**Protocol scientific title:** SWIPE: An open-label pilot feasibility study of a novel approach bias modification smartphone application to reduce alcohol use among people drinking at hazardous levels and who wish to reduce their alcohol consumption

**Public title:** “SWIPE”: A Personalised brain-training app to reduce alcohol cravings and consumption

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**Trial registration and identification information:**

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**Countries of recruitment**: Australia

**Background**

Recent reports indicate that, in 2016, 17% of Australians aged 14 and over drank at levels that put them at risk of lifetime alcohol-related harm (AIHW, 2017), while one-in-five Australian adults have met criteria for an alcohol use disorder (AUD) in their lifetime (Slade et al., 2016). Globally, alcohol was estimated to have led to 5.1% of the global burden of disease and injury in 2016, and alcohol intoxication often leads to health, social, and economic harms not only to the drinker, but to those around them, particularly (in many cases) their families (WHO, 2018). However, despite the harms and risks of alcohol use often being evident to the drinker, heavy drinkers frequently find it difficult to cease or reduce their alcohol use. In studies of people who seek treatment for alcohol use problems, post-treatment relapse rates typically range from 55% to 85%, depending on the population being studied, the type of treatment administered, and the definition of relapse used (Batra, Muller, Mann, & Heinz, 2016; Maisto, Hallgren, Roos, & Witkiewitz, 2018; Rinck, Wiers, Becker, & Lindenmeyer, 2018).

While there are numerous factors that may contribute to the difficulty many heavy drinkers face in reducing/ceasing alcohol use, or avoiding relapse after ceasing heavy drinking, one important factor is likely to be strongly ingrained associative learning. The highly-influential incentive-sensitisation model (Robinson & Berridge, 1993) posits that, at least in some people, repeated use of addictive drugs sensitises neural processes underlying the incentive salience of the drug. Expression of this exaggerated incentive salience is influenced by learned associations, such that excessive incentive salience develops for stimuli associated with previous episodes of substance use, such as physical and social contexts, sights, sounds, scents, etc. which have often been present during these episodes. This incentive salience is often equated with ‘wanting’ the drug, or cue-induced craving (Carter & Tiffany, 1999), but may also be reflected in less conscious ‘cognitive biases’, such as attention bias (the exaggerated tendency for drug-associated cues to capture attention) and approach bias (the automatic action tendency to approach drug-related cues) (R. Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). Indeed, Berridge and Robinson (2016) posit that the less-conscious aspects of incentive salience may influence behaviour in the absence of conscious ‘wanting’, or even in the presence of conscious desire to *not* use the drug. Thus, while there is some evidence that alcohol craving and cognitive biases are associated with each other (Field, Mogg, & Bradley, 2005), cognitive biases may also influence alcohol consumption even when a drinker does not consciously ‘want’ alcohol. In any case, craving (Schneekloth et al., 2012; Sinha et al., 2011), approach bias (Martin Braunstein, Kuerbis, Ochsner, & Morgenstern, 2016), and attention bias (Cox, Hogan, Kristian, & Race, 2002) have all been reported as predictors of alcohol use in people with AUD seeking to cease or reduce their drinking. Since alcohol-related cues are ubiquitous in Australian society, and largely unavoidable, the craving and cognitive bias that can be elicited by these cues is likely to pose a serious challenge for people seeking to reduce or cease drinking.

The challenges experienced by heavy drinkers wishing to reduce their alcohol use (particularly when exposed to alcohol-related cues) are likely exacerbated by other effects that heavy alcohol use has on the brain. The neurotoxic effects of heavy alcohol consumption impair numerous cognitive functions, including the “reflective” processes responsible for decision-making, inhibition of maladaptive impulses, and long-term planning, and these deficits persist after cessation of drinking (Crowe, Cammisuli, & Stranks, 2019). This results in an “imbalance”, whereby impulsive urges and cravings for alcohol (triggered by alcohol-related cues) can more easily override the brain’s ability to inhibit these reactions in favour of more adaptive choices (Gladwin, Figner, Crone, & Wiers, 2011). Typical psychotherapeutic interventions for AUD, such as cognitive behavioural therapy (Magill et al., 2019) and motivational interviewing (Smedslund et al., 2011) aim to strengthen reflective processes, but don’t directly address these less conscious cue-induced cognitive biases.

