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Retraining automatic action-tendencies to approach alcohol in hazardous drinkers

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ABSTRACT

Aims The main aim of this study was to test whether automatic action-tendencies to approach alcohol can be modified, and whether this affects drinking behaviour. **Design and participants** Forty-two hazardous drinkers were assigned randomly to a condition in which they were implicitly trained to avoid or to approach alcohol, using a training variety of the alcohol Approach Avoidance Test (AAT). Participants pushed or pulled a joystick in response to picture-format (landscape or portrait). The pictures depicted alcoholic or non-alcoholic drinks. Participants in the avoid-alcohol condition pushed most alcoholic and pulled most non-alcoholic drinks. For participants in the approach-alcohol condition these contingencies were reversed. After the implicit training, participants performed a taste test, including beers and soft drinks. Automatic action tendencies at post-test were assessed with the AAT, including both trained and untrained pictures, and with a different test (Implicit Association Test, IAT). We further tested effects on subjective craving. **Results** Action tendencies for alcohol changed in accordance with training condition, with the largest effects in the clinically relevant avoid-alcohol condition. These effects occurred outside subjective awareness and generalized to new pictures in the AAT and to an entirely different test using words, rather than pictures (IAT). In relatively heavy drinking participants who demonstrated changed action tendencies in accordance with their training condition, effects were found on drinking behaviour, with participants in the approach-alcohol condition drinking more alcohol than participants in the avoid-alcohol condition. No effect was found on subjective craving. **Conclusions** Retraining automatic processes may help to regain control over addictive impulses, which points to new treatment possibilities.

Keywords Alcohol, approach bias, approach avoidance, cognitive bias, IAT, implicit cognition, modification, problem drinking, retraining.

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INTRODUCTION

A central paradox in the psychology of addictive behaviours is why addicted people continue their self-destructive behaviours, despite knowing the harms [1,2]. Research on implicit or automatic processes provides clues to understanding this paradox. The essential notion is that addictive behaviours are governed partly through automatic processes that often exert their influence outside conscious control. This perspective has led to the formulation of a variety of dual process models of addictive behaviours [1–5]. In these models, addictive behaviours are predicted by at least two semi-independent systems: a fast associative 'impulsive' system, in which stimuli are evaluated automatically in terms of their emotional and motivational significance, and a slower 'reflective' system, which includes controlled processes related to conscious deliberations and emotion regulation [6]. Translated to everyday life, a problem drinker may be aware that drinking alcohol should be discontinued in view of increasing negative consequences, but at the same time alcohol-related stimuli automatically capture attention [7,8], elicit memory associations [9,10] and action-tendencies to approach alcohol [11–14]. To counter the impulse to drink alcohol, the reflective system must have both sufficient resources and motivation to do so [3,5,15–17].

*This study was conducted when the first author was still at Maastricht University.

Emerging evidence reveals that information is represented in different ways in the two systems: the impulsive system is supported by bidirectional associations, while the reflective system relies on propositional representations [6,18]. This suggests that perceptions not only automatically trigger a motivational orientation and corresponding action-tendencies (approach attractive stimuli, avoid dangerous stimuli), but that the opposite should also hold true: approach or avoid movements should influence the motivational orientation to the eliciting stimuli. Strack and colleagues found evidence for feedback from motor-movements on evaluations in different paradigms [6], and Palfai [19] found that men who lifted a drink (action priming) drank more than men who leaned towards the drink (control action).

The central movement here is arm flexion versus arm extension. These movements are assessed and manipulated with new variations of a joystick task, the Approach-Avoidance Task (AAT; [14,20]). Previous research with joystick tasks demonstrated that positive stimuli facilitate approach (pull) movements and negative stimuli avoid (push) movements [21]. The new aspect of the AAT is a 'zooming feature': upon a pull movement, the stimulus increases in size on the screen and it decreases upon a push-movement. This 'zooming feature' generates a sensation of approach or avoidance [22] and disambiguates the task [20]. We recently developed a variety of the AAT in which participants react to a feature unrelated to the contents of the presented pictures [14,20]. Concretely, participants were instructed to pull the joystick in response to pictures in one format (e.g. 'portrait') and to push the joystick in response to pictures in the other format (e.g. 'landscape', cf. [23]). Reliable differences in pulling versus pushing a category of pictures can be interpreted as implicit or relatively automatic action-tendencies, because the difference emerges independently of the goal to react to the picture format and is thus driven by the automatic evaluation of the stimulus contents [24]. With this variety we found that heavy drinkers were faster to pull than to push pictures of alcoholic drinks, and this approach bias was associated with the presence of a g-allele in the human μ opioid receptor (OPRM1) gene [14], which we also found related to cue-induced craving [25].

