Running head: EVALUATIVE CONDITIONING AND DRINKING BEHAVIORS

Effects of evaluative conditioning on implicit evaluation of alcohol and drinking behaviors: A direct replication

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Open Practices:
The study was fully preregistered at https://osf.io/yxvwp/registrations/. All materials, data, and code have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/yxvwp/. A supplementary online material is available at https://osf.io/t3epj/.

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Abstract

Background. Recent research suggests that evaluative conditioning can change implicit evaluation of alcohol and reduce drinking behaviors among college students (Houben, Havermans *et al.,* 2010). This study has been conceptually replicated in two previous studies. To date, however, there is no direct and independent replication of the original study. In this paper, we report a high-powered direct replication of Houben, Havermans *et al.'s* (2010) study. *Method*. One hundred and sixty-eight French college students took part in this preregistered study. Drinking behavior was assessed before the intervention and two weeks after. The intervention consisted of 120 trials of words related to alcoholic beverages or to soft drink, paired with neutral, positive, or negative pictures. The two conditions were factually equivalent and only differed by the contingency between alcohol-related words and negative pictures. In the evaluative conditioning condition, but not in the control condition, alcohol-related words were systematically paired with negative pictures. *Results.* Evaluative conditioning did not change implicit evaluation of alcohol and drinking behaviors. However, evaluative conditioning reduced drinking behaviors specifically among hazardous drinkers. *Conclusion.* This high-powered pre-registered direct replication of Houben, Havermans *et al.* (2010) suggests that the original effects are more fragile than initially thought. The effect of evaluative conditioning on drinking behaviors may be restricted to heavy drinkers, and we found no evidence that this effect is mediated by a change in implicit attitudes. Further studies are needed to test the original effects in clinical populations.

Keywords: Direct replication, Alcohol, Hazardous drinking, Evaluative conditioning, Implicit evaluation

Short abstract

In this paper, we report a high-powered direct replication of Houben *et al.'s* (2010) study. In contrast to the original study, evaluative conditioning did not change implicit evaluation of alcohol and drinking behaviors. However, evaluative conditioning reduced drinking behaviors specifically among hazardous drinkers.

Effects of evaluative conditioning on implicit evaluation of alcohol and drinking behaviors: A direct replication

Recent research suggests that a single session of a brief computed-mediated intervention based on evaluative conditioning could reduce positive implicit attitudes towards alcohol and drinking behavior among college students (Houben, Havermans *et al.,* 2010). In their study, Houben, Havermans et al.'s assessed the number of alcoholic beverages consumed the week before and after a single session of evaluative conditioning. An alcohol implicit association test was also administered twice, just before and after evaluative conditioning. This intervention was either composed of negative images taken from the International Affective Picture System (IAPS; Lang *et al.,* 2008) or of frowning faces pictures (unconditioned stimuli). Houben, Havermans *et al.* (2010) found that the evaluative conditioning based on the negative IAPS pictures reduced positive implicit evaluation of alcohol and alcohol consumption. Evaluative conditioning based on the frowning faces had no effects on these two variables.

Despite the major implications these results could have, they have never been exactly and independently replicated. To our knowledge, Houben, Havermans *et al.'s* (2010) study was conceptually replicated twice, once by the same team (Houben, Schoenmakers *et al.,* 2010) and once by an independent team (Tello *et al.,* 2018). Houben, Schoenmakers, *et al.* (2010) found that participants had more negative implicit attitudes toward beer, experienced less craving for beer, and actually consumed less alcohol right after the evaluative conditioning and the following week. In contrast, Tello *et al.* (2018) found no evidence that evaluative conditioning reduced implicit evaluation of alcohol. However, they successfully replicated Houben, Havermans *et al.'s* (2010) second key finding showing that evaluative conditioning reduced drinking behavior. All in all, this suggests that the effect of evaluative

conditioning on drinking behavior is reliable as it can be conceptually replicated by both the same authors and some independent researchers. Yet it seems that the effect of evaluative conditioning on the implicit evaluation of alcohol is not consistently found.

