Gamified Cognitive Bias Modification for Treating High Alcohol Consumption

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Abstract

Background. High alcohol consumption is a global problem and treatment may benefit from using technological innovations such as implementing video game elements. This study uses a virtual reality-based cognitive bias modification (VR-CBM) game designed for university students in order to combat cognitive biases linked to alcohol use. **Aims**. This study aimed at assessing the effectiveness of an originally designed game to reduce alcohol consumption in university students. This VR-CBM game integrates techniques used in treatment to modify underlying tendencies which are related to alcohol consumption. Additionally the relationship between the effectiveness of the game and personality traits that predict substance abuse was analysed. **Methods**. Eighteen university students underwent two experimental sessions. Measures included the Alcohol Use Disorders Identification Test (AUDIT), Approach-Avoidance Task (AAT), and Implicit Association Test (IAT). To measure the personality traits, the Substance Use Risk Profile Scale (SURPS) was used. **Results.** A marginally significant decrease of alcohol consumption was found. Although measured biases did decrease, it was not statistically significant. Only the personality traits Hopelessness and Impulsivity were found to marginally predict the effectiveness of the game and only for the IAT measurement. Hopelessness predicted improvement after the game and Impulsivity worsening after the game. **Conclusion**. The VR-CBM game shows potential in helping combat high alcohol consumption by reducing corresponding biases.

Introduction

Millions of people around the globe suffer from abusing alcohol (World Health Organization, 2024). It is one of the leading factors contributing to a large number of injuries and deaths every year, not only self-inflicted but also damaging and bystanders through tragedies such as drunk driving accidents or alcohol-induced aggressive behaviour (World Health Organization, 2024). But a very specific group that is often found to have a problematic relationship with alcohol are young adults (Ranker & Lipson, 2022). The World Health Organization points out 13% of deaths that can be attributed to alcohol were people between the ages 20-39, making it the most affected group (World Health Organization, 2024). The start of an abusive relationship with alcohol at this age has been observed to continue throughout their lives, carrying with it several issues related to alcohol such as higher levels of mental health distress and symptoms (Caldwell et al. 2002). While the main form of treatment for alcohol abuse is cognitive behavioural therapy, another form of intervention is the cognitive bias modification (CBM) (Wiers et al., 2010). This form of intervention aims at modifying underlying tendencies the patient has towards alcohol, through the use of specifically designed and repetitive tasks the patient is instructed to do (Cristea et al., 2016). Despite the success of the common treatments and CBM techniques, modern research is eager to find potential benefits of new technologies to make treatment more effective. One such explored technology is Virtual reality (VR), which promises beneficial features that may aid conventional treatment (Ghiţă & Gutiérrez, 2018). One such advantage that may improve treatment is the creation of immersive 3D environments and scenarios that mirror real life situations in which addiction triggers appear (Mazza et al., 2021).

1.1 Dual Process Model & Cognitive Biases

As mentioned, CBM techniques are used in treatment to modify underlying tendencies the patient has towards alcohol. These tendencies are referred to as cognitive biases and can be explained with the dual process model, a model that describes how thoughts arise in the mind (Norman et al., 2017). Both cognitive biases and the dual process model have been observed to play a part in addiction development and perpetuation (Fleming & Bartholow, 2014). Cognitive biases are distortions in the perception of an individual in comparison to the actual reality. These distorted perceptions may influence behaviour and decision making, and have been identified as factors in the development of addictions (Noworyta et al., 2022). In the perpetuation or development of addiction or substance abuse, a variety of cognitive biases are present such as the immediate gratification bias or the negative self bias. The former entails the human gravitation towards pleasurable activities despite long term effects such as drug use, the latter is the tendency of addiction prone individuals to view themselves in a negative way, drugs are taken in order to change one's self-perception (Bowler et al., 2011). Additionally, implicit association has been linked with alcohol abuse in university students (Ostafin et al., 2006). Implicit association describes how two concepts are cognitively associated, for example how Paris is connected with romance or alcohol with something positive, in the case of alcohol abuse.

The dual process model aims to explain how thoughts can arise in the mind: Either through an implicit, automatic, unconscious, faster route or through an explicit, controlled, conscious, slower route (Fleming & Bartholow, 2014). The faster route is often referred to as system one and is further described as intuitive. The slower route is often referred to as system two and monitors cognitive processes by scanning for biases and stopping automatic responses when necessary (Kahnemann, 2011 & Miyaki et al., 2000). In the context of alcohol abuse and addiction it is described that the automatic route becomes trained through repeated exposure to

respond to alcohol stimuli in a faster way, thus a cognitive tendency to respond faster towards alcohol stimuli can be observed (Fleming & Bartholow, 2014). An explored way of managing and treating cognitive bias towards alcohol, through the use of the dual process model, has been the cognitive bias modification (Wiers et al., 2013).

1.2 Cognitive Bias Modification & VR Treatment

One form of treatment that has been established is the cognitive bias modification (CBM). CBM makes use of technology with the aim of accessing and changing the underlying bias of an individual. In the case of alcohol abuse, CBM aims to change the patient's bias away from alcohol, towards neutral stimulus (Wiers et al., 2013). Research incorporating these techniques suggests that retraining automatic actions, such as approaching stimulus linked to alcohol, does lower relapse rates and alcohol cravings. This is done by targeting the underlying mechanisms and automatic inclinations of a cognitive bias (Wiers et al., 2011).

There are two central techniques that can be found within the realm of CBM, approach-avoidance bias (AAB) and attentional bias (AB). AAB is defined by the tendency of an individual to approach a cue that is connected to a specific behaviour. In the case of someone with an alcohol abuse problem, the individual would rather approach a stimulus connected to alcohol rather than a neutral stimulus (Watson et al., 2013). AB is defined by an individual's tendency to pay more attention to stimulus connected to a specific behaviour rather than neutral stimulus (Williams et al., 1996). In the case of alcohol abuse, the individuals pay more attention to stimulus connected to alcohol rather than neutral stimulus, for example a bottle of alcohol versus a bottle of water. Both these biases are usually measured using implicit tasks, designed to measure if a bias is present and how intense it is.

Since alcohol abuse is prevalent in younger groups such as university students, incorporating elements from video games, a medium that is generally enjoyed by a younger audience, is a possibility that has been researched as well (Boendermaker et al., 2015). It has been concluded that existing or proposed CBM tests with gaming elements are lacking in terms of enrichment and engagement as compared to conventional video games, as well as being outright boring and inducing fatigue (Geerts et al., 2023) This dullness may as well have a detrimental effect on the adhesion and effectiveness of treatment using CBM. The dullness of conventional CBM tasks especially is a point of critique because university students as young people show less willingness to actually change their drinking behaviour (Lowinger, 2012). Recent research in the realm of physical rehabilitation does suggest that designing therapies with gaming elements, such as using a video game controller with motion control, may benefit due to higher engagement resulting in higher adhesion of the treatment (Lohse et al., 2013). This indicates that creating CBM techniques incorporating or being made up out of video game elements may have a beneficial effect in terms of treating alcohol abuse and managing relapse rates and cravings due to the heightened immersion or engagement (Lohse et al., 2013). Game elements that can be incorporated within an intervention include rewards, difficulty that rises with the player's mastery of the game, interactivity, feedback, clear goals or even socialisation features (Lohse et al., 2013).