The rationale of the present study was to apply the experimental logic of recent attentional retraining paradigms [26] to retrain automatic action tendencies for alcohol. In attentional retraining a test used to assess an attentional bias is changed so that attention is trained either towards or away from alcohol [27–30]. This has two purposes: the first is to test causality, and secondly, if a maladaptive cognitive bias can be retrained, this may lead ultimately to new clinical interventions [31]. Here, we adapted our recently developed alcohol AAT [14], with the aim to modify rather than to assess automatic action tendencies to either approach or avoid alcohol. This was conducted by manipulating the percentage of pictures of alcoholic or soft drinks, which were to be pushed or pulled. In the avoid-alcohol condition 90% of the alcohol pictures came in push-format (and 90% of the soft drinks in the pull-format), and these contingencies were reversed in the approach-alcohol condition (cf. [29]). We hypothesized that participants in the avoid-alcohol condition would become faster to push alcohol pictures compared with participants in the approach-alcohol condition. We tested generalization to new pictures in the same test used for retraining (AAT), and further generalization by assessing approach avoidance tendencies with a very different test, the Implicit Association Test (IAT), which uses words rather than pictures [12,13]. We tested effects on behaviour (alcohol consumption) in a taste test. In line with dual process models and findings from attentional retraining, where a 90% contingency was used [26,29], we expected that participants would not become aware of the changed contingencies.

METHOD

Participants and recruitment

Participants were 42 male hazardous drinking students [Alcohol Use Disorders Identification Test (AUDIT), [32], scores of 8 or higher, cf. [13]], recruited with flyers and posters with pictures of beers and colas and the text 'Can you taste the difference?'. In a brief telephone interview inclusion criteria were screened: males between 18–28 years who consumed a minimum of 15 standard alcoholic consumptions per week. One participant was an extreme outlier regarding alcohol use and problems [more than 3 standard deviations (SD) above the average on both variables] and was removed from the analyses. All main findings were checked later and remained unaffected. Participants in the avoid-alcohol condition drank somewhat more alcohol than participants in the approach-alcohol condition (25 and 20 drinks per week on average, respectively, $P = 0.11$; see Table 1) and scored significantly higher on the AUDIT index of problem drinking (14.0 and 11.8, respectively; $t_{39} = 2.5$, $P = 0.02$), which was therefore covaried in statistical analyses when it was related significantly to the dependent variable. The study was approved by the Ethics Committee of the Psychology Faculty of Maastricht University. Participants received €15 for participation.

MATERIALS AND MEASURES

Alcohol use and problems

Alcohol use was measured with a self-report questionnaire, based on the time-line follow-back method [33].

Table 1 Means of alcohol and reaction time tests at pre and post-test for the two experimental groups.

