Double up!

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Double up! Examining the effects of adding inhibition training to food cue exposure in chocolate-loving female students

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ABSTRACT

In the present we study investigated whether addition of a Go/No Go training enhanced the effects of food cue exposure. We assessed desire to eat, salivation, CS-US expectancies, and eating in the absence of hunger (EAH) during and after cue exposure. Participants ($N = 71$) were chocolate-loving female students who tried to eat less chocolate in daily life. They received two sessions of either cue exposure with Go/No Go training (EXP + GNG), cue exposure with a sham training (EXP + shamGNG), or a control procedure with sham training (CON + shamGNG). Results showed that the exposure groups had higher desire to eat and higher levels of salivation during exposure compared to the control group during the control intervention, and that within session and between session habituation occurred in all conditions. In contrast to our hypotheses, lower levels of desire and salivation in the EXP + GNG compared to the EXP + shamGNG group at the end of exposure were not found. In addition, there was an overall decrease in CS-US expectancies with no group differences, and these beliefs were unrelated to EAH. Furthermore, groups did not differ on intake of either the exposed chocolate, non-exposed chocolate or other snack food items. It is concluded that a short Go/No Go training does not have an effect on two sessions of cue exposure treatment.

People tend to be reactive to cues (e.g., sights and smells) in the environment that signal the presence of food. This so-called food cue reactivity manifests itself through physiological processes (such as saliva production, gastric activity, and insulin release) that prepare the body for food intake, as well as through psychological responses such as desire to eat (Jansen, Houben, & Roefs, 2015; Jansen, Schyns, Bongers, & van den Akker, 2016; Nederkoorn, Smulders, & Jansen, 2000). Importantly, food cue reactivity often results in actual food consumption – even when one is not physically hungry. It is therefore not surprising that food cue reactivity has been associated with weight gain and obesity (Boswell & Kober, 2016).

It has been suggested that food cue reactivity is the result of classical conditioning processes (Jansen, 1998; Jansen, Havermans, & Nederkoorn, 2011, pp. 1431–1443; Jansen et al., 2016), in which a cue becomes associated with food intake (unconditioned stimulus; US) through repeated pairings with food. This cue can develop into a conditioned stimulus (CS) that signals intake and elicits conditioned responses (CR) that prepare for intake (e.g., increase in salivation, insulin release and eating desires). Then, merely encountering the cue that has become associated with food is enough to trigger processes that prepare the organism for food intake and to elicit eating desires. Studies in the lab (Bongers & Jansen, 2015; Bongers, van den Akker, Havermans, & Jansen, 2015; Papachristou, Nederkoorn, Beunen, & Jansen, 2013; van den Akker, Havermans, Bouton, & Jansen, 2014; van den Akker, Havermans, & Jansen, 2015; Van den Akker, Jansen, Frentz, & Havermans, 2013; Van Gucht, Baeyens, Vansteenwegen, Hermans, & Beckers, 2010; Van Gucht, Vansteenwegen, Beckers, & Van Den Bergh, 2008; Van Gucht, Vansteenwegen, Van den Bergh, & Beckers, 2008) and in real life (van den Akker, Havermans, & Jansen, 2017) have shown that appetitive conditioning occurs easily to a variety of cues, including objects, geometrical figures, mood states, and times of day. Only a few CS-US pairings are necessary for the CS to elicit eating expectancies and eating desires.

It is possible to influence conditioned associations – and thus reduce cue reactivity – by presenting the CS *without* the US; the organism learns that the CS is no longer fully predictive of the food. The clinical equivalent of this so-called extinction process is termed

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'cue exposure' – a behavioral intervention in which an individual is repeatedly exposed to cues that elicit craving but which remain unreinforced – and a number of studies have been dedicated to investigate its effectiveness. These studies have shown cue exposure to reduce cravings and eating binges in patients with bulimia nervosa (Jansen, Broekmate, & Heymans, 1992; Jansen, Van den Hout, De Loof, Zandbergen, & Griez, 1989; Martinez-Mallén et al., 2007; McIntosh, Carter, Bulik, Frampton, & Joyce, 2011; Toro et al., 2003), to maintain weight loss and to reduce eating desires, if-then expectancies, and eating in the absence of hunger (EAH) in overweight and obese adults (Mount, Neziroglu, & Taylor, 1990; Schyns, Roefs, Mulkens, & Jansen, 2016; Schyns, van den Akker, Hilberath, & Jansen, in revision; Schyns, van den Akker, Roefs, Houben, & Jansen, in revision), and to reduce binges and EAH in overweight and obese children and adolescents (Boutelle et al., 2014; Boutelle et al., 2011; Schyns, Roefs, Smulders, & Jansen, in revision).

Importantly, presenting the CS without the US does not mean that the old association is unlearned or replaced, but rather that a new association is formed that will compete with the old association (i.e., CS predicts US vs. CS predicts no US) (Bouton, 1993, 2011). As extinction and exposure are considered to be forms of inhibitory learning (Bouton, 2011), it has been suggested that the effectiveness of exposure could be improved by strengthening inhibitory regulation (Craske, Liao, Brown, & Vervliet, 2012; Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014; Jansen et al., 2016). One promising way to enhance inhibition is through short computer training using a Go/No Go task. In this task, participants are presented with pictures accompanied by a Go or No Go cue (e.g., a symbol, letter or frame). They are instructed to press the spacebar when they see the Go cue and to refrain from pressing when they see the No Go cue. Crucially, the target pictures of the training (e.g., chocolate pictures) are always presented together with the No Go cue, thus encouraging an inhibitory association with these food items. Recent studies suggest that performing a Go/No Go task induces automatic inhibitory associations (Houben & Jansen, 2015; Verbruggen & Logan, 2008) and that only one Go/No Go training session inhibits responses to palatable food, reduces the desire to eat such food, and decreases actual consumption of that food (e.g., Houben & Jansen, 2011, 2015; Jones et al., 2016; Koningsbruggen, Veling, Stroebe, & Aarts, 2014; Veling, Aarts, & Papies, 2011).

