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Assessment of virtual environments for alcohol Relapse Prevention in a less immersive and cost-effective setup: A qualitative study

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ABSTRACT

Relapse prevention (RP) - helping people to develop relevant coping skills in high-risk situations that challenge abstinence - is an important part of alcohol use disorder treatment. Recreating personalised, high-risk situations can be challenging in clinical contexts. Virtual Reality Therapy (VRT) has the potential to offer immersive exposure to relevant, interactive stimuli presented in Virtual Environments (VEs). The use of VRT in RP remains unexplored. In this study, 10 casual and 13 high-risk drinkers assessed, via unstructured interviews, the realism of three 'high-risk' VEs: a home, a supermarket and a pub, and the extent to which they induced alcohol temptation when presented in a less immersive, cost-effective setup. Template analysis revealed that proximal (alcohol stimuli) and contextual (stimuli typically associated with alcohol) cues, and a sense of presence within the VEs, were key aspects to inducing realism and alcohol temptation. High-risk drinkers were tempted to drink in any VE and regular drinkers primarily in a social, pub VE. Temptation to smoke was induced in smokers. The results suggest that the VEs may help people with alcohol or comorbid tobacco misuse to practice coping with craving, refusal skills (saying 'no' to prompts to drink) and emotion regulation in social, private and alcohol vending contexts. The interconnections of realism, presence, alcohol temptation and related cues discussed here can inform future VRT applications for alcohol treatment.

1. Introduction

Alcohol misuse poses a prominent health risk factor worldwide (World Health Organisation, 2020). Alcohol-related harm is linked to early mortality, diseases such as cancer, cardiovascular disease and liver cirrhosis, and health conditions resulting from road injuries and violent incidents (National Institute on Alcohol Abuse and Alcoholism, 2021; World Health Organisation, 2020). Alcohol-related harm also results in financial costs through health and social care and other state services such as the welfare and criminal justice systems (Public Health England, 2018). The poor living conditions and mental health problems often experienced by people who engage in alcohol misuse and their families lead to further indirect costs (Public Health England, 2018).

Current treatments for alcohol dependence typically consist of community- or residential-assisted withdrawal, depending on the alcohol dependence's severity of the individual, followed by pharmacological and psychological interventions to promote abstinence and prevent relapse (National Institute for Health and Care Excellence, 2011). Psychological interventions such as cognitive behavioural therapies, behavioural therapies and social network and environment-based therapies (involving forms of social support such as community reinforcement) are also recommended for high-risk drinkers and those with any level of alcohol dependence (National Institute for Health and Care Excellence, 2011). Rates of remission from alcohol use in individuals with alcohol dependence that have received treatment appear higher than the ones who have not received any treatment (Moos & Moos, 2006). In either case of having received treatment or not, the relapse rates range from 40% to 60% respectively (Moos & Moos, 2006). For those receiving treatment, the relapse rate during the first year of treatment rises to 75% (Menon & Kandasamy, 2018). Predictors of

relapse are found to be craving, negative affect and limited social and personal resources such as decreased self-efficacy, lack of emotional support, decreased motivation to change and less reliance on coping (Witkiewitz & Marlatt, 2004).

A core part of alcohol treatment therefore involves interventions to prevent relapse once abstinence has been achieved. A cognitive behavioural approach, Relapse Prevention (RP), specifically focuses on the identification of high-risk situations that could challenge the individual's abstinence, and the development of coping techniques to manage craving (Menon & Kandasamy, 2018). Coping involves building refusal skills for resisting drinking in social and peer pressure contexts, and preparing to manage craving and regulate emotions for when high-risk situations would be encountered in reality (Witkiewitz & Marlatt, 2004). Most individuals relapse post-treatment after re-visiting high-risk situations in real life (Mellentin et al., 2016). Virtual Reality Therapy (VRT) could provide controlled exposure to high-risk situations via interactive virtual environments (VEs), helping people to identify triggers and practise coping prior to real-life exposure. Use of interactive, virtual agents and personalisation of the VEs' content could allow simulation of diverse social, interpersonal and emotional scenarios for refusal skills training, and craving and emotional regulation. Mindfulness-based interventions, mediated by relaxing VEs, could also be incorporated to reduce anxiety originating from the cued exposure.

Experimental evidence about the potential of VRT in alcohol misuse treatment is limited. Results obtained so far have shown that alcohol cued VEs, including social pressure and interpersonal cues, were able to evoke craving (Amista, 2017; Bordnick & Washburn, 2019; Ghiță et al., 2019; Ghiță & Gutiérrez-Maldonado, 2018; Grochowska et al., 2019; Hone-Blanchet et al., 2014; Kim & Kim, 2020; Segawa et al., 2020; Trahan et al., 2019; Worley, 2019). Proximal (e.g. glass of alcohol), contextual (e.g. bar) and complex cues (a combination of proximal and contextual ones, e.g. a glass of alcohol in a bar) were included in VEs that represented pubs, bars, parties, home kitchens and apartments (Segawa et al., 2020). Treatment-oriented studies have explored the efficacy of VRT within the therapeutic framework of Cue Exposure Therapy (CET) (Amista, 2017; Bordnick & Washburn, 2019; Ghiță et al., 2019; Ghiță et al., 2021; Ghiță & Gutiérrez-Maldonado, 2018; Grochowska et al., 2019; Hernández-Serrano et al., 2020; Hone-Blanchet et al., 2014; Kim & Kim, 2020; Segawa et al., 2020; Trahan et al., 2019; Worley, 2019). CET is based on the premise of learning theory's classical conditioning, where association of formerly neutral (conditioned) stimuli with unconditioned stimuli (alcohol) happens, eliciting similar responses to the unconditional stimuli (Mellentin et al., 2017). As in traditional CET, VRT-CET aims to unpair the eliciting of the addictive response (craving) when proximal, contextual or complex cues are encountered virtually through repeated exposure. While CET has presented limited efficacy in alcohol misuse treatment, results from VRT-CET studies have suggested moderate decrease in craving (Amista, 2017; Bordnick & Washburn, 2019; Ghiță et al., 2019; Ghiță et al., 2021; Ghiță & Gutiérrez-Maldonado, 2018; Grochowska et al., 2019; Hernández-Serrano et al., 2020; Hone-Blanchet et al., 2014; Kim & Kim, 2020; Segawa et al., 2020; Trahan et al., 2019; Worley, 2019).

The use of VRT in the context of RP remains unexplored (Ghiță & Gutiérrez-Maldonado, 2018). Issues like emotion regulation and coping with craving that originates from alcohol promotion strategies (such as branding, advertisements or multi-buy offers) have not been considered in the design of previous VR applications for alcohol treatment (Ghiță & Gutiérrez-Maldonado, 2018). It is important to incorporate these in alcohol treatment, as both digitalised (found on social media) and non-digitalised promotions have been linked to increased alcohol consumption and binge drinking, particularly in adolescents (Hurtz et al., 2007; Lobstein et al., 2017; Wagenaar et al., 2009). Moreover, while alcohol cued VEs showing social pressure scenarios have been developed and are relevant for refusal skills' training (Ghiță & Gutiérrez-Maldonado, 2018), the effect of positive emotional states as a trigger for drinking under social pressure has not been examined. A consistent body

of VRT work about emotional states exists in mental health disorders, suggesting that virtual dialogs with virtual agents and avatars have elicited adequate cognitive, emotional and physiological responses, and have decreased disorder-related symptoms (Adery et al., 2018; Della-zizzo et al., 2018; Emmelkamp et al., 2020; Falconer et al., 2017; Freeman et al., 2016; Jin et al., 2019; Percie du; Pot-Kolder et al., 2018; Rus-Calafell et al., 2018; Percie du Sert et al., 2018; van Rijn et al., 2017; Veling et al., 2014).