1.3 Personality

An important factor that influences substance abuse and its perpetuation is personality. The relationship between personality and substance abuse has been very well documented, not only is it known which personality traits may influence one’s attitude towards drug use and

potential abuse (Boogar et al., 2014) but also the preferred type of drug (Hokm Abadi et al., 2014). Research has also been very clear in regards to alcohol abuse and personality. Different personality traits can have an effect on the likelihood of abusing alcohol, be it either high neuroticism, the personality trait related to negative emotion, low agreeableness or low conscientiousness, the trait related to diligence and responsibility (Loukas et al. 2001). But also high impulsivity and sensation seeking scores indicate potential alcohol abuse. (Skóra et al., 2020). Furthermore, personality has also been linked with the amount of alcohol consumed (Hakulinen et al., 2015). High extraversion and low consciousness has been found to be predictors of high alcohol consumption (Hakulinen et al., 2015). One questionnaire to assess the relationship between one's personality and substance use risk is the Substance Use Risk Profile Scale (SURPS), it contains four personality dimensions, hopelessness, anxiety sensitivity, impulsivity and sensation seeking (Woicik et al., 2009). These four personality traits showed to be reliable predictors of potential substance abuse, further cementing the connection between personality and substance abuse. Additionally, personality traits have been found to be predictive of treatment engagement and adherence (Kruisdijk et al., 2020), with the trait agreeableness having the most positive influence (Kruisdijk et al., 2020). Observing personality traits may give insightful information that could be used when designing future treatments, these treatments could be designed to be more personalised and more accurately adjusted based on the patient's personality. For example, when designing a treatment that uses high sensory immersion and interaction such as the VR game, personality traits such as sensation seeking or impulsiveness may have a positive effect on adherence and engagement due to the interactive nature of the VR game. This may result in a positive influence on the bias modification, possibly yielding more positive and significant outcomes due to the personalisation.

1.4 Research Aim

Considering the evident dangers of alcohol abuse (World, Health Organization, 2024), the positive results of CBM treatment (Wiers et al., 2010), as well as the potential benefits of integrating gaming elements into treatment (Lohse et al., 2014 & Boendemakers et al., 2015), this study aims at exploring the effectiveness of a VR video game that integrates CBM techniques. The CBM techniques will be designed with the goal of reducing implicit biases towards alcohol in high alcohol consuming younger adults. More specifically the question is asked: Does participation in a VR-based gamified CBM intervention lead to a decrease in approach-avoidance and attentional biases toward alcohol among university students, leading to a decrease in alcohol consumption?

Taking into account the increased risk of substance abuse as well as the amount of alcohol consumed that can be predicted by certain personality traits, this points out personality traits as a factor that has to be considered as potentially influencing the effectiveness of the intervention. Therefore, the secondary aim of this study will be to explore to what extent the results of the intervention can be predicted by personality traits linked with substance abuse.

Methods

2.1 The Experiment & Variables

This study used an experimental design to examine the effect of VR-CBM on alcohol-related behaviour using a within subject analysis. The independent variable (IV) was the

exposure to the VR-CBM game, which was done over two sessions, called day one and day two. The IV for the subquestion of this study were the four scores of the Substance Use Risk Profile Scale (SURPS), which measured personality dimensions associated with substance abuse, the four scores correspond with the personality traits. The dependent variable (DV) includes the results of the AAT, IAT and the Alcohol Use Disorders Identification Test (AUDIT). Both the AAT and IAT, which measured changes in cognitive bias, used a D-score. The AUDIT measures the severity of alcohol consumption behaviour with a total score.

2.2 Participants

20 participants took part in this study (13 men, 7 women). The participants were selected through the researcher‘s social circle, snowball sampling as well as the SONA website provided by the university which allows for volunteers to participate by signing up without being addressed by the experimenter. Participants that signed up through SONA gained 4.5 credits on the website. Originally, university students with a self-reported high alcohol consumption were asked to participate, this meant eight standard units of alcohol per week for females and thirteen units for males. Because many possible participants were unsure about their alcohol consumption it was broadened up to university students with any kind of alcohol consumption. A control group was not present due to lack of time.

2.3 General Materials

Several materials were used over the course of this study. The hardware for the gamified VR CBM was the Meta Quest 2 VR headset by Meta. For data analysis the program RStudio was used in order to use the statistical programming language R. All of these named materials and the

following, were displayed and handled using a Computer with a keyboard and mouse. The whole experiment was conducted inside a neutral room, provided by the university. The participants were monitored using CCTV equipment.

2.4 AUDIT

To measure potential problematic alcohol consumption, the AUDIT was used. The AUDIT is a 10-item self screening tool developed by the World Health Organization (Saunders et al., 1993 & Saunders et al., 2001). The scores of the items are added together, resulting in a total score ranging from 0 to 40. A score range of zero indicating abstention, from one to seven suggesting low-risk consumption, eight to 14 indicating hazardous or harmful alcohol use, and 15 or higher pointing to probable alcohol dependence. The AUDIT is globally used (Saunders et al., 1993 & Saunders et al., 2001) due to its stable psychometrics and effectiveness in measuring risky behaviour even in diverse settings (Reinert & Allen, 2007). The questionnaire was conducted using the Qualtrics online survey software.

2.5 AAT

The AAT is used to measure underlying tendencies towards specific stimuli in the form of approaching or avoiding. Pressing the button “T”shrinks the image and pressing the button“B” enlarges it. Shrinking means avoiding the stimulus and enlarging means approaching the stimulus The participants are instructed to avoid images in landscape format and approach images in portrait format. In the context of this study, pictures of alcoholic drinks or sodas were shown. The strength of the underlying bias is represented by the D-score, based on reaction speed and accuracy of the responses. A negative and low score means a faster avoidance than

approach and a positive and high score means a faster approach than avoidance. In other words, a stronger bias towards alcohol. The AAT task was conducted on the Inquisit Lab 6 program, which is made by Millisecond and takes roughly six minutes to complete.

2.6 IAT

The IAT is a sorting task used to measure implicit associations and preferences. This is done by measuring the reaction time when sorting terms and visuals to one of two categories which are made up out of two subcategories. The subcategories are “good” or “bad” and are combined with either “alcohol” or “soda”. Thus, the two categories to sort the items to can be for example, “good or soda” and “bad or alcohol”, or vice versa.. To sort the items one of two keyboard buttons, representing the two categories, has to be pressed. The IAT consists of practice rounds and two test blocks for the alternating categories. The D-score indicates the measured intensity of the associations. A negative and low D-score indicates a stronger implicit association for “good or soda” and “bad or alcohol”, while a positive score indicates a stronger implicit association for “good or alcohol” and “bad or soda”. The IAT takes about 5.5 minutes to complete and is also done with the Inquisit Lab 6 program.

2.7 SURPS

Personality traits related to substance abuse were measured using the SURPS questionnaire. This questionnaire consists of 23 items that measure four personality dimensions linked with a higher risk of substance use (Woicik et al., 2009). These dimensions are Hopelessness ,measured by seven items. Impulsivity, measured by five items. Anxiety sensitivity, measured by five items. Lastly, Sensation seeking, measured by six items. The items

are answered on a four-point Likert scale, ranging from 1 to 4, strongly disagree to strongly agree. The scores are added up to total scores for each personality dimension. The SURPS was found to have stable validity and reliability, and praised for being brief yet sensitive (Schlauch et al., 2015 & Long et al., 2018).

