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I didn't feel like drinking, but I guess why: Evaluative conditioning changes on explicit attitudes toward alcohol and healthy foods depends on contingency awareness

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ABSTRACT

Background and objectives: Addictive behaviors are influenced both by impulsive processes headed toward consumption, and by higher-order, reflective, control-oriented processes. Our objective here was to (i) change automatically-activated action tendencies and explicit attitudes toward alcohol and softdrinks, as well as fat and healthy food through evaluative conditioning (EC) and (ii) investigate the role of contingency awareness in producing an EC effect.

Methods: In the EC conditions, alcohol-related stimuli or fat foods (CS) were associated with negative pictures (US), while stimuli related to softdrinks or healthy foods (CS) were associated with positive pictures (US). In the control conditions, CSs were paired with neutral pictures (US). Measures of explicit attitudes and approach tendencies (AAT) were assessed before and after the EC procedure. Participants ($n = 95$) then indicated whether they remembered, for each CS, the valence of the associated US.

Results: Significant EC effects were found on explicit attitudes toward alcohol and marginally significant change on attitudes toward fat foods. The effect on alcohol appeared to depend on awareness of CS-US contingencies. No effects of EC were found on approach tendencies.

Limitations: Difficulties to find EC effects on action tendencies can be attributed to structural features of the AAT and strategies during EC.

Conclusions: We conclude that EC alone may not be efficient in reducing addictive behaviors in populations with reduced capacity to process CS-US pairs and for which impulsive behaviors are strong predictors of consumption.

1. Introduction

Problematic drinking and eating behaviors are widespread, despite the fact that their negative short and long-term consequences are well-known such as being one of the leading causes of physical (e.g., cancers, [IARC, 2012](#)) illness and behavioral issues ([National Drug Monitor, 2011](#)). In parallel, obesity shares common neurocognitive mechanisms with addiction, including enhanced sensitivity

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of the dopamine and opiate systems (Hoebel, Rada, Mark, & Pothos, 1999; Nieto, Wilson, Cupo, Roques, & Noble, 2002). Both overweight and alcohol-dependent individuals show increased activity in brain regions related to reward (e.g., amygdala, insula, striatum, dorsolateral prefrontal cortex) in response to food-related and drug-related cues, respectively (McBride, Barrett, Kelly, Aw, & Dagher, 2006). In the Netherlands (where this study took place) approximately 10% of the adults are problem drinkers (Van Dijk & Knibbe, 2005) and nearly half (47%) of the adult Dutch population could be considered overweight ($\text{BMI} \geq 25 \text{ kg / m}^2$) and about 11% is obese ($\text{BMI} \geq 30 \text{ kg / m}^2$, Baker & Zantinge, 2009).

The discrepancy between knowledge of consequences and actual behaviors has been related to impulsive processes taking precedence over reflective, higher-order processes (Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010; Strack & Deutsch, 2004). Typically, dual-process models have distinguished “impulsive” bottom-up, and reflective top-down processes. Impulsive processes have been defined as fast, resource-independent and automatically activated by relevant environmental triggers, and “reflective” processes as resource-consuming and controlled top-down biasing processes. Different conditions may prioritize either impulsive or reflective processing, for example impulsive processes gain relative control over behavior when control resources are low (e.g., fatigue, stress, intoxicated, etc., Wiers, Gladwin, & Rinck, 2013). Impulsive processes are thought to affect behavior by associating perceptual stimuli with previously learned behavioral schemata. In contrast, reflective processes are thought to generate a meta-representation which may be activated in order to adjust the impulsive responses and create a new action plan or adjust a current plan (i.e., behavioral schemata, Deutsch & Strack, 2006). Thus, more positive experiences with alcohol or fat food would activate approach-oriented behavioral schemata triggered by the relevant stimuli. Appetitive processes have been related to evaluative responses (i.e., approach tendencies facilitated for positive stimuli; Neumann & Strack, 2000). While noting that at a neural level this distinction might be oversimplistic (Gladwin, Wiers, & Wiers, 2017; Hommel & Wiers, 2017; Wiers & Stacy, 2006), it remains an important issue at the psychological level to explain why individuals engage in behaviors that they know will be harmful to them.

1.1. Evaluative conditioning (EC) to reduce impulsive behaviors

One learning procedure that may be used to influence automatically triggered positive evaluations by alcohol or food-related cues is Evaluative Conditioning (EC). In this procedure, stimuli (i.e., CSs) are paired with stimuli that unconditionally produce an affective response (i.e., USs). An EC effect is obtained when evaluative responses to the CSs change as a result of this pairing. As a matter of fact, EC procedures have already been successfully used to modify health-relevant attitudes on self-reported measures (Hollands, Prestwich, & Marteau, 2011; Houben, Havermans, & Wiers, 2010; Houben, Schoenmakers, & Wiers, 2010) and implicit (indirect) measures (Houben, Havermans et al., 2010; Zerhouni, Bègue, Comiran, & Wiers, 2018). The effectiveness of EC on approach and avoidance tendencies toward substances has not yet been investigated, and conclusions with respect to contingency memory in this particular setting remain unclear (Zerhouni et al., 2018). This latter aspect is particularly important, because heavy drinkers and alcohol-dependent patients (Houston, Derrick, Leonard, Testa, & Quigley, 2014) could be impaired in encoding CS-US pairs. These deficiencies are also found to some extent in individuals suffering from obesity (Duchesne et al., 2010; Qavam, Anisan, Fathi, & Pourabbasi, 2015). In this sense, the role of contingency awareness is central to evaluating the effectiveness of EC not only on clinical populations, but also in populations at risk. In this paper, we focus on testing whether EC is an effective method to reduce automatic reactions to alcohol and food and to investigate whether the memorization of CS-US pairs is a necessary, boundary condition to reduce these impulsive reactions.