In order to explore the potential of VRT in alcohol RP, we have developed a VR application with three VEs; a home, a supermarket and a pub. These VEs represent high-risk situations that individuals in recovery might encounter daily, involving alcohol promotions in a public and private setting, and social pressure applied under a positive emotional perspective. We used a low-cost VR setup, to evaluate the relevance of these VEs and explore the capacity of cost-effective VR for use in RP. We conducted an online, interview study with regular drinkers to assess the realism and the capability of the VEs to trigger alcohol temptation in this cost-effective setup. Unstructured interviews were conducted to explore the factors of realism and alcohol temptation in the three environments, which could inform the use of these VEs in clinical, immersive VR setups (involving a Head Mounted Display - HMD) or the design of similar, VRT applications for alcohol treatment.

2. Methods

2.1. Virtual environments and videos

Three VEs were assessed: a living room VE (Figs. 1–4), a supermarket VE (Figs. 5–11) and a pub VE (Figs. 12–15).

For each VE of the A-PLAN app, a YouTube video was recorded with the first author navigating each VE for approximately 2–3 min. The videos were recorded in a first-person perspective to clearly present the view that participants would have if they were to be immersed in the VEs themselves, via a VR headset. Participants thus experienced the navigation within the environments as if they were the VR users. The video of the home VE (YouTube link: https://youtu.be/7nxbnqNoz5c) involved standing in the living room and watching an alcohol TV advertisement, grabbing a supermarket leaflet with drinks offers and navigating within the living room. The video of the supermarket VE (YouTube link: https://youtu.be/fhl21Nd-IhQ) involved navigating the alcohol aisle while observing a variety of drinks and grabbing a vodka bottle. The video of the pub VE (YouTube link: https://youtu.be/j55 fSGXHPnU) involved standing at the bar and being offered a pint of

Fig. 1. Home VE - Living room & TV advertisement of alcohol.

Fig. 2. Home VE - Supermarket leaflet with drinks offers.

Fig. 3. Home VE – Hallway.

Fig. 4. Home VE - Entrance.
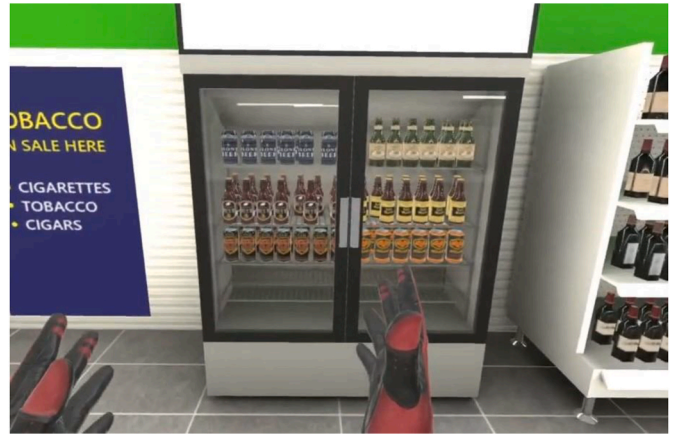
Fig. 5. Supermarket VE - Beers in the fridge & "in-store selling tobacco" signage.
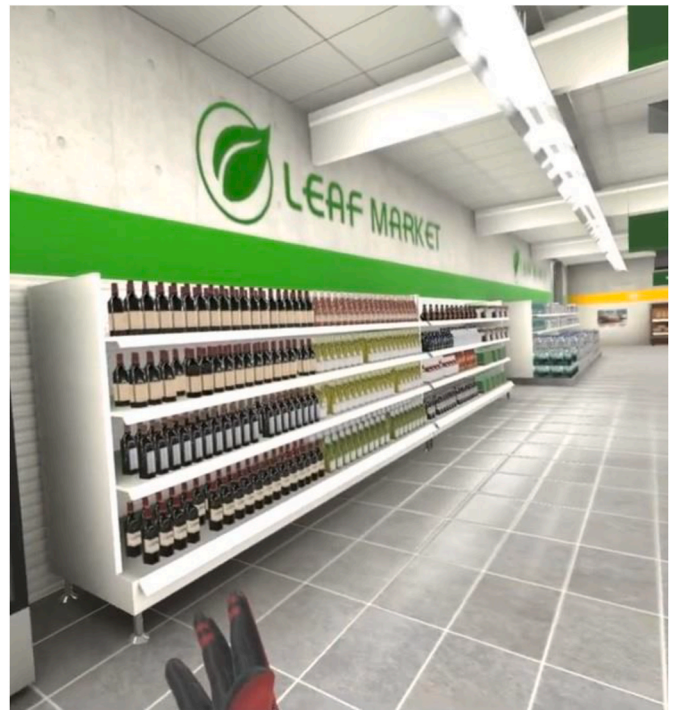
Fig. 6. Supermarket VE - Wines section.

beer by an interactive, virtual agent whose behaviour was controlled by the pre-defined, application's storyline. The interactive, virtual agent was applying social pressure, by mentioning that they have just found a new job and they wanted to celebrate and buy the VR user drinks (Fig. 12). The VR user grabbed the pint of beer offered and drank it in the first-person perspective (Fig. 15). Smoking cues (a pack of cigarettes and a lighter – Fig. 13) were also present at the bar counter and were grabbed by the VR user.

2.2. Equipment

To create the videos of this study, the 'HTC VIVE Pro' VR headset was used with two hand-held controllers. Navigation within the VEs happened via the trackpad of each controller, that on touch, sliding across each direction was possible. By design, sliding occurred in a slow pace and as the VEs represented enclosed spaces, the movement threshold was limited. This approached was informed by the potential of

Fig. 7. Supermarket VE - Spirits section.

Fig. 8. Supermarket VE - Grabbing the vodka bottle.

Fig. 9. Supermarket VE - Multi-buy drinks offers.

Fig. 10. Supermarket VE - Customer virtual agents.

Fig. 11. Supermarket VE - Soft drinks section.

fast-paced movements to cause cybersickness - symptoms such as nausea, eye tiredness and, in rare cases, vomiting (Kim et al., 2020; Stanney et al., 2020).

To record the videos, the free and open-source 'OBS' (Open Broadcaster Software) recording program was used. Each video was then uploaded to the YouTube channel of the study.

Participants used their personal computers, paired with earphones or headphones when needed, and watched the videos on their 2D computer screens.

2.3. Participants and recruitment

Participants were recruited via purposive and convenience sampling. The inclusion criteria for participating in the online interviews were (1) to be 18 years old or older and (2) to drink alcohol at least once a week. The study was advertised on social media and in email newsletters to students and staff at the University of Manchester, UK. Individuals who were interested in taking part emailed the first author and were screened to confirm eligibility to participate. Participants were also emailed a link that directed them to the information about the study procedures and consent was taken to record their alcohol use. Informed, verbal consent for audio-recording the interviews was taken by the participants at the

Fig. 12. Pub VE - Customer virtual agent.

start of the interviews.

2.4. Procedure

Participants were asked to complete a brief Alcohol Use Questionnaire online detailing their recent alcohol consumption (frequency of drinking, units consumed). After completion, participants were contacted to arrange the interview. Prior to the interview a link to a YouTube video was also sent, where the first author demonstrated how the VR gear worked, through a free, VR game offered by the 'SteamVR' store (https://store.steampowered.com/app/468700/NVIDIA_VR_Funhouse/). In the video, it was showcased (1) how the hand-held controllers were used to interact with objects and to navigate within the VE and (2) how the user view and their VR hands virtually corresponded to their physical movements with the hand-held controllers. The online interviews were conducted by the first author. Interviews were audio recorded. The first author explained the study procedures and asked participants if they needed further clarification, ensuring that they had also watched the demonstration video of how VR worked. Participants were also asked if they had used VR before in any context.

The link of each YouTube video was sent to the participants in the Zoom chat. Participants were asked to watch each video in full screen and in high quality (1080p60), to achieve the best immersion possible under this setting. While participants were watching each video, the first author muted themselves and turned their video feed off to minimise distraction. After each video, the first author unmuted themselves and turned their video feed on. Interviews were unstructured, with participants being asked to share their thoughts in a spontaneous manner about the video that they had just watched, irrespective of whether they were relevant to alcohol or to the content of the given VE. The first author requested clarifications on points that the participants had raised as required.

