Performing Cognitive Bias Modification training on a smartphone compared to an online version in young adults

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ABSTRACT
Excessive substance abuse in young adults could develop into addiction. A possible cost-effective intervention that could reduce excessive alcohol consumption is Cognitive Bias Modification (CBM). However, use of this intervention in youth proves more difficult, as motivation is usually low in this group, and paradigms used are often tedious. This study will examine the effects of performing a CBM intervention on a mobile application. Participants completed a CBM training either on a computer or on their mobile device. Performing the CBM on a smartphone led to more completed CBM training blocks. No change in alcohol approach bias and alcohol use was found.

Keywords
Cognitive Bias Modification, alcohol, smartphone.

INTRODUCTION

Dual-process models of addiction and Cognitive Bias Modification interventions

In today's society, excessive substance use is a major problem; this is especially among adolescents and young adults a widespread problem (Meier *et al.*, 2012). Excessive substance abuse in young adults can result into serious health problems later in life and could develop into addiction (Thatcher & Clark, 2008). For instance, excessive alcohol consumption could lead to a progressive neurocognitive disorder called alcoholism (Koob & Volkow, 2009). Alcohol abuse can cause severe damage to the adolescent and young adults brain functions such as memory and concentration impairment (Tapert *et al.*, 2004).

In the recent years, there has been a lot of research on possible cost-effective interventions that could reduce excessive alcohol consumption in young adults. This kind of research is currently more focussed on mechanisms underlying addictive behaviours that are not conscious, rational or under individual voluntary control (Hofmann *et al.*, 2009). According to Wiers *et al.* (2013) these mechanisms are the outcome of two qualitatively different classes of cognitive processes, impulsive and reflective processes. Impulsive processes govern automatic and associative behaviour and are fast processes evoked by substance-related stimuli. Furthermore, impulsive processes are mostly driven by implicit motivational aspects and are difficult to control due to unawareness. In the literature, these processes are referred to as cognitive biases, including for example the approach bias (Wiers *et al.*, 2013). An approach bias is the tendency to automatically approach substance-related cues. In contrast, reflective processes govern controlled and more conscious behaviour and are

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slower than impulsive processes. These processes involve rational decision-making and top-down control processes, and continuously update information inputs into coherent behaviour that is relevant to achieve goals on the long-term. The interplay between the two classes of processes could be elaborated with the horse and rider metaphor (Friese, Hofmann, & Wiers, 2011). In this metaphor, the horse represents the impulsive processes, which can only be tamed by a skilled and strong rider (the reflective processes).

These processes can eventually become difficult to control for someone who is alcohol dependent. Weak reflective processes are strong when substance abuse is present at a young age, which could impair cognitive and emotional regulatory processes. Furthermore, binge drinking in humans could also lead to impaired executive functions (Wiers *et al.*, 2015). This imbalance between the impulsive and reflective processes makes people more at risk to consume drugs and respond to substance related cues (Wiers *et al.*, 2013).

In this study, the focus is on addictive behaviour with regard to alcohol (ab)use. One type of novel intervention that has been created following dual-process conceptualization of cognitive processes driving behaviour is *Cognitive Bias Modification* (CBM) (for a review see, Wiers *et al.*, 2013). CBM is used to alter the automatic approach tendencies (i.e., approach bias) towards alcohol-related stimuli by training an alternative automatic response. This is implemented with an adapted version of the approach bias assessment task, the *Approach Avoidance Task* (AAT) (Wiers *et al.*, 2009). This kind of training has shown positive results in alcoholic patients (Eberl *et al.*, 2013; Wiers *et al.*, 2011). However, CBM is a very dreary program for patients because of the duration and repetitive nature of the task (Beard & Weisberg, 2012). This can impair treatment adherence, motivation to train and induce a large dropout of participants. To enhance this intrinsic motivation of young adults, this study will examine the effects of performing an AAT training intervention on a smartphone in comparison with the already existing computer-based online version (Wiers *et al.*, 2009; Rinck & Becker, 2007).

The number of people who own a smartphone has largely increased in recent years (Garritty & El Emam, 2006), which is why interventions on a smartphone are gaining popularity. Moreover, mobile applications also provide high accessibility towards individuals seeking help and could reduce costs of treatment (Kazdin & Rabbitt, 2013). Further evidence in the field of anxiety CBM treatments showed that combining fun elements and training on a smartphone, also called serious games for health (Boendermaker *et al.*, 2015), can reduce anxiety in patients after one training session (Dennis & O'Toole, 2014). However, the few studies about mobile CBM applications are based on Attention Bias Modification instead of Approach Bias Modification. So far,

little is known about the effects of a mobile version of this training program targeting automatic tendencies towards alcohol cues.