Despite the many studies about EC, the underlying mechanisms of EC are unclear (Corneille & Stahl, 2018; De Houwer, Baeyens, & Field, 2005). A debated aspect in EC is whether the recollection of CS-US pairings, i.e., the knowledge that a certain CS was paired with a specific US (i.e., contingency awareness) is a necessary condition for EC to occur. Dual-process models posit that automatically triggered action tendencies are preferably learned only by associative processes that need little or no attention and conscious awareness (Gawronski & Bodenhausen, 2006). However, recent evidence points toward the explicit encoding of CS-US pairs being a necessary condition for EC to occur (Mierop, Hütter, & Corneille, 2017; Sweldens, Corneille, & Yzerbyt, 2014). More generally, the notion that automatic evaluations reflect an associative learning process has been questioned, in part by studies showing the sensitivity of indirect evaluative measures to instructed-based learning procedures, such as instructed EC (Gast & de Houwer, 2012; Van Dessel, De Houwer, Gast, Smith, & De Schryver, 2016), but also instructed approach-avoidance training (e.g., Van Dessel et al., 2016) and instructed mere exposure (e.g., Van Dessel, Mertens, Smith, & De Houwer, 2017).

1.2. Role of contingency awareness

EC research distinguishes between demand awareness (i.e., awareness that some pictures were paired with others during the procedure) and contingency awareness, which relates to the knowledge that a particular CS was paired with a specific US identity or valence. While demand awareness is generally assessed using general questions presented to participants in a post experimental questionnaire, contingency awareness is measured through the ability to recollect or identify the valence or identity of the US presented with a CS (e.g., Field & Moore, 2005). Studies usually differ with respect to how contingency awareness was assessed. A first set of studies used participant-based analyses in which researchers used a recall task in which participants were asked to recall the identity or the valence US for each CS. Participants were then assigned to an “aware” or an “unaware” group according to whether they were able to report the majority (i.e., more than half) of these USs (e.g., Field, 2000; Hammerl & Fulcher, 2005). In addition to using participant-based analyses, other studies combined contingency awareness as well demand awareness criteria in order to categorize participants into an awareness level. However, participants are rarely either completely aware or unaware of all CS–US

contingencies (see also Field, 2000, 2001), but tend to recall some CS-US pairs but not others. This limitation has been addressed by developing item-based measures for contingency awareness, in which CSs during recall are first categorized as “aware” or “unaware”. Evaluative ratings scores for “aware” and “unaware” CS are then compared. EC effects are thus stronger on CSs that were correctly linked to the US (or US valence) that they had been paired with. Conversely, EC effects for CSs for which the US has not been recalled correctly are consistently smaller or even non-existent (Pleyers, Corneille, Luminet, & Yzerbyt, 2007).

While previous EC research on alcohol has only assessed demand awareness (Houben, Schoenmakers et al., 2010; Houben, Havermans et al., 2010, with the exception of Zerhouni et al., 2018), we assessed the effect of contingency awareness on EC with participant-based and an item-based score for contingency awareness. As stated earlier, and since it has been shown that finding an effect of contingency awareness with participant-level scores is harder, we expect the item-based scores of contingency awareness to be more predictive of explicit evaluative ratings. However, according to dual-process approaches, contingency awareness should have no effect whatsoever on approach tendencies, whether it is the participant or the item-based score. Conversely, propositional models would not distinguish between these two types of processes, which would both be dependent on contingency awareness.

Hence, we aimed to (i) test whether EC-induced changes in explicit attitudes depend on awareness of the contingency between CS-US pairs, (ii), test whether EC also changes automatically activated approach tendencies toward beverages (i.e., alcohol and soft-drinks) and foods (i.e., fat and healthy). We expected participants in the active EC conditions (see further under procedure for more details) to show more negative explicit attitudes toward alcohol or fat food, with EC effects being contingency-dependent. We further expected the EC procedure to also influence automatically activated approach tendencies toward alcohol and food (reduced approach tendencies in active EC vs. Control conditions).

2. Method

2.1. Participants

Ninety-five participants (62 women, mean age = 22.74, $SD = 6.21$) were randomly assigned to one of the four experimental groups. Participants were recruited using posters in the University of Amsterdam and through www.proefpersonen.net. Participants received course credit or 7 euros as compensation. Participants for whom Dutch was not their first language and colour-blind participants were excluded. In our sample, 44.2% scored 8 or higher on the AUDIT ($M = 8.43$, $SD = 5.8$), which indicates hazardous drinking. This rather high score is to be expected in a student population in the Netherlands (Fergusson, 2005). Mean BMI score on the normal range (i.e., between 18 and 25, $M = 21.68$, $SD = 2.44$), with 11.6% being overweight, and 7.4% underweight.

2.2. Procedure

Participants first filled out the informed consent form, before taking part in the study. Participants started with the AAT and then filled out a VAS (visual analogue scale) for food and drinks. Participants were then randomly allocated to one of the two groups of the EC-task. In the first group, all food-related CSs were paired with neutral USs, while in the second, all beverage-related CSs were paired with neutral USs. In the first group where food-related CSs were paired with neutral stimuli, alcohol and softdrink-related CS were respectively paired with negative and positive USs (Beverage EC). In the second group, alcohol-related CSs were paired with neutral USs, unhealthy food and healthy food-related CS were respectively paired with negative and positive USs (Food EC, see Table 1 for a summary of all conditions). The VAS and the AAT were then administered a second time. In half of groups 1 and 2, participants received the instruction, in the AAT, to pull the joystick toward them if the picture (CS) was turned to the left and to push the joystick if the picture was turned to the right. Conversely, in the other half of groups 1 and 2, participants received the instruction to pull the joystick toward them if the picture (CS) was turned to the right and to push the joystick if the picture was turned to the left. A questionnaire measuring contingency awareness by means of a forced 24-choice items with four choices (positive, negative, neutral or “I don’t know”) was then administered. Participants eventually completed the AUDIT, NVE, BMI (formula: height / weight²) and demographic questionnaires. Participants were then debriefed (see Table 1 and Appendix A for a summary and illustration of the experimental design).