In the current study, we investigated whether combining chocolate cue exposure with a chocolate Go/No Go training (EXP + GNG condition) improves cue exposure therapy as compared to cue exposure with a control training (equal pairings of chocolate with the Go and No Go cues; EXP + shamGNG condition). We also included a control condition with the sham training but no exposure (CON + shamGNG). We conducted cue exposure in a sample of chocolate-loving female students and assessed their desire to eat and salivation repeatedly during exposure, as well as eating in the absence of hunger (EAH) after exposure. In addition, we measured CS-US expectancies before and after exposure. CS-US expectancies reflect the participants' belief that the CS will be followed by the US (e.g., if I smell tasty food (CS), then I cannot resist eating it (US)), and it has been argued that violation of these expectancies is crucial to the effectiveness of cue exposure therapy (Craske et al., 2008, 2012, 2014). In line with this, a number of recent studies (Schyns et al., 2016; Schyns, Roefs, et al., in revision; Schyns, van den Akker, Hilberath, et al., in revision; Schyns, van den Akker, Roefs, et al., in revision) have shown that CS-US expectancies decrease (i.e., are violated) in participants who receive food cue exposure, whereas they do not change in control participants. In addition, in some of these studies, lower CS-US expectancies after exposure were found to be associated with less intake of the exposed food (Schyns et al., 2016; Schyns, van den Akker, Roefs, et al., in revision). Furthermore, we conducted exposure on two consecutive days, as there is substantial evidence that sleep is critical for learning and memory consolidation (see for example Stickgold, 2005; Walker & Stickgold, 2004). Thus, a night's sleep could benefit extinction learning. Indeed, spider-fearing women who slept after exposure showed increased retention and generalization of extinction learning compared to women who did not sleep (Pace-Schott, Verga, Bennett, & Spencer, 2012). For food cue exposure, Schyns and colleagues showed generalization of the exposure effect to non-exposed foods in a two-day exposure study (Schyns, Roefs, et al., in revision), but not in an earlier study in which exposure occurred on one day only (Schyns et al., 2016).

We hypothesized that participants in the exposure conditions would show within session habituation (WSH) and between session habituation (BSH) as indicated by reductions in desire to eat and salivation. In addition, we expected that the EXP + GNG condition would show reduced cue reactivity (i.e., desire to eat and salivation) at the end of the exposures compared to participants in the EXP + shamGNG condition. We also hypothesized that the EXP + GNG participants would show a stronger decrease in CS-US expectancies than the EXP + shamGNG participants, whereas we expected no change in food cue reactivity and expectancies in the control group. In addition, we expected CS-US expectancies to be positively associated with chocolate intake. With regard to EAH, we hypothesized that participants in the EXP + GNG condition would consume less of the chocolate they had been exposed to than the EXP + shamGNG condition, and that both exposure conditions would consume less of this chocolate than the control condition. We also tested whether a reduction in intake would generalize to other chocolate, other sweet snack foods, and savory snack foods.

1. Methods

1.1. Participants

Participants were 71 female undergraduate students aged between 18 and 25 (M = 19.68, SD = 1.75) who participated in exchange for course credit or a monetary reward. Participants were recruited through advertisements for a study on cognitive and sensory processes in chocolate lovers. After signing up, participants (N = 166) filled out a short online questionnaire to check for eligibility (n = 95 were not eligible). The questionnaire consisted of some demographic questions as well as three statements regarding chocolate liking and consumption ('I like chocolate a lot', 'I find it hard to resist eating tasty chocolate', and 'I wish I was better able to resist eating tasty chocolate'). The statements could be responded to on a 100 mm VAS scale ranging from 'not at all like me' to 'very much like me', and participants were included in the study when they scored at least 67 (top tertile) on all questions, meaning that they liked chocolate a lot, found it hard to resist eating it, and wished they were better able to resist eating it. Eligible participants were instructed to eat something small (e.g., an apple or sandwich) 30 min before each session, and refrain from eating or drinking anything except water thereafter. Furthermore, they were not allowed to eat chocolate from 24 h before the first exposure/control session until after the second exposure/control session. The study design was approved by the ethics committee of the Faculty of Psychology and Neuroscience of Maastricht University.

1.2. Design

Participants were randomly divided over three conditions: (1) cue exposure + Go/No Go training (n = 24), (2) cue exposure + sham Go/No Go training (n = 24), and (3) control procedure + sham Go/No Go training (n = 23). In each condition,

participants visited the lab three times (approximately 15, 75 and 120 min). The pre-session was used to establish the participants' preferred chocolate. The first session consisted of sham or real GNG training (10 min) and cue exposure or control (45 min). The second session was identical to the first session, but with the addition of a bogus taste test (10 min) to assess snack food intake. The first session was planned at least 24 h after the pre-session. The first and second session took place on two consecutive days.

1.2.1. Chocolate preference

Participants were presented with 9 types (3 milk, 3 dark, 3 white) of A brand chocolate bars (Tony's Chocolonely milk chocolate with sea salt and caramel, Cote D'Or milk chocolate, Verkade milk chocolate, Tony's Chocolonely dark chocolate, Lindt dark chocolate 70% cacao, Cote D'Or dark chocolate with hazelnuts, Verkade white chocolate, Cote D'Or white chocolate with praline filling, Ritter Sport white chocolate with hazelnuts). The bars were presented on a table, and each was presented in a small bowl containing approximately 4 pieces of that chocolate. Participants were asked to indicate their top 3 of the chocolates in terms of tastiness and they were allowed to try as little or as much as they wanted. Participants also provided ratings on a scale of 1–10 (higher ratings reflect higher palatability) for their 3 chosen chocolates. The 3 chosen chocolates were used in the first and second sessions.

