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# Reward-related attentional capture predicts non-abstinence during a one-month abstinence challenge

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ARTICLE INFO

"I participated in this abstinence challenge; I even wore a coloured bracelet saying IkPas (NoThanks). After work I went to a bar and at some point I found myself looking at that strange bracelet on my arm when I carried a round of beers to our table...."

*Keyword:*
Reward learning
Alcohol
Behaviour change
Sign-tracking

ABSTRACT

*Background:* While it is generally recognised that cognitive attributes can predict behaviour change outcomes in the field of addiction this question is typically studied in treatment seeking samples (to predict treatment outcomes and relapse). However the concept of behaviour change applies to the entire spectrum of addiction-like behaviours and initiatives such as temporary abstinence challenges offer insight into an understudied but equally relevant point of the spectrum. Thus the current study examined whether reward-related attentional capture predicted non-abstinence during IkPas (the Dutch national dry January campaign translated: NoThanks!).
*Method:* Participants included 1130 adults who had complete baseline data and performed above chance level on the cognitive task. Of these 683 participants completed the post-IkPas assessment and were included in the primary analysis. A binary logistic regression examined whether reward-related attentional capture predicted drinking during IkPas controlling for alcohol use at baseline (among other potential confounders).
*Results:* Participants who showed greater reward-related attentional capture before IkPas were more likely to not remain abstinent from drinking during IkPas ($p = .014$). Findings were replicated using multiple imputation to replace missing data ($p = .013$).
*Conclusion:* These findings provide important insights into the cognitive mechanisms that support successful behaviour change such as the ability to ignore task-irrelevant reward cues and may inform the development of tools that individuals could use to maximise their likelihood of achieving successful behaviour change.

## 1. Introduction

Individuals who use alcohol and other drugs excessively or who have been diagnosed with a substance use disorder typically show an attentional bias towards stimuli associated with that substance (Lubman, 2000; Field & Cox, 2013, 2008; Cousijn, 2013). Such biases have been argued to reflect drug-related learning processes. Specifically through repeated pairing of drug-related stimuli and the rewarding effects of taking the drug those previously neutral stimuli are thought to acquire *incentive salience* becoming attractive in their own right (Berridge et al., 2009; Robinson and Berridge, 2000).

Importantly a growing body of research suggests that there is variability in the likelihood that individuals attribute incentive salience to signals of reward and hence in the ability of such signals to capture attention (Flagel et al., 2008; Colaizzi, 2020) . The ability of reward-predictive cues to direct attention and approach towards themselves has been well-documented in Pavlovian conditioning studies in animal subjects a phenomenon termed 'sign tracking' (Boakes, 1977; Hearst & Jenkins, 1974). This research was extended recently through findings that individuals differ in their tendency to show a sign-tracking response. Specifically some rats approach and contact a lever that signals the arrival of food (sign trackers) whereas other rats learn to approach the food magazine (goal trackers) when the lever is presented. The sign trackers treat the lever as if it were the food (the lever has acquired incentive salience as well as signal value) whereas the goal trackers use the lever to tell them when to approach the magazine (the lever has acquired signal value only). Critically the extent to which an individual shows a sign-tracking response prior to any drug exposure has

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been shown to predict a range of addictive behaviours once exposed to drugs (Robinson & Flagel, 2009; Flagel et al., 2009). These findings have led to the view that the propensity to show a sign-tracking response reflects a vulnerability to addiction. And further they raise the possibility that the attentional biases toward drug cues seen in addiction may reflect at least in part these pre-existing individual differences (Colaizzi et al., 2020).