Condition / *Variable*	*Pull alcohol*	*Pull alcohol*	*Push alcohol*	*Push alcohol*	*Difference*
Time	*Pre-test*	*Post-test*	*Pre-test*	*Post-test*	*pre-test, t(39 df)*
Mean number of standard alcoholic drinks last week (SD)	20.3 (9.8)		25.4 (10.4)		$P = 0.11$
Alcohol problems: AUDIT (SD)	11.8 (2.6)		14.0 (3.0)		$P = 0.02$
Alcohol AAT difference medians (SD)	33.6 (73.5)	41.4 (78.5)	−14.6 (71.3)	−68.1 (101.7)	$P = 0.04$
Alcohol AAT difference medians adjusted for AUDIT (SD)	38.4 (107.8)	42.7 (137.5)	−19.2 (105)	−69.4 (134)	$P = 0.024$
Soft drink AAT difference medians (SD)	40.9 (94.9)	−21.9 (88.3)	2.4 (87.4)	5.3 (99.3)	$P = 0.18$
Soft drink AAT difference medians adjusted for AUDIT (SD)	46.9 (135.6)	−4.2 (125.7)	−3.3 (132.1)	−11.6 (122.5)	$P = 0.11$
Mean scores IAT (SD)	0.05 (0.14)	0.09 (0.18)	0.09 (0.15)	0.00 (0.17)	$P = 0.36$
Urge to drink beer (SD)		6.15 (2.64)		6.48 (2.25)	
Beer consumed during taste-test (SD)		223 (163)		209 (145)	

Mean scores for the Approach Avoidance Test (AAT) are calculated by subtracting the median reaction time (RT) scores per category of pictures (alcohol or soft drinks), with positive values denoting faster pulling than pushing (approach tendencies). Given the pre-test difference in Alcohol Use Disorders Identification Test (AUDIT) scores, the AUDIT adjusted estimated marginal means of these variables are also provided. Mean scores for the Implicit Association Test (IAT) are also difference scores where a positive value denotes faster categorization of alcohol with approach words (and soft drinks with avoidance words) than alcohol with avoidance words (and soft drinks with approach words). All values for AAT and IAT are in milliseconds. Urge scores are on a visual analogue scale (0–10), and beer consumed is reported in millilitres. SD: standard deviation.

For every day of the past week, participants indicated the number of standard alcoholic consumptions. They also indicated the number of occasions on which they had drunk five or more alcoholic drinks during the past 2 weeks. Alcohol-related problems were assessed with the AUDIT, a validated screening instrument for alcohol-related problems, in the general population [32] and in students [34].

Urge to drink, picture ratings and drink rating

Urge to drink soft drinks, alcohol, beer and cola were assessed with 11-point Likert scales. Similar scales were used to assess how much participants liked each drink presented during the taste test and the attractiveness of all pictures used in the AAT.

Approach-avoidance IAT

The IAT is a computerized timed classification test, in which two target categories (here alcoholic versus non-alcoholic drinks) are sorted in different combinations with two attribute categories (here approach versus avoidance), using two response keys (see [9,12,13], and for an example test: http://www.implicit.harvard.edu). The IAT effect is the difference in reaction times (RTs) between one sorting condition (here alcohol/approach versus soft drink/avoid) and the other sorting condition (alcohol/avoid versus soft drink/approach; [12,13]). Response assignments and order of the combined blocks was counterbalanced. Participants received exactly the same version of the IAT in the post-test, to minimize error variance (cf. [35]). The IAT consisted of 20 trials in practice phases and 40 in both combination phases and took 5 minutes. We tested primarily the effect of the training on the original IAT scoring algorithm [36], rather than on the later developed D-algorithm [37], because in an earlier study we found hypothesized within-subjects effects using the original algorithm but not with the D-algorithm, which was validated in web-based studies using between-subjects designs only [35].

AAT

The AAT used in this study consisted of two different phases: a brief-assessment AAT [14] and a training AAT. The assessment AAT began with 20 practice trials in which participants learned to push or pull the joystick in response to picture format (landscape or portrait), for rectangles. The practice phase was followed by 80 test trials in which pictures of alcoholic drinks and non-alcoholic drinks came equally often in push- or pull-format. Picture format to response assignment was counterbalanced, with half the participants pulling landscape pictures and half portrait pictures.

Unbeknown to participants, the assessment AAT then changed to the training AAT. For participants in the avoid-alcohol condition, 90% of the alcohol pictures now came in the push-format and 10% in the pull-format, with reversed contingencies for soft drinks. For participants in the approach-alcohol condition, all contingencies were reversed, resulting in 90% pull-responses to alcohol pictures and 90% push-responses to soft drinks. Note that in both versions, the total number of push and pull-trials remains 50%. The training AAT consisted of 440 trials with a short break. Half the pictures of the pre-test AAT were used in the training AAT (10 alcohol and 10 non-alcohol pictures) to allow a test of generalization (untrained pictures). The pre-test/training AAT took about 20 minutes. The post-test AAT was identical to the pre-test assessment AAT, including 20 trained and 20 untrained pictures (each half alcohol and half non-alcohol).