Research has shown that approach biases can be reduced, or even reversed, through a form of computerised “brain-training” known as approach bias modification (ABM) (R. W. Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011), including in AUD patients with major neurocognitive disorders (Loijen et al., 2018) who might have difficulty engaging in traditional psychotherapeutic interventions. ABM works by repeatedly presenting individuals with alcohol-related pictures to which they must make an “avoidance” movement (by pushing away images of alcoholic beverages using a joystick) and non-alcoholic beverage images to which they must make an “approach movement” (by pulling on the joystick). Over time, individuals learn to automatically “avoid” alcohol-related cues. In one study, completing just six 15-minute ABM training sessions “dampened” cue-induced neural activity in the amygdala in male AUD patients, and this reduction in neural activation was associated with reduced self-reported alcohol craving (C. E. Wiers et al., 2015). Importantly, several randomised controlled trials (RCTs) have shown that, when delivered as an adjunctive intervention during residential AUD treatment, 4-6 sessions of ABM can reduce likelihood of post-treatment relapse (Eberl et al., 2013; Manning et al., 2016; Rinck et al., 2018; R. W. Wiers et al., 2011).

Residential treatment is appropriate for people with very severe AUD. However, there is a much larger population of people with less severe alcohol use problems that do not warrant residential treatment, but which still pose substantial risks to health and quality of life. Thus, expanding the application and availability of ABM beyond the residential settings where its efficacy has been demonstrated may have widespread benefit, provided it can be shown to be feasible and effective in these other settings or modes of delivery. One way in which this can be done is through the development of smartphone apps, which would allow people who wish to reduce their drinking to freely access ABM training when it is convenient for them, and without even having to engage with traditional addiction treatment services.

Thus far, we are aware of only two studies examining ABM smartphone apps, both of which had promising outcomes. Crane, Garnett, Michie, West and Brown (2018) tested apps containing various combinations of 5 different modules (including an ABM module) among people drinking at hazardous levels, and found that combinations in which both ABM and normative feedback were included reduced participants’ weekly alcohol consumption. Laurens et al. (2020) piloted an ABM app in people who were concerned about, or wished to reduce, their drinking. Participants were encouraged to complete at least 2 ABM sessions per week over a 3-week period. While the majority of those who enrolled failed to complete the 3-week post-training questionnaire, of those who did complete the post-test, the majority completed the recommended 6 sessions. Weekly alcohol consumption declined over this 3-week period, and even further at a 3-month follow-up, though there was no control group with whom to compare these outcomes, which may have also been biased by the high drop-out rate. Participants were asked to provide feedback regarding the app, and Laurens et al. (2020) reported that, while feedback was generally positive, participants criticised the lack of personalisation as well as the monotony and repetitiveness of the ABM training, suggesting that game-like features could make it more engaging.

Participants’ criticism of lack of personalisation of Laurens et al.’s (2020) app is unsurprising, given that all participants were trained using the same standardised set of beverage images. In our research on AUD treatment, we have noticed that most participants tend to drink a limited range of beverages. When ABM programs use a standard picture set of beverages for all participants, the majority of images may have little relevance to most individuals (e.g., being repeatedly trained to avoid images of beer may do little for someone who only drinks wine). Moreover, since approach bias is the product of repeated associative conditioning experiences, it is likely to be specific to stimuli resembling the drinks frequently consumed by an individual. Designing ABM tasks where individuals can use their own “personalised” images is therefore likely to be more engaging, as well as potentially more “potent” at reducing approach bias. Smartphones can make this easy by allowing participants to incorporate their own photos of the beverages they most wish to “avoid”. Additionally, personalised ABM can simultaneously be used to strengthen motivations to reduce drinking by training individuals to repeatedly “approach” images representing positive goals using their own photos of family, friends, hobbies, etc. Including gamified aspects in the task may also improve its acceptability even further, enhancing completion rates, and thereby further enhancing efficacy.

**Aims and hypotheses**:

We aim to test the feasibility and acceptability of a novel smartphone-delivered personalised ABM app to help reduce alcohol consumption and cravings in a sample of people reporting hazardous alcohol use, recruited from the general community. In addition, we aim to gather preliminary data on drinking, alcohol craving, and alcohol dependence outcomes following training to assess whether there are grounds to proceed to a randomised controlled trial testing its efficacy.