2.8 Gamified VR-CBM & Gameplay

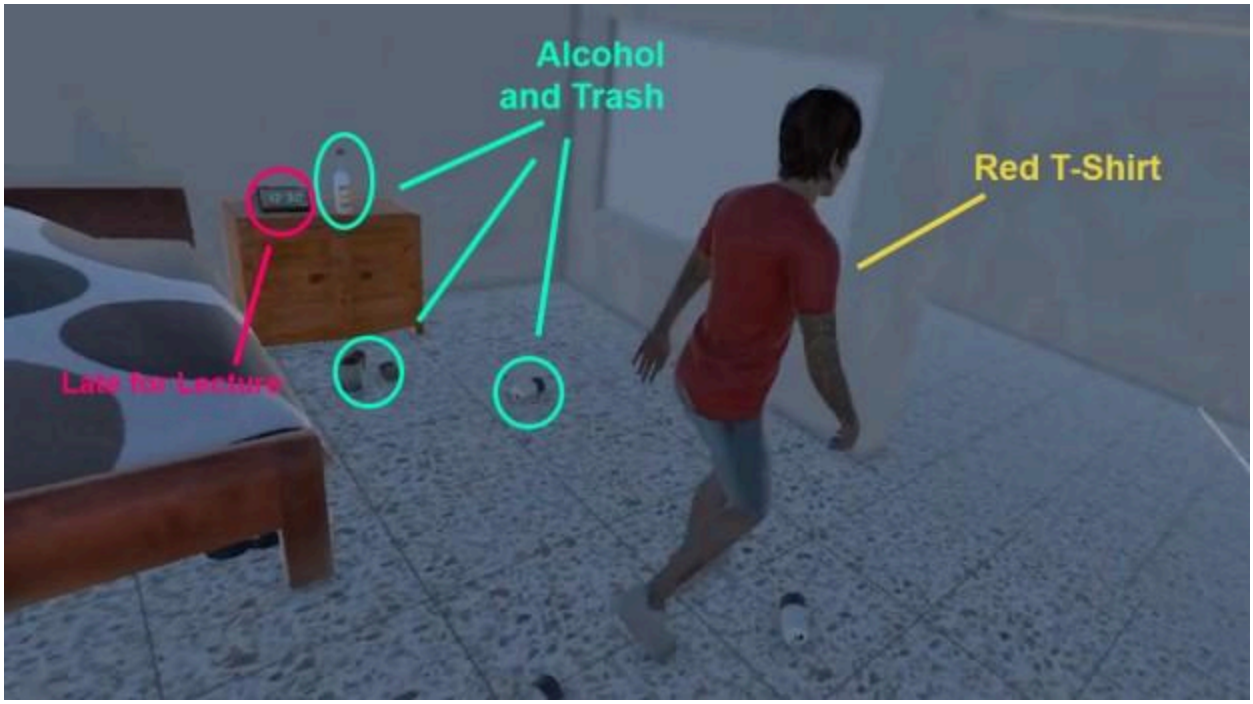
The VR game was made in the game engine program Unity, version 2022.3.19f1, using the XR Interaction Toolkit. The assets out of which the game consists, were either made in-house or taken from "Sketchfab", a 3D asset website. In the gamified VR CBM task, the participants followed two days of a university student called Alex who wakes up after consuming a large amount of alcohol as per usual. During these two days, the participant had to face Alex's daily tasks which were related to alcohol consumption. What the participant had to do for each task was always presented as a text message on the phone of the character.

Day 1

At the beginning of the first in-game day, the protagonist wakes up in a bedroom filled with empty beer cans and being generally messy (Figure 1). His hangover is illustrated through voice acting lines, complaining about his condition, subtly implying the effects of excessive drinking.

Figure 1

Day One: Waking Up

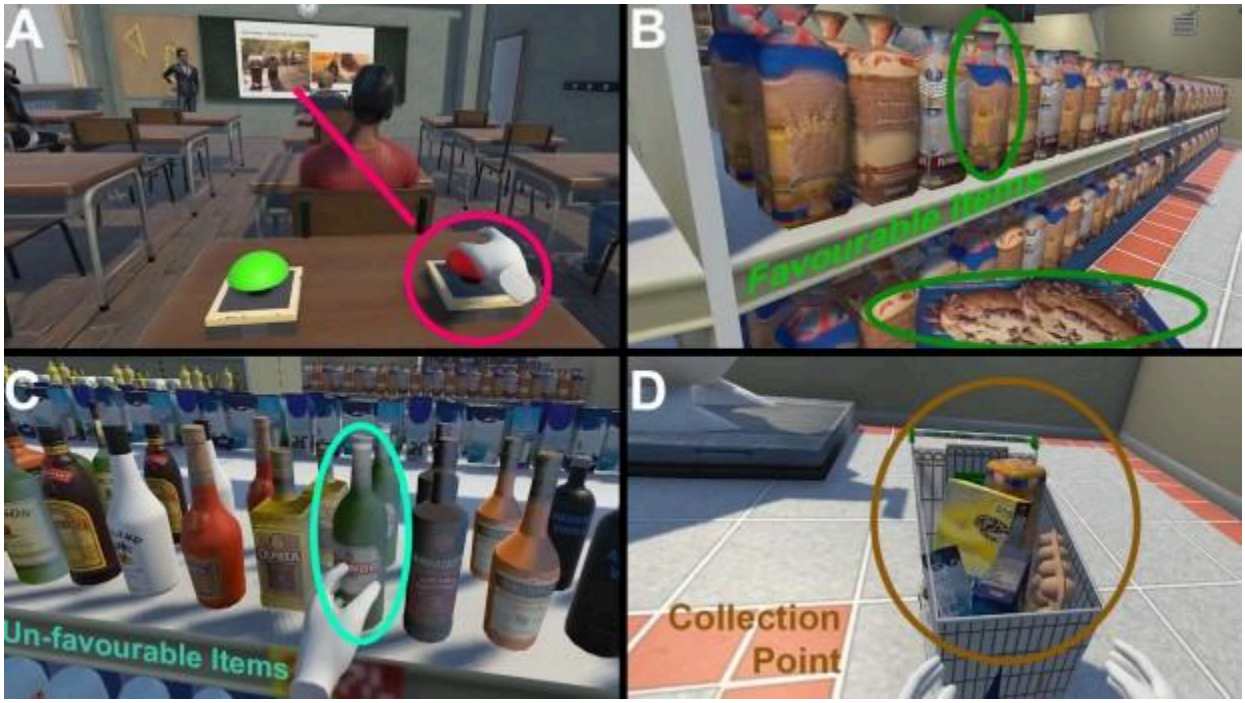


After this scenario, the participant was moved to a classroom, with a teacher and other students present. This is the first task and intended to integrate implicit association training. The task was to sit down at the desk with a computer, this computer showed ten pictures of ten different drinks from different cultures. Five alcoholic drinks and five non-alcoholic drinks, the player was instructed to press the green button when seeing a non-alcoholic drink and the red button when seeing an alcoholic drink (Figure 2, Image A), the button colour represents green for positive and red for negative, such is the case traditionally in Western cultures. The player gained one point for each correct pushing of the instructed button, additionally, an error sound and a positive feedback sound further underlined the success or failure of the player. By instructing the player to associate something positive with non-alcoholic drinks and something negative, the player underwent an attempt at modifying underlying biases and associating

alcohol with something negative. During the task, the non-player student characters were talking about an upcoming party, which could be overheard by the player.

