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Controlled and implicit processes in evaluative conditioning on implicit and explicit attitudes toward alcohol and intentions to drink

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HIGHLIGHTS

- We found that EC modify implicit attitudes toward alcohol.
- Attitude change seem to happen through controlled processes.
- EC lead to change in intentions to drink through controlled processes.

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ABSTRACT

Since implicit attitudes (i.e. evaluations occurring outside of complete awareness) are highly predictive of alcohol consumption, we tested an evaluative learning procedure based on repeated pairing to a critical stimulus (i.e. alcohol, the CS) with a valenced stimulus (the US) in order to modify implicit attitudes (i.e. evaluative conditioning; EC). We hypothesized that manipulating the learning context to bolster implicit affect misattribution should strengthen EC effects on implicit attitudes toward alcohol, while encouraging deliberate processing of CS-US pairs, should strengthen EC effects on explicit attitudes.

In our study (n = 114 students) we manipulated whether CS-US pairs were presented simultaneously or sequentially. Recollective memory was estimated with a Process Dissociation Procedure. Both implicit and explicit attitudes were assessed immediately after the procedure. Behavioral intentions were measured directly after and one week after the EC-procedure. We found that EC with sequential presentation had a stronger impact on implicit and explicit measures and on purchase intentions immediately after the procedure and one week after. The present findings provide new evidence that (i) EC is an effective way to change implicit attitudes toward alcohol and (ii) evidence that EC may be better described by propositional rather than dual process accounts.

1. Detrimental effect of alcohol and drinking impulses: reducing the paradox

Reducing alcohol consumption is of primary importance in Public Health, since 3.2% of worldwide deaths could be attributed to alcohol (WHO, Global Alcohol Report, 2014). Even more alarming, the efficiency of prevention programs aimed at postponing or limiting alcohol consumption remain limited, despite reaching a large part of the population (Larimer, 2015). Then, why do some people continue to engage in risky alcohol abuse, despite knowing its detrimental effects? Different alcohol-related cognitive-motivational processes have been identified: explicit or reflective considerations about expected outcomes and reasons to drink, and implicit or automatically activated cognitive motivational processes with a unique contribution of both (Stacy & Wiers, 2010). Implicit attitudes have been found to be particularly predictive of consumption for people with relatively weak executive functioning, while explicit alcohol-related cognitions were found to be a better predictor in individuals with relatively strong executive functions (for a review, see Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). Based on this perspective, one well-established procedure to change both explicit and implicit attitudes is evaluative conditioning (EC), which has been defined as a change in the

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evaluation of the valence of a conditioned stimulus (CS, neutral) after it has been paired with a non-conditioned stimulus (US, positive or negative; for a review, see Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010).[1] Initial studies have indicated that this procedure may have some effect in reducing alcohol consumption (Houben, Havermans, & Wiers, 2010; Houben, Schoenmakers, & Wiers, 2010), but the underlying mechanisms remain to be established. Influential dual-process models of attitude change postulate, schematically, two distinctive processes by which attitudes can be changed: propositional and deliberative processes, which require the conscious validation of relations between objects, and implicit processes, which involve the formation of associations between an object and an evaluative response, often in an automatic (i.e., in a non-conscious, unintentional or efficient) way. Each process (i.e. propositional and associative) outcome has its specific measure. While propositional and associative processes are supposed to interact, and overlap to some extent, explicit measures (i.e. measures requiring a deliberate response from the individual, usually self-reported questionnaires) are supposed to be more sensitive to propositional learning, while implicit measures (i.e. responses tapping into automatic processes, usually reaction times) are supposed to be more sensitive to associative learning.

In this paper, we aim to establish whether propositional or associative processes can lead to stronger EC effect respectively on explicit and implicit attitudes toward alcohol.

2. Tapping into implicit attitudes through EC

Traditionally, EC was thought to change associations and to exert its effects outside conscious awareness (for a review, see Sweldens, Corneille, & Yzerbyt, 2014), hence distinguishing between implicit associative processes and explicit propositional processes (e.g., Gawronski & Bodenhausen, 2006, 2014). However, more recently, a propositional model of EC has been proposed (De Houwer, 2014). From this perspective, consciously detecting contingencies between objects and inferring relational properties between them is considered a necessary condition for EC to occur.