The audio recordings produced by the interviews were transcribed verbatim and anonymised. Interview duration ranged from 40 to 80 min. After the interview, compensation was given for taking part in the study and a participant debrief sheet was emailed to the participants with contact details of organisations that could help if they felt any level of distress or if they were concerned about their drinking.

Fig. 13. Pub VE - Lighter & pack of cigarettes, & the bartender virtual agent.

Fig. 14. Pub VE - Pub layout & customer virtual agents.

Fig. 15. Pub VE - Action of drinking beer pint.

2.5. Data analysis

Template analysis was chosen as the data analysis method as it facilitates detailed, hierarchical coding while analysing the data and, at the same time, allows for adjusting the focus of the under-analysis data to the study's objectives (Brooks et al., 2015). In accordance with the research questions, only data that were relevant to the realism of the VEs and alcohol temptation were coded. In template analysis, the focus can expand on both descriptive and interpretive themes (Brooks et al., 2015). This was necessary in the current study as the degree to which a VE would be realistic or induce temptation might depend on the background of an individual, leading to interpretive codes, apart from descriptive ones.

The template analysis followed the methodology outlined by Brooks et al. (2015). The first author, having conducted the interviews and transcription, was familiar with the content of the transcripts. Initial coding of the data was undertaken, using the 'NVivo' software for qualitative analysis. After coding the first five transcripts, the emerging codes were refined to form a template that clearly showed their interconnections. This template was then used as a guide while coding the next five transcripts. Refinement of the template's codes happened while coding this next cluster of transcripts. This process was used for the remaining clusters of transcripts, such that the template was finalised once all data relevant to the research questions were coded without requiring further additions to the template. The final version of the template was shared with all members of the research team for validation. Quotes belonging to each code of the template were also given as examples, to justify the naming of the codes and themes and facilitate validation across all stages of the analysis.

2.6. Ethical approval

Ethical approval for the study was granted by the University of Manchester Research Ethics Committee (Ref.: 2020-8466-17087).

3. Results

3.1. Participants

In total, 23 participants were interviewed online. Ten participants (43.5%) were casual drinkers, typically drinking within safe limits ($\leq$14 alcohol units), and thirteen (56.5%) were high-risk drinkers, drinking above safe limits ($>$14 alcohol units), according to the drinking units limit set by the NHS guidelines (NHS, 2018). Eighteen participants (78.3%) drank alcohol more than once per week typically, with the average alcohol units drunk per week to be 18.76. On average, participants consumed alcohol 3 days a week. Fifteen participants (65%) drank 3 or more times per week. Fourteen participants (60.9%) had used VR before. Fifteen participants were male (65%) and eight were female (35%). Descriptive data of participants are presented in Table 1. Data saturation was achieved in the last three interviews (Guest et al., 2006).

3.2. Themes

Three main themes emerged from the template analysis of the interviews. The themes mapped to (1) the effect of contextual cues, (2) the effect of proximal cues and (3) the effect of the sense of presence in the VE on the realism perceived by participants and their temptation to drink. An overview of the themes and subthemes is presented in Table 2.

Table 1

Descriptive data of participants.

Participant ID	Gender	Age	Alcohol Units/Week	Drinking days/Week
1	Male	42	16	3
2	Male	31	6	1
3	Female	54	16	4
4	Male	22	54	6
5	Male	28	42	5
6	Female	52	20	4
7	Female	26	8	3
8	Female	29	8	3
9	Male	26	24	6
10	Male	21	42	4
11	Female	25	17	3
12	Male	35	9	3
13	Female	28	12	3
14	Male	31	22	2
15	Male	33	42	3
16	Male	29	18	4
17	Male	38	5	2
18	Male	37	4	1
19	Male	65	44	4
20	Female	31	3	1
21	Male	28	15	1
22	Female	24	3	2
23	Male	30	3	1

Table 2

Template of the analysis.

1. Effect of proximal cues
1.1 Perceived alcohol presence
1.2 Perceived alcohol realism

2. Effect of contextual cues
2.1 Relevance of layout and furnishing to individual experiences
2.2 Association of virtual agents with human behaviour and social drinking
2.3 Immersiveness of background sounds
2.4 Interconnection of lighting with time of day and ambiance
2.5 Association of smoking-related objects with drinking
3. Effect of the sense of presence
3.1 Projection of personal narrative
3.2 Association of self with VR hands

3.2.1. Effect of proximal cues

3.2.1.1. Perceived alcohol presence. The extent to which alcohol was present in the VE seemed to affect the degree to which participants were tempted to drink alcohol and the realism of the situation represented. Animated alcohol cues, entailing motion, like a beer being poured into a glass, the effect of beer foam and bubbles forming on the beer's surface or the glass frosting due to the coolness of the served beer, were considered by participants to be the most tempting. "… what looks attractive to me is when I see … the glass getting cold and getting frosted." (P3; female/54 years old/drinking past safe limits). In the home VE participants suggested that having glasses in front of them containing alcohol instead of empty glasses on the table would trigger their desire to drink more. "… the glasses were not indicating that there was like alcohol drunk, it's just two empty glasses that could be just like full of water." (P20; female/31 years old/drinking within safe limits), "… it's like more tempting when you're actually seeing something served." (P23; male/30 years old/drinking within safe limits). In the pub VE, the pint of beer on the bar was considered tempting, but some participants noted that if it was served at that moment it would look fresher, with more foam, and, in turn, even more attractive. "… the beer looked like it was standing there for a while … it didn't look fresh … if the beer … was like served to me I would have even more desire to drink it." (P10; male/21 years old/drinking past safe limits). The action of grabbing the pint of beer with the VR hand and drinking it was considered by participants to increase their alcohol temptation in a more dynamic way. "… the action of grabbing the pint … it's completely

different. It's more inviting to actually do it." (P23; male/30 years old/ drinking within safe limits).

In the home VE, participants found an alcohol advertisement on the television more tempting than the static advertisement of a supermarket leaflet with drinks offers. "… it also has motion to it, like you can see it pouring in the pint. So, to me that's more appealing rather than looking at the poster …" (P17; male/38 years old/drinking within safe limits). At the same time, a few participants noted that an alcohol advertisement on television would not be a common scenario and, thus, less realistic. "… it's been a long time to see an alcohol related advertisement on TV." (P14; male/31 years old/drinking past safe limits). Participants said they would be tempted to drink even more if the VE involved watching somebody else drinking on the television, be it in the context of an advertisement or a film, reality show or a series, as they would empathize with them. "… if like there was an advertisement of someone else drinking a beer. I think that would spark me more than just a beer" (P10; male/21 years old/drinking past safe limits), "I think it's both seeing the beer being poured, but also seeing other people drinking it … I'd empathize with the person drinking." (P3; female/54 years old/drinking past safe limits).

In terms of less interactive advertising and non-animated alcohol cues, some participants were not tempted at all by the supermarket leaflet with drinks offers, mentioning that they would usually throw away such advertising leaflets, as they were exposed to them regularly and largely desensitised. "… we're just surrounded by tons of leaflets about different products. I mean you do not pay attention." (P1; male/42 years old/drinking past safe limits). Several participants added that they associated offers with alcohol of lower quality and binge drinking, decreasing their alcohol temptation. "I don't like offers on drinks … it reminds me of … like binge drinking … drinking for the sake of drinking as opposed to really enjoying it." (P18; male/37 years old/drinking within safe limits). In contrast, some participants explained that they were tempted by the leaflet due to it including offers that they could exploit as they would typically do. "… what I would be tempted to do is instantly like grab my phone and check if the discounts are there. And possibly order some." (P4; male/22 years old/drinking past safe limits). Similarly, in the supermarket VE, most participants referred to the offer presented in the alcohol aisle and to the offers that usually supermarkets would have as a temptation factor, especially if a more expensive alcoholic spirit of their preference would be reduced in price, "… they obviously have an offer of buy two and get three, I think it was. So that probably makes you have a second look at our whatever's on the shelves." (P21; male/28 years old/drinking past safe limits), "If I saw something at a really good price … that would tempt me." (P19; male/ 65 years old/drinking past safe limits).