We hypothesise that:

1. We will recruit 500 participants within 3 months of launching the app, supporting the feasibility of this programme.

2. At least 60% of participants will complete 8 sessions of ABM, supporting its feasibility and acceptability.

3. Mean ratings of the app will be greater than 3 on each subscale of the Mobile Acceptability Rating Scale, demonstrating adequate acceptability.

4. There will be statistically significant decreases in number of standard drinks per week, number of days on which alcohol was used in the past 7 days, alcohol craving, and Severity of Dependence Scale scores at the end of the 4-week intervention, relative to pre-training scores, suggesting its potential effectiveness.

5. There will be “dose-response” relationships, whereby the degree of reduction between the pre-training and 4-week assessments in measures of alcohol drinking, craving, and dependence will be related to the number of ABM sessions completed over this period (i.e., more sessions will be associated with larger reductions).

6. The reduction of drinking over the intervention period will be larger in those with more severe baseline alcohol use/problems, and also larger in those with greater motivation and confidence to reduce alcohol use.

We also intend to explore participants’ reaction time and error rate data from their ABM sessions as this will inform further refinement of the technical parameters of the app after this study is complete.

**Design**

This is a single-group, open-label study. Assessment of drinking, craving, and dependence severity will use a repeated measures design.

**Methods**

**Participants:** 500 participants reporting hazardous alcohol use will be recruited through social media and web advertising. Participants must be aged 18+, have an AUDIT score of at least 8, own an Android or Apple iOS smartphone with an Australian phone number, and wish to reduce their drinking.

**Measures:**

*Demographic information*: Participants will be asked to enter their age, gender, and postcode of residence in an online survey hosted on Qualtrics.

*Motivation and confidence to change*: We will use the “Readiness Rulers” (Center for Evidence-Based Practices at Case Western Reserve University, 2010) which measure how important participants feel it is to change their drinking (motivation to change) and how confident they feel in their ability to change. Both motivation and confidence are measured on a 1-10 scale.

*Alcohol problem severity*: The Alcohol Use Disorders Identification Test (AUDIT) (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993) will be used at baseline to measure the severity of alcohol use and related problems during the past year. The Severity of Dependence Scale (SDS) (Gossop et al., 1995) will be used to measure severity of psychological dependence on alcohol in the past month. Since the SDS was initially developed to measure dependence on heroin, cocaine, and amphetamines, wording of some items will be slightly modified to enhance its relevance to alcohol, similar to the wording used by Gossop, Marsden, and Stewart (2002) when they validated the SDS for measuring alcohol dependence. Gossop et al. (2002) reported that this version of the SDS had high internal consistency (Chronbach’s α=0.86 among substance use treatment patients who had endorsed at least one SDS item for their alcohol use) and SDS scores correlated moderately with frequency of drinking, indicating its validity.

*Alcohol craving*: The Craving Experience Questionnaire (CEQ) (May et al., 2014) will be used to measure the frequency of alcohol cravings over the past week and the intensity of the most severe alcohol craving that occurred in the past week. Both the frequency and intensity scales of the CEQ consist of two 10-item scales, with each item rated on a scale of 0-10. Each 10-item scale can further be broken down into 3 factors: “intensity”, “imagery”, and “intrusiveness”, and this 3-factor structure has been validated (May et al., 2014).

In addition to the CEQ, we will also utilise a single-item visual analogue scale (VAS) to measure current intensity of alcohol craving immediately before and after each ABM session. Participants will be asked “How strongly are you craving alcohol right now?”, with a line displayed below the question and a slider that they can place between ends anchored with the words “not at all” on the left end and “extremely” on the right. A participants’ placement of the slider will be converted to a number ranging from 0-100 for data storage.

*Alcohol consumption*: At baseline, participants will be asked to estimate the number of days on which they consumed alcohol out of the past 28 days. Using a calendar chart covering the past 7 days, they will also be asked to enter the number of standard drinks consumed on each of those 7 days so that total weekly drinking amounts can be calculated. This 7-day drinking assessment will be repeated at weekly intervals over the course of the intervention. 28 days after completing the intervention, participants are again required to complete the alcohol consumption calendar chart, where they will estimate the number of days on which they consumed alcohol out of the past 28 days, and the number of standard drinks consumed on each day in the past week.

