< 0.001
	9. Total Engagement Score (Cronbach's α = 0.94)		**9.43±1.22**		**83.82**	**< 0.001**
	10. Comfort	21. Did you experience dizziness?	1.22±0.08	1.11±0.08	1.3	0.26
		22. Did you experience discomfort in this test environment?	1.59±0.18	1.37±0.21	1	0.33
	11. Drinking beer	23. Did you experience problems with consuming the beer?	2.37±0.26	1.56±0.23	9.31	0.01

[R] *Indicates items that were reverse-coded.*

Interestingly, a significant difference was observed between VR and Evoked session for each mean dimensional score and total engagement score ($p<0.05$). The total engagement score for the VR session was significantly higher than the Evoked session ($p<0.0001$). In general, participants felt the VR experience was more appealing, engaged with their senses (Environmental Aesthetics), was more fun (Involvement) than testing in the Evoked scenario. Participants also felt their senses were more involved with the environment (Sensory awareness), and the test environment was more realistic (Realism) than testing in the Evoked context. Although a relatively low Cronbach's α was found for novelty, immersion and distraction, when looking at individual statements, VR incited significantly higher curiosity, made participants feel more like they were in a bar, and they reported losing track of time more than Evoked context. The VR experience was also associated with lower awareness of the physical world, less time adjusting to the environment and less distraction to perform sensory evaluation than the Evoked context. For the additional questions regarding comfort and beer consumption, the comfort rating for the VR session was not significantly different to the Evoked session, which agrees with the interview results that participants generally feel quite comfortable in the VR environment. However, participants did experience more problems with consuming beers in the VR compared to the Evoked session, which is expected due to the technical challenges described in section 3.1.3.

3.2.2. Emotional response and liking

As shown in Figure 5, a significant context effect (VR vs Evoked) was observed, where the VR context evoked significantly higher *content* and *excited* emotions, but less *bored* emotion than the Evoked context ($p<0.05$). No significant differences were found for *shocked, nostalgic*, *disconfirmed, disgusted*, and *tame/safe* emotions when comparing the VR and Evoked session ($p>0.05$). For product effect, in general, no significant beer effects were found for liking and emotional responses ($p>0.05$), apart from *bored* ($p=0.05$). Interestingly, the lager beer evoked significantly higher *bored* emotion than the ale beer. No significant interactions between context*beer were found, indicating the context effect found for some emotions are a general effect independent of the beer type. However, caution needs to be taken when interpreting the data, as the sample size is small.

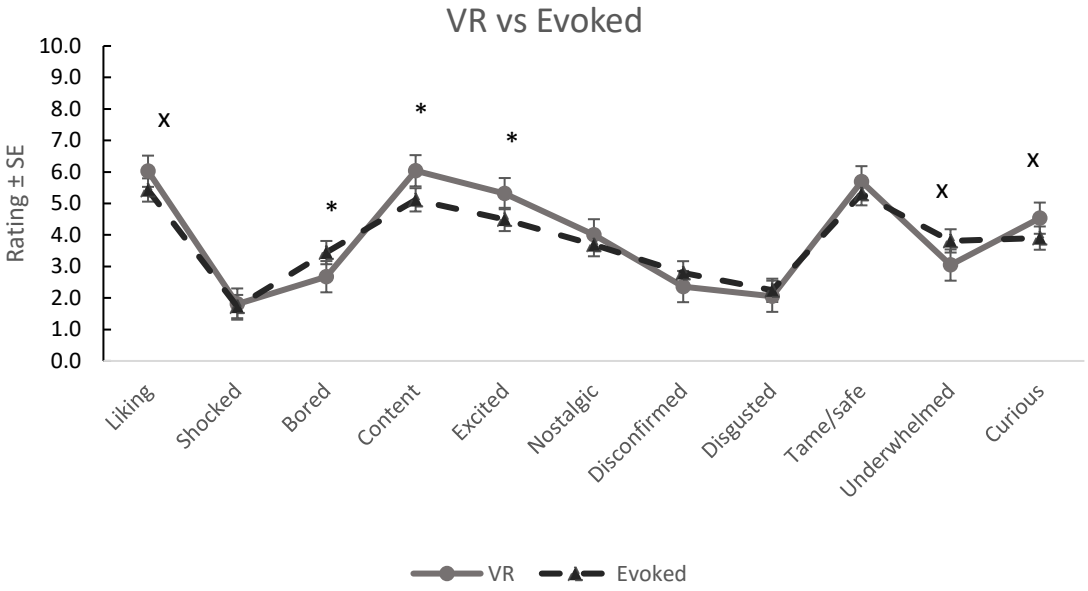

Figure 5: Mean ratings ± SE for liking and ten emotion categories during VR session and Evoked session. **indicates significant difference at p<0.05, [x]indicates approaching significant difference at p<0.1.*