Despite these two conceptual replications, Houben, Havermans et al.'s (2010) study has never been directly replicated. According to some researchers, direct replications are more valuable than conceptual replications because they are more likely to set up the reliability of a study (Finkel *et al.,* 2015; Simons, 2014). For example, because Tello *et al.* (2018) study was a conceptual replication, the failure to replicate could be explained by methodological differences (i.e. different stimuli in the evaluative conditioning task).

Our aim in this present study was to overcome this limitation by conducting a direct preregistered high-powered independent replication of Houben, Havermans, *et al.* (2010). Hence, relying on a larger sample and on a more direct replication design should allow the effect of evaluative conditioning on the implicit evaluation of alcohol to be observed if it is replicable. We also aimed to extend the original results by testing whether the findings generalize to hazardous drinkers specifically. Indeed, hazardous drinking behaviors such as 'binge drinking' and associated alcohol use disorders are widespread among college students and are recognized as major public health concerns (World Health Organization, 2018). Hazardous drinking behavior is defined as a drinking pattern of 14 units of alcohol per week for men and 7 for women (NIAAA, 2016). This drinking pattern leads to behavioral and psychological disorder (Kuntsche et al., 2004; Rehm et al., 2010). It is thus important to develop interventions for reducing hazardous drinking behaviors among college students.

We predicted that evaluative conditioning would change implicit evaluation of alcohol and would reduce drinking consumption. Finally, we predicted that evaluative conditioning would be particularly efficient among hazardous drinkers.

Method

The hypotheses, materials, and analysis plan were preregistered on Open Science Framework (https://osf.io/yxvwp/registrations/) before the data were collected.

A priori power analysis

The present study is a direct replication of Houben, Havermans *et al.'s* (2010) study. Required sample size was determined in advance using G*Power 3.1 (https://osf.io/xuvcz/) to have at least 90% power to replicate Houben, Havermans *et al.'s* (2010) original findings and to find a significant moderation by hazardous drinking behavior. Original findings fall in the range of medium to large effect sizes (Cohen's $d = 0.58$ and 0.66 for the measure of change in implicit evaluation of alcohol and in drinking behavior, respectively). Thus, in order to replicate the original finding with 90% power, we will need a total sample size of 52 participants (https://osf.io/xuvcz/). However, we decided to use a much larger sample to prevent possible inflation of the original effect sizes and to allow testing possible moderations by hazardous drinking behavior. A total sample size of 148 participants was required (if Cohen's $d = .40$, $1 - \beta = .90$) to find a significant moderation ($p < .05$) of evaluative conditioning by hazardous drinking behavior (dichotomous variable) in an analysis of variance. Thus, we decided in advance to include a minimum of 150 participants in this study. To avoid a smaller sample size than intended due to outlier deletion or non-responses, we recruited a couple of additional participants.

Participants

Participants were 168 students* from the University of Poitiers (132 females and 36 males, $M_{age} = 20.20$ years, $SD = 2.55$), recruited from our research pool (https://osf.io/xuvcz/). They received course credit as compensation for their participation. Following the preregistered plan, three participants were excluded from the analyses because they were

detected as outliers on the measure of change in drinking behavior (2 participants with z-scores below 3SD from the mean and 1 with z-scores above 3SD from the mean), leaving 165 students in the final sample.

Materials and procedure

This experiment was composed of two sessions separated by approximately two weeks (M = 14.53 days, SD = 3.09 days). Participants completed the measures in our laboratory (for a video of the lab setup, see https://osf.io/4vy3w/).

In the first session, participants first completed the TimeLine Follow Back (TLFB, Sobell and Sobell, 1992) questionnaire. The TLFB was used to assess the number of alcoholic beverages consumed in the past week. Then, participants completed the Alcohol Use Disorder Identification Test (AUDIT, Saunders *et al.,* 1993). AUDIT was used to screen and identify participants with hazardous drinking behavior.

Afterwards, participants completed the same alcohol implicit association test (IAT, Greenwald *et al.,* 1998) used by Houben, Havermans *et al.* (2010). The IAT is a computer delivered test that, in this study, was used to measure implicit evaluation of alcohol. This test is based on reaction time to categorize words that appear in the middle of the screen into one of two categories presented on the top left and right of the screen. Participants had to press the "E" key for the left category and the "I" key for the right one. This test included 5 practice blocks and 2 test blocks (with one compatible block and on incompatible block, Greenwald et al., 2003). In the compatible block "alcohol" and "positive" were assigned to the same response key, whereas in the incompatible block "alcohol" and "negative" were assigned to the same response key. Participants had a positive implicit evaluation of alcohol (i.e., high IAT scores) if they were quicker to respond to the compatible block (alcohol-positive associations) compared to the incompatible block (alcohol-negative associations).