The above research points to the idea that attention to reward cues may be a useful marker of addiction vulnerability comparable to sign-tracking in the animal literature. While research on sign-tracking originated in animal studies Le Pelley et al. (2015) developed a procedure to assess an analogue of sign-tracking in humans the value-modulated attentional capture (VMAC) task. Briefly in this task participants search for and respond to a diamond target among circles of which one is coloured one of two colours e.g. blue or orange (all other shapes including the diamond target are grey). The colour of this colour-singleton circle—referred to as the *distractor*—determines the size of the reward available on that trial but is *not* the target that participants are required to respond to in order to receive that reward. What is found using this paradigm is that responses to the target become significantly slower for trials with a high-reward distractor compared to trials with a low-reward distractor suggesting that the signal of high reward is more likely to capture participants' attention slowing their response to the target even though this enhanced capture is counterproductive an effect referred to as *value-modulated attentional capture* (VMAC). Thus just as sign-tracking animals may approach and contact signals for reward even when such approach is at the expense of obtaining the reward people likewise attend to reward-related cues in the VMAC protocol even when such attending is at the expense of procuring the reward.

Research in humans using the VMAC task or similar procedures has found that in line with the sign-tracking animal literature greater reward-related attentional capture is associated with a range of addictive behaviours (Colaizzi et al., 2020; Albertella et al., 2019, 2017; Anderson et al., 2013; Watson et al., 2019). No study to date however has examined this relationship prospectively which would more strongly support the idea of reward-related attentional capture as a marker of the tendency to experience difficulties in maintaining behaviour change guided by a long-term goal with which an attention grabbing reward opportunity may interfere. Toward this aim the current study will examine the prospective relationship between reward-related attentional capture and successful behaviour change i.e. abstinence. Temporary abstinence challenges such as the one-month Dutch national dry January campaign IkPas (English: NoThanks!) provide an ideal opportunity to answer this question. While it may be argued that not keeping one's abstinence resolution during a public health challenge is different from the 'loss of control' that is characteristic of relapse in addiction such arguments are not in line with current approaches in psychiatric research that view behaviour and underlying neurocognitive drivers as dimensional in nature (Cuthbert, 2014). From this perspective non-abstinence during a one-month abstinence challenge and non-abstinence in addiction both reflect difficulty changing behaviour.

In addition to being a useful approach for better understanding the drivers of behaviour change understanding the predictors of abstinence challenges is in itself a valuable pursuit. Importantly individuals who succeed in temporary abstinence challenges experience a range of long-term benefits from reductions in drinking to a range of psychological benefits such as improvements in well-being and general self-efficacy (de Visser & Piper, 2020; de Visser & Nicholls, 2020; de Visser et al., 2016). Critically these changes are not seen in participants who are unsuccessful in the challenge nor in the general population across the same timeframe. This suggests that if the rates of success can be maximised then challenge benefits may be conferred to a greater number of people. Understanding the mechanisms associated with challenge success such as individual differences in cognition has potential of informing future interventions aimed at supporting successful behaviour change.

## 2. Methods

### 2.1. Participants and procedure

The IkPas challenge is organized by the Positive Lifestyle foundation. Every year adult alcohol users (aged 18 years and over) who are interested in the challenge register on the website IkPas.nl. The IkPas privacy policy states that the organization of IkPas makes the e-mail addresses of participants available to Tilburg University for carrying out an online evaluation study of the campaign. Respondents were contacted to complete an online questionnaire (see Measures) and asked whether they would be interested in taking part in an additional study looking at cognition and alcohol use (i.e. the current study). If so they were asked to fill in their email address so they could be invited by the research team. All participants provided informed consent prior to participating including consent for their data from the baseline online questionnaire to be used in this study. Ethics approval was obtained from the Tilburg University School of Social and Behavioral Sciences Research Ethics Review Board.

Overall 12 402 individuals undertook the main IkPas evaluation study (Bovens et al., 2019) and 2576 expressed interest in taking part in the additional (VMAC) cognitive study. Of these 1260 participants consented and completed the VMAC study component and 1130 performed above chance level in the VMAC task and had complete age gender and baseline alcohol use data. These 1130 participants were included in the present analyses.