*App acceptability*: At the end of the 4-week intervention, participants will be asked to complete the complete the "functionality" and "aesthetics" sub-scales and the "app subjective quality" section of the user version of the Mobile Application Rating Scale (uMARS) (Stoyanov, Hides, Kavanagh, & Wilson, 2016). Additionally, participants have the option to enter free text in response to 3 open-ended questions: "what did you like about this app?", "what did you not like about the app?", "any further comments about the app?".

**Intervention**: Prior to commencing the intervention, participants will be prompted to select 6 alcohol-related pictures that represent the drinks they most frequently consume. Participants can either take and upload photographs using their phone or select pictures from a library of alcohol-related images chosen to represent a broad range of alcoholic beverages commonly consumed in Australia. Participants will then be prompted to select 6 pictures that “represent your goals and motivations”. Again, participants can either take and upload photographs or select pictures from a library of pictures representing a range of healthy activities or positive goals and sources of pleasure (including family or friends enjoying time together; financial success; employment; exercise, sports, and recreational activities; healthy foods; pets; travel and holidays) which do not contain any depiction of alcohol.

Once the participant selects their 12 pictures, they will be presented with instructions for the ABM task. Pictures (200 x 200 pixels) will be displayed with a white “frame” around them which will be in either landscape or portrait orientation. When the frame is in landscape orientation, the participant is required to swipe downwards (i.e., towards themself), which (if the movement is at least 40 pixels downward) causes the picture to expand, increasing to 600 x 600 pixels over a period of 500 milliseconds (ms), as if the participant has “pulled” the picture “towards” themselves. When the frame is in portrait orientation, the participant is instructed to swipe upwards (i.e., away from themself), which (if the movement is at least 40 pixels upwards) causes the picture to shrink until it disappears, which takes 500 ms, as if they have “pushed” it “away”. If the participant swipes (at least 40 pixels) in the wrong direction, a red “X” is displayed to inform them that they made an error. After the picture expands/shrinks to its maximum/minimum extent, there is a 250 ms inter-stimulus interval before presentation of the next picture.

Following the display of the instructions, participants complete 10 practise trials (including 5 images in portrait frames and 5 in landscape frames, in random order) to familiarise them with the task before commencing scored trials. Following the practise trials, participants will complete the first session of ABM. Each session consists of 156 trials, comprising 13 presentations of each picture. For alcohol pictures, 12 of the 13 presentations are framed in portrait orientation, and one is framed in landscape orientation. This is reversed for positive pictures, whereby 12 of the 13 presentations of each positive picture are framed in landscape orientation, while one is framed in portrait orientation. Thus, participants are supposed to push away 92.3% of alcohol images and pull 92.3% of positive images towards themselves. If participants make the incorrect response, they are informed that it was an error, but the trial is not repeated.

To increase engagement and encourage participants to respond both quickly and accurately, the task is gamified with a scoring system. Each time the participant swipes an image in the correct direction, they are awarded 10 points. Additionally, they score 'bonus points' for correct responses if their response is fast enough. If they swipe correctly and within 500 milliseconds (ms) of picture onset, they receive 30 bonus points (yielding a total of 40 points for that trial). If they swipe correctly within 500-1000 ms of picture onset they receive 20 bonus points (i.e., 30 points total). If they respond correctly within 1000-1500ms they receive 10 bonus points (i.e., 20 points total). Correct responses that are slower than 1500 ms following picture onset earn only 10 points. If they swipe an image incorrectly (i.e., swipe down for portrait or swipe up for landscape), they lose 100 points, regardless of their reaction time. Note that reaction time is recorded as the time taken to complete the swipe movement (i.e., the interval between picture display and the time at which the participant has moved their finger at least 40 pixels upwards/downwards).

Participants’ score will be displayed on the screen as they perform the task. Upon completion of the task, the final point score is displayed. On the second, and subsequent, sessions, participants’ previous session score, and the score of their highest-scoring session, will be displayed prior to commencing the task, to encourage them to try to score higher. At the end of these sessions, their final score for that session will be shown (and, if it is not their first session, their previous personal best score will also be displayed, so they can compare their performance). On the second and subsequent sessions, participants are offered the opportunity to review the task instructions and complete the 10 practise trials, but from the second session onwards they are provided with the option to skip these steps.