Figure 2

Day One Levels: Lecture & Supermarket

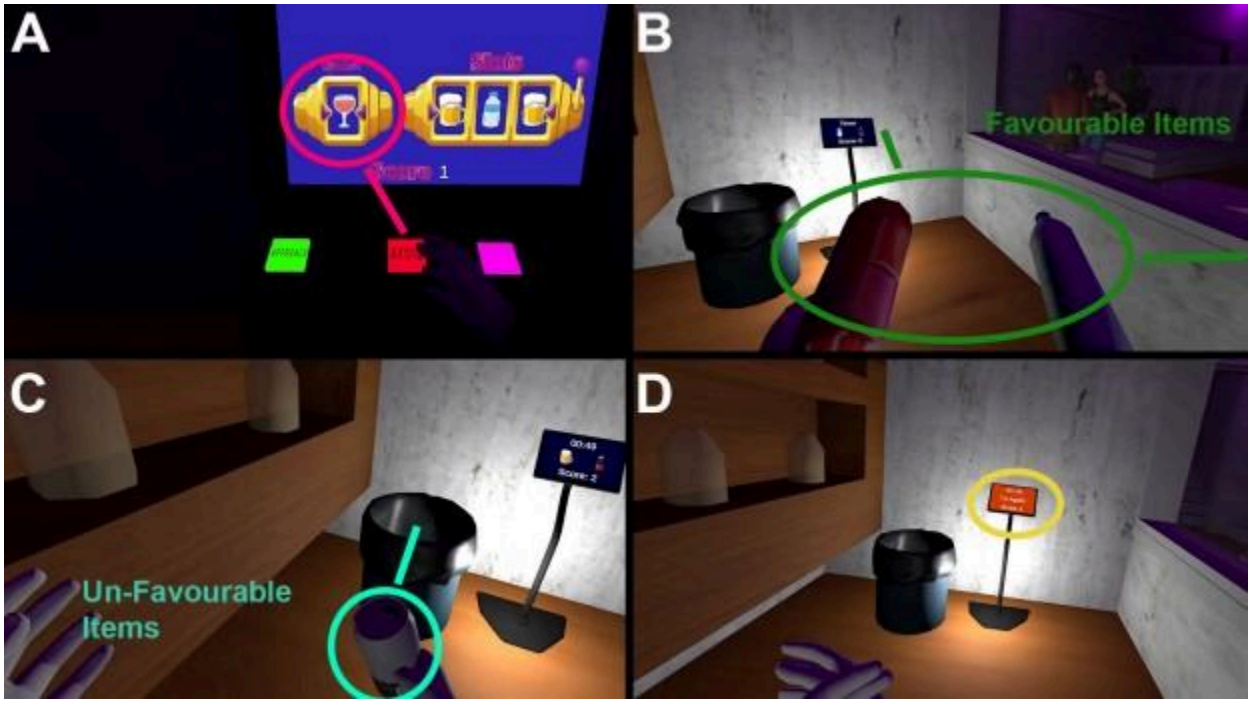


After the first task, the player appeared in a supermarket, instructed to grab milk, eggs, bread, cookies and cereal using the VR controllers and put them in the shopping cart (Figure 2, Images B, C & D). The supermarket shelves consisted roughly of 50% alcohol related items and 50% non-alcoholic items. This level aimed to integrate approach-avoidance training, avoiding alcohol and approach neutral items. When alcoholic items were put into the shopping cart, the task started again, the player may have done this due to having overheard an upcoming party. This task expected the player to approach neutral items and avoid alcoholic items.

For the third and fourth task, the player got moved to a nightclub with people dancing and loud party music playing. The player was instructed to move to the slot machine in the room. The Slot machine consisted of a screen showing one single reel and three reels in a row (Figure 3, Image A) and integrated approach-avoidance training. To start the game, the player had to press the purple button, this started to spin the singular reel, it either showed a water bottle or different alcohol bottles. The player is told to either approach or avoid by pressing either the green button with Approach written on it or the red button with Avoid, depending if they believed the spun reel to be favourable or not. This mirrored the first task where the button colours are culturally associated with positive and negative, furthermore the text written on them are also linked to the same cultural narrative, either approaching something positive or avoiding something negative. The correct response was to press the green button when the singular reel showed a water bottle and to press the red button when it showed alcoholic bottles. After the correct button was pressed, the three reels in a row would spin and the player was awarded two points when approaching the water bottles or one point when avoiding the alcohol bottles. When the wrong button was pressed, one point was deducted. The points were given for the correct pressing of the button, the three reels in a row served as decoy. The task ended when ten points were gained. This task again attempted to modify the player‘s bias to see non-alcoholic stimuli more favourable, the green button with Approach written on it as well as gaining two points rather than one aimed at doing so. The opposite is true for the alcoholic stimuli, the red button with Avoid on it and gaining only one point aimed at influencing the player as seeing alcoholic stimuli less worth approaching.

Figure 3

Day One Levels: Slot Machine & Bar Tending



For the fourth task the player was simply moved behind the bar to act as a substitute bartender, since in the narrative the original bartender blacked out due to excessive alcohol consumption, subtly implying dangers of risky alcohol use. This task integrated approach-avoidance training. For this task the player was shown successive orders of drinks, displayed on a screen. Each order consisted of two drinks, each drink could have two options (Figure 3, Image B), either a water bottle or a beer can. The player was instructed to place the water bottles that appeared on the shelf behind the bar, on the dropoff zone that was on the bar‘s surface and to throw the beer cans away into the trash can (Figure 3, Image C). The player had a time limit of one minute for each order, functioning as a gamification and adding urgency (Figure 3, Image D). For each correct order the player gained one and the task ended with five. If

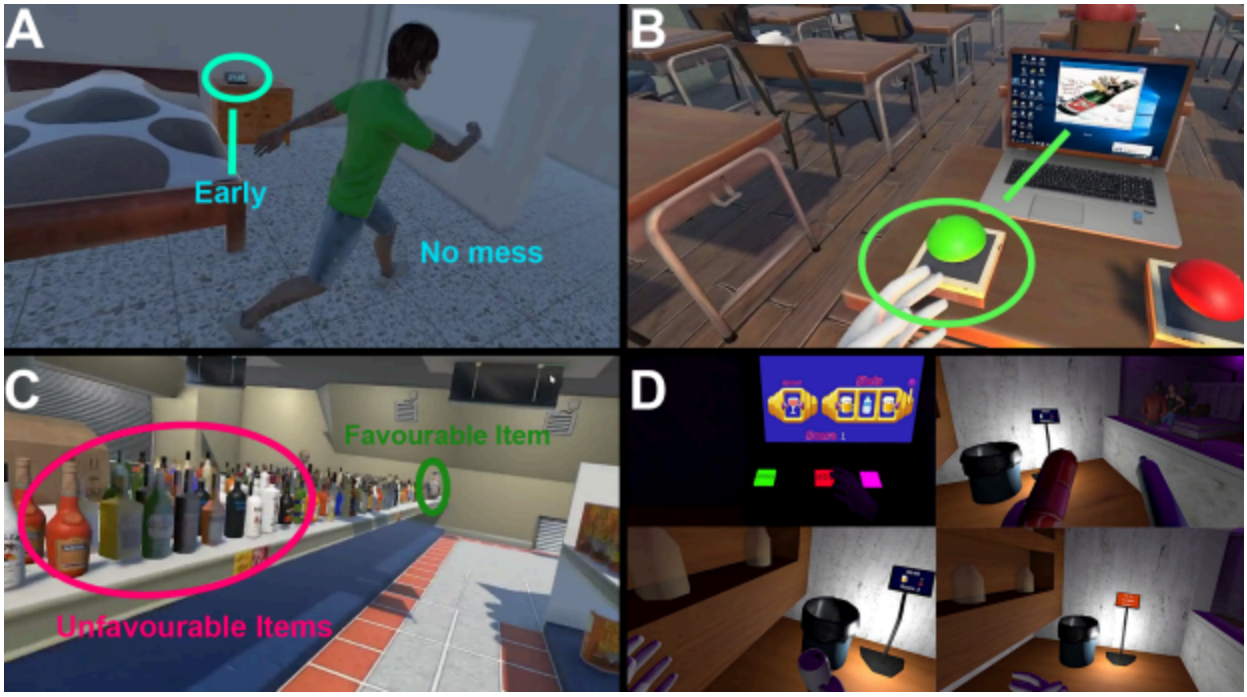
an order was served wrongly, a point was deducted. Auditory cues similar to the first task underlined a successful or wrong serve of the order. The point system and the auditory feedback served as positive reinforcement of avoiding alcohol by throwing the beer cans away. This task concluded the first day. The first day of the game took about 27.36 minutes on average to complete.