Then, participants completed the exact same evaluative conditioning task than the one used by Houben, Havermans *et al.* (2010). Participants were randomly assigned to one of the two conditions (evaluative conditioning or control intervention). The evaluative conditioning procedure lasted for five minutes and was composed of 120 trials. In this task, participants were repeatedly exposed to words (related to alcohol, soft drink, or neutral) paired with an image (positive, negative, or neutral). The positive, negative, and neutral images, taken from the IAPS database are available here: https://osf.io/p6g2c/. In the experimental condition, alcohol-related words were systematically followed by a negative picture; soft-drink related words were systematically followed by a positive picture; and, neutral words were systematically followed by a neutral picture. In the control condition, alcohol and soft drink related words were systematically followed by a neutral picture, and neutral words were followed by a positive or a negative picture. All participants were exposed to the same materials and only the pairings of words differed between the two conditions.

Finally, participants completed once again the IAT. Change in implicit evaluation of alcohol was our first dependent variable. To this end, we computed the mean difference between responses on the two IAT (before and after evaluative conditioning). Higher scores on this measure indicated more positive implicit evaluation of alcohol after the intervention, compared to before.

The second session took place about two weeks later. Participants were asked to complete the TLFB questionnaire. Our second dependent variable, change in drinking behavior, was the difference between the two TLFB questionnaires (before and about two weeks after the evaluative conditioning). Higher scores on this measure indicated an increase in drinking behaviors in the 2 weeks following the intervention, compared to before the intervention.

Known differences with the original study

We tried to minimize differences with the original study, however four remained. Three were listed in the preregistration (https://osf.io/xuvcz/). *First*, our study was conducted in France, whereas the original one was conducted in the Netherlands. Thus, our study was conducted in French rather than in Dutch. *Second*, we conducted our study in a laboratory (a well-controlled environment) rather than online, as in the original study. *Third*, because of time constraints, we did not use all Houben, Havermans *et al.'s* (2010) measures, but only those needed to replicate the key findings.

In the preregistration, we omitted a fourth difference. In the present study, we assessed alcohol use before rather than after the first IAT.

The protocol was approved by the French national medical ethics research committee (https://osf.io/xyt9q/), and participants provided their written informed consent.

Results

Preliminary analyses

In some preliminary analyses, we first examined possible effects of gender and age by introducing these variables as covariates in analyses of covariance (ANCOVA). We used the same dependent variables as Houben, Havermans *et al*. (2010). The first one was the measure of change in the implicit evaluation of alcohol (mean IAT difference scores between pre- and post-intervention). The second dependent variable was the measure of change in drinking behavior (mean TLFB questionnaire difference scores between pre- and post- intervention).

An ANCOVA on change in the implicit evaluation of alcohol with condition as independent variable, and age and gender as covariates, there were no effects of the covariates. In the same way, we found no effects of gender and age in an ANCOVA on the measure of change in drinking behavior. Therefore, we did not include these variables in the subsequent pre-registered analyses (see the SOM for the results of the ANCOVAs).

In further preliminary analysis, we tested whether hazardous drinkers and control participant differed in their baseline implicit association of alcohol. In an independent sample *t*-test, we found that hazardous drinkers had less negative implicit association of alcohol than control participants $t(163) = -3.32$, $p = .001$, $d = -.57$. This result was consistent with previous studies (Houben & Wiers, 2006, 2007; Lindgren *et al*. 2013).