**Procedure**: Individuals interested in participating in the study will be directed from social media and other online advertisement to an online survey hosted by Qualtrics. Participant information will be displayed along with the option to provide consent to participate. Those who agree to participate then proceed to a survey that will screen for eligibility and collect information regarding alcohol problem severity and craving (i.e., demographic questionnaire, a question to confirm that they intend to reduce or cease drinking, AUDIT, Readiness Ruler, SDS, and CEQ). Those screened as eligible will be required to provide their mobile phone number to be sent a link via SMS to download the app, where they are prompted to provide information about their past-month and past-week alcohol use. In addition, if a participant’s score on the “dependence” items of the AUDIT (i.e., items 4, 5, and 6) totals at least 4, contact details for DirectLine (a free 24-hour telephone alcohol and other drug counselling and referral service) and counselling online (an web-chat-based alcohol and other drug counselling service) will also be displayed. Participants are then prompted to upload or select their alcohol-related and positive pictures and then will proceed to the first session of ABM. Each session of ABM is immediately preceded and followed by a VAS craving rating. If a participant’s post-session VAS score is 90 or above after any session, DirectLine’s phone number will be displayed.

Participants will be prompted by the app to complete a minimum of two ABM sessions each week for four weeks. In addition, every 7 days, participants will be prompted to report their alcohol consumption over the past week. At the end of the four-week training protocol, participants will be prompted to complete a second Qualtrics survey which will include the CEQ, SDS, and uMARS. Participants who complete this post-test survey will be given the option to provide contact details to be in a draw to win one of 10 $100 gift vouchers. Four weeks after completing training, participants will be prompted to complete a final 1-month follow-up questionnaire which will assess past-month and past-week alcohol consumption.

**Primary outcomes**

The primary outcomes will be the number of sessions completed, the proportion who complete 8 sessions of ABM, and the number of days of alcohol use in the past 7 days. The primary time-point for all three of these outcomes is 4 weeks after a participant commences using the app.

**Secondary outcomes**

uMARS sub-scale scores will serve as a secondary measure of acceptability, and will be measured at the post-test (i.e., 4 weeks after commencing the app). An additional secondary outcome to measure feasibility will be the number of participants recruited within 6 months of launching the app. Secondary outcomes pertaining to alcohol use, dependence, and craving will include:

1. Number of days of alcohol use in the past 28 days (primary time-point at post-test; secondary time-point at the 1-month follow-up).

2. Total standard drinks consumed in the past 7 days (primary time-point at post-test; secondary time-points 1, 2, and 3 weeks since commencing the app and at the 1-month follow-up).

3. SDS score (primary time-point at post-test).

4. CEQ score (primary time-point at post-test).

5. Craving VAS score (primary time-point immediately after the final session of ABM).

Additional secondary outcomes will include trial error rates, reaction times, and session durations over the course of all ABM sessions.

**Data management**

Demographic, AUDIT, Readiness Ruler, SDS, CEQ, and uMARS data will be stored in a password-protected online Qualtrics database, from where it will be downloaded for storage and analysis on a password-protected shared drive hosted by Turning Point. At post-test, participants will be asked to provide the mobile phone number used to sign up to the app, to allow pre-test and post-test responses to be matched at the individual level. Alcohol use data and back-end user metrics (number of sessions commenced, number completed, session duration, session total score, trial reaction time, and error data) will be stored on a secure Google Firebase server, which will be downloaded for storage and analysis on a password-protected shared drive hosted by Turning Point at the end of the study. To protect participants’ confidentiality, data will be accessible only to the research team involved in this project.

**Statistical analysis plan**

Feasibility and acceptability will be assessed using descriptive data, including number of participants recruited, number of sessions commenced, number of sessions completed, and means and distributions of each uMARS subscale score. Changes in alcohol consumption, craving, and SDS scores will be analysed using linear mixed modelling. To analyse whether there is a “dose-response” relationship between number of ABM sessions completed and these outcomes, we will examine the interaction term between number of sessions and time to test whether number of sessions moderates the effect of time on these outcomes. We will also explore, using linear mixed modelling, whether other factors measured prior to commencing the intervention moderate changes in alcohol use outcomes, including motivation to change alcohol use, self-reported importance of changing alcohol use, and self-reported confidence to change alcohol use, AUDIT score, quantity and frequency of alcohol use, dependence and craving symptoms, age, and gender. To inform refinement of task and scoring parameters for future versions of the app, we will examine rates of errors and distributions of reaction times for each image type. We will also examine the mean and distribution of session durations.

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