Hence, current theoretical debates center around the question whether in addition to propositional learning, associative learning alone could result in EC effects. One hypothesis to explain unaware EC is that the effect of conditioning is the result of attributing the evaluative response caused by the US to the CS (i.e. affect misattribution; Jones, Fazio, & Olson, 2009). Moreover, recent data supported the idea that affect misattribution depends on differences in allocating attentional resources allocated toward the source and the target of the misattribution (Payne, Hall, Cameron, & Bishara, 2010). That is, allocating attentional resources to the prime as well as allocating attentional resources to the target while experiencing an affective reaction were negatively correlated, which suggests that bottom-up processes are dedicated to detect the source of affective reactions, which depends on the allocation of attention resources during the first stages of stimulus processing (i.e. under 500 ms; Hashimoto, Minami, & Nakauchi, 2012).

Awareness of the CS-US contingency was measured with a Process Dissociation Procedure (PDP). While measures of contingency awareness are traditionally measured at the participant level (e.g. Jones et al., 2009) or at the CS level (Pleyers, Corneille, Luminet, & Yzerbyt, 2007). Using both these types of measures lead to the conclusion that EC was strongly associated with contingency awareness, which was then confirmed by an influential meta-analysis (Hofmann et al., 2010). However, there exist statistical (Stahl, Unkelbach, & Corneille, 2009) and methodological (Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012) reasons why both participant and CS-based measures could lead to overestimating the proportions of CS-US correctly remembered. To address these limitations, Hütter et al. (2012) proposed a method to assess contingency awareness based on a process dissociation approach (see also Jacoby, 1991). Hence, we used a PDP to estimate memory processes, as it is the optimal measure to assess unaware EC without overestimating CS-US pairs conscious recollection (Hütter et al., 2012).

Eventually, each process (i.e. propositional and associative) outcome has its specific measure. While propositional and associative processes are supposed to interact, and overlap to some extent, explicit measures (i.e. measures requiring a deliberate response from the individual, usually self-reported questionnaires) are supposed to be more sensitive to propositional learning, while implicit measures (i.e. responses tapping into automatic processes, usually reaction times) are supposed to be more sensitive to associative learning.

3. Study rationale

In this study, we chose to manipulate the learning context by changing the presentation modality of the pairs of stimuli (i.e. sequential vs simultaneous) in order to favor the occurrence of false affective attribution (Hütter & Sweldens, 2012). Because affect misattribution results from an error in the allocation of attentional resources to stimuli, the simultaneous presence of the stimuli on the screen should favor the allocation of attentional resources to the target (i.e. to the CS) during US evaluation, therefore leading to a stronger EC effect through associative processes. In parallel, a propositional model would predict a stronger EC effect when CS-US pairs are presented sequentially, as they incur cognitive resources and voluntary processing of the stimuli for the affect transfer to occur.

4. Study design

We manipulated stimulus presentation (i.e. sequential vs simultaneous) to enhance either controlled processing of the CS-US pairs (i.e. sequential condition) or associative learning through affect misattribution (i.e. simultaneous condition; for a similar reasoning see Hütter & Sweldens, 2012). Learning through explicit processes posit that conditioning should depend on conscious detection and encoding of CS-US pairs, which should be more likely when participants must detect co-occurrence of CS-US and voluntarily engage in a process of keeping CS-USs pairs in memory (i.e. when they are presented sequentially). In the sequential condition, CS-USs pairs must be kept in working memory as they are not displayed together, and requires participants engaging in voluntary processing of the pairs. Conversely, simultaneous presentation of CS-US pairs should bolster confusability of the source of the affective reaction, and therefore strengthen affect misattribution. EC with CS-US pairs presented simultaneously should therefore have a greater influence on implicit attitudes toward alcohol, and EC with CS-US pairs presented sequentially should favor a propositional mode of treatment and thus further modify explicit attitudes toward alcohol. Awareness of CS-US pairs was assessed with a PDP through the MultiTree Software (Moshagen, 2010). Eventually, we included a behavioral measure (i.e. buying alcohol products) immediately after the procedure as well as one week after. We predict that implicit measures would be related to behavioral intentions immediately after as well as one-week after the conditioning procedure.