The majority of participants started the IkPas challenge straight away ($n = 955$) while a minority started the challenge after four weeks ($n = 175$). This delay was in place as part of a separate study. Importantly the time between the baseline assessment including VMAC task completion and starting the challenge was one month or less for all participants. Further participants in the waiting condition completed the VMAC task again (with a different colour set) just prior to starting the challenge.[2]

Participants were contacted again at the end of their IkPas challenge and asked about their alcohol use during the challenge. A total of 683 (60%) participants completed the Post-IkPas assessment. This follow-up rate is similar to that seen in other campaigns. For instance the follow-up rate for the British Dry January is around 55% (de Visser & Nicholls, 2020).

## 3. Value-modulated attentional capture task – reward-only variant

The visual search task used a modified[3] reward-only variant (Albertella et al., 2019, 2020) of Le Pelley et al.'s [Experiment 2; Le Pelley et al., 2015] VMAC procedure. In Le Pelley et al.'s original version of the task participants were punished (by loss of points) for incorrect responses. By contrast in the reward-only variant errors do not result in losses. Another point of difference between the present study and past studies using the original or reward-only VMAC variants is that points earned on the current task were not incentivised with monetary value (e.g. points being converted to money (Le Pelley et al., 2015). However recent VMAC studies have shown that the VMAC effect can be established through a points system only – there is no need for a monetary

[2] Rerunning the analyses with these VMAC data for the relevant participants resulted in the same results. We chose to use the VMAC data collected at the same time as the past 6-month alcohol data to ensure that we were controlling for current alcohol use in relation to cognitive performance to a similar extent for all participants.

[3] The current version was shorter than that used previously [19], with three training blocks (instead of five) and had a longer response window (1600 ms vs 1000 ms). These changes were made to make the task more acceptable across the diverse sample that takes part in the challenge.

incentive (Albertella et al., 2019; Watson et al., 2019).

The task was delivered online and presented using Inquisit Web 5 (Inquisit, 2016). All stimuli were presented on a black background. Each trial began with a central fixation cross followed 500 ms after by the search display. The search display comprised six shapes arranged evenly around an imaginary ring. Five of these shapes were circles each containing a white line tilted 45° randomly to the left or right. One shape (the *target*) was a diamond containing a line oriented horizontally or vertically. On most trials one of the circles (termed the *distractor*) was coloured; all other shapes were grey. Distractor colour sets could be blue and orange pink and green and purple and yellow with assignment of one colour in each set to the role of high-reward and the other colour to the low-reward distractor. These were counterbalanced across participants.

The task of participants was to respond to the orientation of the line within the target diamond as quickly as possible—by pressing either the 'C' key (horizontal) or 'M' key (vertical)—with faster responses earning more points. The location of the target and distractor and the orientation of the target's line segment (vertical or horizontal) were randomly determined on each trial.

Each trial-block of the task comprised 30 trials: 13 trials featuring a distractor rendered in the high-reward colour 13 trials with a distractor in the low-reward colour and 4 distractor-absent trials (in which all shapes were grey) in random order. For correct responses on trials with a low-reward distractor and distractor-absent trials participants won 0.1 points for every ms that their response time (RT) was below 1600 ms. Trials in which the display contained a high-reward distractor were labelled as bonus trials and points were multiplied by 10. Correct responses with RT>1600 ms and incorrect responses earned no points. The search display remained on-screen until the participant responded or the trial timed-out (after 2000 ms). A feedback screen then appeared. On 'standard' (low-reward distractor or distractor-absent) trials if the response was correct feedback showed the number of points earned on that trial; if the response was incorrect feedback showed "ERROR"; and if the trial timed-out feedback was "Please try to respond faster" (in Dutch). On bonus (high-reward) trials the corresponding feedback was accompanied by a box labelled "10 × bonus!".