Funnelled debriefing

A funnelled debriefing procedure was used (cf. [38]) with four questions with open-answer format, beginning with general ('What do you think this study was about?') to more specific ('Do you think the joystick task influenced you in any way? If so, how?') questions.

Procedure

Upon arrival, participants were informed about the study and signed informed consent. They were seated in a cubicle with a computer. They first indicated their urge to drink. The pre-test IAT was then performed, followed by the combined pre-test assessment and training AAT. Directly afterwards, participants received three colas and three beers (3.5% alcohol), served in glasses containing 200 ml, from an experimenter blind to training condition. The participants' task was to guess the correct brand name and to rate how much they liked each drink. The dependent variable was the amount of beer consumed. After the taste test, participants performed the post-test AAT, followed by the rating of the pictures used in the AAT and the post-test IAT. After completing questionnaires assessing alcohol use and problems, the funnelled debriefing was administered and participants were breathalysed, thanked and paid.

Statistical approach

In keeping with earlier research using the AAT [14,20] and other studies of RT-based retraining procedures [26,29,39] we used medians as summary variables to summarize participants' performance on the AAT. Median scores are often used in preparatory analyses of RT paradigms because they are less sensitive to outliers than means, and no arbitrary cut-off points need to be formulated regarding outliers (e.g. discard RTs above 2000 ms or 3 SD above mean and RTs below 200 ms). In this manner, for each participant four median RTs were calculated for pulling and pushing alcohol and soft drink pictures. From these median RTs, AAT difference scores were calculated per drink category ($RT_{push} - RT_{pull}$), so that a positive AAT score indicates a faster approach than avoidance reactions to this category. These AAT difference scores were then subjected to standard analysis of variance (ANOVA) procedures, which analyse the means of the difference in median RTs.

RESULTS

Pre- and post-test AAT scores for alcohol and soft drink pictures were analysed with a mixed $2 \times 2 \times 2 \times 2$ analysis of covariance (ANCOVA), with drinktype (alcohol or softdrink), and time (pretest or post-test) as within-subjects factors, experimental condition (approach- or avoid-alcohol), and picture set (trained or untrained) as between-subjects factor and AUDIT score as covariate. There was a significant interaction between drinktype, time, and experimental condition, $F_{(1,38)} = 8.02$, $P = 0.007$. There were no other significant effects in this analysis. Tests of simple effects on the adjusted means indicated that, in the push-alcohol condition, the change in AAT scores was significant for alcohol pictures ($P = 0.04$), but not for soft drink pictures ($P > 0.50$). The push-alcohol condition resulted in more negative AAT values, hence in stronger action tendencies of avoidance of alcohol. In the pull-alcohol condition (push soft drinks), there was a statistical trend for the soft drink pictures ($P = 0.052$) and no effect for the alcohol pictures ($P > 0.50$). The differential training effects on the alcohol pictures are depicted in Fig. 1. The fact that picture set had no effect (all P-values involving picture set >0.15) indicated that there were no differences depending upon whether or not specific pictures were used during the training, hence there was generalization to new pictures in the same test.

The next question was whether the effect of the retraining would generalize to another task: the approach-avoidance IAT. Pre- and post-test IAT-scores for alcohol and soft drink pictures were analysed with a mixed 2×2 ANCOVA, with time (pre- or post-test) as within-subjects factor, treatment condition (approach- or avoid-alcohol) as between-subjects factor (AUDIT was first entered as a covariate, but showed no effects, $F < 1$, and removed again). The time × condition interaction was significant, $F_{(1,39)} = 4.93$, $P = 0.032$, with simple effects indicating a significant change towards stronger associations between alcohol and avoidance words in the