5. Participants & procedure

We used a 2 (contingency awareness: inclusion vs exclusion, explained below) × 2 (stimulus presentation: simultaneous vs sequential) × 2 (valence of US: valenced vs neutral) experimental design. One

[1] To avoid any confusion regarding the terminology, it should be noted that Evaluative Conditioning differs from Pavlovian Conditioning such that the CS is not a signal preceding the appearance of the US. In other terms, there is no signal-response mechanism in EC, as CS and US only differ in their respective valence and rather refer to objects encoded an associated in memory. Moreover, Pavlovian conditioning is known to be sensitive to blocking, extinction, and statistical contingency, which appears not to be the case in evaluative conditioning (Hofmann et al., 2010).

hundred and fourteen students from University of Grenoble-Alpes (75, 9% women) were recruited for two separate studies, with two different experimenters, for a total of 30 min. The first was advertised as a study on categorization and memorization of pictures, and the second as a marketing study where participants had to evaluate the ergonomics of a website. In phase 1, participants went through the EC procedure, followed by a Process Dissociation Procedure (PDP) to assess contingency awareness of CS-US pairs. In phase 2, participants answered the standard and modified AMPs (i.e. respectively the implicit and explicit measure) and evaluated the website. All subjects did fill an informed consent form before taking part in the experiment and were fully debriefed in the end. No participant expressed any complaint about the experiment.

6. Material

6.1. Stimuli selection

A set of 20 alcohol pictures were pretested to serve as CSs (10 beers and 10 spirits)[2] as well as 10 water pictures. USs comprised 10 negative images, 10 positive pictures and 10 neutral pictures (Mathieu et al., 2014).

6.2. EC procedure

The EC procedure was an incidental learning task (Fazio & Olson, 2003), in which participants were instructed to press the space bar as fast as they could when a target picture appeared on screen. No instructions were given on how to process CSs-USs pairs. Participants were randomly assigned in an experimental condition in which all Alcohol-CSs were paired with negative USs and Non-Alcohol CSs were paired with positive USs (experimental condition), or all were paired with neutral USs (control condition[3]). In the control condition, all CSs were paired with neutral images from the same database. In each block, each CS was paired with 5 USs with the same valence, chosen randomly among the 10 available USs for 3 blocks (total CS-US pairs = 150). CS-US pairs were presented simultaneously onscreen for 3000 ms. Inter-stimuli intervals were fixed to 2000 ms.

6.3. Contingency awareness

We used a PDP approach to estimate memory processes immediately after the conditioning procedure. Participants had to indicate for each CS the valence of the USs with which it had been associated. Participants had to rely on their memory first, but could also rely on their evaluation toward the CS if their memory fails them. In the inclusion condition, participants are instructed to give the same response whether they relied on their memory of US valence or their feeling toward the CS (e.g. “unpleasant” for a negative stimulus, “pleasant” for a positive stimulus). Conversely, in the “exclusion” condition, participants are instructed to reverse their response (i.e. answer “pleasant” for an unpleasant stimulus, and unpleasant for a pleasant stimulus) so that evaluation-based processes lead to opposite responses. The procedure is a between subject condition (“inclusion” vs “exclusion”), and allows us to compute 3 parameters expressing (i) explicit memorization of CS-US pairs (the “memory” parameter) (ii) conditioned attitudes in the absence of memorization (the “attitude” parameter) (iii) the proportion of responses given at random (the “guessing” parameter).

[2] We pretested the valence, arousal and whether the drink was identified as an alcohol beverage of all CSs (see Appendix 1).

[3] We did not reverse CS-US pairings in the control condition (i.e. alcohol CSs with positive USs and NAB CSs with negative USs) for ethical reasons (avoid raising participants' alcohol consumption).

6.4. Affect misattribution procedure (standard)

We used an AMP with all CSs and a neutral stimulus (a gray square) as primes (similar to Payne, Govorun, & Arbuckle, 2008) as a measure of implicit attitudes toward alcohol. The task comprised 72 trials (20 pictures that served as CSs, 10 water pictures, 3 food pictures, and 3 gray squares, all pictures were presented 2 times). Seventy-Two Chinese pictograms were presented after each prime (randomly selected among 200). For each trial, the prime was presented onscreen for 100 ms, followed by an empty screen for 100 ms (200 ms SOA), followed by the Chinese pictogram for 100 ms and a mask that stayed onscreen until the participant entered his response. Participants were instructed to rate the Chinese pictogram without taking the prime into consideration on a scale from -2 (very pleasant) to 2 (very unpleasant).