Table 1
Group Design for the EC Procedure.

					Group status		AAT Characteristics	
	Alcohol	Softdrinks	Fat Food	Healthy Food	Model 1	Model 2	Orientation ^a	Instruction ^b
Group 1 Beverage EC	Negative	Positive	Neutral	Neutral	Active EC	Control	Left/Right	Pull/Push
	Negative	Positive	Neutral	Neutral	Active EC	Control	Right/Left	Pull/Push
Group 2 Food EC	Neutral	Neutral	Negative	Positive	Control	Active EC	Left/Right	Pull/Push
	Neutral	Neutral	Negative	Positive	Control	Active EC	Right/Left	Pull/Push

Note. US valence for each type of CSs in each Active EC group, ^a Stimulus orientation during the Approach-Avoidance Task, ^b Instruction to push or pull the lever.

2.3. Materials

2.3.1. Evaluative conditioning task

We used the same evaluative conditioning task used by Houben and collaborators (2010b, based on Baccus, Baldwin, & Packer, 2004). In this task, the computer screen was divided into four quadrants. At the beginning of each trial, one word appeared randomly in one of the quadrants. The participant was instructed to press the space bar as fast as possible as soon as the word appeared. The CS always disappeared after 1000 ms, even if the participant has not pressed the space bar. Immediately after pressing the space bar, a picture appeared in the same quadrant as the word during 400 ms. Intertrial interval was set to 1500 ms, and the CS always disappeared after 1000 ms, even if the participant did not press the space bar. A word was never presented twice in a row in the same quadrant.

The task was composed of 120 trials; containing 30 trials with alcohol-related words, 30 trials with softdrink-related words, 30 trials with unhealthy food-related words and 30 trials with healthy food-related words. All words were selected randomly. Thirty pairs of CS-US were formed by randomly selecting, without replacement, among the six possible words and the six possible pictures (36 options; see Appendix B for words and pictures). All USs were taken from the IAPS (Lang, Bradley, & Cuthbert, 1995).

2.3.2. Explicit attitudes toward beverages and food

Explicit attitudes were assessed through a Visual Analogue Scale (VAS) before and after the procedure. Participants were asked to indicate whether they thought drinking alcohol was rather (i) stupid or wise, (ii) healthy or unhealthy, (iii) pleasant or unpleasant and (iv) fun or boring. The same questions were asked about eating healthy and unhealthy foods.

2.3.3. Approach-avoidance tendencies

Participants performed an Approach Avoidance Test to assess automatic approach-avoidance tendencies (e.g., Wiers, Rinck, Kordts, Houben, & Strack, 2009) before and after the EC procedure. Participants were either asked to push the picture away from himself/herself (the image becoming smaller) or to pull the picture toward himself/herself (the image becoming bigger), based on tilt of the picture (e.g., pull all pictures tilted to the left, push all pictures tilted to the right or vice versa, Cousijn, Goudriaan, & Wiers, 2011). Four categories of stimuli were used (i.e., softdrinks, alcohol, healthy and unhealthy food) each containing 12 different pictures.

2.3.4. Self-reported measures

Self-reported measures were administered to assess baseline alcohol and food consumption. Participants filled out the AUDIT (Alcohol Use Disorders Identification Test, Babor, Higgins-Biddle, & Saunders, 2001) to assess drinking problems and the NVE (Dutch Eating Behavior Questionnaire; Van Strien, 2005) to assess eating behaviors. Internal consistency was excellent to acceptable for explicit attitudes toward alcohol (Cronbach's $\alpha = 0.85$), softdrinks (Cronbach's $\alpha = 0.84$), fat (Cronbach's $\alpha = 0.84$) and healthy food (Cronbach's $\alpha = 0.67$).

2.3.5. Contingency awareness

Two different methods were used to assess contingency awareness. Based on the method described in Pleyers et al. (2007), participants were asked, for each CS, whether they remembered if the word was followed by a positive, negative or neutral picture, or whether they don't remember. Two types of contingency awareness scores were computed, leading to six separate scores (the participant-based score, and five item-based scores). The first was a participant-based contingency awareness score, in which participants were either classified as "aware" (coded "1") or "unaware" (coded "0"). Participants were considered as contingency aware if they had correctly identified the US for more than 62.5% of the CSs (Pleyers et al., 2007) and unaware below this threshold. The second type of scores was an item-based recall score for each category of CS (i.e., alcohol, softdrinks, healthy and unhealthy food) as well as a global recall score (pooled for all categories). Hence, five separate item-based recall scores were computed.

2.4. Informed consent & ethics

Participants had to sign an informed consent form in order to take part in the study. The consent form contained information on the procedure and mentioned risks as well as the purpose of the investigation. The research proposal was approved by the local ethical committee. All subjects gave informed consent for the study.

2.5. Analysis

Power analysis was computed with G*Power 3.1.9.2 « Linear Multiple Regression: Fixed model, R^2 deviation from zero » module. We chose a middle-sized effect for EC ($d = .52$, $f^2 = 0.15$). Power analysis showed that we needed 88 participants for a power level of .90 with 2 predictors ($f^2 = 0.15$, $\alpha = 0.05$, Power = .90). Sample size was not increased after analysis.