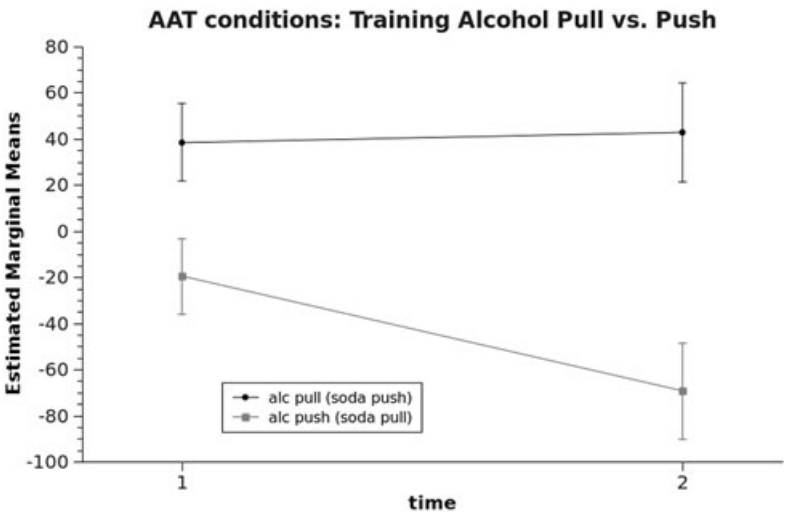

Figure 1 Effect of the training condition (approach alcohol or avoid alcohol) on automatic action-tendencies to approach or avoid alcohol. A positive value denotes that the tendency to approach alcohol is stronger than the tendency to avoid alcohol. The negative slope in the avoid-alcohol condition indicates that participants in this condition became faster in pushing away alcohol pictures. AAT: Approach Avoidance Test

push-alcohol condition ($P = 0.032$), in the absence of a change in the pull-alcohol condition ($P = 0.35$).

The training had no effect on subjective urges to drink alcohol, beer, soft drink or cola (all P-values > 0.50). In addition, no effect of the training was found on the subjective evaluation of the beers and colas, nor on the ratings of the pictures for attractiveness (all P-values > 0.50).

The final question regarded whether the training resulted in effects on drinking. Initial analyses indicated no effect of training condition on the amount of beer consumed during the taste test ($P > 0.50$). Given the observed variability of the training effects on the AAT, we tested whether the training had an effect on drinking in individuals who were trained successfully (i.e. individuals in the approach-alcohol condition who became faster in pulling alcohol and individuals in the avoid-alcohol condition who became faster in pushing alcohol). This is equivalent to a manipulation check: if the AAT score is not changed in the expected direction, there is no reason to expect an effect of the training on behaviour. Eleven subjects in the approach-alcohol condition showed an increased AAT score at post-test (difference between post-test and pre-test AAT scores larger than 0, mean change 73 ms) and 12 participants in the avoid-alcohol condition showed stronger negative AAT scores at post-test (difference between post-test and pre-test AAT score below 0, mean −122 ms). Beer consumption during the taste test of these individuals was analysed with hierarchical multiple regression analysis, which is preferable over an ANCOVA approach when multiple continuous predictors are to be included [40]. The results are summarized in Table 2. In the first step, weekly alcohol consumption and urge to drink beer were entered, and they predicted 42% of the variance in beer consumption ($P = 0.004$). In the second step experimental condition was entered, which explained an additional 11% of variance in beer consumption ($P = 0.046$). The interaction between (centred, see [40]) regular weekly alcohol consumption and experimental condition was entered in the third step, and explained an additional 13% of variance in beer consumption ($P = 0.018$). All predictors were significant in the final model and there were no influential outliers. The interaction is depicted in Fig. 2. Heavy drinkers trained successfully to push alcohol away drank a full glass of beer less than heavy drinkers trained to pull alcohol.