6.5. Affect misattribution procedure (modified)

A modified version of the AMP was used to assess explicit attitudes, to avoid at maximum variations in answers that could be attributed to variations in structural features of the tasks (e.g. nature of the stimuli, proposition vs pictures, likert scales vs reaction times; for a more detailed discussion, see Payne, Burkley, & Stokes, 2008). In this variation of the AMP, participants have to evaluate the picture and not the pictogram.

6.6. Assessment of behavioral intentions

Participants were requested to choose three beverages among ten and three foods among ten. Each product category was composed of five alcohol-containing products (e.g. beer, wine for drinks rum baba, tiramisu for foods) and five non-alcohol containing products (e.g. fruit juice for drinks cake for foods). Participants were told that one of them would receive the chosen products if picked in a lottery. Once completed, the website crashed and they were then informed that they would be able to access the website in one week, and would receive the link by email. Participants were debriefed electronically one week after the procedure, at the same time that they completed the second assessment.

7. Results[4]

We conducted a mixed ANOVA design 2 × (presentation type; simultaneous vs sequential) 2 × (US valence; valenced vs neutral) 2 × (recollective memory; inclusion vs exclusion) 4 × (stimulus; beer, Non-Alcoholic Beverages, spirits, gray square).

7.1. Main analysis on implicit attitudes (standard AMP)

We computed a global EC index score obtained by subtracting mean scores for non-alcohol containing CSs from mean scores for alcohol-related CSs. No significant effect of the EC procedure was found on the index score ($ps > 0.38$). We found a small effect of EC on alcohol primes, at statistical trend level, $F(1, 110) = 4.3$, $p = 0.07$, $\eta^2 = 0.030$,[5] and a significant interaction between presentation type and US valence $F(1, 110) = 6.8$, $p = 0.01$, $\eta^2 = 0.06$, showing stronger negative judgments for CSs paired with negative USs presented sequentially rather than simultaneously (see Fig. 1). We did not find a main effect or interaction on Non-Alcoholic Beverages ($p > 0.26$).

[4] Power analyses are available in Appendix A.

[5] We removed participants 99, 67, 66 and 14 due to their high Cook value (around 0.09, next being 0.04) since observations high Cook value can alter the slope of a linear model, hence biasing estimates.

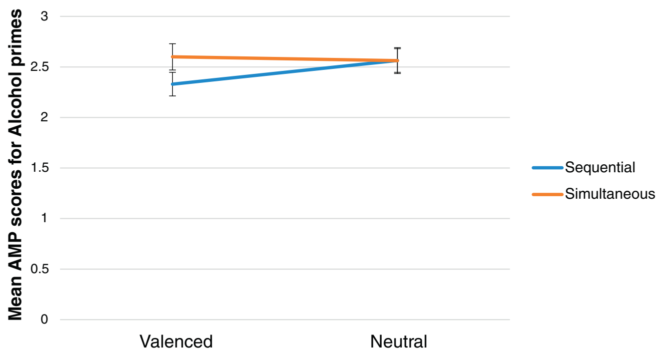

Fig. 1. EC effect on alcohol primes for sequential and simultaneous presentation of stimuli. The higher the score, the more positive the judgment.

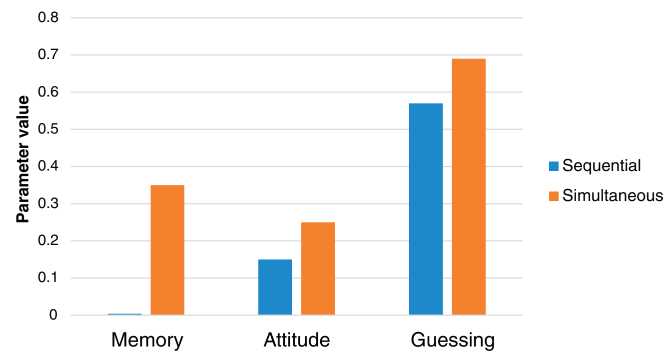

Fig. 2. Parameters values on the PDP on the sequential and simultaneous condition (calculated only on the "valenced" condition).

7.2. Main analysis on explicit attitudes (modified AMP)

No significant effect of the EC procedure was found on the index score ($ps > 0.26$). We found no main EC effect on Non-Alcohol-containing Beverages, $F(1, 108) = 0.035$, $p = 0.85$, $\eta^2 < 0.005$,[6] but we did find an indication of an interaction between valence of the US and presentation, at statistical trend level, $F(1, 108) = 3.55$, $p = 0.06$, $\eta^2 = 0.032$. As for the standard AMP, we only found an EC effect when participants where in the sequential condition. We found no significant effect on alcohol primes ($p < 0.21$).