1.2.2. Go/No Go training

The Go/No Go training consisted of 2 blocks of 160 trials. During the task, participants were presented with 4 pictures of chocolate, 4 neutral items (plates) and 8 filler items (snack foods such as crisps, nuts etc.). Filler items were included to mask the goal of the task. Participants were instructed to press the space bar when a 'go' cue appeared on the screen, and to withhold responding when a 'no go' cue appeared. These go and no-go cues were represented by the letters 'p' and 'f', which were displayed randomly in one of the four corners of the picture. Instructions were counterbalanced across participants, so that for half of the participants 'p' was the go cue and 'f' the no-go cue, and for the other half 'f' was the go cue and 'p' the no-go cue. For participants in the EXP + GNG condition, each chocolate picture was presented 10 times (i.e., 40 chocolate trials) per block, and these were always accompanied by the no-go cue. The neutral pictures were also presented 10 times (40 neutral trials) in each block, but were always paired with the go cue. The filler items were presented 10 times each per block, and were equally often paired with the go and no-go cues. In the other two conditions (EXP + shamGNG and CON + shamGNG), all pictures (i.e., chocolate, neutral, filler) were presented with the go cue on half of the trials and with the no-go cue on the other half of the trials. During each trial, a picture and the go or no-go cue were simultaneously presented on the screen (1000 ms). Correct (non-) responding by the participant was followed by a green circle presented underneath the picture, incorrect (non-)responding by a red cross (500 ms). The inter-trial interval was 500 ms. Go and no-go trials were always presented in random order.

Four different versions of the Go/No Go task were created, so that the chocolate pictures represented the participant's preferred type of chocolate: a task with only milk chocolate pictures for participants for whom their top three rated chocolates were all milk chocolate, a task with white chocolate pictures for participants who had selected only white chocolate, and a task with dark chocolate pictures for those who selected only dark chocolate. The fourth task consisted of a mix of pictures (dark, milk, and white) and was presented to participants who had more than one type of chocolate among their highest-ranked ones.

1.2.3. Cue exposure and control sessions

During cue exposure, participants were presented with two bowls of chocolate. For every participant one of these bowls consisted of the chocolate they ranked third in the pre-session. For half of the participants the other bowl contained the chocolate that was ranked first, for the other half this bowl contained the second-ranked chocolate. Participants were instructed that they were going to smell the chocolate for 2 blocks of 20 min, and were told that they should smell, touch and break the chocolate, but not eat it. They were given the following rationale for this: *"Often when we smell good food, we also eat it. Because your body knows that it gets food when it smells something delicious, it starts preparing for food intake. What we will do today is smell chocolate without eating it. The body then gradually learns that smelling something good doesn't always mean food will be consumed, and the body will ultimately, over time, not prepare for intake anymore."* In between the 2 20-min exposure blocks, participants had a 5-min break. The experimenter engaged in cue exposure together with the participant; she modelled the skills and encouraged the participant to focus her attention on the food and to do the exposure exercises. In the control condition, participants brought their own study books and they were instructed to study for 45 min.

1.3. Measures

1.3.1. CS-US expectancies

Participants indicated how strongly they believed in the statement 'If I have tasty chocolate in front of me, then I cannot resist eating it' on a 100 mm VAS ranging from 'not at all' (0) to 'very strongly' (100).

1.3.2. Desire to eat

Participants rated their desire by filling out a VAS headed 'how strong is your desire to eat chocolate at this moment?' which ranged from 'no desire at all' (0) to 'very strong desire' (100).

1.3.3. Salivation

To measure salivation, participants placed two pre-weighed cotton rolls (Hartmann No. 2) in the left and right side of their mouth, between their cheek and lower gums. Cotton rolls were left in place for precisely 1 min and were weighed again. The amount of salivation was computed by subtracting the original weight of the cotton rolls from their final weight and is reported in grams (Epstein, Paluch, & Coleman, 1996; Peck, 1959).

1.3.4. Hunger

To avoid high hunger levels before exposure, hunger was assessed by means of a 10-point Likert Scale right before the start of exposure/studying. If participants scored an 8 or higher, they were given a selection of moderately healthy snack foods (cereal bar, cereal cookies, and Dutch gingerbread) and they were instructed to consume one of these foods.

1.3.5. Eating in the absence of hunger (EAH) paradigm

EAH was modelled after the paradigm by Birch and Fisher (2000). Participants were given the choice to eat either two prepackaged roasted chicken sandwiches (Albert Heijn; 325 kcal) or two tomato mozzarella sandwiches (Albert Heijn; 310 kcal). The sandwiches were presented under the pretense of a taste questionnaire, and participants filled out some questions on the taste and quality of their chosen sandwich (not used for analyses). To achieve satiety, participants were given some magazines and told to relax for 15 min after finishing the sandwiches. Hunger was assessed on a 100 mm VAS before presentation of the sandwiches and after the 15-min relaxation period. Subsequently participants

were presented with 6 bowls generously filled with snack food for the bogus taste test. Two of the bowls contained the two chocolates (~223 g, ~556 kcal/100 g) previously ranked as most palatable by the participant: the chocolate in the first bowl had also been used during exposure; the chocolate in the second bowl was included to assess generalization to other chocolate – for the control participants neither chocolate was used for exposure and the bowls contained the top two chocolates in counterbalanced order of preference. The other bowls contained two sweet snack foods (Skittles (Wrigley): ~304 g, 404 kcal/100 g; Gummy bears (Haribo): ~283 g, 343 kcal/100 g) and two savory snack foods (salted crisps (Lay's): ~44 g, 541 kcal/100 g; pretzel sticks (Bolletje): ~46 g, 390 kcal/100 g) to assess generalization to other sweet and savory snack foods. Participants were given a questionnaire concerning the palatability and texture of the different kinds of food, and were told that they had 10 min to fill out the questions and could eat as much of the food as they wanted.