Two sets of analysis were conducted on beverage-related cognitions (Model 1) and on food-related cognitions (Model 2, see Table 1). More specifically, Models 1a and 1b refer to analyses on explicit attitudes toward alcohol and softdrinks and Models 1c and 1d to analyses on approach bias toward alcohol and softdrinks, respectively. Similarly, Models 2a and 2b refer to analyses on explicit attitudes toward fat and healthy foods and Models 2c and 2d to analyses on approach bias toward fat and healthy foods, respectively. Two outcomes were measured: (i) changes in explicit attitudes (measured by VAS) and (ii) the change in participants' action

Table 2
Independent Samples *t*-test for Baseline Questionnaire by Condition.

	t	df	p	Mean Difference	SE Difference	Cohen's d	95% Confidence interval Lower	
Sex	1.743	93.00	0.085 a	0.169	0.097	0.358	−0.024	0.363
Age	0.425	93.00	0.672	0.543	1.280	0.087	−1.998	3.085
Education	1.087	93.00	0.280	0.262	0.241	0.223	−0.217	0.740
AUDIT	−0.676	93.00	0.501	−0.807	1.194	−0.139	−3.178	1.564
BMI	−1.083	93.00	0.282	−0.543	0.502	−0.222	−1.539	0.453
NVE	0.362	93.00	0.718	1.199	3.311	0.074	−5.376	7.774

Table 3
Group Descriptives for Baseline Questionnaire.

	Group	N	Mean	SD	SE
Sex	Active EC for Beverages	49	0.735	0.446	0.064
	Active EC for Foods	46	0.565	0.501	0.074
Age	Active EC for Beverages	49	23.000	5.824	0.832
	Active EC for Foods	46	22.457	6.642	0.979
Education	Active EC for Beverages	49	6.653	0.991	0.142
	Active EC for Foods	46	6.391	1.341	0.198
AUDIT	Active EC for Beverages	49	8.041	5.156	0.737
	Active EC for Foods	46	8.848	6.446	0.950
BMI	Active EC for Beverages	49	21.422	2.566	0.367
	Active EC for Foods	46	21.965	2.304	0.340
NVE	Active EC for Beverages	49	90.286	17.059	2.437
	Active EC for Foods	46	89.087	15.073	2.222

tendencies (measured by the AAT¹). Explicit attitudes and approach tendencies toward food and drinks were assessed at pre- and post-test.

3. Results

3.1. Analyses at baseline

We found no difference between conditions at pre-test for alcohol, softdrinks, high and low caloric food for explicit measures and AAT scores ($ps > .57$). We did not find any significant difference for participants at baseline on other control variables (see [Tables 2 and 3](#) for details and descriptives statistics). Before conducting analysis per substance (see models 1 and 2 below), we ran a mixed ANOVA including all scores at pre and post-test for all CSs, as well as between-subject variables (i.e., conditions) and contingency awareness-covariates (i.e., participant and global item-based scores). We found a significant difference between CSs ratings at pre and post-test, $F(1, 93) = 8.12, p = .005, \eta_p^2 = 0.085$. A marginally significant Time x Condition interaction was found $F(1, 93) = 3.51, p = .064, \eta_p^2 = 0.038$. Significant differences between CSs ratings were found, $F(1, 93) = 100.83, p < .001, \eta_p^2 = 0.53$, with no significant interaction, with Condition, $F(1, 93) = 1.17, p = .31, \eta_p^2 = 0.013$. A marginally significant interaction was found between Time of measurement and type of CS, $F(1, 93) = 2.54, p = .056, \eta_p^2 = 0.028$, but no three-way interaction between Time x CS x Condition, $F(1, 93) = 1.45, p = .22, \eta_p^2 = 0.016$ (see [Table 4](#) for details).

3.2. Model 1: analyses for alcohol and softdrinks

Four 2 (Condition: Active EC vs. control, between subjects) x 2 (Time of measurement: pretest vs. posttest, within subject factor) multiple linear regressions were conducted on difference scores between pre and post test on explicit evaluations and approach bias on alcohol and softdrinks. Models were first run without awareness scores. Evidence for an effect of contingency awareness was tested by (i) entering, in two separate models, both types of contingency scores entered as covariates altered estimates for the moderating

¹ AAT scores were calculated by using the medians to minimize outliers influence. All scores below 200ms and above 2000ms were removed. One participant with an error rate above 33.3% was also removed from the analysis. Separate scores were calculated for pushing and pulling. An Approach bias difference score between pushing and pulling was computed, such that positive scores indicated a tendency to approach (see [Wiers, Rinck, Kordts et al., 2009](#)).

Table 4
Global ANOVA model.

Within Subjects Effects	Sum of Squares	df	Mean Square	F	p	η^2	partial η^2
Time	30.001	1	30.001	8.1287	0.005	0.078	0.085
Time * Condition	12.963	1	12.963	3.5122	0.064	0.034	0.038
Time * CA_Alcohol	1.103	1	1.103	0.299	0.586	0.003	0.003
Time * CA_Softdrinks	16.155	1	16.155	4.3772	0.039	0.042	0.047
Time * CA_Unhealthy	0.551	1	0.551	0.1493	0.7	0.001	0.002
Time * CA_Healthy	0.138	1	0.138	0.0374	0.847	0	0
Time * Aware_Participants	1.056	1	1.056	0.2862	0.594	0.003	0.003
Residual	324.787	88	3.691				
Stim	9038.278	3	3012.759	100.8301	< .001	0.509	0.534
Stim * Condition	105.488	3	35.163	1.1768	0.319	0.006	0.013
Stim * CA_Alcohol	90.328	3	30.109	1.0077	0.39	0.005	0.011
Stim * CA_Softdrinks	266.326	3	88.775	2.9711	0.032	0.015	0.033
Stim * CA_Unhealthy	53.525	3	17.842	0.597	0.617	0.003	0.007
Stim * CA_Healthy	126.537	3	42.179	1.4116	0.24	0.007	0.016
Stim * Aware_Participants	201.283	3	67.094	2.2455	0.083	0.011	0.025
Residual	7888.202	264	29.88				
Time * Stim	23.941	3	7.98	2.546	0.056	0.027	0.028
Time * Stim * Condition	13.666	3	4.555	1.4533	0.228	0.015	0.016
Time * Stim * CA_Alcohol	11.603	3	3.868	1.2339	0.298	0.013	0.014
Time * Stim * CA_Softdrinks	8.991	3	2.997	0.9561	0.414	0.01	0.011
Time * Stim * CA_Unhealthy	4.897	3	1.632	0.5208	0.668	0.005	0.006
Time * Stim * CA_Healthy	1.886	3	0.629	0.2005	0.896	0.002	0.002
Time * Stim * Aware_Participants	10.301	3	3.434	1.0955	0.352	0.011	0.012
Residual	827.481	264	3.134				