Day 2

For the second day, all tasks were done again but with increased difficulty. First, the protagonist woke up much earlier in the morning, in a much cleaner room and in much better mood, signalised by voice acting lines (Figure 4, Image A). For the first task, instead of ten total stimuli, twenty stimuli were shown. They consisted of ten alcoholic drinks and ten non-alcoholic drinks (Figure 4, Image B). For the second task, the supermarket had roughly 90% alcohol related items in the shelves and only 10% of regular items (Figure 4, Image C). The third and fourth task remained the same (Figure 4, Image D). The repetition aimed at solidifying a modification of biases while the increased difficulty was used to keep the game immersive and non-repetitive, also it was hoped to increase the chance of more significant modification of biases. The second day of the game took about 14.31 minutes on average to complete.

Figure 4

Day Two Levels: Waking Up, Lecture, Supermarket & Nightclub



2.5 Procedure

First the participants were asked to read and sign the ethical consent form. Afterwards they were invited into the room where they were instructed to fill out the questionnaires on the computer. After doing so they were instructed to complete the AAT and the IAT task. After the conventional CBM tasks, the day 1 version of the gamified VR CBM was next. During the second session, which was no later than two days after the first session, the order of all steps were reversed, first the day 2 version of the game, then the AAT & IAT measurements and then the questionnaires. During all steps except the VR CBM, the participant was alone but was monitored using CCTV. During the VR CBM step a researcher was present to calibrate the VR Glasses and help the participants were unclear about the instructions and mechanics of the game.

2.6 Data Analysis

The data that was collected using the AUDIT, SURPS, IAT and AAT, was analysed using descriptive, inferential, and additional statistical techniques in order to answer the research questions and the hypotheses. The data analysis was conducted using the statistical programming language R and the corresponding program RStudio. The data was cleaned and preprocessed and made sure to contain the relevant variables and data. The packages used were “readxl”, “psych”, “dpplyr”, “ggplot2”, tidyr” and “gridExtra”.

To analyse the effectiveness of the intervention, the pre- and post-intervention measurements of the AUDIT, DAT and IAT were analysed and compared. The variable used for analysis of the AUDIT was the total score of each participant, reflecting the original scoring procedure (Woicik et al., 2009). For the AAT and IAT the D-Score was calculated, reflecting the strength of the measured bias. The D-Scores for the AAT were gained by subtracting the median latency of correct pull trials from the median latency of correct push trials, specifically for the category containing alcohol-related stimuli. This value was divided by the individual standard deviations. The D-Score of the IAT is the standardised mean difference score of how fast participants can sort the categories “Alcohol-positive” and “Sodas-negative”, versus “Alcohol-negative” and “Sodas-positive”. The final D-Score is the average of the scores from the different test blocks, this is based on the scoring algorithm of Greenwald (Greenwald et al., 2003). For the AAT, a negative D-Score meant faster avoidance than approach of alcohol stimuli, while positive D-Scores meant faster approach than avoidance of alcohol stimuli, indicating a bias of approaching alcohol. A negative D-Score for the IAT meant a stronger association of “Alcohol-negative” and “Sodas-positive” than vice versa. A Positive D-Score meant a stronger association of “Alcohol-positive” and “Sodas-negative” than the other way around, indicating an

implicit bias to associate alcohol with something positive. D-Scores for both AAT and IAT around and near zero indicated that no particular bias existed. For the AUDIT, AAT and IAT, the mean and standard deviation was calculated, for pre- and post-intervention. To gain insight into how significant changes were after the intervention, paired t-tests were conducted, p-values < 0.05 were considered significant while p-values < 0.1 were considered marginally significant.

To analyse the relationship of personality traits on the outcome of the intervention, two multiple linear regression models were created. The first model predicts the relationship between the four personality traits measured by the SURPS and the changes of AAT D-Scores from pre- to post-intervention. The second model uses the same personality traits but predicts their relationship with the changes of IAT D-Scores from pre- to post-intervention. For the four personality traits, Hopelessness, Anxiety sensitivity, Impulsivity and Sensation seeking, the total scores were calculated based on the four point likert scale, higher scores indicated a more pronounced personality trait. The changes of the D-Scores were calculated through their difference, subtracting the D-Scores pre-intervention from the D-Scores post intervention. Higher positive values of this calculation indicate a decrease of the D-Score in the post-intervention measurement, thus a reduction of a potential bias. Lower negative values of this calculation indicate an increase of the D-Score after the intervention, thus an increase of a bias. The models revealed the direction and strength of the relationship between personality traits and changes of D-Scores. p-values < 0.05 were deemed significant and p-values < 0.1 were deemed marginally significant. For the model of personality traits predicting the change of the AAT D-Scores, two observations were omitted due to disrupting the model, resulting in 16 observations included in the model.

The normality of the different data and the models were tested with the Shapiro-Wilk test and histograms for visual inspection. The most important results were illustrated using tables and plots.

Results

3.1 The Sample and Demographic

The experiment was conducted with 20 participants, two participants decided to discontinue with the study after the first session. Due to lack of post-intervention data, the data of these two participants was completely omitted. Overall, 18 participants took part in this study, the average age was 22.48 years. It has to be noted that no IAT data for participants 1, 2 and 3 was collected. Additionally, the data of two participants had to be excluded for the analysis of personality changes of AAT D-Scores, due to being outliers that disrupted the model, leaving the data of 16 participants for this specific step of analysis.

3.2 Results of VR-CBM Game

Table 1

Results AUDIT, AAT & IAT Measures

Measure	Mean	SD
	Pre-Intervention	
AUDIT	12.06	5.36
AAT D-Score	0.36	0.49
IAT D-Score	-0.15	0.42

	Post-Intervention	
AUDIT	11	4.24
AAT D-Score	0.16	0.46
IAT D-Score	-0.35	0.3

AUDIT

After completing the intervention, AUDIT scores decreased from an average total score of 12.056 to 11. This suggests a decrease in alcohol use after the intervention. A paired t-test suggests this decrease to be marginally significant ($t(17) = 1.93$; $p = 0.07 < 0.1$).