1.3.6. Dietary restraint

The Concern for Dieting subscale of the Restraint Scale (Herman & Polivy, 1980) was used to assess dietary restraint. This subscale has been recommended over the full scale when the objective is specifically measuring diet restriction (Blanchard & Frost, 1983; Wardle, 1986). The subscale consists of 6 questions such as 'How often are you dieting' and 'How conscious are you of what you are eating?', which are answered on a Likert Scale. Scores range from 0 to 19 and higher scores indicate higher concern for dieting.

1.3.7. Post-study questionnaire

Participants filled out a questionnaire regarding their adherence to eating instructions, their awareness of the hypotheses of the study ('What do you think we investigated in this study?'), and awareness of the aim of the Go/No Go task ('What do you think the goal was of the computer task in which you compared snacks?'). In addition, they filled out two questions on their alcohol use and hours of sleep the night before. These questions were included to check for factors (excessive alcohol use, sleep deprivation) that could have interfered with memory consolidation.

1.3.8. Height and weight

Participants' height and weight were measured while wearing street clothes but no shoes.

1.4. Procedure

1.4.1. Pre-session

Participants provided informed consent and completed the chocolate preference task. This session lasted 15 min.

1.4.2. Session 1

Participants completed the baseline salivation measure and rated their desire to eat chocolate and CS-US expectancy. They then performed the Go/No Go task and again completed the VAS's for desire to eat and CS-US expectancies. Salivation was measured while participants viewed a chocolate picture on the computer screen. Next, participants rated their hunger and were given a small snack if necessary. Following this, the cue exposure paradigm was started for participants assigned to the exposure conditions. Salivation was measured after 1, 3, and 20 min of exposure in each block (i.e., a total of 6 times during exposure), and desire to eat was measured after 1, 3, 5, 10, 15 and 20 min of exposure in each block (i.e., a total of 12 times during exposure). Participants in the control condition completed salivation and desire to eat measurements after 1, 3, 20, 26, 28 and 45 min of studying (i.e., at the exact same time points as the salivation measures in the exposure groups). The session was concluded with rating of CS-US expectancies and filling out a short questionnaire about adherence to eating instructions. The duration of this session was 75 min.

1.4.3. Session 2

The procedure of session 1 (up until rating of the if-then expectancy after exposure/studying) was repeated in session 2. This was followed by the hunger VAS, consumption of the sandwiches and a 15-min relaxation period to achieve satiety, and the second hunger VAS. Participants were then presented with the 6 bowls of food to assess eating in the absence of hunger. Following this, participants filled out the Restraint Scale and the post-study questionnaire. Finally, they were measured and weighed and compensated for their participation. This session lasted 120 min. A schematic overview of sessions 1 and 2 is presented in Fig. 1.

1.5. Statistical analyses

A one-way ANOVA was conducted to assess differences between conditions on age, BMI, hours of sleep, alcohol consumption, and restraint score. If Levene's statistic indicated violation of homogeneity of variances, Welch's F is reported. 3 (Condition: EXP + GNG, EXP + shamGNG, Control) X 16 (Time: baseline, after go/no go task, 1′, 3′, 20′, 26′, 28′, 45′ for session 1 and identical for session 2) Mixed ANOVA's were performed to investigate development of desire and salivation during exposure. These were followed up with one-way ANOVA's with Bonferroni or Games-Howell corrections at the end of exposure to study group differences. Paired samples t-tests were conducted to determine WSH (end level of cue reactivity at session 1 (or 2) subtracted from peak level of cue reactivity during session 1 (or 2)) and BSH (peak level cue reactivity at session 2 subtracted from peak level cue reactivity at session 1) in each condition, and a one-way ANOVA was performed to test for group differences on WSH and BSH. We report Pearson's correlations between BSH, WSH and food intake. A 3 (Condition: EXP + GNG, EXP + shamGNG, Control) X 2 (Time: baseline session 1, end of exposure session 2) Mixed ANOVA was conducted on CS-US expectancies. For all Mixed ANOVA's, Greenhouse-Geisser statistics are reported in case of violation of sphericity. EAH was analyzed by means of a MANCOVA with exposed chocolate intake, generalization-chocolate intake, sweet snack food intake and savory snack food intake as dependent variables and score on the Restraint Scale as covariate.

2. Results

2.1. Participant characteristics

Groups did not differ on age, BMI, hours of sleep between sessions 1 and 2, alcohol consumption between sessions 1 and 2, and restraint score. Table 1 provides the mean and SD for each of these variables per condition.

2.2. Desire to eat and salivation following Go/No Go training

Participants made few errors on the Go/No Go task (1.46%) and the maximum error rate per participant was below 5%. This indicates that all participants performed the task in a serious and satisfactory way. Five participants (3 who had received the real task, 2 who had received the sham task) guessed the aim of the task correctly, but not its relevance to the subsequent cue exposure training. A Mixed ANOVA on the effects of the Go/No Go training on desire to eat in Session 1 showed a significant main effect of time, $F(1, 68) = 22.37$, $p < 0.001$, $\eta_p^2 = 0.25$, indicating an increase in desire to eat from baseline to post-task across conditions (EXP + GNG:

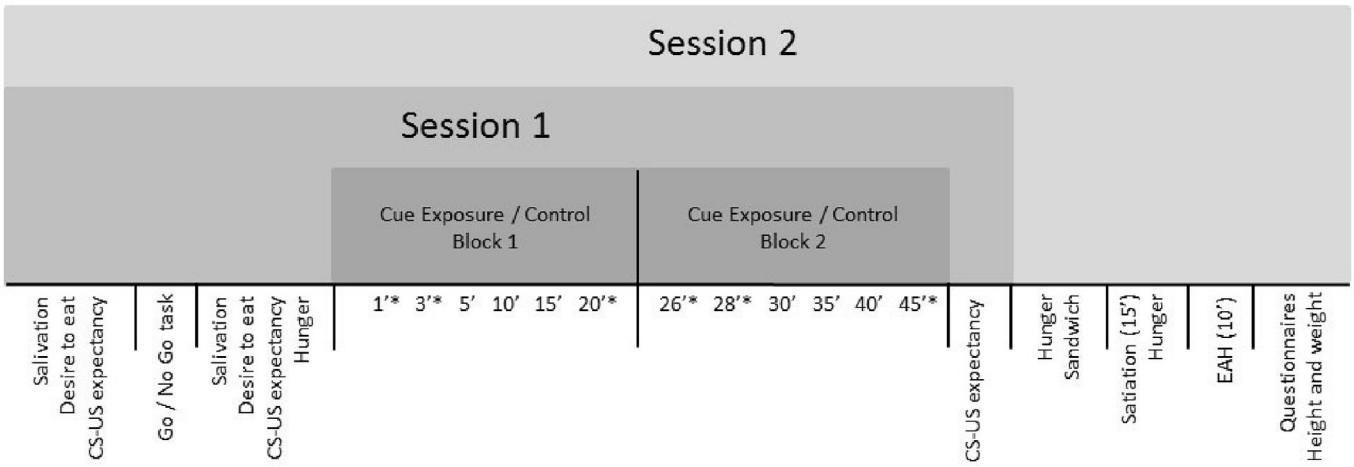


Fig. 1. Schematic overview of sessions 1 and 2. In the exposure conditions, desire to eat was measured at all time-points. Salivation was measured at time-points indicated with *. In the control condition, desire to eat and salivation were measured at time-points indicated with *.

Table 1
Means and standard deviations of participant characteristics per condition.

	EXP + GNG		EXP + shamGNG		Control		*F*	*p*
	M	*SD*	*M*	*SD*	*M*	*SD*		
Age	19.71	1.81	19.67	1.81	19.65	1.70	0.006	0.99
BMI	22.74	2.34	21.91	2.09	22.56	2.60	0.82	0.45
Hours of sleep	7.27	1.41	7.43	1.08	7.74	0.74	1.07	0.35
Alcohol consumption (# of glasses)	0.21	0.83	0.38	1.44	0.13	0.34	0.37	0.69
Restraint Scale	9.83	4.06	9.75	3.38	10.09	2.68	0.06	0.94

baseline $M = 58.04$, $SD = 20.10$, post-task $M = 65.25$, $SD = 22.79$; EXP + shamGNG: baseline $M = 58.42$, $SD = 15.96$; post-task $M = 67.25$, $SD = 16.76$; Control: baseline $M = 55.09$, $SD = 22.54$, post-task $M = 63.91$, $SD = 16.55$), but no Desire to eat X Condition interaction, $F(2, 68) = 0.096$, $p = 0.91$. The same analysis on salivation revealed no interaction effect, nor any main effects, all F's < 2.46, all p's > 0.093 (EXP + GNG: baseline $M = 0.63$, $SD = 0.48$, post-task $M = 0.70$, $SD = 0.49$; EXP + shamGNG: baseline $M = 0.66$, $SD = 0.44$; post-task $M = 0.61$, $SD = 0.47$; Control: baseline $M = 0.48$, $SD = 0.31$, post-task $M = 0.39$, $SD = 0.24$).

2.3. Cue reactivity

2.3.1. Desire to eat

The Mixed ANOVA on desire to eat (on all measurements of both session 1 and session 2) revealed a significant Condition X Time interaction, $F(8.77, 293.83) = 3.03$, $p = 0.002$, $\eta_p^2 = 0.08$, indicating that the cue exposure manipulation was effective in eliciting strong desires to eat. Our hypothesis that the EXP + GNG condition would show reduced desire to eat at the end of exposure compared to the EXP + shamGNG condition was not confirmed, $F(1, 46) = 0.06$, $p = 0.81$. Fig. 2 shows desire at baseline, at the individual peak, and at the end of exposure per condition.