Participants were informed that the aim of the visual search task was to earn as many points as possible. Participants were further informed (1) that when a circle in the high-reward colour was present in the search display it would be a bonus trial on which points were multiplied by 10 and (2) that when a circle in the low-reward colour was present it would not be a bonus trial. Participants completed three 30-trial blocks taking a break between blocks; during this break they were shown the total number of points they had earned so far.

To assess the effect of the reward-signalling distractor on task performance we calculated a VMAC score for each participant by subtracting mean response time on trials with a low-value distractor from response time on trials with a high-value distractor. For this we used correct responses (regardless of whether they were within the 1600 ms timeframe for points). Incorrect responses or responses made after the trial ended (>2000 ms) were not used for calculating the VMAC score. A higher VMAC score indicates greater distraction by the high-reward distractor relative to the low-reward distractor; that is a greater influence of reward on attentional capture.

## 4. Measures

At baseline age and gender information was collected as well as information about alcohol use in the past 6 months. Specifically participants were asked how many days they drank during the week (Monday–Thursday) and weekend (Friday–Sunday) in the past 6 months as well as the average number of drinks consumed per weekday and weekend in the past 6 months. These values were then used to calculate the average number of drinks consumed per week in the past 6 months. [4]A standard drink in the Netherlands contains 10 g alcohol (Mongan & Long, 2015).

At the end of IkPas participants were asked how many days they consumed alcohol during the challenge. This information was used to divide participants into two groups i.e. participants who did not drink ($n$ = 547) versus participants who drank one day or more ($n$ = 136) during the challenge serving as a dichotomised outcome variable.

## 5. Data analyses

Statistical outliers (≥than 3.3 standard deviations from the mean) in VMAC and/or alcohol use data were winsorised.[5] Predictors of drop out were examined by comparing participants who were followed up vs not followed up on baseline variables including: gender age total drinks per week and VMAC score. Independent samples t-tests were used for age VMAC score and alcohol use data. A Chi square test was used for gender. Descriptive data for all participants including those lost to follow-up are shown in Table 1.

Logistic regression was used to examine the predictors of abstinence. Predictor variables included age gender (males = 1; females = 2) baseline alcohol use group (waitlist = 0; immediate start = 1) and VMAC score. For the categorical variables male gender and waitlist condition were used as the reference category. The outcome variable of primary interest was abstinence versus non-abstinence. The assumption of linearity between the continuous variables and the logit was tested using the Box-Tidwell test and met (Hosmer & Lemeshow, 1989).

As a secondary analysis we re-ran the analyses using multiple imputation for missing data. Twenty datasets were imputed using the following variables: age gender alcohol use VMAC proportion correct VMAC score as well as abstinence vs non-abstinence. Multiple imputation even when data are not missing completely at random (assuming certain steps are taken (Sterne et al., 2009) is a technique to reduce bias resulting from missing data (which may limit complete case analyses). The regression results based on complete case data ($n$ = 683) are shown in Table 2 and those based on pooled results from multiple imputed data

**Table 1**
Descriptive information.

| | | Did not drink at all (n = 547) | Drank one or more days (n = 136) | Lost to follow-up (n = 447) |
|---|---|---|---|---|
| Age | Mean | 53.1 | 52.9 | 51.0 |
| | SD | 11.64 | 11.93 | 12.83 |
| Gender | % F | 62% | 66% | 62% |
| Drinks/ week | Mean | 18.4 | 19.0 | 20.5 |
| | SD | 11.05 | 10.78 | 12.95 |
| VMAC score (ms) | Mean | 4.0 | 23.2 | 8.0 |
| | SD | 81.72 | 80.27 | 76.01 |

*Note:* 'VMAC' = value-modulated attentional capture score (in ms) given by the difference in response time on trials featuring a distractor that was paired with high reward and response time on trials featuring a distractor that was paired with low reward.

[4] Results using days/week and drinks/day as separate predictor variables did not differ from results using drinks/week except for a trend-level finding ($p$ = .095) for days/week (in the complete case analysis only). These analyses are provided as Supplementary Materials (Tables 1-2).