Figure 5

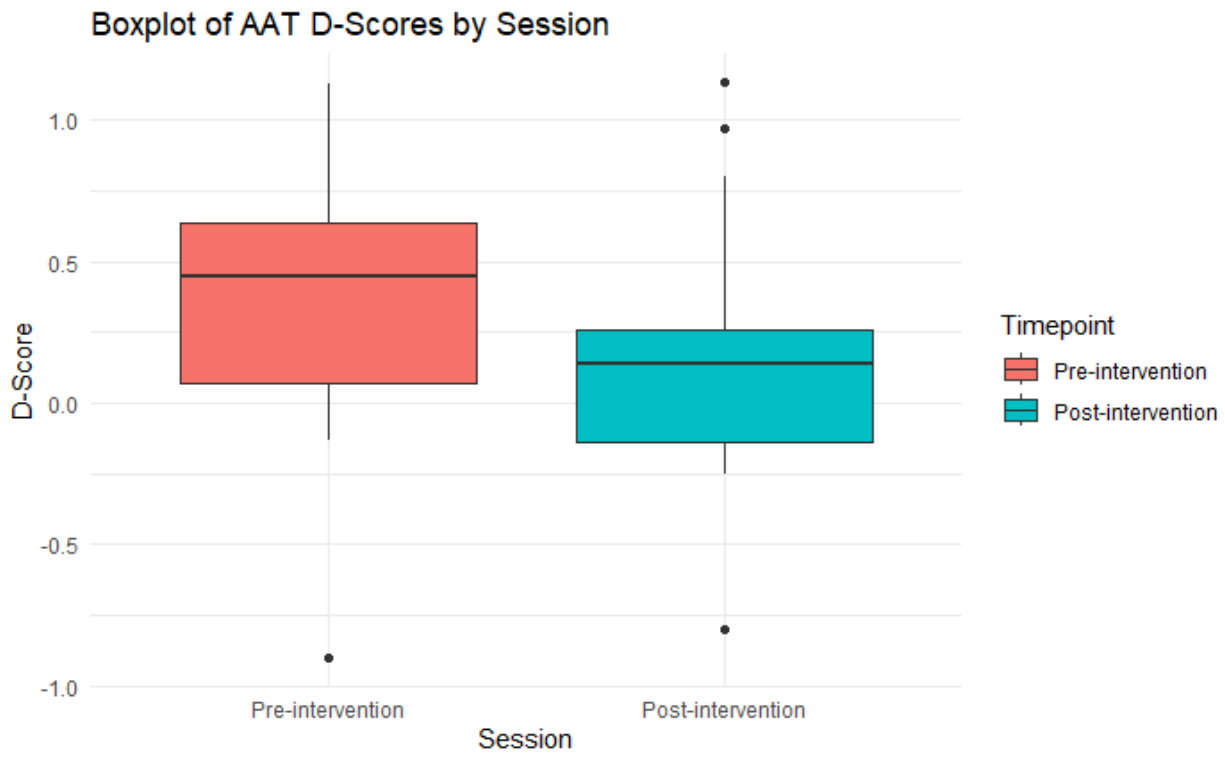
Boxplot AUDIT Pre- & Post-Intervention

AAT

The AAT D-Scores decreased after the Intervention from 0.36 to 0.16, but it was not significant ($t(17) = 1.29$; $p = 0.21 > 0.05$). This suggests a non-significant decrease of an approach bias towards alcohol.

Figure 6

Boxplot AAT D-Scores Pre- & Post-Intervention

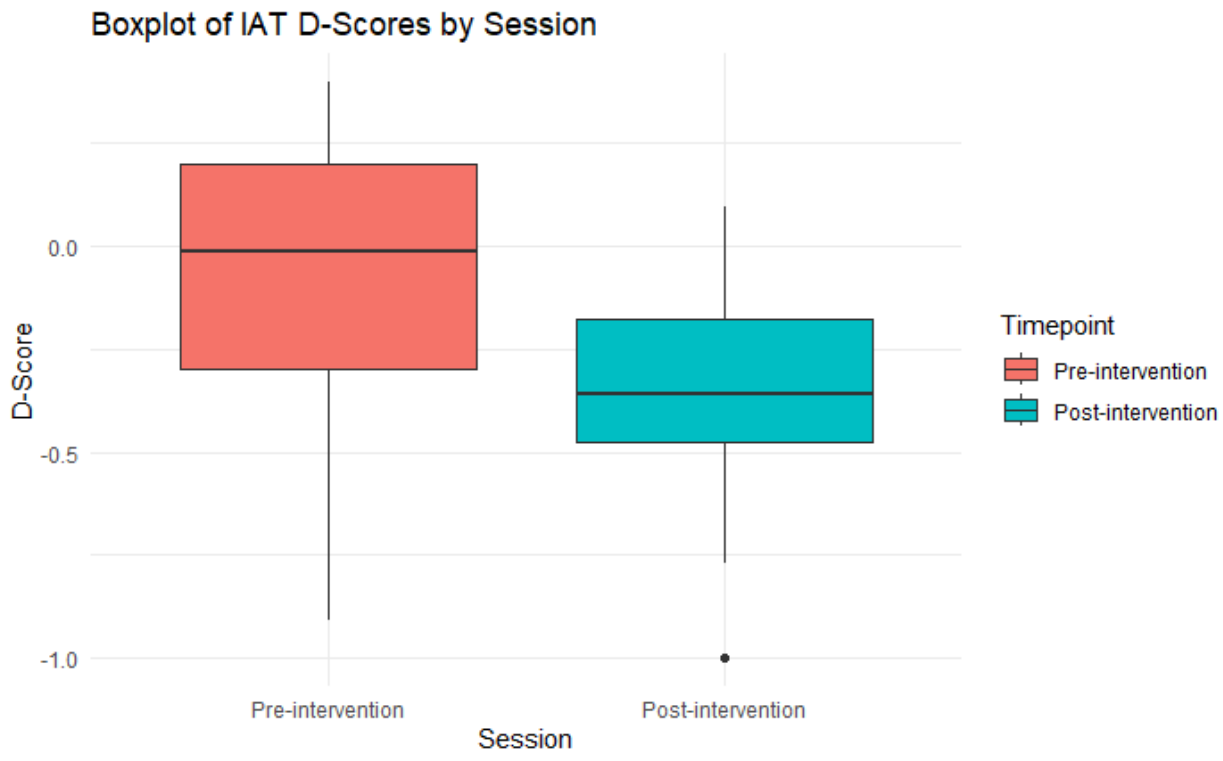


IAT

The IAT D-Scores decreased after the intervention from -0.15 to -0.35. This suggests an improvement of an implicit association bias. The improvement is not significant as revealed by a paired t-test ($t(14) = 1.57$; $p = 0.14 > 0.05$).

Figure 7

Boxplot IAT D-Scores Pre- & Post-Intervention



3.3 Personality Traits on D-Score Changes

Personality Traits on AAT D-Score Changes

Table 2

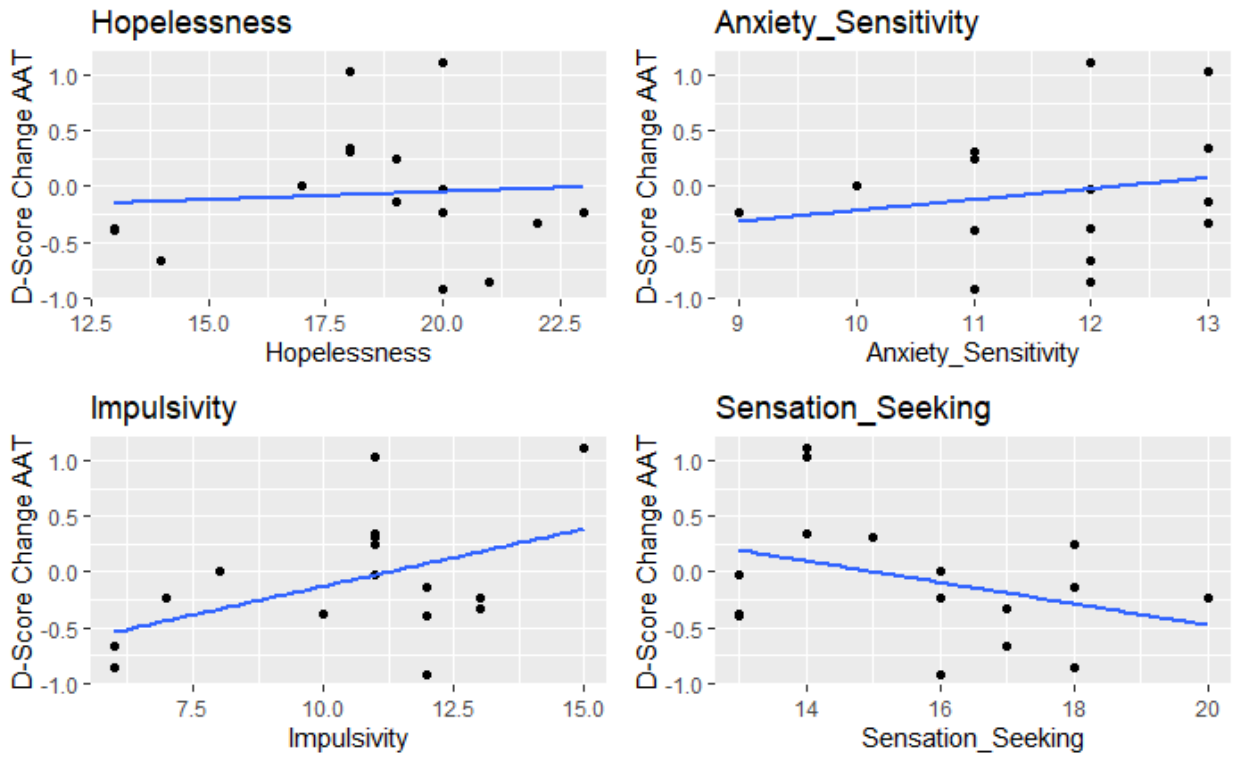
Results Influence of Personality Traits on D-Score Changes of AAT