Table 2 Summary of hierarchical regression analysis for variables predicting beer consumption during the taste test of successfully retrained participants ($n = 23$)

Variable	*B*	*SE B*	*β*
Step 1: change R^2: 0.42**			
Weekly alcohol consumption	5.15	2.26	0.40*
Urge to drink beer	28.7	11.5	0.44*
Step 2: change R^2: 0.11*			
Weekly alcohol consumption	6.63	2.19	0.51**
Urge to drink beer	29.1	10.6	0.44*
Condition	−95.6	44.7	−0.36
Step 3: change R^2: 0.13*			
Weekly alcohol consumption	12.9	3.10	0.99**
Urge to drink beer	32.6	9.36	0.49**
Condition	−105.8	39.4	−0.39*
Condition × weekly alcohol consumption	−10.2	3.95	−0.61*

*$P < 0.05$; **$P < 0.01$. R^2 final model = 0.66 ($P < 0.001$); adjusted $R^2 = 0.58$. SE: standard error.

Given that this result applied only to those participants who were retrained successfully, we explored which variables predicted responsiveness to the training. Urge to drink alcohol ($P < 0.01$) and more specifically beer ($P < 0.001$) were related negatively to success of training;

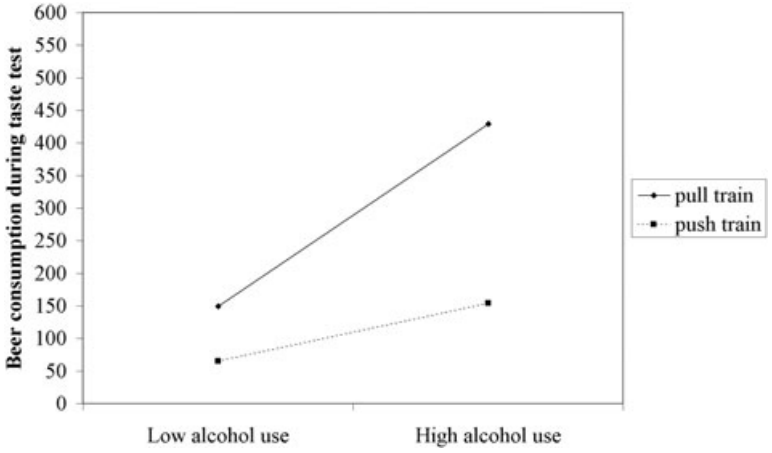

Figure 2 This figure depicts the interaction of drinking-status (low–heavy alcohol use) and training condition in the prediction of beer consumption, in those participants who were trained successfully (i.e. participants in the avoid-alcohol condition who became faster in pushing alcohol and participants in the approach-alcohol condition who became faster in pulling alcohol). Heavy drinkers who were trained successfully to push alcohol away drank less alcohol than heavy drinkers who were trained successfully to pull alcohol

successful training was related to a relatively *low* urge to drink beer prior to the training. Other variables were not related to successful training (P-values > 0.25). During the funnelled debriefing, no participant indicated awareness of the changed contingencies during the training. On the final question, two participants indicated that the AAT might have influenced their behaviour during the taste test, without indicating how. When these participants were excluded, the effects on AAT performance and drinking remained the same, while the effect on the IAT became borderline significant ($P = 0.053$).

DISCUSSION

The main findings of this study were as follows: automatic action tendencies to approach alcohol were changed successfully using a newly developed training variety of the alcohol AAT ([14]). The training was indirect: participants were requested to respond to the format of the pictures, not their contents. In line with previous retraining studies using a 90–10 contingency, participants showed no awareness of the change in contingencies from the pre-test AAT to training AAT [26,29]. Further, no effects on subjective craving or liking were found. Nevertheless, effects on behaviour were found: training effects contingent with training direction (approach or avoid alcohol) were found in the test used during the training (AAT) for the alcohol pictures: participants trained to avoid alcohol became faster in pushing alcohol pictures away, and a similar trend was found for soft drink pictures. Importantly, it was demonstrated that these effects generalized to untrained pictures, which was not found in previous studies using a single session of attentional retraining for alcohol [27–29]. Note that in a recent study we did find generalized effects after multiple sessions of attentional retraining [31,41]. A further noteworthy finding of the present study was that the training effect induced with the adapted pictorial AAT also generalized to an approach-avoidance IAT using words. From a clinical perspective it was promising that the largest change in automatic action tendencies was found in the clinically relevant avoid-alcohol condition (both in the AAT and in the IAT), which again contrasted with findings from attentional retraining of alcohol where the larger effects were found in the theoretically interesting, but clinically irrelevant, approach-alcohol condition [28]. In the subgroup of participants who were trained successfully, effects on alcohol consumption were found. In this subgroup, heavy drinkers in the avoid-alcohol condition drank less beer during the subsequent taste test than heavy drinkers in the approach-alcohol condition.