[5] Results using winsorised data were comparable to those using non-winsorised data.

**Table 2**
Logistic regression. Complete case analysis (n = 683).

| Predictors | B | S.E. | Wald | p | Exp(B) |
|---|---|---|---|---|---|
| Age | −0.004 | 0.008 | 0.178 | 0.673 | 0.996 |
| Gender | 0.176 | 0.206 | 0.731 | 0.392 | 1.193 |
| Condition | −0.379 | 0.255 | 2.217 | 0.136 | 0.684 |
| Drinks/week | 0.010 | 0.009 | 1.270 | 0.260 | 1.010 |
| VMAC score (ms) | 0.003 | 0.001 | 6.046 | 0.014 | 1.003 |

*Note:* 'VMAC' = value-modulated attentional capture score (in ms) given by the difference in response time on trials featuring a distractor that was paired with high reward and response time on trials featuring a distractor that was paired with low reward.

are shown in Table 3.

## 6. Results

Participants had a mean age of 52 years ($SD = 12.18$) and 63% were female. Participants consumed 19 drinks ($SD = 11.8$) across the week[6] on average in the past 6 months. VMAC score was not associated with age ($r = -.012p = .689$) and did not differ significantly between males ($M = 6.5$ $SD = 80.00$) and females ($M = 8.8$ $SD = 79.22$) $t = .472p = .637$. Further VMAC was not associated with past 6-month alcohol use ($r = -.049p = .101$) as indexed by drinks/week.

Across participants response time for high-value distractor trials ($M = 997$ $SD = 172.7$) was significantly greater than for low-value distractor trials ($M = 989$ $SD = 171.7$) $t_{1129} = 3.9p = .001$. That is across all participants there was a clear VMAC effect during training i.e. the reward manipulation produced an attentional bias in line with past studies across VMAC task variants (Le Pelley et al., 2015; Albertella et al., 2019). Further there was a trend-level difference showing that the proportion of correct responses for high-value distractor trials ($M = 0.86$ $SD = 0.11$) was lower than for low-value distractor trials ($M = 0.87$ $SD = 0.12$) $t_{1129} = 1.9p = .061$ in line with research using the reward-only variant of the VMAC task (Albertella et al., 2019) used in this study. Thus participants were slower and less accurate (at trend level) on trials with a high-reward distractor ruling out an interpretation in terms of speed–accuracy trade-off. While the overall VMAC effect ($M = 8$ ms $SD = 80$ ms) was of small effect size ($d_{Cohen} = 0.1$) it is similar in magnitude to that originally reported under laboratory conditions (Le Pelley et al., 2015) [10 ms]). Notably of more interest for the current study is the ability of this measure to assess individual variation (cf. overall group effect) as highlighted by the findings below.

As mentioned previously sixty percent ($n = 683$) of participants (out of $n = 1130$) completed the post-IkPas assessment. Participants who were lost to follow-up were younger than participants who were followed-up $t_{1128} = 2.7p = .005$ as well as drank more drinks per week $t_{1128} = 2.8p = .005$. VMAC score was not found to differ significantly between participants who did not drop out ($M = 7.9$ $SD = 81.73$) and those who did ($M = 8.0$ $SD = 76.01$) $t_{1128} = .03p = .976$. Of those participants who completed the post-IkPas assessment 547 (80%) did not drink during IkPas.

**Table 3**
Logistic regression. Pooled results (20 datasets).

| Predictors | B | S.E. | p | Exp(B) |
|---|---|---|---|---|
| Age | −0.003 | 0.008 | 0.746 | 0.997 |
| Gender | 0.199 | 0.199 | 0.321 | 1.220 |
| Condition | −0.347 | 0.285 | 0.228 | 0.707 |
| Drinks/week | 0.010 | 0.009 | 0.300 | 1.010 |
| VMAC score (ms) | 0.003 | 0.001 | 0.013 | 1.003 |

*Note:* 'VMAC' = value-modulated attentional capture score (in ms) given by the difference in response time on trials featuring a distractor that was paired with high reward and response time on trials featuring a distractor that was paired with low reward.