7.3. PDP estimates

The initial model containing a "memory", "attitude" and "guessing" parameter showed sufficient fit to the data: $\Delta G2(2) = 4.09$, $p = 0.12$. In the "sequential" condition, the "memory" parameter was significantly lower than the "attitude" parameter, ($m = 0.004$; $a = 0.15$), $\Delta G2(1) = 4.27$, $p = 0.03$. In other words, in 15% of the cases, participants without memory of the CS-US answered due to a conditioned attitude, while they consciously memorized around 0.004% of CS-US pairs. Similarly, the "memory" parameter in the "sequential" condition (0.004) and the "simultaneous" condition (0.35) were significantly different, $\Delta G2(1) = 29{,}20$, $p < 0.001$. However, this could be attributable to the fact that the "memory" parameter was extremely low in the sequential condition (see Fig. 2).

7.4. Effect on behavioral intentions

Participants were sorted in 4 categories, depending on the products they chose: "Only alcohol beverages (3 alcohol beverages)", few alcohol beverages (2 alcohol beverages and 1 Non-Alcohol containing Beverage), "few Non-Alcohol containing Beverages (2 Non-Alcohol containing Beverages and 1 alcohol-containing beverage)" and "Only Non-Alcohol containing Beverages (3 Non-Alcoholic Beverages)".[7] We computed a multinomial logistic regression on T1 and T2 scores for drinks and foods choices. A model with the effect of US valence for drinks at T1 was marginally significant, $\chi^2(1) = 6.61$, $p = 0.08$, but no interaction was found between US valence $*$ stimulus presentation, $\chi^2(1) = 1.469$, $p = 0.69$. Participants in the valenced EC condition had a stronger probability to be in the "Only Non-Alcoholic Beverages" category. A model with the effect of US valence for drinks at T2 was not significant, $\chi^2(1) = 0.111$, $p = 0.73$, but we did find a significant interaction between US valence $*$ stimulus presentation, $\chi^2 = 10{,}70$, $p = 0.01$, showing decreased probability for participants to be in the "few alcohol beverages" category one week after the procedure, when CS-US pairs were presented sequentially. We conducted the same analysis on food choices and did not find any effect of EC (models' $p > 0.56$).

8. Discussion

Our hypothesis was that EC would be stronger on explicit measures when processing of CS-US pairs was done through controlled processes (i.e. sequential presentation), while EC would be stronger on implicit attitudes when EC occur through affect misattribution (i.e. simultaneous presentation of CS-US pairs). We observed a stronger effect of EC in the sequential condition on implicit measures, but not on explicit measures. First, our results strengthen the emerging evidence that EC could be an effective procedure to change implicit attitudes toward alcohol as well as behavioral intentions to drink alcohol, as evidenced by the change we observed on implicit attitudes and on behavioral intentions immediately after and one week after the procedure (although these later results were moderate), confirming previous results from Houben et al. (2010) and Houben et al. (2010). Second, we add to the body of evidence that EC is more effective when it relies on deliberative encoding of CS-US pairs, as proposed by recent models of EC (De Houwer, 2014) and recent failure to observe nonconscious EC under optimal circumstances for unaware learning (Mierop, Hütter, & Corneille, in press; Stahl, Haaf, & Corneille, 2016).

These results suggest that EC effects do not emerge when CS-US pairs are presented simultaneously, in contrast to earlier findings by Hütter and Sweldens (2012). We explain this by the fact that Hütter and Sweldens used neutral CSs (i.e. black and white photographs of mildly attractive men and women faces, unknown from the participants), whereas we used more ecologically valid stimuli, toward which participants are more likely to have more stable attitudes. Since processes related to declarative knowledge are now thought to play a greater part in EC than implicit processes (Hofmann et al., 2010) as it is reflected in our studies, one would expect that attitude change would require more resources and efficient cognitive processing to effectively change cognitive processes. Another explanation to the fact that we found stronger EC effect in the sequential condition could lie in the fact that our study was conducted on a student sample that is likely to show strong executive functions, which is associated with high working memory. Conversely, individuals with lower executive functions (i.e. alcohol-dependent patients) might be more sensitive to EC in a context that bolster associative processes.