3.2.3. Impact of VR training session on emotional response and liking

Data collected in the VR training session and the VR session were compared to explore whether the novelty of the VR experience affected emotional response to beer. As shown in Figure 6, significantly higher *content, excited* and *curious* emotions were found for the VR training session compared to the VR session ($p<0.05$). Additionally, *nostalgic* approached significance ($p= 0.06$), where the VR training session elicited higher *nostalgic* emotion than

the VR session. The data here agrees with the findings from the interview, where in general, the VR training session evoked higher *excited* and *curious* emotions when tasting beer, which could be the fact that consumers reported how they felt about the VR experience rather than how they felt about the beer products. A similar finding was observed in a previous study (Sinesio, Moneta, et al., 2019). This could also be due to first order effect for emotional response measurement, as previously reported (Dorado, Pérez-Hugalde, Picard, & Chaya, 2016; Macfie, Bratchell, Greenhoff, & Vallis, 1989).

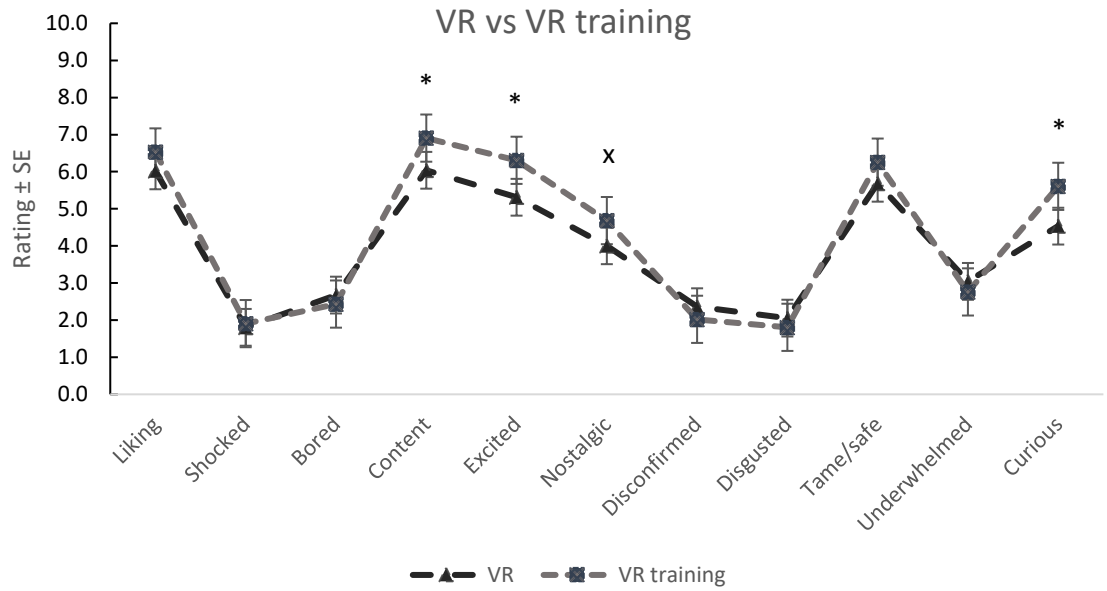

Figure 6: Mean ratings ± SE for liking and ten emotion categories during VR session and VR training session. **indicates significant difference at p<0.05, ˣindicates approaching significant difference at p<0.1.*

4. Discussion

4.1. VR design

The current study explored an innovative approach whereby a questionnaire was integrated in designed objects in the virtual environment, and used a tracked marker pen to rate emotion categories on the table within the environment itself. Wang, Barbosa Escobar, Alves Da Mota, and Velasco (2021) published a review which described the hardware, software and response measurement used in different VR studies. In previous VR studies, some VR experiences require participants to remove the headset to answer questions (Andersen et al., 2019; Stelick et al., 2018), whilst others ask participants to describe their answers verbally (Ammann, Stucki, & Siegrist, 2020; Wang et al., 2020) which disturbs the flow of the study and thus data collection. There is a general concern for sensory and consumer scientists that testing often involves too many questions and products in a session, which leads to tedious data collection,

and could further influence the consumer engagement and quality of data, as any additional questions may bias the reponse (Köster, 2009; Prescott, Lee, & Kim, 2011). In the current study, the embedded interactive task allows sensory and consumer scientists to collect consumer responses within the VR environment, which is believed to increase participant engagement. The interview data supported this theory, where participants reported an overall positive experience and described this data collection method as clear, easy and intuitive. In line with this study, researchers also built questionnaire options into the VR experience as another layer of information by using a remote control or moving their head around to give responses (Picket & dando, 2019; Stelick et al., 2018), however, the unique feature of the current study is to augment a physical pen with a tracker to collect responses and so allow it to be used naturalistically within the VR environment, which is believed to be more similar to reality.