Another element that affected participants' temptation to drink was the variety of the alcohol offered in the supermarket and pub VEs. In the supermarket VE, participants mentioned that different options for alcoholic beverages were available, enough for them to start thinking about trying something new and drinking. "… there was quite a huge selection of alcoholic beverages, so that really caught my eye …" (P7; female/26 years old/drinking within safe limits). A few participants added that a greater variety would increase temptation. "… because I like variety, I wouldn't have all these bottles exactly the same … to have an experience … all of these different drinks you can try." (P13; female/ 28 years old/drinking within safe limits). In the pub VE, participants found the existence of beer pumps relevant and tempting, again triggering their curiosity. "It's got a selection of lagers which I tend not to drink, but also a selection of cask ales which I do drink." (P19; male/65 years old/drinking past safe limits), "And then I saw the handpumps … I was surprised how much I thought, aw, this looks delicious." (P3; female/54 years old/drinking past safe limits).

3.2.1.2. Perceived alcohol realism. The extent to which the appearance of the alcohol presented matched participants' expectations affected the

perceived realism of the VEs and participants' temptation to drink. In the supermarket VE, most participants found the bottles of alcohol in the aisle realistic, with most reminding them of popular alcohol brands. "I notice a few bottles that look similar to the spirits that I drink." (P15; male/33 years old/drinking past safe limits). The fact that the brand names were not identical to the real brand names due to copyright did not bother some of the participants as they explained that they could make the connection with the brand regardless, just by the shape of the bottle. "… at this point it is very intuitive the way that you can distinguish which content is what, because you've been buying those bottles for a long time." (P12; male/35 years old/drinking within safe limits), "… my first thought was that, aw, this is obviously this brand of alcohol, but they're not putting the name, of course, for copyright reasons." (P7; female/26 years old/drinking within safe limits). The resemblance of the alcohol bottles to known brands was thought by participants to increase their alcohol temptation. "I could see some brands, well, different names that refer to famous brands of alcohol … it made it more appealing to drink." (P8; female/29 years old/drinking within safe limits).

In contrast, some participants mentioned that not seeing the exact brand names decreased their alcohol temptation as they would not trust a brand they had never tried before. "I think it will help to kind of know which bottle belongs to which brand, or what type of alcohol … I would like to know and not get something randomly … is a better idea to know what you get." (P5; male/28 years old/drinking past safe limits). However, participants added that for wine, knowing the type is more important than the brand name. "I don't really have a clue about the brand names, but, obviously, the type of wine, Chardonnay, Pinot noir, whatever, seeing those … I tend to look for that first, actually." (P19; male/65 years old/drinking past safe limits). For several participants, involving more colours would denote a greater variety of drinks and a more realistic representation of a supermarket drinks section, triggering their temptation to try an alcoholic beverage more, "… it wasn't really tempting to go get a bottle because they didn't have, like, different colours … like they would have in real life." (P22; female/24 years old/ drinking within safe limits).

In the pub VE, some participants similarly added that with draft beer, the brand is not important as every pub would normally have their own selection. "I will go for the, for the local brewery trying their own brands which I never know." (P21; male/28 years old/drinking past safe limits). Finally, several participants commented on the appearance of the pint of beer grabbed by the VR hands during the action of drinking it. They noticed that the beer level was not decreasing after each sip or being fizzier, making the beer look unrealistic. "… the level of the beer remained the same and it wasn't fizzy. And I was like, oh, it's a plastic beer." (P14; male/31 years old/drinking past safe limits).

3.2.2. Effect of contextual cues

3.2.2.1. Relevance of layout and furnishing to individual experiences. The extent to which the VEs' layout and furnishings matched the experiences of participants about those places in real life influenced the realism of the VE and the temptation to drink. For the home VE, participants described it as a standard living room of an apartment. "… it resembles any living room. I would say like a standard one." (P23; male/30 years old/drinking within safe limits). Some participants found it realistic, having assumed that it was a room of a minimalistic style or a living room in a shared house, or even a hotel. "I know that minimalistic is like quite a trend at the minute or this could just be like you know the living room and you know some people that are just living together." (P20; female/31 years old/drinking within safe limits). However, most participants felt that it was too empty and too tidy, and, subsequently, less cosy. "It felt quite stark and it was a little bit … sterile. You know, plush furnishings or anything I wish to cuddle up into and snuggle up or anything like that and just back out and have a nice glass of wine." (P6;

female/52 years old/drinking past safe limits). Due to this, participants felt that, although it was graphically realistic, it didn't seem like an environment that they would typically inhabit, be it their home or other people's house. "I wouldn't be in such a living room, it was quite cold for me." (P16; male/29 years old/drinking past safe limits), "I think it is realistic, but probably not so in relation to the sort of places or houses where I go." (P19; male/65 years old/drinking past safe limits). A few participants also mentioned that the living room was too spacious, introducing, again, a less cosy sensation. "… I felt like the room was very big and empty and it had like an unwelcoming feeling for me." (P8; female/29 years old/drinking within safe limits). The lack of a cosy feeling was seen to affect participants' desire to drink in that place. "I realized that I didn't want to drink because the whole environment wasn't like cosy." (P21; male/28 years old/drinking past safe limits).

Participants believed that the supermarket VE layout was consistent with a British supermarket. "… this is like a typical British supermarket." (P9; male/26 years old/drinking past safe limits). Some participants found the layout representative of real-life supermarkets where beers', spirits' and soft drinks' sections would be present and put together, and closer to the tills, too. "So all those sections were quite relevant to me and I would say pretty familiar in terms of the layout." (P19; male/65 years old/drinking past safe limits), "I thought this was pretty realistic because, like, it was all the alcohol near the counters." (P13; female/28 years old/drinking within safe limits). In the shelves, some stock missing was also commented positively by several participants, as it resembled what would typically happen. "I could realise that there were some missing bottles on the shelves, so it's realistic if you think about it." (P23; male/30 years old/drinking within safe limits).

Some participants felt that the aisles were too wide whereas, in reality, supermarket aisles would be narrower. "I think I would probably make the corridor bit narrower … because you know in the supermarket you feel a bit more trapped inside." (P13; female/28 years old/drinking within safe limits). Refinement of the floor texture was suggested by a few participants. "In my mind it would be a bit more realistic if it was just one floor [rather than tiles]." (P17; male/38 years old/drinking within safe limits). Adding labels with prices was a further suggestion. "I didn't see prices or like the description of like, even if it's like a tiny label or something." (P2; male/31 years old/drinking within safe limits). Although several participants mentioned that they were tempted to buy alcohol in there, others suggested that a snack section close to the alcohol one or an advertisement for food to match with specific alcoholic beverages would increase their temptation to drink. "… if it was me there, I would buy a bottle or something, like it." (P13; female/28 years old/drinking within safe limits), "… another thing that I may have added is like, when you go to supermarket, they used to have some small, like chips, close by … usually when you buy alcohol, you will buy some chips or some snacks." (P11; female/25 years old/drinking past safe limits).

Participants felt that the pub VE resembled a typical British pub, with the colour scheme, wallpapers and layout representative of pubs in real life. "… it's an actual, very good simulation of an English pub" (P5; male/28 years old/drinking past safe limits). Some participants added that they imagined smelling the beer or wine scents as they would normally do in a pub. "I could imagine it looked like it might smell of old wine and beer in there as well." (P6; female/52 years old/drinking past safe limits). However, few participants mentioned that they would prefer a carpet instead of tiles. "… all the pubs from my experience or most of the pubs have some sort of carpet … it was more of a traditional pub, so I would like it to have a carpet." (P17; male/38 years old/ drinking within safe limits). The furnishings and their wooden textures, and the blackboards with drinks and their prices were also seen as representative and realistic. "I like the place … the wooden columns, the chairs … it's all like cosy … The couple of barrels that were behind that door … the boards on top of the bar. The chairs are also sort of styling." (P21; male/28 years old/drinking past safe limits). The existence of glasses and bottles on the tables where virtual agents were sitting was

commented on in a positive way. "I think it was very realistic, like the pub environment, like there were tables. There were glasses on the tables." (P10; male/21 years old/drinking past safe limits).