The present study: aims and expectations

The main objective is whether the effect of implementing a Cognitive Bias Modification intervention in the form of an alcohol AAT on a smartphone in comparison to the standard computer-based version will a) equally decrease alcohol use and alcohol-related approach bias and implicit associations in young adults and b) affect motivation to train.

The main goal of this study implies testing whether alcohol use and approach bias towards alcohol have changed between the baseline assessment immediately before the intervention and the second assessment immediately after the training intervention. It is hypothesised that there is a decrease in alcohol use for both the mobile version and the computer-based version as a function of number of completed training blocks. Furthermore, it is expected that the motivation to train is higher in participants using the mobile version in comparison with the computer-based version. In addition, the objective number of completed training blocks will be higher in the mobile group when compared to the computer-based group which is also a behavioural measure of motivation. Lastly, the intrinsic motivation to change the drinking behaviour of the participants is expected to be the same in both the mobile and computer-based group at baseline.

Methods

Study design and procedure

In the present study participants (mainly students, with a minimum age of 18) completed both a baseline and a post-intervention assessment session and were allocated to one of two experimental groups according to Android or non-Android smartphone. Participants with a non-Android smartphone were directly assigned to the computer-based training condition. Between these two lab assessments, participants had a time span of two weeks to complete an infinite number of training sessions. The baseline assessment of approximately one hour was implemented on the computer and consisted of the following questionnaires: *Alcohol Use Disorder Identification Test* (AUDIT), questions relating to alcohol use background, *Alcohol Use Questionnaire* (AUQ), *Time Line Follow-Back* (TLFB) questionnaire, *Readiness to Change Questionnaire* (RCQ) and questions relating motivation pre-test. Furthermore, a *Stimulus-Response Compatibility task* (SRC), an *Implicit Association Test* (IAT) and an alcohol AAT were also performed. The AAT assessment task was used to measure the approach bias towards alcohol. However, because the modified version was used for training a SRC was also used to avoid a bias due to practice effects in the computer-based training group. The IAT was used to evaluate generalizability of training effects to different alcohol stimuli and associations, in this case words. Both before and after every training session the motivation to train was assessed in the form of a questionnaire. 15 days after baseline the post-intervention measurement took place at the same location of the baseline assessment. The post assessment consisted of the *User Experience Questionnaire* (UEQ), a general individual evaluation of the training intervention, TLFB, SRC, AAT and IAT. Main outcome measures were the change in alcohol use after the training intervention and at post assessment together with the number of completed training blocks. Differences in completed alcohol AAT training blocks between females and males were also examined. Secondary outcome measures include the change in approach bias between the baseline and post assessment, measured by the SRC task and the alcohol AAT assessment, and the change in approach and avoidance implicit associations towards alcohol as measured with the IAT. The study was approved by the Ethics Committee of the Department of Psychology of the University of Amsterdam (Protocol Number: 2015-DP-4286).

Stimulus-Response Compatibility task

The Stimulus-Response Compatibility (SRC) task (De Houwer *et al.,* 2001) is a reaction time task in which the tendency to approach different kinds of stimuli is measured. In this study the SRC was used to measure the approach bias towards alcohol. In this task participants are instructed to move a manikin away or towards a specific image by pressing two response keys ('U' or 'B') on the keyboard, one for moving the manikin towards the image and one for moving the manikin away from the image. According to Field *et al.* (2008) excessive alcohol users are faster in approaching stimuli related to alcohol with the manikin in comparison to light drinkers.

Approach Avoidance Task

The Approach Avoidance Task (AAT; Rinck & Becker, 2007) is a speeded reaction-time computerised task used to assess automatic approach tendencies towards motivationally salient stimuli, in this case alcohol-related pictures in comparison to soft-drink pictures. Participants have to react to an irrelevant-feature of the presented stimuli (e.g., tilt direction of the picture) by pushing the stimuli away or pulling them closer with a joystick or keyboard buttons (Wiers *et al.,* 2009; Wiers *et al.,* 2011). When participants pull the stimulus towards them, the picture on the computer screen enlarges. This will create a more realistic feeling of approach (Wiers *et al.,* 2009 & 2011). In contrast, when participants push the picture away from them, the image becomes smaller. This will create the feeling of avoidance.