Interestingly, we found evidence for differential effects of EC on explicit and implicit measures, suggesting direct influence of higher order processes on implicit attitudes, which is in line with a propositional approach of attitude change (De Houwer, 2014). Taken together, our results show that not only do reflective components play a role in regulating impulsive behaviors (Wiers et al., 2007), but they can also be

[6] Due to a computer malfunction, one participant was not able to answer to the modified AMP.

[7] A substantial part of participants gave a wrong identifier after rating the website and/or did not answer at time 2, our sample size for this analysis has been reduced to 97 participants for T1 and 47 participants for T2.

employed to modify the antecedents of these impulses (as predicted by propositional models of EC, see Mitchell, De Houwer, & Lovibond, 2009). While these findings are not in line with dual systems models that strictly separate associative and propositional processes (e.g., Rydell & McConnell, 2006), they are in line to some extent with dual process models that posit interactions between both routes (Gawronski & Bodenhausen, 2006; Strack & Deutsch, 2004), and are also compatible with iterative reprocessing dual process models (Cunningham & Zelazo, 2007; Gladwin, Figner, Crone, & Wiers, 2011). Iterative reprocessing dual processes models posit that evaluations are formed by an unfolding pattern of activation including re-iterations of the information which makes the representation fall on a continuum between purely "automatic" (early processing) and "deliberative" (later iterations). Future research should aim at disentangling specific predictions of both models as to bolster the efficiency of attitude change procedures. Importantly, also from a practical perspective, EC was found to affect implicit attitudes toward alcohol, which is important because implicit attitudes have a long-lived effect on behavior, compared to explicit attitudes (Sweldens, Van Osselaer, & Janiszewski, 2010). Finally, EC influenced behavioral intentions (i.e. intentions to purchase) toward alcohol immediately after the procedure, as well as one week later. This effect may be attributable to heightened preference for Non-Alcoholic Beverages immediately after the procedure, independent of presentation type during the procedure and to lowered intentions to purchase alcohol products for participants for which alcohol CSs have been paired with negative USs in the sequential condition.

9. Limitations

Since EC appears to depend mainly on deliberative processes, one might be concerned if EC could be useful in a clinical population, which may suffer from impaired executive functioning due to chronic alcohol consumption (Oscar-Berman & Marinković, 2007). This is problematic, because alcohol-dependent patients tend to suffer from chronic deficiency in executive resources (Houston et al., 2014); possibly decreasing their ability to engage in such processes, thus decreasing the effectiveness of EC. Eventually we did not find any effect on explicit measures in our studies. Although speculative, a possible explanation to this lack of effect could be due that the modified AMP might be sensitive to contamination by the implicit measure (though both were counterbalanced).

Finally, it is important to keep in mind that if implicit attitudes are modifiable through conditioning procedures, they are also primarily shaped through environmental exposures to alcohol (e.g. media exposure, Zerhouni, Bègue, Duke, & Flaudias, 2016), alongside which the conditioning procedure represents a small proportion of total exposures. Henceforth, bolstering the effectiveness of EC aimed at reducing implicit attitudes toward alcohol could only be achieved through repeated practice of the procedure (e.g. through an online procedure, or applications for smartphones and tablets; see Wiers et al., 2015).

9.1. Changing behaviors with EC: future directions

Therefore, what do our results imply for the use of EC in practical settings? We see two ways that could use the present results in order to boost the efficiency of EC. First, existing procedures should be paired with training of improving executive control more broadly, which has shown some promise in the treatment of addiction (Bickel, Yi, Landes, Hill, & Baxter, 2011; den Uyl, Gladwin, & Wiers, 2015; Houben, Wiers, & Jansen, 2011), and/or with the use of tools such as transcranial direct current stimulation (tDCS), which also increase working memory capacity (Au et al., 2016). More precisely, tDCS could be used on the left ventrolateral prefrontal cortex which is implied in cognitive control (Inzlicht, Berkman, & Elkins-Brown, 2014), decision tasking and response selection (Race, Badre, & Wagner, 2010). Consequently, the use of tDCS to bolster executive functions such as working memory during EC could maximize attitude change toward alcohol.

Second, strengthening controlled processes could also be done with less costly procedures, for example by relying on self-control spillover. While exerting self-control *prior* to a second task leads to decreased performance in a subsequent task, exerting an unrelated self-control task *simultaneously* to another task requiring volitional control leads to increased self-control (Tuk, Zhang, & Sweldens, 2015). For example, it as has been shown that restraining from eating tempting food (e.g. Pringles), leads to augmented performance in volitional (e.g. eating unhealthy food) and cognitive tasks (e.g. a Stroop Task).