3.2.2.2. Association of virtual agents with human behaviour and social drinking. The presence of virtual agents influenced the realism of the supermarket and the pub VEs, and the participants' temptation to drink. Some participants mentioned that seeing virtual agents in the VEs helped them feel more immersed. "… there were other like avatars [virtual agents] in the, in the room, which for me, like, added to the immersiveness." (P4; male/22 years old/drinking past safe limits). However, participants suggested that more virtual agents in either VE would increase their realism, as they would look busier as supermarkets and pubs would normally be. "If there were people there who were sort of chatting … like more organic, more representative atmosphere of what a pub looks like or feels like, then probably would have tempted me quite a lot to just like call a friend and then go to a pub, which even at this point I probably would have done." (P18; male/37 years old/drinking within safe limits).

Since participants humanised the virtual agents involved in the VEs, they also expected them to appear and behave correspondingly. In the supermarket VE, several participants paid attention to whether the two cashier virtual agents and the two customer virtual agents checking out the shelves were actually moving. Although the cashier virtual agents were static, this did not seem to influence the realism felt, "… it had people … the cashier people … I wouldn't change anything or add anything. It resembles reality to me." (P23; male/30 years old/drinking within safe limits). In contrast, in the pub VE, most participants believed that the bartender virtual agent was too static, decreasing realism and creating the impression that they were bored or not very friendly. "Maybe the avatar [virtual agent] of the woman in the bar, she seemed a bit static … but that made her like less realistic." (P8; female/29 years old/drinking within safe limits). Instead, they suggested that the bartender virtual agent be moving, as attending to clients and serving drinks would be the expected behaviour for this job role. "I understand that maybe she had a long day, but she looked bored. And she wasn't really willing to do anything or come over and ask us, are we OK for drinks? She wasn't pouring pints." (P17; male/38 years old/drinking within safe limits).

For the customer virtual agent in the pub VE (Fig. 12), some participants mentioned that improving his facial expressions, such as adding the action of smiling, would make him more realistic and engaging and less unfriendly. "… he was stiff and his face didn't move." (P9; male/26 years old/drinking past safe limits). Similarly, few participants added that the blinking and lip movements were not clear enough. "… this guy is just staring at me … not even blinking" (P18; male/37 years old/drinking within safe limits), "Maybe if he made any gestures like … his lips could move like clearly. I don't know if he did that, but I couldn't see clearly." (P22; female/24 years old/drinking within safe limits). Several participants further suggested that the way the customer virtual agent held the pint of beer from the handle of the glass was not realistic enough. "… the way he was holding the pint was kind of odd, right? … you don't hold the pint from the handle." (P18; male/37 years old/drinking within safe limits). Whilst some participants found that the ability to talk back to the virtual agents would complement realism, others believed that simple gestures on their behalf could bridge this gap. "I would like to speak back … you can express yourself … it will make it more like a complete realistic experience." (P5; male/28 years old/drinking past safe limits), "I think for me it wouldn't have mattered so much that I couldn't say anything back … it could be a little bit of body language to make up for a lot, I think, without saying anything." (P6; female/52 years old/drinking past safe limits).

Perceiving virtual agents as human led to participants associating them with feelings related to social interaction, even though they could not talk to them. More specifically, participants suggested that the presence of virtual agents in the VEs made them feel less alone while putting them in the mood to buy or drink more alcohol. "… more busy means more, let's say, energy, so it puts me in a better mood to have a good time later, which translates into buying more booze." (P17; male/38 years old/drinking within safe limits), "… in my mind … it's more about the social context than more about drinking because, well, to be fair, the one that makes us drink was the first one [social context]." (P1; male/42 years old/drinking past safe limits). Interacting with the customer virtual agent in the pub VE was thought by participants to further increase their alcohol temptation while affecting their emotions positively. "I like the interaction, …and I wouldn't find it tempting to drink on my own or without interacting with someone, so this interaction also makes me want to drink more, like to celebrate." (P5; male/28 years old/drinking past safe limits). The virtual agent offering to buy a pint to celebrate their new job was another element that participants endorsed, adding that it prompted them to feel happy and willing to share the virtual agent's joy. "I felt that it has, had this feeling when you're going out with a friend and they buy you a pint, especially if something good has happened, like finding a job, it brings like feelings of joy, feelings of sharing with the other person." (P8; female/29 years old/drinking within safe limits).

3.2.2.3. Immersiveness of background sounds. Participants considered background sounds as an important factor of realism in the VEs. They believed that sounds added to the immersiveness of the VEs, facilitating the sense of presence - that they were actually there. "… this is how I perceive the situation because you have the audio cues, yeah OK, I'm in this place now.'' (P9; male/26 years old/drinking past safe limits). The need to integrate sounds for every movement or action that would usually produce a sound in reality was also identified. "… the immersion would be total if you even listen to the sounds of what you're doing." (P23; male/30 years old/drinking within safe limits). A specific example was the sound of footsteps while the avatar of the participants was walking. "I didn't hear any footsteps." (P4; male/22 years old/drinking past safe limits). Similarly, participants commented on the existence of background sounds that would typically be present in corresponding VEs in a positive way, such as people moving in the supermarket aisles, the beep sound in the supermarket check-out or people's chat in the pub. "… you could hear the check-out beeping … I could hear people walking around … that was good." (P15; male/33 years old/drinking past safe limits), "I like the thing that you had always noise, you know, from people that were speaking inside the pub because it's really realistic." (P11; female/25 years old/drinking past safe limits).

However, in the supermarket VE participants believed that more announcements, music and the noise of more people shopping would increase its realism. "Supermarket music, keep things going on, more announcements, more frequently. Bit more of a noisier environment I think generally." (P6; female/52 years old/drinking past safe limits). In the pub VE, some participants suggested that adding more virtual agents would make the background noise of people chatting more believable as it would be synchronised with the visual representation of it. "I guess a few more people that would be, that would be in sync with the background noise." (P17; male/38 years old/drinking within safe limits). Moreover, adding music in the pub VE was thought by several participants necessary, whereas for others a typical pub wouldn't involve any. "I didn't hear any music because also when you go to a pub it's little bit rare … I would prefer, you know, the talks rather than music in a pub." (P11; female/25 years old/drinking past safe limits).

Specific sounds were seen to influence the craving for alcohol by immersing participants further into the situation presented in the VEs. For example, participants perceived the sound of glasses clinking in the pub VEs as well as the noise of people chatting as tempting. "… if you, you know, listen to glasses clinking. You say OK, this is a drinking place, I should drink now …", "Only with the sound of drinking and talking. You're like OK. I want a pint." (P9; male/26 years old/drinking past safe

limits)". In any of the VEs, adding the sound of the beer being poured was perceived as a trigger for inducing alcohol craving. Adding music was also considered by some participants to increase alcohol temptation due to the social association with it in the pub VE, "I am definitely more tempted in a social environment with music." (P23; male/30 years old/drinking within safe limits), or due to the personalisation it offers in the home VE, "It would make me want to go get a drink even more 'cause I would feel like it's home. It's homey, it's cosy, it's my music." (P22; female/24 years old/drinking within safe limits). In contrast, one participant noted that if a song played that they didn't like it would decrease their temptation to drink. "… if there was like a really bad song or if there was no if there was no music at all then I would be less inspired to drink." (P10; male/21 years old/drinking past safe limits).