Implicit Association Test

The Implicit Association Test (IAT; Greenwald *et al.,* 2003) is a categorisation task that measures implicit, automatic associations between concepts in memory. In the current study the IAT was used to measure approach and avoidance association between alcohol and soft drinks. During the test blocks of the task, the participants were presented with two pairs of words combined in the left and right corner of the screen. These pairs consisted of a combination of a word from the target category (soft drink or alcohol) and a word from the attribute category (approach or avoidance). For example: alcohol and approach and soft drink and avoidance in the first test block and soft drink and approach and alcohol and avoidance in the second test block.

Experimental Intervention

The training intervention used a modified version of the AAT whereby participants had to consistently avoid every stimulus containing alcohol content and approach images containing a soft drink content. Approach and avoid responses are accompanied by a zooming effect or a decreasing effect on the picture, mimicking actual approach or avoidance. The participants were instructed to react to an irrelevant feature of the image and ignore the content. In both the mobile version and the computer-based version, the irrelevant feature was a letter randomly superimposed on one of the 4 corners of the image (e.g., the letter 'P' for pull and the letter 'F' for push. Letter and response pairing was counterbalanced between participants.

In the mobile version of the training, participants were instructed to utilize both hands while swiping other words, one hand was used to hold the smartphone while the other hand conducted the swipe movements. These instructions were given in order to prevent participants performing the one-handed swipe movement. According to Kraus and Hofmann (2013) the one-handed swipe movement is ergonomically constraining for downward swipe movements because of the writs motion. In the computer-based version of the training, participants were instructed to use the up and down arrow keys of the keyboard. At the end of each training block participants were shown a feedback message of the amount of money earned.

Results

Clinical outcomes

No significant difference between the baseline and post assessment TLFB scores was found for time ($F(1,58) = 1.628$, $p= 0.207$, $\eta^2 = 0.028$), condition (mobile or computer-based) ($F(1,58) = 1.594$, $p= 0.212$, $\eta^2 = 0.028$) and number of completed training blocks, $F(1,58) = 0.522$, $p= 0.473$, $\eta^2 = 0.009$. In order to conduct a median split to investigate a possible difference in TLFB scores between light and heavy drinkers a Kendall's tau-b test was carried out for the AUDIT scores, AUQ scores and TLFB baseline scores. Kendall's tau-b indicated that all questionnaires were significantly positively correlated. Subsequently, the median split was performed between light drinkers (median < 12.00) and heavy drinkers (median ≥ 12.00). For light drinkers no significant difference was found between baseline and post assessment ($F(1,32) = 0.099$, $p= 0.755$, $\eta^2 = 0.003$). The same applied to heavy drinkers ($F(1,25) = 3.026$, $p= 0.095$, $\eta^2 = 0.116$). Training effects on the AAT and SRC approach bias scores at baseline and post assessment were analysed. Due to violation of normality assumption for the SRC, AAT and IAT a Friedman Two-Way ANOVA was carried out. No significant difference was found between the approach bias scores at baseline and post assessment for both the SRC (χ^2 (1) = 0.600, p = 0.439), and the alcohol AAT ($\chi^2(1) = 1.786$, $p = 0.181$). No significant effect was found between the implicit associations at baseline and post intervention for the IAT (χ^2 (1) = 0.258, p = 0.611).

Lastly, the difference in delivery modes (mobile or computer) on the number of completed alcohol AAT training blocks was also examined. A Mann-Whitney U test was carried out to compare both variables. A significant difference was found between condition and number of completed training blocks ($U = 336.500$, $p= 0.045$). The completed training blocks in the mobile group (Mean Rank = 36.40, n = 29) were significantly higher than the online group (Mean Rank = 27.20 , n = 33) (Figure 1).

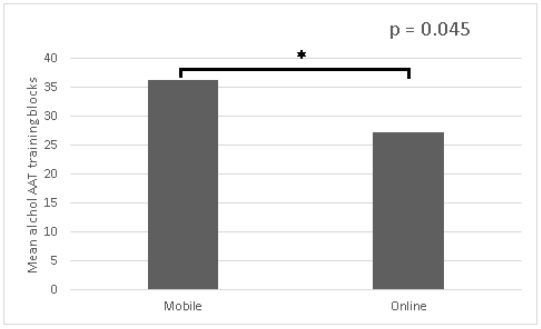

Fig1. Difference in completed alcohol AAT training blocks between the two conditions.