Preregistered analyses

In line with our first hypothesis, we expected a significant effect of the condition on the measure of change in the implicit evaluation of alcohol, indicating a larger change in implicit evaluation of alcohol in the evaluative conditioning (EC) condition, compared to the control condition. To test this hypothesis, we conducted an analysis of variance (ANOVA) on the measure of change in the implicit evaluation of alcohol with EC as independent variable. Our results indicated no effect of EC on the measure of change in the implicit evaluation of alcohol $F(1, 166) = 0.274$, $p = .61$, $\eta^2 < .002$. Changes in the implicit evaluation of alcohol were not different in the EC condition ($M = -0.01$, $SD = 0.46$) compared to the control condition ($M = -0.03$, $SD = 0.37$). In the control condition, the implicit evaluation of alcohol was not different after ($M = -0.36$, $SD = 0.36$) and before the intervention ($M = -0.33$, $SD = 0.41$), $F(1, 78) = 0.66$, $p = .42$, $\eta^2 = .008$. In the EC condition, we found no difference between after ($M = -0.36$, $SD = 0.35$) and before the intervention ($M = -0.36$, $SD = 0.43$), $F(1, 88) < 0.01$, $p = .99$, $\eta^2 < .001$.

In line with our second hypothesis, we expected a significant effect of the condition on the measure of change in drinking behavior, indicating a larger change in drinking behavior in the EC condition compared to the control condition. To test this hypothesis, we conducted an ANOVA on the measure of change in drinking behavior with condition as independent variable. In this study, we found no effect of EC on the measure of change in drinking behavior, $F(1, 163) = 0.36$, $p = .55$, $\eta^2 = .002$. The change in drinking behavior was not

different between the EC condition ($M = -0.71$, $SD = 2.88$) and the control condition ($M = -0.44$, $SD = 2.88$). In the EC condition, participants showed reduced alcohol use after ($M = 3.19$, $SD = 3.82$) compared to before ($M = 3.89$, $SD = 4.69$) the intervention, $F(1, 86) = 5.23$, $p = .025$, $\eta^2 = .057$. This difference was not significant in the control condition ($M = 3.28$, $SD = 4.26$, and $M = 3.72$, $SD = 4.43$, after and before the intervention, respectively), $F(1, 77) = 1.79$, $p = .19$, $\eta^2 = .023$. However, the difference between the two conditions was not statistically different.

Following the pre-registered plan, we tested whether hazardous drinking moderated the effects of EC on our dependent variables. We classified participant as hazardous drinker (n = 47) based on their AUDIT score (>7 for women and >8 for men). To test the moderation hypothesis, we conducted an ANOVA, on the measure of change in the implicit evaluation of alcohol with condition and AUDIT as independent variables. On the measure of change in the implicit evaluation of alcohol, an ANOVA revealed no main effect of EC, $F(1, 164) = 0.287$, $p = .59$, $\eta^2 < .001$, no main effect of AUDIT scores (dichotomous variable), $F(1, 164) = 1.15$, $p = .29$, $\eta^2 = .007$, and no interaction between these variables, $F(1, 164) = 0.04$, $p = .84$, $\eta^2 < .001$. Thus, EC did not change the implicit evaluation of alcohol and hazardous drinking did not moderate this effect.

On the measure of change in drinking behavior, we conducted an ANOVA with condition and AUDIT as independent variable. The ANOVA revealed a marginal main effect of EC, $F(1, 161) = 3.30$, $p = .07$, $\eta^2 = .019$. There was no main effect of AUDIT scores (dichotomous variable), $F(1, 161) = 0.00$, $p = .98$, $\eta^2 < .001$. However, we found a significant interaction between EC and AUDIT scores, $F(1, 161) = 8.62$, $p = .004$, $\eta^2 = .050$. As expected, hazardous drinking moderated the effect of EC on drinking behavior. Hazardous drinkers showed reduced drinking behaviors in the EC condition ($M = -1.75$, $SD = 4.39$), compared to the control condition ($M = 0.57$, $SD = 3.30$), $F(1, 45) = 4.14$, $p = .048$, $\eta^2 = .084$. Control

participants did not show reduced drinking behaviors in the EC condition ($M = -0.31$, $SD = 1.94$), compared to the control condition ($M = -0.85$, $SD = 2.60$), $F(1, 116) = 1.69$, $p = .196$, $\eta^2 = .014$.