The current study aimed to develop a familiar context by using a specific bar to feature in the 360° video and recruiting participants that had been to that bar previously. Based on participants' responses during their interviews, all participants recognised the bar as a familiar environment and for a majority of the participants this was found to increase the level of realism and immersion and helped to make them feel more comfortable. Therefore, we conclude that the 360° video successfully created a familiar environment to evoke the relevant context, which agrees with previous studies (Andersen et al., 2019; Sinesio, Moneta, et al., 2019; Stelick et al., 2018; Torrico et al., 2021; Worch et al., 2020). However, it should be noted that a participant's personal history impacts how they interpret and experience a contextual setting (Andersen et al., 2019; Köster, 2003), so the perceived level of realism of a context is likely to be linked to past experience which raises the question of whether the VR context should be based on a 'real' environment that participants have past experience of or a 'typical' one that they have no experience of but would recognise as being appropriate.

Furthermore, as the image quality of the 360° video was frequently mentioned as an aspect that reduced realism, future studies should look to optimise image quality by using a high performance 360° camera and hiring a 360° video expert to capture high-quality footage. This would also help to avoid issues with image distortion on the peripheral of the 360° footage as also found by Sinesio, Moneta, et al. (2019).

The presence of people in the VR Bar was found to be a key element that enhanced realism. The captured images of real people behaving naturally in a way that is expected in a bar strongly impacted the atmosphere of the environment. Since the same footage was used in both the VR Training and VR session, any eye-catching behaviour such as participants move closer to or further away from the camera was avoided to prevent the risk of scale issues.

The time spent in VR also impacted realism and immersion. The longer participants were exposed to the VR Bar, the more their sense of realism and immersion increased. For this reason, it is advisable to allow adequate time for participants to experience the VR environment and adjust to it before starting any evaluation task. Further research is needed to determine the ideal exposure time and if this is the same over different and familiar/real versus unfamiliar/typical contexts. The use of a dummy sample to increase exposure time before evaluating the product of interest might offer a good solution whilst at the same time reducing first-order effects which are known to impact emotion data (Dorado, Pérez-Hugalde, et al., 2016).

The current study took an innovative approach to develop the VR experience by combing both 360° video (a real bar environment) and modelled 3D features located with tracking devices (A virtual table, beer bottle and pen that match physical objects) to create a relevant beer consumption context to enable beer evaluation in the immersive environment. Object tracking technology was used in this study, which allows participants to pick up the bottle and drink directly from it, as well as use the pen to rate their liking and emotion to the beers tasted and is a similar approach to that used by Wang et al., (2020) and Nivedhan, Mielby, & Wang (2020) whereby tracking devices were attached to cups that matched 3D modelled cups in the VR. However, they have not included a background context in their VR environments. The VR design in the current study has proven to allow participants to stay fully immersed during consumption. Drinking from a cup can be challenging unless a straw is used which was not appropriate for a study on beer. A training session was provided in this study for familiarisation of the techniques and the VR environment. After training, all participants were able to consume the beers from the beer bottle within the VR environment without any assistance from researchers. Being able to consume products without taking off the headset is crucial for the context to have an effect, since participants can quickly adjust back to reality after the headset is taken off (Andersen et al., 2019). Another advantage of the object tracking technique is that product appearance in VR is fully immersed, thus the appearance and sample presentation can be manipulated, which would provide a novel tool to study cross-modal interactions between different sensory modalities (Nivedhan, Mielby, & Wang, 2020; Wang et al., 2020). However, one of the limitations of the tracking technique is that it does not give researchers the flexibility to test different product categories without a computer scientist's input. As a consumer scientist would need to create the model product in the VR environment that matches the physical product, this could lead to additional expenses when adopting VR technologies in consumer testing. Thus, future work is necessary to develop a reconfigurable and reusable system for long term consumer testing. Also, sometimes inaccuracies and

glitches can happen when tracking signals are blocked between the sensors and tracking devices, which could reduce realism of the experience, as reported in the current study.