2.3.2. BSH and WSH with regard to desire to eat

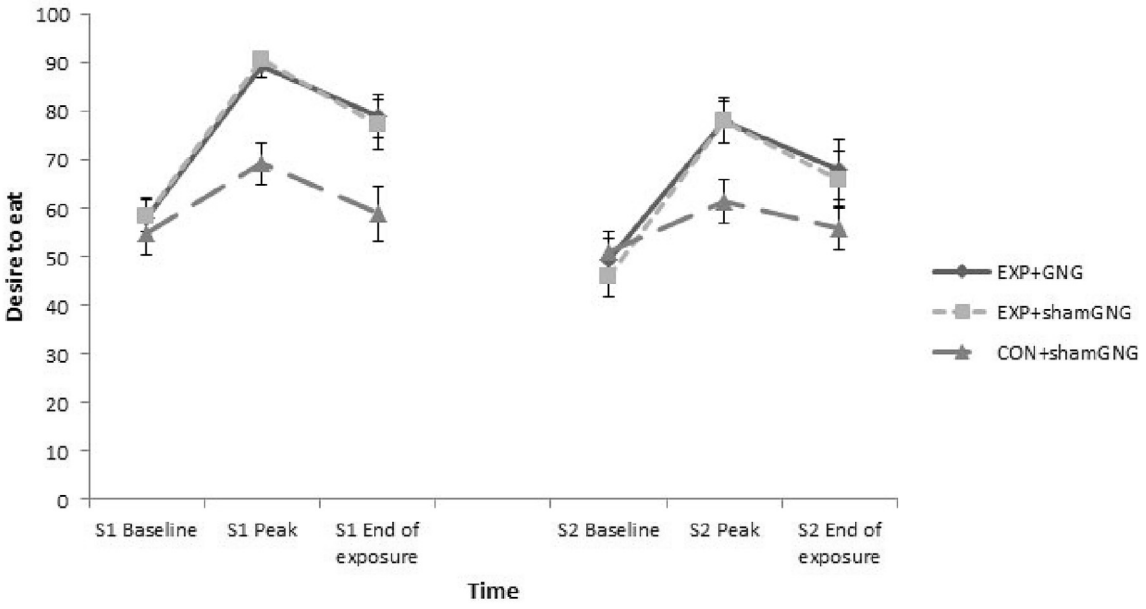
WSH (EXP + GNG session 1, $t(23) = 3.68$, $p = 0.001$/session 2, $t(23) = 2.98$, $p = 0.007$; EXP + shamGNG session 1, $t(23) = 3.09$, $p = 0.005$/session 2, $t(23) = 2.85$, $p = 0.009$; CON + shamGNG session 1, $t(22) = 2.45$, $p = 0.023$/session 2, $t(22) = 2.68$, $p = 0.014$) and BSH (EXP + GNG, $t(23) = 3.11$, $p = 0.005$; EXP + shamGNG, $t(23) = 3.29$, $p = 0.003$; CON + shamGNG, $t(22) = 2.26$, $p = 0.034$) occurred in all conditions, but there was no difference in degree of habituation (WSH session 1, $F(2, 68) = 0.23$, $p = 0.80$; WSH session 2, $F(2, 68) = 0.92$, $p = 0.40$; BSH, $F(2, 68) = 0.47$, $p = 0.63$). Neither WSH nor BSH correlated significantly with either exposed or non-exposed chocolate intake or total food intake (WSH session 2 with exposed chocolate intake, $r = 0.21$, $p = 0.08$; all other rs < 0.13, all ps > 0.28).

2.3.3. Salivation

There was a significant Condition X Time interaction for salivation (analysis on all measurements of both session 1 and session 2), $F(13.57, 434.24) = 1.99$, $p = 0.018$, $\eta_p^2 = 0.06$, again indicating successful elicitation of cue reactivity. With regard to salivation at the end of exposure, there was no difference between the EXP + GNG and EXP + shamGNG conditions, $F(1, 46) = 0.25$, $p = 0.62$. Salivation at baseline, individual peak salivation, and salivation at the end of exposure per condition are displayed in Fig. 3.

2.3.4. BSH and WSH with regard to salivation

There was WSH in all conditions (EXP + GNG session 1, $t(23) = 4.55$, $p < 0.001$/session 2, $t(23) = 4.27$, $p < 0.001$; EXP + shamGNG session 1, $t(23) = 5.33$, $p < 0.001$/session 2, $t(23) = 4.94$, $p < 0.001$; CON + shamGNG session 1, $t(22) = 5.07$, $p < 0.001$/session 2, $t(22) = 6.89$, $p < 0.001$), but no BSH (EXP + GNG, $t(23) = 1.46$, $p = 0.16$; EXP + shamGNG, $t(23) = 0.10$, $p = 0.33$; CON + shamGNG, $t(22) = 1.70$, $p = 0.10$. The degree of WSH did not differ between conditions (session 1, $F(2, 68) = 0.22$, $p = 0.80$; session 2, $F(2, 68) = 0.25$, $p = 0.78$). With the exception of the correlation between BSH and non-exposed chocolate ($r = 0.24$, $p = 0.04$), there were no significant correlations between habituation and chocolate intake or total food intake (all rs < 0.12, all ps > 0.34).



(WSH session 2 with exposed chocolate intake, $r = .21$, $p = .08$; all other rs < .13, all ps > .28).

Fig. 2. Mean desire to eat scores (+- SEM) per condition at baseline, at the individual peak, and at the end of cue exposure for each of the two sessions (S1 and S2).

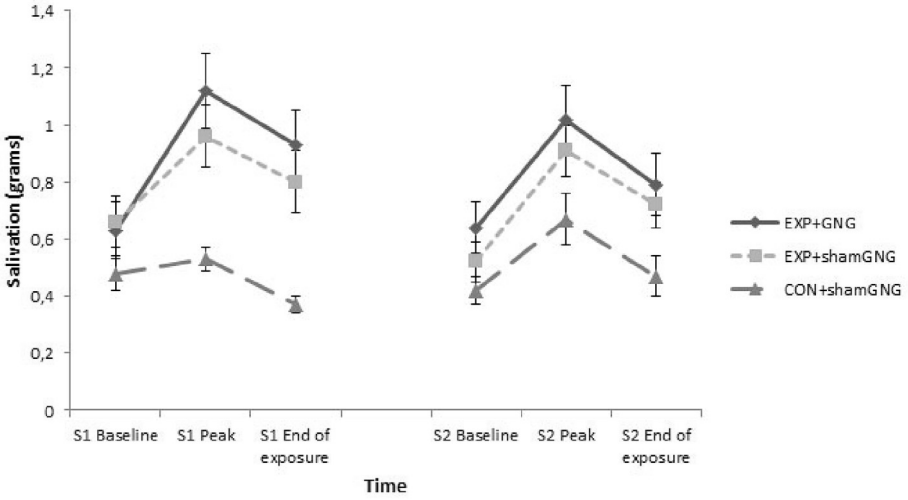


Fig. 3. Mean salivation (+- SEM) per condition at baseline, at the individual peak, and at the end of cue exposure for each of the two sessions (S1 and S2).