We found similar findings when AUDIT scores were used as a continuous variable rather than as a dichotomous variable in regression analyses. There were no significant interaction between EC and AUDIT scores (continuous variable) to predict the change in implicit evaluation of alcohol, $B = -0.005$, $SE = 0.016$, $t(164) = -0.29$, $p = .76$. However, there were a significant interaction between EC and AUDIT scores (continuous variable) to predict the change in drinking behavior, $B = -0.22$, $SE = 0.11$, $t(164) = -2.04$, $p = .043$. The more participants were high in AUDIT scores, the more they showed reduced drinking behaviors in the EC condition, compared to the control condition.

Further non-preregistered analyses

Since we did not replicate Houben, Havermans et al.'s (2010) two main findings, we decided to test the relative evidence for the null hypothesis compared to the alternative hypothesis using Bayesian ANOVA. For the measure of change in the implicit evaluation of alcohol, a Bayesian ANOVA with a default prior of $r = 0.50$ (fixed effects) provided substantial support for the (null) hypothesis that EC did not change the implicit evaluation of alcohol, $BF_{01} = 5.71$, error < 0.001%. For the measure of change in drinking behavior, a Bayesian ANOVA with a default prior of $r = 0.50$ (fixed effects) provided substantial support for the (null) hypothesis that EC did not change drinking behavior, $BF_{01} = 5.01$, error < 0.001%.

Regarding EC effects on implicit evaluation of alcohol and drinking behavior among hazardous drinkers, a Bayesian ANOVA with a default prior of $r = 0.50$ (fixed effects) provided substantial support for the (null) hypothesis that EC did not change the implicit evaluation of alcohol among hazardous drinkers, $BF_{01} = 3.05$, error < 0.022%. For the change

in drinking behavior, a Bayesian ANOVA with a default prior of $r = 0.50$ (fixed effects) did not provide much support for the (alternative) hypothesis that EC changed drinking behavior among hazardous drinkers, $BF_{10} = 1.51$, error < 0.001%.

Finally, following the recommendation of Braver, Thoemmes, and Rosenthal (2014), we conducted a meta-analysis including the four studies (Houben, Havermans, et al., 2010; Houben, Schoenmakers, et al., 2010, Tello et al., 2018; and the present study) testing the effect of EC on the implicit evaluation of alcohol and on drinking behavior. Results for the effect of EC on the change in the implicit evaluation of alcohol revealed a small pooled effect size of $d = 0.18$, 95% CI [-0.09, 0.45], with moderate heterogeneity $I^2 = 48\%$, Q = 5.77, p=.12. For the effect of EC on the change in drinking behavior the meta-analysis showed a larger pooled effect size, $d = 0.32$, 95% CI [0.09, 0.54] with low heterogeneity $I^2 = 21{,}6\%$, Q = 3.82, p=.28. In sum, this mini meta-analysis revealed that EC had no significant effect on change in the implicit evaluation of alcohol, but a significant effect on change in drinking behaviors.

Discussion

The aim of this high-powered preregistered study was to conduct a direct replication of Houben, Havermans *et al.'s* (2010) study. We tested the hypothesis that evaluative conditioning can change implicit evaluation of alcohol and drinking behaviors among college students. Overall, we found little evidence that a single session of evaluative conditioning was sufficient to change implicit evaluation of alcohol and drinking behaviors, even if we used the same materials than the ones used in the original study. However, we found evidence that evaluative conditioning reduced drinking behaviors among hazardous drinkers.

According to Quertemont (2011), non-significant results can occur for three reasons: a lack of statistical power, a measurement error, or an absence of real effect. In our study, we can reasonably dismiss a lack of statistical power. We had 90% power to replicate the original

findings. Also, there were little reasons to believe that our findings were caused by a measurement error. The IAT used in our study was correlated with the AUDIT, which is a classical result in the scientific literature (Houben & Wiers, 2006, 2007; Lindgren *et al*. 2013). In the same way, it seems unlikely that our findings were due to some cultural differences between our study and the original one. Actually, another study conducted in France showed a decrease in implicit bias toward alcohol after an evaluative conditioning task (Zerhouni *et al.,* 2018). It seems to us that the most credible hypothesis is that the effect of evaluative conditioning on implicit bias could be weaker and less reliable than was suggested by the scientific literature. Our results on the cumulative meta-analysis supported this conclusion. Therefore, the present study contributes to the extent literature by identifying a boundary condition of evaluative conditioning effects on drinking behaviors. This study also contributes to a growing body of works that aim to test the reliability of psychological findings.