Although the object tracking technology used in the current study has the potential to run with multiple participants at the same time, it does require a reasonable amount of space for sensors to be able to detect the objects for each VR headset, thus limiting the number of participants completing the test at one time. In addition, each VR headset (HTC vive) requires a high performance computer, which can be an expensive investment. Future studies using a much larger sample size would be needed to validate the findings observed in this study. The combination of object tracking and 360°video delivered a successful VR bar environment that enabled evaluation of beer samples, suggesting 360° video can effectively create a relevant consumption contexts. 3D models can also be used to create the context in VR (Sinesio, Moneta, et al., 2019), however, they would not capture the social interaction element in the background, which was found to be an important characteristic for creating a realistic bar environment in this study. Object tracking technology could be used to test any kind of products presented in a drinking vessel and in theory, different questionnaire types, as these can be built in the VR environment as the interactive task. However, if considering using this technology for further commercial consumer testing, it offers limited flexibility to sensory and consumer scientists in terms of testing other kinds of food/drink and modifying questions to be asked as additional programming would be needed from computer scientists. In addition, testing solid/semi-solid food would require complex hand movements, and often require participants to see the products in a real-time manner, which would not be achieved by the object tracking technology.

Some of these issues may be reduced with the development of newer VR headsets that benefit from operating standalone without a computer, or feature more advanced camera-based tracking solutions (Oculus Quest, Oculus, United States) that allow for the tracking and reproduction of the participants' hands and arms. The latter would serve to increase participant presence in the VR environment and also afford a more natural sense of interaction with the products. However these solutions are predominantly designed to recognise gestures rather than support interaction with arbitrary objects. Further studies could consider exploration of Mixed-reality technologies that enable participants to see their own hands and the food in front of them, rather than digital facsimiles, thus enabling complex hands movement and supporting testing of solid/semi-solid foods.

Although the interactive task of data collection in the current study is intuitive and received positive feedback, additional programming would be needed for any changes in the questions to be used. Thus, future studies investigating a more effective way to embed a flexible

questionnaire would also be needed. In addition, a systematic study exploring different technologies including object tracing, hand-tracking (Ung, Menozzi, Hartmann, & Siegrist, 2018), and augmented-reality or mixed-reality technologies (Flavián, Ibáñez-Sánchez, & Orús, 2019) should be explored to evaluate the most optimal technique that could be used in consumer testing. The current VR environment only allows testing on one-to-one basis, which is time consuming, thus, further investigation is needed into which techniques would best allow multiple participants to experience the VR context simultaneously to both increase consumer testing efficiency and maintain a good level of immersion and engagement for participants.

4.2. Participant engagement between VR and evoked contexts

It was believed that providing relevant contextual information could enhance consumer engagement and improve product discriminability and increase quality of data compared to blind testing (Bangcuyo et al., 2015; Hannum et al., 2019; Hathaway & Simons, 2017). The engagement questionnaire used in this study was based on Bangcuyo et al. (2015)'s study, which is a useful tool for the purpose of measuring participant engagement in virtual environment testing. Although the internal consistency of some of the dimensions was relatively low (Novelty, Immersion and Distraction), indicating certain items in these dimensions need to be reconsidered. For example, in the Novelty dimension, the item 'testing environment incited my curiosity' and the item 'the testing environment distracted me' are likely measuring two different aspects. In more recent studies, another engagement questionnaire was established to measure consumer engagement in sensory and consumer testing, which is shorter (10 items) than the one used in the current study (20 items), covering three key dimensions (active involvement, purposeful intent and affective value) rather than 8 dimensions (Hannum & Simons, 2020). Thus, it would be interesting to use the newly developed engagement questionnaire in future studies to validate its efficiency.

Agreeing with previous literature, this study also found that a VR experience enhances participant engagement compared to a method using pictures and participants' imagination (Andersen et al., 2019), and in the broader sense immersive technologies have been shown to increase engagement compared to standard lab settings (Bangcuyo et al., 2015; Hannum, Forzley, Popper, & Simons, 2020; Hathaway & Simons, 2017; Sinesio, Moneta, et al., 2019; Zandstra et al., 2020). This data is in line with the data observed in the interviews, where overall positive feedback was observed, such as on the interactive contextual background and audio that increased realism and the interactive activity of using an actual pen to rate on scales on the table was easy and intuitive, which increases engagement further.