3.2.2.4. Interconnection of lighting with time of day and ambiance. Lighting was another aspect that had an impact on the realism of the VEs, as it created the ambiance of the situation. Participants believed that dimmer lighting would increase cosiness in the home VE, as it would be in line with common, lighting preferences of people relaxing in their living rooms. "… it would seem more realistic … the lights were a bit like a hospital." (P22; female/24 years old/drinking within safe limits). However, in the supermarket VE, bright lighting was considered appropriate. "… it felt quite realistic, …that you have the intense light. So you can see each product." (P5; male/28 years old/drinking past safe limits). In the pub VE, dimmer lighting was again preferred as it recreated the relaxed atmosphere of pubs and bars, "… it wouldn't be that bright because usually you know pubs and bars have low lights." (P13; female/28 years old/drinking within safe limits).

Dimmer lighting was also associated with increased alcohol temptation in the home and pub VEs. Lower lighting would translate into cosiness and, in turn, into a relaxing atmosphere where alcohol would be consumed. "I would create my own cosy environment for a night … lights very dim … a plan to marry up with that beer.'' (P21; male/28 years old/drinking past safe limits). Linking lower lighting to night-time and, subsequently, to relaxation and entertainment at the end of the day, when most people drink alcohol, was another way that lighting impacted alcohol temptation. "I think it felt like this was probably like early in the day and I'm not someone who likes to go to the pub early in the day." (P20; female/31 years old/drinking within safe limits). In contrast, one participant linked bright lighting in the home VE to a sunny day which triggered his temptation to drink. "… it felt more like bright and colourful. And maybe I would translate it into more sunny. So I kind of make this association to drinking alcohol." (P5; male/28 years old/drinking past safe limits).

3.2.2.5. Association of smoking-related objects with drinking. Smoking-related paraphernalia seemed to influence not only the temptation to smoke but also to drink. In the supermarket VE, current or ex-smokers noticed the tobacco sales signage: "It makes it, you know, tempting to also buy cigarettes or the other way around. If you buy cigarettes you want to buy something, you know, a pint to drink." (P11; female/25 years old/drinking past safe limits). Similarly, including a pack of cigarettes in the pub VE and a lighter on the bar counter was seen by participants as important in recreating the pub experience, due to smoking being strongly tied to drinking alcohol. "… the pack of cigarettes too, it added to, I don't know, the pub feeling." (P4; male/22 years old/drinking past safe limits). Smoking was also largely connected to the desire to drink alcohol in the pub VE for participants who smoked either on a regular basis or socially, or for participants who have quit smoking. "… if you are a smoker, I mean the thing you connect most with alcohol is smoking … as soon as you drink a beer and you want a cigarette, and then you smoke and then you have a sore throat. And then you want more beer. And it's a positive feedback loop." (P9; male/26 years old/drinking past safe limits). However, participants who did not smoke reported no interest in the sight of cigarettes in relation to their temptation to drink. "I don't smoke so cigarettes wouldn't work for me." (P6; female/52 years old/drinking past safe limits).

3.2.3. Effect of the sense of presence

3.2.3.1. Projection of personal narrative. Participants projected their personal narrative to the VEs, creating a sense of inner presence. More specifically, the personal narrative of the participants influenced their interpretation of the VEs and, in turn, their thoughts about drinking alcohol. They projected their own drinking habits on to the situation, building an internal context as to why they were navigating the alcohol aisle in the supermarket VE, and leading them to feel more present in the experience. Some participants associated the visit to the supermarket VE with social events and entertainment like pre-drinking at a friends' house or parties. "It makes me feel like I'm either visiting a friend, so I'm getting some drinks, or whether it's pre-drinks or whether we're spending the night at someone's place." (P17; male/38 years old/drinking within safe limits). Others focused more on the act of buying alcohol because they were specifically drawn to one of the available options, but intending to consume it later, at a relevant point. "It was more about tasting like … there was a selection of different things … I was like, OK, what tastes the best or like? What am I in the mood for the most?" (P10; male/21 years old/drinking past safe limits).

Participants were also more tempted to drink in the VE that matched the usual location they would drink, be it their home or the pub. "… it's like being at home … you know I don't go out and drink anymore. My drinking I do at home." (P15; male/33 years old/drinking past safe limits), "… when I'm alone in the house, it's sad to drink alone. I wouldn't open a beer, but when you're in this social situation, …this is a place to drink [Pub VE]." (P9; male/26 years old/drinking past safe limits). Likewise, when their preferred alcoholic beverage was involved, they were more tempted to drink, particularly in the home and supermarket VEs. "… it's more tempting exactly when you do have the alcohol that you like the most in the in the shelf." (P1; male/42 years old/drinking past safe limits). However, in the pub VE this was not the case, as most participants explained that beer was the most appropriate drink in that setting, even if, for some, it would not ultimately have been their preferred alcoholic beverage. "… so it's really a more social environment, like beer matches that context for me." (P21; male/28 years old/drinking past safe limits). The decision to accept the pint offered by the customer virtual agent in the pub VE arose for most participants from a feeling of obligation to abide by the cultural norms of accepting a drink when it is offered, out of politeness. "… it is because of my cultural framework … but whenever someone offers me a drink. I should take it." (P1; male/42 years old/drinking past safe limits).

The time of the day was perceived as an additional factor that affected participants' immersion and their subsequent temptation to drink. This was influenced by when they would usually visit corresponding places in real life. "… one week you might feel that you want to drink and then the week after that you are not. I'm replying as I feel today, right now, right?" (P21; male/28 years old/drinking past safe limits), "… when I think of pubs I think of like going on a Friday afternoon after work with your colleagues. And just like having one or two drinks." (P20; female/31 years old/drinking within safe limits). The COVID-19 pandemic and the associated social restrictions were further determinants of whether the VEs were engaging and tempting. In particular, participants experienced feelings of happiness and nostalgia, and, in turn, the temptation to drink since they had not visited a pub for a long time. "It reminded me of fun times that you can go wild and everything, and I was feeling a bit happy as well." (P14; male/31 years old/drinking past safe limits), "… it reminded me the good old times … You know, just go to a pub and drink a couple of pints and you know just have some fun with your friends." (P11; female/25 years old/drinking past safe limits).

3.2.3.2. Association of self with VR hands

The VR hands that were used to visually represent the movement of controllers, through which navigation and interaction with objects is technically possible in VR, affected the overall realism and spatial presence felt by participants. The "gloves" texture (Fig. 2) was employed across all three, alcohol cued VEs, as it was the default option for the 'HTC VIVE Pro' VR setup. While none of the participants found the hands realistic, some were not worried about their appearance, suggesting that they only paid attention to them at first and then focused solely on the experience. "… it was very neutral for me. I mean only at the beginning of the video I would notice the hands, but then I would focus on the environment and I would stop seeing them at all …" (P7; female/26 years old/drinking within safe limits), "I don't think the gloves would necessarily destroy anything, I just think it looks better without the gloves." (P19; male/65 years old/drinking past safe limits). In contrast, some participants believed that personalisation of the VR hands was necessary, to look like human hands, or, optimally, to match the skin colour and gender of the user. "I think it would just be a thing that would make it easier for me to find it immersive. If they were roughly looking my hands." (P3; female/54 years old/drinking past safe limits). This was considered to fit better with the photorealistic style of the VEs. "I would have preferred human hands … You can wear gloves in games, but it looks a bit, a bit robotic, a bit futuristic." (P15; male/33 years old/drinking past safe limits).

In addition, a few participants noted that, in some instances, they felt disembodied. This was attributed to the fact that the hands were wearing gloves, they did not expand visually to form forearms and they would occasionally disappear. "It was the fact that the virtual reality gloves, they kind of disappeared for a bit and also like they didn't have forearms." (P2; male/31 years old/drinking within safe limits). However, they also acknowledged that if they were trying VR in reality and were in control of the hands, this might have decreased the sense of disembodiment perceived through the videos. "I think this may have been completely different if I was actually in control of those hands, that may have made it very different." (P18; male/37 years old/drinking within safe limits). Several participants further explained that grabbing the objects with the VR hands was not realistic enough, as the fingers of the hand did not precisely touch the object grabbed. "… the hands weren't touching the lighter." (P22; female/24 years old/drinking within safe limits). Other participants found the ability to grab objects realistic regardless, as they felt the urge to interact with objects as they would do in real life. "… you can feel like you get to hold kind of something. So it felt more like real. I like it." (P5; male/28 years old/ drinking past safe limits), "Also I could pick up stuff … My brain wanted to be able to pick up stuff." (P4; male/22 years old/drinking past safe limits).