According to research on cognitive bias modification, a change in drinking behavior following evaluative conditioning entails a change in implicit evaluation of alcohol (Wiers *et al.*, 2010; Eberl *et al.*, 2013). The results of the present study contradict this theoretical stance. Yet, they are in line with recent research showing that evaluative and fear conditioning can change addictive behaviors without generating a concomitant change in the implicit evaluation of substance use (Tello *et al*., 2018; see also Van Dessel, *et al.,* 2018).

Our results could be interpreted given the Incentive-Sensitization theory of addiction (Robinson & Berridge, 1993, 2008). This theory distinguishes between two processes, the ‘wanting’ and the ‘liking’ of alcohol, which are mediated by distinct neural systems. In alcohol disorder, an increase in ‘wanting’ but not in ‘liking’ is observed. In the present research, in order to replicate exactly Houben, Havermans *et al.’s* (2010) study, we measured the implicit liking of alcohol. Thus, it may not be the process underling the decrease in

alcohol consumption. Future research needs to assess implicit 'wanting' of alcohol to examine whether it could be changed by an evaluative conditioning and its link with alcohol consumption.

Even if we failed to replicate the original findings, our results are important as they suggest for the first time that evaluative conditioning could reduce drinking behavior only or mainly among hazardous drinkers. From a clinical perspective, this moderation effect is an important finding because it shows that evaluative conditioning affects especially students who most need it in the first place, that is, those who are potentially at risk for alcohol use disorders. However, this effect should be replicated and further investigated, as there are alternative explanations of our findings. For example, the moderation effect found here might simply be due to the low alcohol consumption of non-hazardous drinkers. Indeed, non-hazardous drinkers' consumption is quite low and it could thus be difficult to reduce further. Another potential explanation of the moderation effect could be that hazardous drinkers are more sensitive to the effects of evaluative conditioning because they are more vulnerable to anxiety and stress. Previous studies indicated that people who are vulnerable to anxiety and stress are more sensitive to the effects of conditioning (Lissek *et al.,* 2005; Beckers *et al.,* 2013). Furthermore, anxiety is strongly related to substance use and abuse (Kushner *et al.,* 1990; Kushner *et al.,* 1999). This could explain hazardous drinking sensibility to evaluative conditioning in the present study. Finally, we cannot rule out an experimental demands effect as an alternative explanation for our results. Even if the participant were not informed of our hypothesis, and even if all participants were exposed to the same stimuli (only the contingency differed), they could have been aware of the contingency and understand the study's hypothesis and therefore responded in such a way as to confirm the hypothesis.

Our study has limitations that deserve to be addressed in future studies. First, participants were mostly female. We did not find any effect of gender on our dependent

variables, nevertheless further studies including more males are necessary to allow the generalization of our results across gender lines. Second, our sample of hazardous drinkers was relatively small (n = 47). Future studies using larger samples should try to replicate the effect of evaluative conditioning on the change in drinking behavior among hazardous drinkers. Thirdly, in order to replicate Houben, Havermans *et al.'s* (2010) results, we used a single session of evaluative conditioning. Future research is needed to test whether a multiple session of evaluative conditioning could increase its effect on the reduction of implicit evaluation of alcohol and alcohol consumption. Finally, our study was conducted on a non-clinical sample. In order to determine evaluative conditioning clinical value, it needs to be tested on alcohol dependent patients.

To conclude, the present preregistered study failed to replicate Houben, Havermans *et al.'s* (2010) results. This study suggests that evaluative conditioning does not have a major bearing on the implicit evaluation of alcohol. It adds to a growing body of work suggesting that procedures that aim at changing implicit bias towards alcohol have limited efficacy on implicit bias. Nevertheless, our results suggest that a brief 5-minute computer intervention based on evaluative conditioning may be sufficient to reduce hazardous drinkers' alcohol consumption. These results could have important clinical implication and need to be tested on a clinical sample.

Footnote

*168 students were recruited in this study to ensure a minimum of 150 students (as calculated in the power analysis) despite a possible exclusion of outliers.

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