Effect	Estimate	SE	t-value	*p*
Intercept	-0.46	2.08	-0.22	0.83
Hopelessness	0.04	0.06	0.67	0.52
Anxiety sensitivity	0.03	0.12	0.27	0.79

Impulsivity	0.08	0.06	1.41	0.19
Sensation seeking	-0.1	0.08	-1.23	0.24

Figure 8

Scatterplots Personality Traits on D-Score Change of AAT



The multiple linear regression model created to analyse the relationship between personality traits and the D-Score changes of the AAT, indicates a stronger decrease of an approach-avoidance bias after the intervention when the traits Hopelessness, Anxiety sensitivity and Impulsivity were higher in the participant, suggested by the positive relationships. On the other hand, higher Sensation seeking is linked with an increase of the bias after the intervention, as indicated by the negative relationship. Overall, the model is not significant ($F(4, 11) = 1.32$; p

= 0.32 > 0.05; *R^2* = 0.32; *Adjusted R^2* = 0.08), this is also true for the relationships between the individual personality traits and the AAT D-Scores Changes ($p > 0.05$).

Personality Traits on IAT D-Score Changes

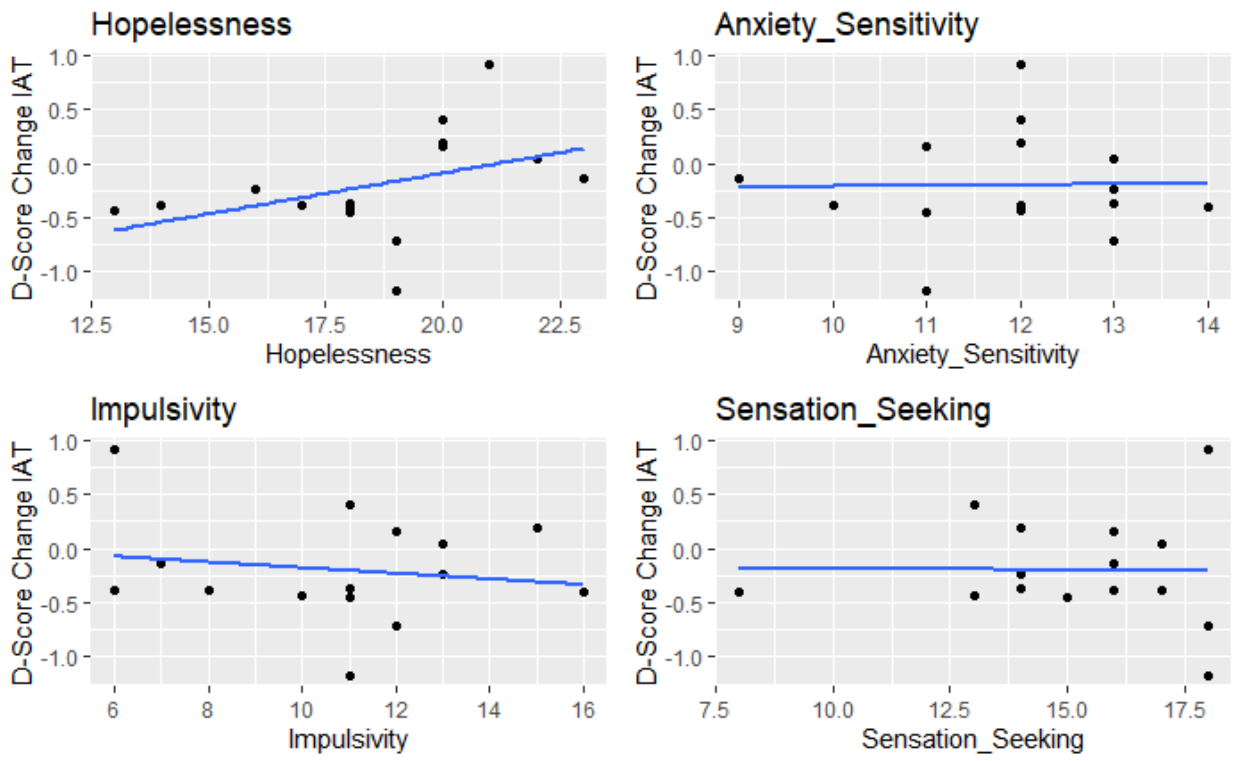
Table 3

Results Influence of Personality Traits on D-Score Changes of IAT

Effect	Estimate	SE	t-value	*p*
Intercept	-1.926	1.89	-1.019	0.332
Hopelessness	0.121	0.05	2.421	0.036
Anxiety sensitivity	0.153	0.121	1.263	0.235
Impulsivity	-0.111	0.06	-1.858	0.093
Sensation seeking	-0.075	0.059	-1.264	0.235

Figure 9

Scatterplots Personality Traits on D-Score Change of IAT



The multiple linear regression model predicting the relationship between personality traits and the D-Score changes of the IAT, indicates stronger decrease of an implicit association bias after the intervention when the traits Hopelessness and Anxiety sensitivity were higher, suggested by the positive relationships. On the other hand, a higher Impulsivity and Sensation seeking trait suggest an increase of the bias after the intervention, indicated by the negative relationships. The model is not significant overall ($F(4, 10) = 1.7$; $p = 0.23 > 0.05$; $R^2 = 0.4$; *Adjusted* $R^2 = 0.17$). The traits Anxiety sensitivity and Sensation seeking are not significant predictors ($p > 0.05$). The relationship between the trait Hopelessness and the decrease of the bias after the intervention, was marginally significant ($p = 0.036 < 0.1$). The relationship between the trait Impulsivity and the increase of the bias after the intervention, was marginally significant as well ($p = 0.093 < 0.1$).

Discussion

4.1 Conclusion

This study aimed to explore a new way of identifying and managing cognitive biases towards alcohol in university students through the use of a VR game. This VR game used CBM techniques as game mechanics and the idea of making an immersive VR game was introduced to tackle the problem of dullness and fatigue of conventional CBM tasks (Geerts et al., 2023). This dullness was attempted to negate by creating an immersive and interactive experience that was made possible by VR technology (Ghiţă & Gutiérrez-Maldonado, 2018). Additionally, it was also explored what role personality traits would play in the effectiveness of the intervention. This was done due to the relationship found between personality traits and substance abuse (Loukas et al., 2001 & Skóra et al., 2020) as well as personality traits and cognition (Schaie et al. 2004) in earlier research. This study was conducted with 18 participants (after two participants discontinued with the study), over the course of two sessions. To measure alcohol consumption and biases towards alcohol, the AUDIT questionnaire and two cognitive tests, the AAT and IAT were used. Furthermore, the SURPS questionnaire was used to measure the participants' extent of four personality traits commonly linked with substance abuse.