[6] This was comparable to the average number of drinks of the overall sample (18.9 drinks/week, N = 12,402) [22]

The logistic regression on abstinence outcomes for complete cases (Table 2) was not significant overall $X^2 = 9.8p = .081$ had a classification success rate of 80% and good model fit (as revealed by a nonsignificant Hosmer-Lemeshow test $X^2 = 8.3p = .405$). It revealed that greater VMAC score at baseline was associated with non-abstinence during IkPas ($B = 0.003$ S.E. $= 0.001$ $OR = 1.003p = .014$) indicating that for every 10 ms increase in VMAC score (the odds of drinking during the challenge increased by 3%. Using VMAC $z$ scores to get a standardised odds ratio ($OR = 1.267$) revealed that for one standard deviation increase in VMAC score the odds of drinking during the challenge increased by 26.7%. No other variables were significant in the model. Similarly the logistic regression on abstinence outcomes using multiple imputed data (Table 3) revealed that greater VMAC score ($B = 0.003$ S.E. $= 0.001$ $OR = 1.003p = .013$) predicted non-abstinence during IkPas.

## 7. Discussion

This is the first study (to the best of our knowledge) that has examined the prospective relationship between reward-related attentional capture and unsuccessful behaviour change in the domain of addictive behaviour. We found that participants who showed greater reward-related attentional capture ('sign-trackers') prior to starting IkPas were more likely to resume drinking during IkPas. Importantly this association was significant over and above baseline alcohol use and was replicated using multiple imputed datasets to address missing data.

There are several possible interpretations for the finding that greater reward-related attentional capture at baseline predicted non-abstinence during IkPas. One such interpretation is that sign-trackers may be more likely to be attracted to alcohol-related cues by virtue of their tendency to be attracted to reward cues generally (at least to the extent that alcohol cues may be considered reward cues). Following this argument through sign-trackers would find themselves attending to alcohol cues more often which in turn may trigger cravings (Franken, 2003) making it more difficult to abstain from drinking.

An important feature of the current study that sets it apart from the majority of studies in this area is that participants here had made a commitment to not drink during the challenge. The relationship between a cognitive disposition toward addictive behaviours and addictive behaviours themselves is arguably likely to be revealed once an individual wants to change their behaviour even if this is for a temporary goal like in a voluntary abstinence challenge. The main reason for this is that consumption even problematic consumption is generally not driven by cognitive disposition alone but also by current goals (among other things). In fact goal-trackers have been shown to be more likely to drink compulsively when their main motivation for drinking is relief-based hence drinking is the means to achieve their goal (Liu et al., 2021; Köpetz et al., 2013). In line with this reasoning when examining the relationship between reward-related attentional capture and current alcohol use (before IkPas) no relationship was found. The relationship between sign-tracking and addictive behaviours (i.e. non-abstinence during an abstinence challenge) was revealed only once abstinence became the goal. The issue about an individual's goals providing important context for interpreting consumption might also explain why the present study did not find a relationship between alcohol consumption at baseline and abstinence success. While greater levels of consumption are not without risk (e.g. long term health risks (Rehm et al., 2010) consumption alone is not necessarily an indicator of one's ability to change their drinking behaviour.