2.4. CS-US expectancies

The Mixed ANOVA on if-then expectancies showed no Condition X Time interaction, $F(2, 68) = 0.72$, $p = 0.49$. However, there was a main effect of time, $F(1, 68) = 13.20$, $p = 0.001$, $\eta_p^2 = 0.16$, indicating a decrease in CS-US expectancies from S1 baseline to end of S2 exposure across conditions (Fig. 4). CS-US expectancies after exposure were not significantly related to intake of the exposure chocolate ($r = 0.10$, $p = 39$) or total food intake ($r = 0.15$, $p = 0.23$) but were marginally correlated with intake of the non-exposed chocolate ($r = 0.22$, $p = 0.07$).

2.5. EAH

Mean hunger score (rated on a 100 mm VAS) before the bogus taste test was 22.32 ($SD = 19.88$) with no differences between groups, $F(2, 70) = 0.15$, $p = 0.86$. This was significantly lower than hunger levels before the consumption of sandwiches ($M = 57.16$, $SD = 21.88$), $t = 15.12$, $p < 0.001$. Because the control condition was not exposed to chocolate, average intake from the two chocolate bowls was calculated for these participants. Restraint Score was added as a covariate but was not significant for any of the dependent variables, all F's < 2.09, all p's > 0.15. The analysis revealed no group differences on consumption of the exposure chocolate, $F(2,67) = 0.001$, $p > 0.99$, the generalization chocolate $F(2,67) = 0.02$, $p = 0.98$, sweet snack foods, $F(2,67) = 0.008$, $p = 0.99$, or savory snack foods $F(2,67) = 1.26$, $p = 0.29$. In addition, the exposure groups did not differ on intake of exposure and generalization chocolate (EXP + GNG, $t(23) = 0.19$, $p = 0.85$; EXP + shamGNG, $t(23) = 0.22$, $p = 0.83$). Means and SD's of kcal intake per condition are presented in Table 2.

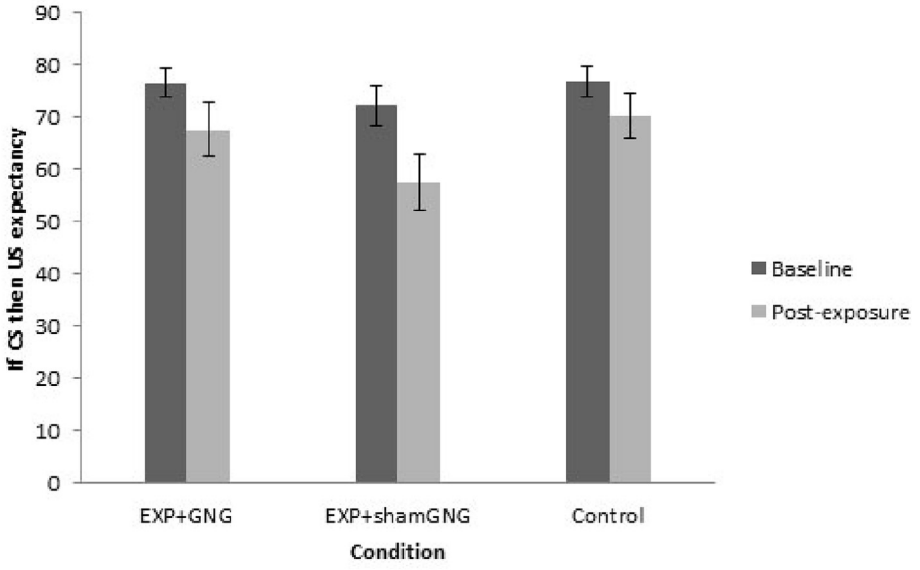


Fig. 4. CS-US expectancies (+- SEM) per condition at S1 baseline and after S2 exposure.

Table 2
Mean and SD of intake (in kcal) of chocolate, sweet snack foods and savory snack foods.

	EXP + GNG		EXP + shamGNG		Control	
	M	*SD*	*M*	*SD*	*M*	*SD*
Exposure chocolate[a]	123.61	74.08	122.76	93.99	125.10	70.96
Generalization chocolate[a]	127.83	80.82	129.53	101.12	125.10	70.96
Sweet snack foods	42.32	30.20	41.89	32.29	42.72	38.68
Savory snack foods	44.41	35.34	50.39	45.04	32.65	37.85

[a] As the control condition was not exposed to food, the data refer to the average consumption of the two bowls of chocolate. These bowls contained the first and second ranked chocolates in counterbalanced order.

3. Discussion

In the current study we investigated whether the strengthening of inhibition skills, by adding a Go/No Go training, enhanced the effectiveness of cue exposure therapy. We divided participants over three conditions (EXP + GNG, EXP + shamGNG, CON + shamGNG) and measured their desire to eat, salivation, CS-US expectancies, and food intake. The increase of desire and salivation during cue exposure indicated that our cue exposure manipulation was successful. Habituation within and between sessions was observed in all conditions, with the exception of BSH of salivation. The successful cue exposure procedure was not followed by an expected stronger decrease in CS-US expectancies and it did not lead to less food consumption for the exposure groups, indicating that cue exposure treatment in itself was not effective in the current study. Although CS-US expectancies decreased from baseline at the first session to the end of the second exposure session, this decrease did not significantly differ across groups. In addition, expectancies did not correlate with chocolate consumption. In terms of food intake there were no differences between the three groups on intake of exposure chocolate, generalization chocolate, sweet snacks, or savory snacks.