10. Conclusion

In conclusion, we provide novel evidence that EC relies on deliberative processes rather than mere automatic association. Our studies suggest that there are specific procedural details that should be taken into account if one wants to bolster the effectiveness of EC on actual behaviors, such as excessive alcohol consumption. We also provide evidence that EC impacts both implicit and explicit attitudes toward alcohol. Although there are some issues that need to be addressed, we confirmed that EC is a promising intervention to modify implicit attitudes, and proposed an original theoretical approach and evidence for the basic understanding of EC, as well as improving existing cognitive remediation techniques. Crucially, our results open the path to potential new ways by which EC could be used on chronically "depleted" clinical samples.

Role of the funding source

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All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Contributors

Oulmann Zerhouni, Francisco Comiran and Laurent Bègue generated the hypothesis, theoretical reasoning and designed the study together. Oulmann Zerhouni and Francisco Comiran coded the Inquisit scripts for the implicit task, contingency awareness and evaluative conditioning procedure. The website was coded by an independent programmer. Data were collected by Oulmann Zerhouni and Francisco Comiran, as well as two undergraduate students working with Oulmann Zerhouni, Francisco Comiran and Laurent Bègue. Oulmann Zerhouni and Francisco Comiran analyzed the data independently. Oulmann Zerhouni wrote the first draft, and Laurent Bègue and Reinout Wiers made substantial, major modifications and improvements, leading to the final version. Francisco Comiran checked and approved the final version. All authors contributed to and have approved the final manuscript.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Acknowledgments

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Appendices

Appendix 1
CS Valence, craving and identifications scores.

Stimulus name	Craving M (SD)	Valence M (SD)	Alcool ?% Yes
Beer (48.7, SD = 22.6)			
Alc1	56.28 (24.51)	58,08 (22.77)	93%
Alc2	47.56 (25.58)	47.52 (20.91)	93%
Alc3	40.44 (27.55)	43.63 (24.22)	100%
Alc4	48.48 (26.04)	49.04 (23.71)	96%
Alc5	47.96 (24.69)	48.81 (22.58)	96%
Alc6	40.96 (27.13)	49.85 (24.52)	93%
Alc7	51.07 (26.50)	54.26 (24.15)	100%
Alc8	55.35 (23.26)	54.54 (20.82)	92%
Alc9	51.74 (21.46)	53.22 (22.55)	100%
Alc10	47.41 (24.67)	47.81 (20.57)	100%
Water (65.49, SD = 28.41)			
Wat1	59.19 (30.87)	64.63 (29.31)	4%
Wat2	59.85 (29.74)	71.30 (24.17)	4%
Wat3	49.41 (32.65)	59.15 (30.75)	7%
Wat4	54.56 (32.19)	65.15 (29.35)	15%
Wat5	58.67 (33.14)	64.67 (30.20)	0%
Wat6	53.89 (31.68)	64.44 (26.13)	4%
Wat7	61.42 (30.36)	69.60 (26.20)	4%
Wat8	59.93 (30.15)	68.04 (28.43)	7%
Wat9	50.07 (28.19)	64.85 (30.62)	7%
Wat10	55.30 (33.27)	63.11 (28.99)	0%
Spirits (42.59, SD = 23)			
Fort1	43.92 (25)	51.31 (21.69)	96%
Fort2	27.38 (25.39)	30.62 (23.88)	96%
Fort3	28.31 (26.42)	30.16 (25.65)	93%
Fort4	45.19 (26.87)	51.85 (21.14)	96%
Fort5	45.04 (25.03)	49.96 (19.06)	96%
Fort6	42.33 (26.90)	51.78 (23.48)	100%
Fort7	51.44 (28.64)	61.56 (23.46)	96%
Fort8	50.30 (29.23)	58.89 (26)	100%
Fort9	47.92 (29.16)	58.12 (26.19)	100%
Fort10	44.15 (25.47)	52.19 (19.98)	93%
Non-Alcoholic Beverages (Non Alcoholic Beverages) (57.36, SD = 24.2)			
Sod1	44.22 (31.59)	50.96 (25.20)	4%
Sod2	50.22 (32.22)	49.44 (26.03)	4%
Sod3	62.59 (29.05)	71.15 (23.20)	4%
Sod4	55.41 (24.59)	66.48 (24.40)	0%
Sod5	63.70 (30.41)	72.04 (22.13)	11%
Sod6	66.37 (25.61)	73.3 (22.22)	0%
Sod7	51.93 (28.5)	55.74 (27.38)	4%
Sod8	48.42 (26.39)	47.54 (20.63)	11%
Sod9	36.63 (30.78)	43.15 (26.67)	7%
Sod10	40.47 (31.10)	44.78 (24.22)	8%