4. Discussion

This study assessed three, alcohol cued VEs that represented daily, high-risk settings - a home, a supermarket and a pub - where individuals in recovery might struggle to remain abstinent. The objective was to determine their potential to be realistic and tempting in a less immersive, cost-effective VR setup, and, subsequently, their relevance for use in clinical practice for RP. Participants were casual (n = 10) or high-risk (n = 13) drinkers. Key factors of realism and alcohol temptation, as outlined via the template analysis, were the proximal and contextual cues, and the sense of presence within the VEs. Almost all high-risk drinkers experienced temptation to drink alcohol in any VE, while casual drinkers were mostly tempted in the socially interactive pub VE. Animated alcohol cues were considered more tempting than static ones. The action of drinking in the first-person perspective facilitated a strong alcohol temptation. Smoking temptation was elicited via related cues and affected alcohol temptation. Realism and alcohol temptation were further increased by sounds and interactivity, while personalisation in

the home VE was thought to facilitate them. Participants' personal narrative and the user's reaction to the VR hands were determinants of presence.

The cost-effective VR setup of the study involved exposure to the VEs via videos presented on a 2D computer screen, which displayed the navigation within the VEs in a first-person perspective. Similar, less immersive VR setups, like stereoscopic monitors or one-screen projection displays, were able to elicit the desired response, be it anxiety, fear or craving, in VRT studies focusing on social anxiety, phobias and substance use disorders treatment, respectively (Ling et al., 2014; Ghiţă & Gutiérrez-Maldonado, 2018). Where comparisons were made to more immersive VR setups, like a HMD, lower levels of presence were reported, but in clinical samples the elicited response didn't differ significantly (Ling et al., 2014; Ghiţă & Gutiérrez-Maldonado, 2018), indicating the therapeutic potential of such VR set ups. In line with previous research utilising less immersive set ups (Ghiţă & Gutiérrez-Maldonado, 2018), alcohol temptation and realism were reported by participants. Interestingly, realism was manifested dually; as visual-auditory or physical, in terms of the graphical and auditory fidelity of the VEs to the corresponding, real-life ones, and as psychological, involving the relevance of the VEs to participants as situations that they could experience in reality. This distinction of realism has been discussed in reviews about the clinical effectiveness of VRT, suggesting that psychological realism could be the more critical for patient engagement (Hoorn et al., 2003; Slater et al., 2020).

Due to the current VR setup, assessment of physical realism was limited to the quality of the proximal and contextual cues rather than the immersion and the sense of spatial presence offered. In contrast, psychological realism was widely assessed, with participants reporting a sense of inner presence in the VEs. Exposure to the current VEs via a HMD could have increased the sense of spatial presence and enhance the level of inner presence felt within the VEs, eliciting a stronger physiological and emotional response, while also increasing alcohol temptation. This, however, would be subject to the degree of the visual-auditory realism achieved via the HMD, since previous literature suggested that only high fidelity, audio-visual cues would evoke virtually responses identical to the ones experienced via exposure to corresponding environments in real life (Loomis, 2016).

Previous VRT studies in alcohol misuse have reported that healthy participants were more tempted by social pressure contexts than alcohol stimuli per se, and the opposite was found for alcohol dependent participants (Ghiţă & Gutiérrez-Maldonado, 2018). While quantitative comparisons in the alcohol temptation elicited by distinct cues were not made in this study, casual drinkers similarly found the socially interactive scenario of the pub more tempting than the other, non-socially interactive VEs whilst high-risk drinkers were tempted in all three VEs. Proximal cues in all VEs and social pressure in the pub VE were viewed as the most tempting elements. Animated proximal cues (video of beer being poured, fizzy beer, alcohol being served) were perceived as more tempting than static representations of alcohol (alcohol bottles, leaflet with drinks). The action of drinking was considered highly tempting by participants. Some participants suggested that if the feature of somebody drinking alcohol on TV, or in other entertainment media, was added in the home VE, it could create the urge to imitate this action, due to empathising. Similarly, the action of drinking a pint of beer in the first-person perspective in the pub VE triggered strong alcohol temptation. A previous VRT study with smokers has also reported that exposure to a virtual pub with enactment of virtual smoking evoked higher craving than without (Hone-Blanchet et al., 2014). In the current study, temptation to smoke was also elicited by relevant cues in social, regular or former smokers, agreeing with previous literature (Hone-Blanchet et al., 2014; Trahan et al., 2019), and was associated with alcohol temptation, suggesting the potential of the A-PLAN VEs for regulating alcohol and smoking craving in individuals with co-dependency.

In the supermarket and pub VEs, participants instinctively humanised virtual agents. This affected the realism felt, as they compared the

virtual agent interactions with those expected of humans. Not having the ability to talk back emerged as a drawback but some participants suggested that body language and non-verbal cues, such as the virtual agent having facial expressions or smiling, could have counterbalanced this. Similar research has shown that non-verbal cues had a greater effect on the social presence experienced by participants than a realistic virtual agent appearance (Roth et al., 2016). Having photorealistic virtual agents also increases the chances of the 'uncanny valley' effect, according to which virtual agents that would nearly resemble humans would be perceived as uncanny - causing a feeling of eeriness (Pan & Hamilton, 2018). Interaction with virtual agents was also linked to social drinking and emotions triggered by social interactions, increasing participants' alcohol temptation. Previous studies of diverse contexts have shown that participants behaved and responded emotionally to human avatar and human virtual agent interaction similarly to corresponding human interaction (de Borst & de Gelder, 2015). This suggests the potential of VR for use in RP contexts where emotional regulation and avatar or virtual agent interaction would be relevant (e.g., an argument scene or a family fight).

Another factor in realism and alcohol temptation was sound. Background sounds relating to the visual content of the VEs were considered to improve physical realism and increase immersion. Previous research about immersion and sound has also indicated that, assuming a VR application featured a sophisticated sound design, sounds would be perceived in the VE in the same way as in real life, facilitating spatial awareness (Loomis, 2016; Poeschl et al., 2013). Similarly, sounds have been shown to enhance physical realism in VEs, by replicating to a greater degree corresponding, real-life situations (McRoberts, 2018; Poeschl et al., 2013). Alcohol-related, auditory cues (glasses clinging, beer pouring) also increased the alcohol temptation of participants here, agreeing with the findings of previous studies with alcohol-dependent participants (Heinze et al., 2007; Qureshi et al., 2018). Some participants associated listening to their preferred music genre or songs with increased alcohol craving and vice versa. Likewise, an increase in the craving of alcohol dependent participants was reported when listening to their chosen song in a previous study (Short & Dingle, 2016), highlighting the importance of relevance for engagement with cues.

Relevance of drinks offers affected participants' responsiveness in the home and supermarket VEs. Some participants were tempted by them, having internalised them as positive by relevant life experiences, while others perceived them as negative, having associated them with binge drinking and alcohol of low quality. However, a few of the participants who viewed offers negatively, reported that they would be tempted by these offers if their favourite drink was involved. Marketing strategies such as multi-buy offers and lowered prices on drinks have been linked to increased alcohol purchasing and consumption in both adults and adolescents (Hurtz et al., 2007; Wagenaar et al., 2009). While previous VRT studies in substance misuse have not considered the effect of alcohol promotions (Ghiţă & Gutiérrez-Maldonado, 2018; Hone-- Blanchet et al., 2014), in this study, branding was also investigated. Participants identified alcohol brands by the bottle shape, even with altered names. For some participants, recognising the brand promoted a feeling of trust in the alcohol quality, increasing alcohol temptation. For others, seeing the actual brand name was thought necessary to facilitate authenticity and trigger alcohol craving. However, as depiction of brands would not be possible due to copyright issues, imitating the bottle shape appeared to be a valid alternative for referencing the real-life brand in therapeutic VEs. This would be important for addressing craving induced in vending contexts, as promotion of alcohol brands is becoming digitalised and mediated by the daily use of social media (Carah & Brodmerkel, 2021; Lobstein et al., 2017). Such alcohol promotions have been linked to increased alcohol intake and binge drinking, and often target younger individuals, who are regular users of these platforms, through illicit marketing strategies (Lobstein et al., 2017).