The absence of differences on any of our outcome measures for the two exposure groups is surprising. We had expected the inhibitory training provided by the Go/No Go task (Houben & Jansen, 2015; Verbruggen & Logan, 2008) to lead to lower desire and salivation levels at the end of exposure (i.e., better extinction) in the group that received the real compared to the sham training. We had also expected that performing the real (as opposed to the sham) training would result in a stronger decrease in CS-US expectancies and lower food intake for the exposure chocolate. It might be that adding a Go/No Go training simply does not enhance the effects of exposure. Another possibility is that the Go/No Go task in our study was not optimal, as there was an unexpected increase of eating desires across groups after performing the task. This could be explained by the fact that the Go/No Go task can also be considered as a form of exposure, as participants view pictures of chocolate. However, it is unclear whether this is a common effect of the task; only one previous study (Houben & Jansen, 2015) assessed desire to eat, but only after task completion, making it impossible to determine task-induced changes in desire. It could also be that a short training as incorporated in the present study is not enough to have an effect on 80 min of exposure. Perhaps a more intensive or continuous training, or providing the training *after* the cue exposure procedure, would have had different results. Previous studies with Go/No Go training lasting for several days show promising effects on energy intake and weight loss (Lawrence et al., 2015; Veling, van Koningsbruggen, Aarts, & Stroebe, 2014) and a longer training might be needed to affect exposure. Future studies could test the effects of more intensive inhibition training in clinical samples.

We unexpectedly found no differences between the control group and the two exposure groups on any of the outcome measures. Although the control group showed less cue reactivity, there was no significant difference on level of WSH and BSH, a similar decrease in CS-US expectancies, and no significant differences in

food intake during EAH. This stands in stark contrast to previous exposure studies, which have generally documented differences on for example CS-US expectancies, habituation and food intake between experimental and control groups (Boutelle et al., 2014; Mount, Neziroglu, & Taylor, 1990; Schyns et al., 2016; Schyns, Roefs, et al., in revision; Schyns, van den Akker, Hilberath, et al., in revision; Schyns, van den Akker, Roefs, et al., in revision). It is surprising that the control group, which did not receive exposure, still showed habituation and a decrease in CS-US expectancies. This might be due to the questions the participants in the control condition were asked to answer; they had to indicate their desire to eat chocolate several times during studying. This reminder of chocolate may have initially slightly triggered desire to eat and salivation – especially since they already tasted chocolate in relation to the current study during the pre-session – only to decrease again over time.

It is intriguing that earlier studies – in which cue exposure and Go/No Go training were investigated separately – convincingly showed decreased food consumption, whereas a combination of the two techniques in the current study did not demonstrate such effects. There are some differences in design that could help towards explaining the diverging results. With regard to cue exposure, we used a student sample whereas previous exposure studies used clinical samples. Although participants were selected on their liking of chocolate, difficulties to resist eating chocolate, and desire to eat less chocolate, they do not show the more generalized loss of control or even eating psychopathology that is often present in overweight/obese or eating disordered individuals who truly struggle with their weight and eating behavior. In addition, whereas previous studies recruited participants by explaining the study as a treatment that aims at weight loss and less overeating, we recruited them for a study on 'cognitive and sensory processes in chocolate lovers'. These differences raise the question whether cue exposure might be suitable in particular for overweight/obese samples and eating disorders patients with a strong motivation to change, and whether exposure is most effective when an individual believes it will decrease eating behavior or stimulate weight loss. Interestingly, in two previous studies among students who were not informed about the rationale of cue exposure treatment, there was also no evidence of reduced chocolate intake in the exposure compared to the control group (Frankort et al., 2013, 2015). It would be worthwhile for future research to investigate under which circumstances and for which groups cue exposure works. With regard to Go/No Go training, previous studies provided a measure of food intake immediately after performing the Go/No Go training, whereas in the current study there were approximately 70 min of other activities in between. It is possible that the effects of a single Go/No Go training on food consumption are short-lived or are undone by an intensive cue exposure session, and are therefore only apparent directly following the training.

Finally, our hypothesis that CS-US expectancies would be associated with food intake was not confirmed. It has been suggested that violating CS-US expectancies is crucial for effective cue exposure treatment (Craske et al., 2014) and studies in the field of anxiety disorders support this assumption (Deacon et al., 2013; Salkovskis, Hackmann, Wells, Gelder, & Clark, 2007). However, evidence for the importance of expectancy violation in food cue exposure is mixed (Schyns et al., 2016; Schyns, Roefs, et al., in revision; Schyns, van den Akker, Hilberath, et al., in revision; Schyns, van den Akker, Roefs, et al., in revision). Taken together, these results suggest that expectancy violation might not be a crucial factor in food cue exposure. However, it is also possible that expectancy violation in some exposure studies was not optimally induced. CS-US expectancies have been measured but not explicitly targeted and challenged. In addition, the presence of a therapist and the imposed prohibition of eating during exposure could prevent strong expectancy violation from occurring. Patients may ascribe the non-occurrence of the US to the presence of the therapist or to not being allowed to eat, which prevents them from developing a strong intrinsic belief that the US does not follow the CS. It is necessary for future exposure studies to manipulate expectancy violation in order to investigate its importance for food cue exposure.

The current study has some limitations. First, the EAH paradigm was conducted on the same day as the second exposure session, while it may have been beneficial to allow another day for memory consolidation. Second, cue exposure was relatively short, with two 40-min exposure sessions. Although this has been found to be sufficient to reduce food intake in some earlier studies, it could be that two sessions were not enough to reach the intended effects in our sample.

To conclude, we showed that addition of a short Go/No Go training did not have an effect on the effects of food cue exposure in chocolate-loving female students. There were no differences between the exposure groups with real vs. sham Go/No Go training on desire to eat and salivation at the end of exposure. In addition, both exposure groups and the control group showed no significant differences in decrease in CS-US expectancies, WSH and BSH, and did not significantly differ on the amount of food consumed in an EAH paradigm. CS-US expectancies were not related to food intake. A more extensive Go/No Go training or more cue exposure sessions may be necessary to reduce food consumption.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.appet.2017.11.096.

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