Between Subjects Effects	Sum of Squares	df	Mean Square	F	p	η^2	partial η^2
Condition	12.736	1	12.736	0.2781	0.599	0.003	0.003
CA_Alcohol	0.232	1	0.232	0.00505	0.943	0	0
CA_Softdrinks	19.512	1	19.512	0.42606	0.516	0.005	0.005
CA_Unhealthy	13.412	1	13.412	0.29286	0.59	0.003	0.003
CA_Healthy	32.36	1	32.36	0.7066	0.403	0.008	0.008
Aware_Participants	8.911	1	8.911	0.19457	0.66	0.002	0.002
Residual	4030.15	88	45.797				

Note: Type 3 Sums of Squares. Here, Condition refers to Active EC toward alcohol and beverages.

effect of condition on pre-post scores and (ii) conducting three-way interactions between awareness, condition and time of measurement. In each analysis, the item-based score used is that of the substance used as a dependent variable. Participant and item-based contingency score were never entered together in the same model. We also conducted Bayesian analyses on the non-significant results. Since we were interested in the effect of adding a variable (i.e., contingency awareness) in matched statistical models, we reported Bayes Factors for models and the Inclusions Bayes Factor for variables of interest. $BF_{\text{Inclusion}}$ refers to change from prior to posterior probabilities for specific term. The higher the inclusion Bayes Factor, the higher the posterior compared to the prior probability, the higher the evidence to include the term. For example, $BF_{\text{Inclusion}} = 3$ means that models including this term are 3 times more supported by data. Conversely, an Inclusion Bayes factor of 0.1 would mean that models including this term are 10 times less supported by data $(1/0.1)^2$.

3.2.1. Model 1a: explicit attitudes toward alcohol

A significant main effect was found for Time, $F(1, 93) = 11.28$, $p = .001$, $\eta_p^2 = 0.10$, $Mdiff_{\text{post-pre}} = -0.758$, $SE = 0.225$. A significant Time x Condition interaction was found $F(1, 93) = 4.74$, $p = .032$, $\eta_p^2 = 0.049$. Follow-up tests showed that explicit attitudes toward alcohol at post-test in the Active EC group were significantly more negative compared to pre-test, $Mdiff_{\text{post-pre}} = -1.224$, $SE = 0.308$, $p < .005$, with no significant differences in the control group, $Mdiff_{\text{post-pre}} = -0.226$, $SE = 0.318$, $p = .413$ (Table 5 and Fig. 1).

Estimates for the moderating effect of condition on pre- vs. post-scores did not change when participant-based contingency scores were entered in the model, however, these estimates became non-significant when the three-way interaction between awareness, condition and time of measurement was entered into the model, $F(1, 91) = 1.21$, $p = .27$, $\eta_p^2 = 0.012$. When item-based contingency awareness scores were added to the model, the moderating effect of condition on the difference between pre- and post-test became marginally significant, $F(1, 93) = 3.36$, $p = .07$, $\eta_p^2 = 0.036$, and non-significant when the three-way interaction between

² Multiple comparison were not used because we were testing the same hypothesis, in the form of a single model, but on different dependant variables, and not different independent variables on the same dataset, or subpart of dataset.

Table 5
Descriptives Statistics for Explicit Attitudes toward Alcohol by Condition.

Explicit Attitudes toward Alcohol	Condition	Mean	SD	N
PreScores	Alcohol Negative/Softdrink Positive	17.22	5.145	49
	Neutral	16.67	4.913	46
PostScores	Alcohol Negative/Softdrink Positive	16.00	5.327	49
	Neutral	16.41	4.938	46

Fig. 1. Descriptives Plot of Explicit Attitudes toward Alcohol by Condition. Error bars represent 95% Confidence Intervals.

awareness, condition and time of measurement was entered into the model, $F(1, 91) = 0.31$, $p = .57$, $\eta_p^2 = 0.003$. For both participants and item-based scores, three-way interaction between awareness, condition and time of measurement were not significant ($ps > .24$). Inclusion Bayes Factor showed little evidence for three-way interaction between item-based contingency scores, condition and time $BF_{\text{Inclusion}} = 0.15$, as well as for three-way interaction with participant-based scores, $BF_{\text{Inclusion}} = 0.20$.

3.2.2. Model 1b: explicit attitudes toward softdrinks

No significant effects were found on explicit ratings of softdrinks between pre- and post-test, nor any significant interactions with the EC condition, ($ps > .17$, $BF_{01} = 24.32$). A marginally significant interaction between participant-based contingency awareness scores * Time * Condition was found, $F(1, 91) = 2.975$, $p = 0.052$, $\eta_p^2 = 0.049$. Bayesian analysis showed that the Time + Condition + Time*Condition Model yielded extreme evidence for H_0 , $BF_{01} = 110.02$. However, simple slope analyses conducted on difference-scores between post- and pre-test, indicated that contingency awareness was not a significant predictor of healthy evaluations for participants for the control group ($b = 0.444$, $SE = 0.33$, $p = .19$) or for the Active EC group, ($b = 0.448$, $SE = 0.33$, $p = .14$). All other analyses were non-significant, ($ps > .17$, $BF_{\text{Inclusion}}$ for three-way interactions < 0.32).