Inner and spatial presence within the VEs was mediated through the projection of participants' personal narratives on the VE and the perceived embodiment via the visual representation of the VR hands, respectively. In the first instance, participants projected their own interpretation of why they were navigating each VE, creating a context that guided their thoughts about drinking and realism of the VEs. This involved approaching the VEs according to their preconceptions of how such environments would look like in reality and the context in which they would typically be in them. Personalisation was important in the home VE, as psychological realism was necessary to believe it was one's own home and induce the temptation to drink in it. This might explain why it was reported to be the least tempting VE. As the supermarket and the pub VEs were public spaces, personalisation was not identified necessary for psychological realism and alcohol temptation, and participants used their personal narrative to bridge the gap of unfamiliarity. This suggests that VRT could assist in RP of those who drink at home if personalisation was applied, whereas for public VEs personalisation would not be needed.

Projecting a personal narrative on the VEs triggered associated emotions in participants, as they approached each VE with a specific mindset. The connection of presence and emotional involvement is supported by studies focusing on virtual presence in clinical settings (Diemer et al., 2015; Gromer et al., 2019). The projection of personal narrative on the VE was also linked to the feeling of presence in social VEs with avatars and virtual agents (Riches et al., 2019). In these social VEs, aspects such as memories, previous experiences, social judgement of oneself and emotions were seen to influence perceived presence (Riches et al., 2019). Correspondingly, in the current study, during social interactions with virtual agents, participants reacted based on their own systems of beliefs and backgrounds. For example, accepting the offered pint through politeness or always exploiting a free drink were reasons that prompted participants to drink in the pub VE. This indicates the suitability of VRT for developing refusal skills in a more personalised and targeted manner, especially for those who struggle in social settings, due to the fact that social pressure is a common, high-risk situation. Interestingly, the projection of personal narrative was expanded in multiple aspects of the VEs, suggesting that individuals' virtual reactions were similar to their real-life ones. From a neuroscientific perspective, relevant literature also interpreted presence as a transfer of consciousness into the virtual self, where the virtual stimuli are perceived personally and trigger corresponding reactions (Sanchez-Vives & Slater, 2005).

The presence of participants' self spatially was mediated by the visual model of the VR hands. Absence of forearms visually, and inconsistency with the expected behaviour in the movement of the hands and in the grabbing of objects were considered elements that decreased the sense of embodiment, and, in turn, presence. This was also reported in previous studies about virtual embodiment and presence, with the former increased when a complete body was used virtually to represent the physical body of participants, instead of hands alone (Sanchez-Vives & Slater, 2005). Nevertheless, personalisation of the virtual hands' appearance was not considered largely important, with more weight given to the refinement of interactions, like the grabbing of objects or talking back to the virtual agents. These interactions were seen to be critical for enhancing realism and immersion rather than presence alone, underlying their strong interconnection in virtual settings.

5. Limitations and strengths

The VEs were assessed in a less immersive, VR setup. While the cost-effectiveness of this approach would be beneficial for its clinical application in alcohol treatments, participants' views might have differed had they been exposed to the same VEs in a more immersive VR setting. In addition, not all participants were high-risk drinkers and they were not assessed clinically for alcohol dependency. This might have affected the degree of temptation experienced or caused other differences regarding attention to cues. However, variety in the drinking levels of

participants offered a greater insight into and indicated the relevance of these VEs for people with diverse levels of alcohol misuse issues who may seek treatment, even if alcohol dependency does not apply.

The majority of the sample was male (65%). This might have biased the results gender-wise, however, inclusion of female participants (35%) was still important. Previous studies of VR in alcohol misuse have mainly recruited males (Trahan et al., 2019), highlighting the need for assessing VRT's effect on females. While some studies suggest that being male was a facilitator of presence and a protective factor for cybersickness (Felnhofer et al., 2012; Melo et al., 2018; Schwind et al., 2017; Shafer et al., 2017), the causality of this was not clear. The possibility of this being attributed to increased familiarity of males with technology, especially in video gaming contexts, was suggested in these studies, as prior video game and VR experience were positively correlated with presence and negatively with cybersickness (Felnhofer et al., 2012; Shafer et al., 2017). In this study, more than half of the participants (60.8%) had used VR before, which indicates that their views were informed regarding the potential of VR to be realistic and immersive. The qualitative nature of the study allowed diverse and detailed aspects to emerge, as participants were interviewed in an unstructured manner, and provided thorough accounts of their dominant thoughts and associated reactions. This also facilitated the interconnections of realism, alcohol temptation and presence in these VEs to emerge profoundly, leading to the formation of a distinct theme about presence, not otherwise possible.

Specific elements of the VEs of this study have not been explored before by VRT research. In particular, a supermarket VE has not been assessed previously for its potential to elicit alcohol temptation, despite being identified by substance use practitioners as a high-risk situation (Skeva et al., 2021). Indeed, supermarkets constitute high-risk places that most people would inevitably visit to buy groceries or other essentials, where alcohol would typically be largely available. Other aspects linked to buying alcohol such as branding, advertising and marketing strategies like multi-buy offers have not been investigated previously and are common, tempting factors in vending contexts or on platforms where advertising applies. Likewise, this is the first study to examine representation of brands in therapeutic VEs, avoiding issues with copyright while eliciting the associated alcohol temptation.

Future research on the acceptability and effectiveness of VRT applications in alcohol treatment should involve more female participants, to investigate potential gender differences in preferences, the sense of presence and cybersickness. Prior experience of VR and video gaming should also be taken into consideration to determine its interconnection with VRT preference, presence, cybersickness and gender. Involvement and assessment of VEs that simulate alcohol vending stores and online shopping experiences should also be addressed by future studies for the alcohol RP of people in recovery and, specifically, adolescents who are regular users of social platforms and targets of embedded alcohol promotions. Assessment of the alcohol cued VEs in VR setups of diverse immersiveness would provide further evidence about the potential of less costly VR equipment to induce presence and alcohol craving while achieving realism, determining their therapeutic value in alcohol treatment and, particularly for RP. The level of personalisation required for VRT to be effective should additionally be investigated, in terms of the appearance of avatars, virtual agents and the user's VR hands, as well as the VE itself, be it private or public.

6. Conclusion

Twenty-three regular drinkers assessed the alcohol cued VEs of a home, a supermarket, and a pub on their potential to induce realism and alcohol temptation in a cost-effective VR setup. Factors of the realism and the alcohol temptation were the proximal and contextual cues, and the sense of presence within the VEs. Animated, alcohol cues, including drinking in the first-person perspective, were considered more tempting than static ones. Smoking temptation was elicited via smoking-related

cues which linked to alcohol temptation. Realism was manifested as physical, involving the audio-visual fidelity of cues, and as psychological, involving the relevance of cues to the participants' lives. Physical realism was a facilitator of the spatial presence and psychological realism of the inner presence felt by participants. Personalisation of the home VE was thought necessary to increase alcohol temptation and realism. In the public VEs (supermarket, pub), projection of participants' personal narrative counterbalanced the unfamiliarity with them. Participants' personal narrative influenced presence and alcohol temptation generally and particularly relating to alcohol brands, drinks offers and social interactions with virtual agents. These VEs could be relevant for people who want to practise (1) coping with alcohol and/or smoking craving, and (2) emotion regulation, in private (home), social (pub) and vending (supermarket) contexts, and (3) refusal skills in social (pub) contexts. These findings could also inform the design of other VRT applications for alcohol treatment, from the perspective of ways to increase realism and levels of induced craving.

Declaration of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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