Motivational outcomes

No significant difference was found between the two conditions for the RCQ score at baseline ($t(55) = 0.605$, $p= 0.548$) as measured with an Independent T-test. Furthermore a median split was assessed to investigate a possible effect of training on participants with a relative high motivation to change their drinking behaviour. No significant difference was found between participants with a low (median ≤ -5) and high (median > -5) motivation to change and completed training blocks as measured with a Mann-Whitney U test ($U = 414.000$, $p= 0.348$).

The motivation to train was also examined and measured with the motivation to train questionnaire at baseline. A Mann-Whitney U test indicated that the motivation to train of the participants between the mobile and online group was not significantly different at baseline ($U = 474.000$, $p= 0.765$).

CONCLUSION

The main findings of the current study were in contrast with the primary hypothesis. No significant difference was found for change in alcohol use before and after the training for both the smartphone group and the online group. This also applied for light and heavy drinkers. Furthermore, there was no significant difference found for the alcohol approach bias scores, alcohol implicit associations and motivation to train even though the readiness to change drinking behaviour was the same for both groups. Based on the results from the current study it could be concluded that performing the CBM training on a smartphone is not an effective method to reduce alcohol use in young adults. It is worth mentioning that performing the training intervention on a smartphone in comparison with the already existing computer-based version results in more executed training blocks in young people. However, this enhancement was not related to intrinsic motivation, motivation to train, decrease in alcohol use and changed approach bias. Moreover, the difference in performed training blocks was not related to either intrinsic motivation or motivation to train. This result was likely due to the motivational aspect concerning the monetary incentive the participants received after each training. Participants in the mobile group were possibly more focussed on receiving money and had more time to train than participants in the online group. This motivational aspect for each participant was measured in the form of a questionnaire before each training session but these results were not used for analysis.

Previous studies have proven the positive effectiveness of the alcohol AAT training in alcoholic patients (Eberl *et al.*, 2013; Wiers *et al.*, 2011). These results are in contrast with the findings of the current study. However, these studies examined the automatic approach bias towards alcohol in alcohol dependent patients after performing CBM. The current study examined this approach bias towards alcohol in young adults who did not necessarily consume a lot of alcohol. The discrepancy in effectiveness of the CBM could be due to this difference in the amount of alcohol consumption. The goal between the two studies and the current study also differed: abstinence for alcohol dependent patients and reduced alcohol consumption for problem drinkers.

Wiers et al. 2015 found that the version of the alcohol AAT used in this study is less effective in comparison to two other versions. The reduction of the alcohol approach bias was the strongest in a task with no irrelevant feature in which the participants had to push all the alcohol related images away and in a task with an irrelevant feature in which the participants had to push 90%

of the alcohol related images away. This could be due to the procedure that the images relating an alcohol content in the experimental task were all pushed, it is not clear if the participants only reacted to the irrelevant feature or to the content of the image. The use of this version could explain the result that there was no reduction found in the approach bias towards alcohol.

Evidence showed that combining fun elements and training on a smartphone can reduce anxiety in patients after one training session (Dennis & O'Toole, 2014). These studies of mobile CBM applications are based on Attention Bias Modification. It is possible that an Approach Bias Modification program is not effective on a smartphone. It was essential to examine if the alcohol AAT training task was more appealing to perform on a smartphone in order to maximise its effects and increase training compliance due to its repetitiveness. This is partly true, participants completed more training sessions in the smartphone group. However, this was probably related to other aspects such as ease of accessing the training and monetary incentives.

Further research should try to study the effects of the CBM on a smartphone in alcohol dependent patients. Secondly, it is not yet known how many CBM training sessions are needed to be effective, the same applies to the time span in which participants have the opportunity to train. What may be concluded from this study is that performing the CBM on a smartphone in comparison with the already existing computer-based online version does not result in less alcohol use and a higher motivation to train for young adults.

ROLE OF THE STUDENT

Nienke van Bueren was an undergraduate student Psychobiology (University of Amsterdam) working under the supervision of Wouter Boendermaker and Marilisa Boffo when the research in this report was performed. The topic was proposed by the supervisors. Data collection, data analysis and the writing were done by the student. This project was completed on July, 2nd 2015.

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