3.2.3. Model 1c: approach bias toward alcohol

No significant effects were found for approach bias scores for alcohol stimuli, $F(1, 92) = .512$, $p = .47$, $\eta_p^2 = 0.039$, and no significant interaction with condition, $F(1, 92) = .154$, $p = .69$, $\eta_p^2 = 0.002$. The Time + Condition + Time*Condition Model yielded extreme evidence for H_0 , $BF_{01} = 104.83$. For both participants and item-based scores, entering the covariate and the three-way interaction between awareness, condition and time of measurement did not change the estimates and were not significant ($ps > .23$, $BF_{\text{Inclusion}}$ for three-way interactions < 0.09). The model including all variables and interaction with participant-based scores yielded overwhelming evidence for H_0 , $BF_{01} = 8141.73$, as well as with item-based scores, $BF_{01} = 9938.90$.

3.2.4. Model 1d: approach bias toward softdrinks

A significant difference between approach bias scores at pre- and post-test was found for softdrinks, $F(1, 92) = 6.982$, $p = .01$, $\eta_p^2 = 0.071$, but no significant interaction with condition, $F(1, 92) = 1.455$, $p = .21$, $\eta_p^2 = 0.016$. The Time + Condition + Time*Condition Model yielded moderate evidence for H_0 , $BF_{01} = 10.02$. Estimates for the difference between pre vs post scores did not change when entering participant-based contingency scores in the model, neither was the three-way interaction between awareness, condition and time of measurement was entered into the model, $F(1, 91) = 1.21$, $p = .27$, $\eta_p^2 = 0.012$.

A marginally significant three-way interaction was found when item-based contingency awareness scores were included, $F(1, 91) = 2.975$, $p = 0.088$, $\eta_p^2 = 0.032$. However, simple slope analyses conducted on difference-scores between post- and pre-test, indicated that contingency awareness was not a significant predictor of healthy evaluations for participants for the control group ($b = -13.77$, $SE = 11.54$, $p = .23$) or for the Active EC group, ($b = 14.46$, $SE = 11.61$, $p = .21$). Analyses on other subscales and two-way interactions were not significant ($ps > .20$, $BF_{\text{Inclusion}}$ for three-way interactions < 0.22).

Table 6
Descriptives Statistics for Explicit Attitudes toward Fat Food by Condition.

Time of Measurement	Condition	Mean	SD	N
PreScores	HC Food Negative / LC Food Positive	15.43	5.180	46
	Neutral	17.02	4.380	49
PostScores	HC Food Negative / LC Food Positive	15.20	4.856	46
	Neutral	15.96	4.646	49

Fig. 2. Descriptives Plot of Explicit Attitudes toward Fat Food by Condition. Error bars represent 95% Confidence Intervals.

3.3. Model 2: analyses for fat and healthy foods

We conducted the same sets of analyses on fat and healthy foods as on alcohol and softdrinks. Again, in each analysis, the item-based scores correspond to those for the substance in DV.

3.3.1. Model 2a: explicit attitudes toward fat food

A marginally significant difference was found for Time, $F(1, 92) = 3.45$, $p = 0.066$, $\eta_p^2 = 0.036$, indicating that fat food was evaluated more negatively at posttest, $Mdiff_{post-pre} = -0.663$, $SE = 0.384$, with no moderating effect from condition, $F(1, 92) = 1.13$, $p = 0.28$, $\eta_p^2 = 0.012$ (see Table 6 and Fig. 2). We found a significant three-way interaction between the participant-based contingency awareness scores and condition between pre and post test, $F(1, 91) = 4.218$, $p = 0.043$, $\eta_p^2 = 0.044$. Simple slope analysis conducted on difference scores between post- and pretest, indicated that contingency awareness was a significant predictor of healthy evaluations for participants in the control group ($b = .31$, $SE = .13$, $p = .022$) but not in the Active EC group, ($b = -.93$, $SE = .14$, $p = .52$). Analysis on item-based scores were not significant ($ps > .70$) and did not alter the estimates. We did not find any effect of both participants and item-based awareness scores, as well as no effect on estimates ($ps > .44$, $BF_{Inclusion}$ for three-way interactions < 0.09).

3.3.2. Model 2b: explicit attitudes toward healthy food

No significant difference was found on overall explicit ratings of healthy food between pre- and post-test, nor any significant interaction with the EC condition, ($ps > .30$). The Time + Condition + Time*Condition Model yielded moderate evidence for H_0 , $BF_{01} = 16.09$. We did not find any effect of both participants and item-based awareness scores, as well as no effect on estimates ($ps > .47$, $BF_{Inclusion}$ for three-way interactions < 0.08).

3.3.3. Model 2c: approach tendencies toward fat food

No significant differences were found between approach bias scores at pre- and post-test for fat food, $F(1, 92) = .841$, $p = .36$, $\eta_p^2 = 0.009$, and no significant interaction with condition, $F(1, 92) = 1.723$, $p = .19$, $\eta_p^2 = 0.018$. The Time + Condition + Time*Condition Model yielded moderate evidence for H_0 , $BF_{01} = 55.01$. We did not find any effect of both participants and item-based awareness scores, as well as no effect on estimates ($ps > .53$, $BF_{Inclusion}$ for three-way interactions < 0.03).

3.3.4. Model 2d: approach tendencies toward healthy food

No significant differences were found between approach bias scores at pre- and post-test for healthy food ($p > .69$). The Time + Condition + Time*Condition Model yielded moderate evidence for H_0 , $BF_{01} = 53.04$. We did not find any effect of both participants and item-based awareness scores, as well as no effect on estimates ($ps > .17$, $BF_{Inclusion}$ for three-way interactions < 0.001).