The present findings contribute to a growing body of research indicating that motor feedback can influence motivational orientation [6], and this may also be relevant for alcohol use and misuse [19]. It should be noted that there is discussion about the question of to what extent the exact movement is relevant (here push alcohol) or whether the effects are due to affective coding [42]. Regarding the effects of approach-avoidance learning on behaviour, a recent paper demonstrated that indirect training with a similar joystick task, in which black faces were responded to with pull-movements, resulted in reduced implicit racial prejudice as assessed with an IAT and in effects on non-verbal social behaviour [43]. In one of those studies reported, effects were reported in response to subliminal primes (black or white faces) followed by push or pull movements. These findings, along with those of the present study, indicate that action-tendency retraining can influence motivational orientation without awareness. Another interesting finding here was that the training-effect was found primarily for one category (alcohol) and not for the other (soft drinks), even though both categories received exactly the same amount

of training. One possible explanation is that prior evaluation of the category moderates the effects of actions on (implicit) attitudes. Alcohol is a highly ambivalent category [44] and heavy drinkers have been shown to have both strong negative and positive associations with alcohol [45], and the same is likely for approach and avoidance [46]. Hence, it is possible that the training effect was specific for alcohol, because the training emphasized one side of an ambivalent category, which may not have been the case for soft drinks.

A number of limitations of should be mentioned. First, only hazardous drinking male students were included, limiting generalization beyond this group. Secondly, a limitation in the interpretation of the training effects on the post-test AAT scores is that these were assessed after the taste test. It cannot be excluded that post-test AAT scores were affected differentially by alcohol, although this seems unlikely given the absence of an overall effect of training condition on alcohol consumption. The reason that we chose this design is that another assessment AAT directly after the training AAT (in which alcohol is again equally often pushed and pulled) could have erased the effects of the manipulation (cf. [47]). Future research could address this limitation by reversing the order, where we would predict that similar effects would be found on AAT and IAT, but not on drinking, because the post-tests would readily erase the bias created previously.

Finally, the work presented may have implications for the treatment of addictive disorders. Following the pioneering work of MacLeod and colleagues [26], there is a surge of interest in possibilities to interfere directly with implicit processes in psychopathology, focusing mainly upon retraining procedures of attentional and interpretation biases, as witnessed by a special section in a recent issue of the *Journal of Abnormal Psychology* [48]. To our knowledge, this is the first study in which psychopathology-related action-tendencies were retrained. First promising effects in clinical populations have also been reported for different attentional retraining procedures, for anxiety [49,50] and for alcoholism [30,31,41]. We are currently investigating the effects of repeated action-tendency training in alcoholic patients in a clinic. While it is theoretically interesting that the effects found here occurred outside awareness, awareness of the rationale for retraining could be clinically useful and may have a positive motivating effect, although the opposite may also hold true (conscious processes impeding changes of automatic processes). Regarding the usefulness of the present retraining technique in a clinical setting, it was noteworthy that only 56% of participants responded and that urge to drink was a negative predictor. With respect to the limited success of a single session of retraining, clinical retraining studies have used multiple sessions of retraining and found stronger effects, both in anxiety [39,49,50] and alcoholism [30,31,41]. The negative prediction of urge to drink beer may indicate that training may work more effectively when a patient is not craving, but this will need to be verified in a patient population. Further, given recent internet-based techniques [39], an interesting possibility may be to continue training from the clinic to the home environment, which may help to prevent relapse. We believe that, ultimately, these training methods may become a useful tool in the treatment of addictive behaviours. Before this promise can be fulfilled, we need more research into the optimal training conditions (implicit or explicit instructions, number of training sessions, etc.) and into the long-term effects of training in a clinical setting and to what extent results generalize to the natural environment.

Declarations of interest

None.

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