The current study has a number of limitations. A major limitation is the high loss to follow-up. We attempted to address the loss to follow-up by controlling for predictors of drop-out as well as re-running the

analyses using multiple imputation (one of the least biased imputation methods (Hallgren et al., 2016). Another limitation is that we did not collect information about acute alcohol use at baseline which may have influenced cognitive performance. While it is unlikely that acute alcohol use contributed to the current findings (because acute alcohol use reduces VMAC (Watson, Pearson, & Le Pelley, 2020) it may have added unnecessary variance to the data. A related limitation is that we did not measure or control for problematic alcohol use which has been shown to predict temporary abstinence outcomes in past research (de Visser & Nicholls, 2020). However alcohol-related harms and problems are dependent on and closely related to heavy use [see Rehm et al., 2013]. Nevertheless future replication of the current findings could be strengthened by including baseline self-reported drinking problems. Another limitation of the current study is the online delivery of the VMAC task. While web-based methods of delivering cognitive tests have shown comparable results to lab-based studies (Stewart et al., 2017; McGraw et al., 2000) around 10% of participants in the present study scored below chance level on the VMAC task suggesting room for improving online delivery of the task. Albeit given that the task aims to an extent to produce errors (in the presence of high-reward cues) errors might provide additional information about risk. While we focused on VMAC response times to remain consistent with previous work (Le Pelley et al., 2015; Albertella et al., 2019) future studies using this task will benefit from analysing response times and errors as well as other task parameters as to obtain data-driven risk profiles in relation to addictive behaviours.

Finally the current sample was distinct in several respects either in relation to other abstinence challenges or the general Dutch population. For instance participants were relatively older than participants who typically engage in abstinence challenges in other countries. For instance the current sample had a mean age of 52 years where a recent Dry January sample had a mean age of 45 years (de Visser & Nicholls, 2020). Second this sample reported a relatively high number of drinks per week (19 drinks/week) which is well above the current guidelines (do not drink alcohol and if you do not more than one drink) and also above high-risk drinking (>14 and 21 drinks for females and males respectively) as about 30% of the Dutch general population do (Dieteran et al., 2020). The current sample's higher level of alcohol consumption (compared (de Visser & Nicholls, 2020) to that of the Dutch general population) is in line with research showing that participants of abstinence challenges (i.e. Dry January) drink at higher levels than the general population (de Visser & Piper, 2020). Thus the current sample is likely different from not only the general population (in terms of drinking) but also general abstinence challenge participants (at least in age). As such the current findings may not generalise to all individuals wanting to reduce their drinking.

Despite these limitations the current findings may have important implications for public health. Specifically the ability to achieve temporary abstinence during these challenges has numerous health benefits including improved well-being liver functioning as well as mediating long-term reductions in drinking (de Visser & Piper, 2020; de Visser et al., 2016; Bovens et al., 2017; Munsterman et al., 2018). Therefore finding ways to increase peoples' success during these challenges can amplify these health benefits. The finding that cognition can predict those who are at risk of not being successful in their abstinence resolution provides the opportunity for identification of risk prior to starting the challenge and in turn providing targeted support. For instance individuals identified at risk may be offered additional psychological support (e.g. online CBT) possibly aided by concurrent cognitive training such as Cognitive Bias Modification which shows better results when supporting an abstinence goal than a reduction goal (Boffo et al., 2019; Wiers et al., 2018). By increasing the likelihood of successful behaviour change during these public health initiatives such targeted support can maximise the number of people who experience the long-term health benefits. Finally the current study highlights the potential of using a dimensional approach to study addictive behaviours with difficulties in maintaining behaviour change as belonging to the same spectrum of risk and thereby the usefulness of abstinence challenges for future research examining the neurocognitive factors that drive risk for addictive behaviours.

## CRediT authorship contribution statement

**Lucy Albertella:** Conceptualization, Software, Methodology, Writing - original draft, Formal analysis, Data curation, Writing - original draft, Investigation, Resources. **Jessie Vd Hooven:** Conceptualization, Methodology, Writing - original draft, Project administration, Data curation, Writing - original draft, Investigation. **Rob Bovens:** Writing - review & editing, Conceptualization, Methodology, Supervision, Resources. **Reinout W. Wiers:** Writing - review & editing, Conceptualization, Methodology, Supervision, Resources.

## Declaration of Competing Interest

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

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2020.106745.

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