4. General Discussion

In this study, we examined first whether EC would change explicit attitudes towards alcohol and softdrinks, and toward fat and healthy foods, and to what extent such an effect would be dependent on contingency awareness. Second, we tested whether EC would also impact action tendencies. Main findings can be summarized as follows. First, when we observed significant effects of EC on explicit attitudes towards alcohol this effect appeared to be at least partly dependent on contingency awareness. Second, contingency awareness predicted explicit evaluations of fat foods and softdrinks depending on condition, even though the results were only marginally significant for the latter. However, for these two cases, neither a significant EC effect, nor a moderating effect of contingency awareness on EC effects were found. Third, EC did not significantly impact approach tendencies for alcohol or foods.

Our aim was to test whether EC could be a reliable method to modify not only explicit attitudes (i.e., declarative responses) but also automatically triggered action tendencies to beverages and food, and whether changes in explicit attitudes would rely on contingency awareness. In this sense, our data supports findings that EC results from deliberative rather than automatic processes (e.g., Stahl, Haaf, & Corneille, 2016). It also appears that EC has a greater impact on the more reflective and deliberative than on automatic and impulsive evaluations. This suggests that here, in addition to the formation of attitudes, the retrieval of attitudes from memory could also be based more on declarative than automatic processes (see Gawronski & Bodenhausen, 2011, 2014).

4.1. Contingency awareness as a precondition for evaluative conditioning

More precisely, we found that both item-based and participant-based scores were relatively efficient in predicting evaluative ratings, at least for alcohol evaluations. Hence, our results remain mixed, since they are (i) not found on all categories of CSs, (ii) that we did not consistently find a differential effect between aware and unaware participants or CSs on evaluative ratings (i.e., through a significant threeway interaction), but a reduction in the EC effect when contingency awareness scores were entered in the model and (iii) that the results were inconsistent between and within participant and item-based measures. This could be explained in different ways, the first being that item-based analysis is typically performed on within-subject designs, in which individual recall scores for each item are used to predict evaluative ratings for each CS. Here, we had to use a between-subject design, as well as aggregated scores for each category of items for evaluative ratings, rather than item-based scores, which could have limited statistical power. Despite these limitations, it should be noted that our results generally go in the same direction, pointing toward conscious recollection of CS-US pairs being needed to some extent for the EC effect to occur, at least on explicit attitudes. Although our direct measures did not directly focus on individual CSs, we nevertheless observed an effect of contingency awareness on these measures (albeit inconsistently), but not on measures of indirect action tendencies. One explanation would be that direct judgments regarding global categories (e.g., "alcohol", "healthy food") are based on similar processes similar to the ones regarding individual conditioned stimuli (i.e., recollection from declarative memory).

Should we conclude, therefore, that EC procedures could be improved by prompting participants to detect CS-US contingencies? We think that would be premature. Indeed, detecting CS-US contingencies in an incidental task in which no information is given to the participants on how to process the stimuli compared to merely memorizing CS-US pairs might not lead to similar outcomes. For example, in attentional bias training task, explicitly informing participants about the task's functioning and contingencies between actions and anxiogenic stimuli is sufficient to produce a reduction of attentional bias. However, these effects did not translate into a reduction of the anxiety generated by a similar potential stressor (Grafton, Mackintosh, Vujic, & MacLeod, 2014). Similarly, one could wonder whether instructing participants about the purpose and contingencies in a conditioning task would result in the same differences in memorization versus evaluative measures. Indeed, one of the explanations for the contingency awareness effect is that the individual memorizes the CS-US pairs in memory because he/she consciously validates the link between the CS and the US. If the instruction was given to consciously memorize CS-US pairs, it may be less likely that the participant will create this link, but rather merely store these two elements in memory. As for now, this question remains unanswered.

4.2. Implication for evaluative conditioning as health intervention

Our study carries implications for the suitability of EC to change unhealthy beverage and food consumption. The first relates to processes leading to attitudinal change, that is at the time of the encoding of CS-US pairs. Individuals with chronic alcohol problems tend to have weakened executive functioning, specifically cognitive flexibility and inhibitory control (Houston et al., 2014). If evaluative conditioning largely depends on propositional processes, the magnitude of the EC effect (i.e., its effectiveness) is undermined by the individual's ability to detect CS-US contingencies in the task, keeping them in memory and store them in short-term memory. Since these tasks incur executive resources, it is likely that conditioning as a cognitive remediation procedure has only a limited effect on the behavior on alcohol-dependent patients, but also to a certain extent on heavy drinkers (Sullivan, Harris, & Pfefferbaum, 2010). Hence, from a clinical perspective, the best approach would be not to inform patients about the purpose of the task (i.e., training) and CS-US contingencies. A better approach would be to couple conditioning with prior training to improve working memory skills (e.g., detecting and keeping pairs of stimuli in memory) to maximize EC effectiveness for alcohol-dependent

patients and heavy drinkers with diminished executive functions (Houston et al., 2014; Uekermann & Daum, 2007). However, it should be noted that studies on the relationship between working memory and (evaluative) conditioning are rare, so a first step would be to conduct theoretical studies on the relationship between working memory and conditioning, as well as on the effects of working memory training on evaluative learning.

In addition to working memory training, other solutions can be adopted to improve the efficiency of the conditioning procedure to improve memorization and association between CS and US. For example, the low US presentation time onscreen is one clear limitation of our procedure (i.e., 400 ms), which renders the perception and memorization of CS-US pairs more difficult. Raising stimulus presentation time may, on the one hand, help memorization. Making the procedure longer would (i) expose the participant to more pairs of CS-US and (ii) increase the number of trials the participant would be exposed to. Finally, modifying the paradigm to lure participants into detecting the relationship between CS and US would be an interesting way to increase evaluative conditioning effects. This could be achieved, for example, by increasing the intertrial intervals to delimit the gaps between CS-US pairs, strengthen and make more salient the link between CS and US. Future research should focus, among other things, on this point.