When evoking context, the aim is to simulate the natural consumption experience as closely as possible. As with any simulation, imagination plays a role for both the Evoked context and the VR experience. The more sensory inputs presented in VR, the easier it is for participants to visualize and feel immersed in the virtual environment (Cowan & Ketron, 2019), and the more closely responses approach those obtained in real-life situations (Stelick & Dando, 2018). Stimulation of all five senses (i.e., vision, taste, touch, smell and hearing) can make virtual experiences more immersive (Cowan & Ketron, 2019). In the current study, all five senses were involved in the VR experience, which are all essential elements for product tasting and these elements are recommended for future immersive VR studies. Since immersion was clearly lower in the Evoked condition, participants likely had to rely more heavily on their imagination than in the VR condition. To get closer to a natural consumption environment, it is always necessary to involve additional elements (e.g. wearing a headset in VR, using photos and sound recordings in Evoked context) that depart from a natural consumption experience. In the case of the current study, participants did comment that the headset was a bit heavy and warm, which reminds them it is not a natural consumption experience. In addition, the quality of the visuals and technical difficulties in VR were the main features that made the experience less realistic, while audio seemed to increase realism. It should be noted that the focus of this study is on the potential improvement of VR technology for evoking context and further research is needed to explore the potential impact of the technology on the worsening of the context.

4.3. Emotional response and liking between VR and Evoked context

The results from this study showed that the VR session generated higher *content, excited* but less *bored* emotions than the Evoked session. Liking scores in the VR session were also rated higher than the Evoked session. Previous studies have found that immersive rooms generated higher hedonic ratings than controlled settings (Bangcuyo et al., 2015; Hathaway & Simons, 2017; Sinesio et al., 2018), however Sinesio, Saba, et al. (2019) did not find a context effect on hedonic response when comparing an immersive room, 360° video, a VR modelled environment, a standard sensory lab setting and a real bar environment. Interestingly, another study looked at consumer responses to two chocolates (no vs full sugar) under three environments: sensory booth, positive VR (environment that appears to be positive with open field environment) and negative VR (environment with a depressive and odd closed-space room), didn't find any context effect for overall liking, however, different emotion terms were associated with the different VR environments (positive vs negative environments) (Torrico et al., 2021). The data in Torrico et al. (2021) and the current study highlighted that emotional responses could be more discriminating than conventional hedonic testing as described in previous studies (Gutjar et al., 2015; Yang et al., 2018; Yang et al., 2020). The results in this

study indicate that there are differences in the intensity of some emotional responses found in the VR setting and Evoked context. Although caution needs to be taken when interpreting the data due to small sample size. The data here suggests that the Evoked session can stimulate the bar experience to some extent, but not as effectively as the VR context. This could link to the fact that the Evoked session needs more imagination to simulate the context than VR session which has the potential to impact some emotions more than others. It would be interesting to compare VR experience, Evoked context, Controlled lab setting and Real bar context, as well as investigate how different relevant environments impact on consumer responses in future studies. It's worth noting that the line scale length for Evoked context and VR session was different, with much longer scale positioned on the table for rating in the VR environment. However, if the scale length impacted on the emotional response, then we would expect to see a higher product discrimination in VR setting rather than an overall higher rating for some emotional categories, as suggested in Nijman (2019). The interview and engagement results showed that consumers expressed novelty when experiencing VR, which were further confirmed by the emotion results. The VR training session evoked significantly higher *content*, *excited* and *curious* emotions than the VR session. The novelty of the VR environment experienced within the training session was shown to impact on consumers' emotional response to beer, highlighting the importance of including a training/familiarisation session to help neutralise the novelty created by the technology.

5. Conclusion

This study explored an innovative approach to develop a VR experience by using 360° video combined with a 3D model with object tracking to facilitate beer consumption and to collect consumer responses in the virtual world. This study shows that this approach can successfully provide an immersive environment to consumers, and the tracking devices used in the VR environment allowed participants to consume beer products independently, while maintaining full immersion. Although limitations were identified for the tracking devices, in general, consumers felt very positive regarding the VR experience, and the training session helped consumers to familiarise themselves with drinking from the bottle and the bar context and reduce the effects of novelty on consumer responses. The interactive questionnaire in the VR for data collection appeared to increase participant engagement. Audio, time spent in VR and presence of other people in the 360° videos were shown to increase perceived realism.

High levels of novelty related to a first exposure to VR were observed, which led to slightly different emotional response to beer compared to a second exposure. A training session prior to a data collection session in VR was observed to reduce novelty and associated effects,

highlighting that a training/familiarisation session is needed when conducting studies involving VR technology. Compared to an Evoked context using pictures and sound recordings, VR showed clear advantages in terms of participant engagement. This paper highlights key learnings and considerations when designing a VR environment to further improve realism and immersion, which contributes to the current literature by continuing improving methodologies in leveraging VR techniques in sensory and consumer research.

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