Note: 40 pictures sorted in 4 categories of 10 pictures each have been pretested (Beers, Water, Spirits and Non-Alcohol Beverages). «Craving» contains mean and standard deviation of answers, on a scale from 0 (not at all) to 100 (a lot), to the question «Does this picture makes you want to drink?». «Valence» contains mean and standard deviation of answers, on a scale from 0 (very negative) to 100 (very positive), to the question «Would you rate this image as rather positive or negative?». «Alcohol» corresponds to the proportion of «yes» answers to the question «Does this drink contains alcohol?». Data has been collected on a sample of 27 participants.

Appendix 2
US valence and arousal scores.

Stimulus name	Arousal M (SD)	Valence M (SD)
ucB1	133.47 (241.28)	951.63 (93.44)
ucB2	114.32 (126.68)	967.37 (78.73)
ucB3	89.47 (130.11)	957.95 (94.65)
ucB4	86.32 (117.49)	967.00 (101.17)
ucB5	89.47 (130.11)	957.95 (94.65)
ucB6	83.00 (99.69)	956.50 (69.22)
ucB7	32.00 (31.37)	972.80 (87.91)
ucB8	6.40 (14.31)	1022.20 (4.02)
ucB9	52.36 (77.41)	989.55 (53.92)
ucB10	175.00 (173.77)	960.38 (74.42)
ucA1	336.63 (152.29)	173.47 (125.29)
ucA2	309.85 (91.7)	161.85 (129.15)
ucA3	233.26 (141.13)	134.74 (134.84)
ucA4	331.37 (156.97)	150.53 (121.97)
ucA5	312.42 (159.54)	95.58 (112.92)
ucA6	319.63 (165.03)	165.47 (156.46)
ucA7	329.68 (156.84)	166.58 (185.36)
ucA8	358.42 (135.81)	160.84 (156.05)
ucA9	379.68 (183.13)	102.53 (126.26)
ucA10	299.43 (96.37)	274.57 (188.39)
ucNeuPic1	430.26 (114.54)	437.84 (181.42)
ucNeuPic2	425.20 (76.9)	425.10 (131.79)
ucNeuPic3	401.71 (116.3)	452.57 (151.34)
ucNeuPic4	433.58 (143.3)	536.58 (119.27)
ucNeuPic5	393.00 (112.69)	449.25 (216.11)
ucNeuPic6	467.11 (68.9)	463.78 (100.91)
ucNeuPic7	422.67 (96.68)	449.33 (216.11)
ucNeuPic8	415.20 (110.77)	435.40 (134.63)
ucNeuPic9	492.75 (180.41)	469.13 (96.5)
ucNeuPic10	453.30 (160.21)	414.60 (158.94)

Note: Valence scores go from 0 (very positive) to 1024 (very negative). A score of 512 represent a perfectly neutral stimulus. Arousal scores go from 0 (very intense) to 512 (not intense).

Appendix A. Power analysis

Mean effect size for unaware EC correspond to $d = 0.21$ (Hofmann et al., 2010). We used the «ANOVA: Repeated measures, within-between interaction» module in G ∗ Power 3.1.5. Since we have two dependent variables (Standard and modified AMP), we applied a Bonferroni correction to our alpha treshold (0.025 instead of 0.05). Power analysis showed that we needed 108 participants ($f = 0.15$, $\alpha = 0.025$, Correction between repeated measures: 0.5, correction for non-sphericity: 1, Power = 0.80). Hütter and Sweldens (2012) observed a middle ($g = 0.47$ for the sequential condition between pre and posttest) to strong ($g = 0.79$ for the simultaneous condition between pre and posttest) effect size, which would be higher effect size than the one we choose for a priori analysis. However, Hütter & Sweldens used a within subject design with neutral CSs. Thus, we preferred to use more conservative estimators.

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