Second, it is worth noticing that implicit measures are more predictive of behaviors for individuals with relatively weak executive functioning, whereas explicit measures (i.e., more sensitive to deliberate responses) are better predictors of behaviors of individuals with high executive functioning (Friese, Giannotti, & Koch, 2015; Grenard, Ames, & Stacy, 2008; Hofmann et al., 2010; Houben & Wiers, 2009). Since we did not find any EC effect on approach tendencies, and because EC seems to have limited efficiency in changing implicit attitudes (see also Hofmann et al., 2010), it is necessary to question its usefulness on clinical populations³. However, EC could still be useful in targeted prevention, aimed at individuals with relatively mild disorders, wanting to reduce their alcohol consumption. Future studies should be aimed at investigating the effectiveness of both explicit instructions and prior training on memorization and conditioning effect.

4.3. Limitations

One limitation lies in the fact that we used the same number of trials (120) for twice as many categories here compared to Houben, Schoenmakers et al. (2010). Participants may also have interpreted the four categories as two categories, unhealthy (alcohol, softdrinks and fatty food) vs. healthy (healthy food)⁴. This could explain the low number of contingency-aware participants, as the questionnaires distinguished four categories. Future studies should be careful in (i) the number of trials in the EC procedure relative to the number of categories of CSs and (ii) on the salient properties of the stimuli, which can bias how CS-US pairs are processed (Field & Moore, 2005). One could argue that the fact that we found greater moderating effects of contingency awareness in participant-based scores could suggest that our results may be due to experimental demand bias; the "aware" participants being more likely to have guessed the purpose of the experiment. However, this interpretation seems implausible because, if the "aware" participants did indeed guess the purpose of the experiment, we would have observed (i) greater effects on explicit measures and (ii) homogeneous effects on the subscales of these measures. However, this was not the case. In addition, the fact that we employed four distinct categories of CSs (i.e., alcohol, softdrinks, healthy and unhealthy foods), each with its own contingencies with USs, makes it more difficult to guess the purpose of the study.

Since our experimental design does not include specific matches (e.g., alcohol and US positive), it is not always possible for us to differentiate an evaluative conditioning effect (i.e., resulting from the matching of two stimuli) from an effect that would occur when a particular type of CS is associated with a particular valence. For example, it is possible that the effect we observed may not occur when an alcohol-related stimulus is associated with a positive stimulus. It is also possible that CSs evaluation was affected, in some case, because of a global mood change. This would explain why contingency awareness explains a change in fat food evaluations in the control condition: simply setting up a context in which positive and negative stimuli are present could have "interfered" with either encoding or reactivation in memory at the time of the evaluation, because the memorization processes are not perfect and subject to errors⁵.

4.4. Future directions

Despite mixed results, our study highlights a limit in the efficiency of EC. Several propositions may serve as a support for future research. First, it would be possible to maximize the effectiveness of EC procedures by coupling them with training to improve long-term executive functions, as to minimize the influence of impulsive reactions and maximize that of explicit attitudes. Second, reduced efficiency of EC procedures also lies in the fact that individuals are likely to hold pre-existing attitudes towards alcohol, where the overwhelming majority of studies on conditioning are conducted on initially neutral CSs. This could be addressed by the use of counter-conditioning (i.e., procedures aiming at reversing previously conditioned attitudes), rather than EC. In this perspective, training cognitive flexibility (i.e., the ability to quickly adapt to a new task and a new environment) could be a crucial lever to act on to bolster the effectiveness of counter-conditioning.

³ This could be due to the fact that these tasks assess different constructs, or due to the lower reliability of the AAT compared with the IAT (typically around .7).

⁴ Which is supported by the fact that our results showed that the fat food category is always perceived more negatively than others.

⁵ Following this reasoning, we tested whether contingency awareness scores for fat food would moderate the EC effect for alcohol, and did not find any significant moderating effect ($p = .29$) while the term for the main effect remained significant ($p = .03$).

Appendix A. Illustration of the Experimental Design

Appendix B. Words used in the Evaluative Conditioning Procedure

Words used as CSs in the evaluative conditioning procedure			
Alcohol-related words	Softdrink-related words	Fat Food-related words	Healthy food-related words
Beer, Lager, Breezer, Vodka, Whiskey, Wine	Coke, Fanta, Orange-juice, Cassis-juice, Spa (sparkling-water), Soda	Chocolate, Chips, Fries, Pie, Donut, Burger	Carrot, Tomato, Pepper, Pear, Banana, Apple.

Pictures used as USs in the evaluative conditioning procedure		
Negative	Positive	Neutral
1300, 9570, 2811, 2900, 9301, 9373	1440, 2070, 2311, 1710, 1603, 5760	7041, 7050, 7052, 7100, 7235, 7500, 7547, 7038, 7150, 7037, 2383, 2840

Note. Numbers correspond to the references of pictures in the IAPS Database

Appendix C. Comparative Analyses

Alcohol vs Sodas comparison. We conducted the same analysis as above but with alcohol vs sodas scores at post test instead of a pretest vs posttest difference. We found a significant differences between the two categories of stimuli at posttest, $F(1, 92) = 5.41$, $p = .022$, $\eta_p^2 = 0.055$, but no significant interaction with the condition, $F(1, 92) = 0.844$, $p = .36$, $\eta_p^2 = 0.009$.

Fat vs Healthy Foods comparison at Posttest. We did not find any significant difference between fat and healthy foods at posttest, $F(1, 92) = 1.95$, $p = .16$, $\eta_p^2 = 0.021$ and no significant interaction with the condition, $F(1, 92) = 0.268$, $p = .60$, $\eta_p^2 = 0.003$.

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