To address the first research aim, a decrease of alcohol consumption, as measured by the AUDIT, after the intervention was found. A decrease of an approach bias towards alcohol stimuli, measured by the AAT, was also found after the intervention. Lastly, a decrease of an implicit association bias towards alcohol, measured by the IAT was also found. Overall, the decrease of the biases using gamified CBM techniques is supported by previous research (Boendemakers et al., 2015). It has to be noted that despite the improvements in all measurements after the intervention, only the improvement of alcohol consumption was found to

be near significant. Nevertheless, this improvement alone points towards the potential effectiveness of the VR CBM game, suggesting that it might help in reducing implicit biases towards alcohol.

Secondly, only two out of four personality traits, Hopelessness and Impulsivity, showed a marginally significant correlation with the IAT measurement changes. No, significant correlation between personality traits and AAT measurement changes were found. While these findings are not confirming previous research to the extent that was aimed at (Loukas et al., 2001 & Skóra et al., 2020), they are not entirely discredited by the two marginally significant correlations found. It can be concluded that the personality traits Hopelessness and Impulsivity may have an influence on the effectiveness of the VR CBM Game, specifically on an implicit associations bias towards alcohol.

4.2 Discussion

Overall, the intervention showed marginal success. The AUDIT results indicated a significant reduction of alcohol consumption after the intervention, this is in line with previous research (Wiers et al. 2010) but the effectiveness of the intervention can be questioned. For instance, a reduction of the biases was found but they were not significant, therefore a reduction of alcohol consumption due to weaker biases cannot be entirely concluded but remains a possibility. Additionally, the reduction of the biases might have been influenced by a training effect (Tao et al., 2019). The participants simply may have gotten better and faster during the second session due to already being familiar with the measurements, possibly explaining the improvements (Tao et al., 2019).This is backed up by the decrease of average time spent on the

measurements (see Appendix B). Nevertheless, the reductions of reported consumption and of the biases are noteworthy and point towards the potential of the intervention.

Furthermore, high hopelessness and impulsivity were found to be marginal predictors of IAT D-Score changes. In the case of high hopelessness, the implicit association bias decreased after the intervention. This may be possible due to gaining hope or self-confidence throughout the intervention, leading to a decrease of implicit association. On the other hand, high impulsivity was linked with a marginal increase of IAT scores, the implicit association did not improve. High impulsivity may lead to unstable and unpredictable behaviour, possibly explaining the decrease of IAT scores, meaning a worsening of a bias. Higher impulsivity has been linked with higher relapse risk due to higher risk-taking behaviours (Pattij & De Vries, 2013), indicating unpredictable behaviour that might not be targeted directly and possibly explaining the worsening of the IAT scores.

4.3 Limitations & Recommendations

This study was subject to several limitations unfortunately. A very prominent limitation was the game itself. While the end product did showcase significant results, the game itself was not up to the original vision. The game was originally planned to be far more interactive and provide far more activities as well as gameplay features such as voice acting, cutscenes and a gripping storyline that would make it more akin to a conventional off-the-shelf video game. Limited time and resources were the reasons for this, the planned immersion and interactiveness were hoped to distract from the obviousness of the CBM tasks and provide a more valid bias modification, untouched by external factors and biases that happen in experimental settings. For example, the participant being aware of the aim of the intervention may have led to a demand

characteristic, meaning the participant acts how they think the experiment wants them to act instead of acting out their natural behaviour (Nichols & Manor, 2010). But on the other hand, this is also present in conventional CBM interventions. Furthermore, the game included different CBM techniques and we do know that the post-intervention scores improved but we do not know which integrated CBM technique had what effect on the measurements. Also, the amount of CBM dosage used in this study was lower than in previous research, this implies that the intervention might not have reached the effectiveness that was initially aimed at (Cristea et al., 2016).

Besides the game itself, it was originally planned to conduct this study with high alcohol consuming university students but due to lack of finding such with our sampling methods we had to draw on university students that do not necessarily have high alcohol consumption, this of course went against the initial premise of study, on the other hand the mean score of the AUDIT was 12.06, which is suggests hazardous drinking (Saunders et al., 1993 & Saunders et al., 2001), so in the end the premise of the study was unintentionally kept. But this implies that university students do not see themselves as having a hazardous relationship with alcohol which confirms well the finding that university students generally do not have the intention to change their drinking behaviour (Boffo et al., 2019). This might have impacted the effectiveness of the intervention due to a lack of willingness to change and not seeing the behaviour as hazardous or problematic, dampening the effectiveness of the intervention. This would explain the non-significance of the results. Additionally, the lack of a control group as well as a group that would do the conventional CBM would benefit this study. Having these groups would allow for a direct comparison between the conventional CBM and the gamified version instead of only

having data for the newly made game. Furthermore, it would help to determine external factors that influence the results of the intervention.

Other limitations include the exclusion of participant data due to the addition of the IAT only after the third participant's turn or due to physical complaints during the VR CBM. This of course leads to a reduced sample size, leading to a lower statistical power, resulting in a weaker ability of making inferences for the bigger population. Similarly, during the analysis of the relationship between personality traits and the AAT results, two observations had to be removed for the linear model to work. This of course led to a smaller sample size for this specific part of the analysis, which might have had an impact on the validity and reliability of the results.

For future studies of similar type we would recommend a control group and a group doing the conventional CBM tasks, maybe even an additional group doing pre existing gamified CBM tasks to further test the actual effectiveness of the VR gamified CBM and allowing for direct comparison. The VR CBM Game would benefit from integrating CBM techniques in a more standardised way and less modified way, yet they should still fit into the narrative and virtual environment of the game in order to ensure immersion and avoid demand characteristics when possible. Moreover, conducting the study over a longer period of time with more sessions would likely improve the effectiveness of it and yield more positive results due to the repetition. Lastly, more studies implementing VR and gaming elements are recommended in order to gain further insight into valuable information, from which future interventions for alcohol abuse may benefit.

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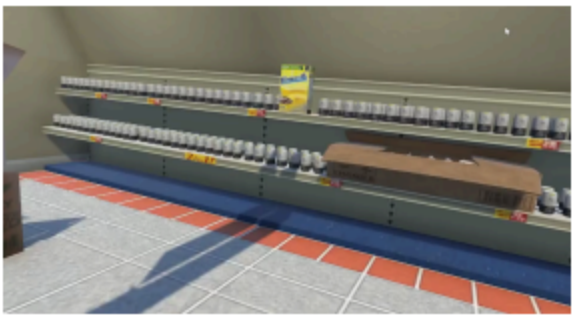
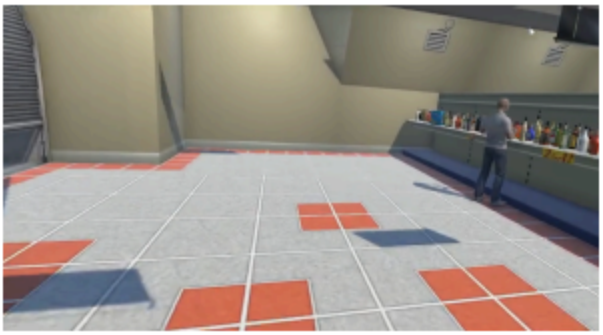
Appendix A

VR-CBM Gameplay

Link to game explanation: https://youtu.be/-10VVCXYKMM


DROP OFF





Appendix B

Average Durations for Activities over both Sessions

Session	Activity	Average Duration (minutes)	SD
1	Questionnaire	12.00	3.63
1	AAT	7.45	1.86
1	IAT	7.00	1.84
1	Game	27.36	5.73
2	Questionnaire	9.45	2.46
2	AAT	5.25	1.06
2	IAT	5.08	0.79

Session	Activity	Average Duration (minutes)	SD
1	Questionnaire	12.00	3.63
1	AAT	7.45	1.86
2	Game	14.31	3.43