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Counterconditioning Reduces Cue-Induced Craving and Actual Cue-Elicited
Consumption

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Abstract

Cue-induced craving is not easily reduced by an extinction or exposure procedure and may constitute an important route toward relapse in addictive behavior after treatment. In the present study, we investigated the effectiveness of counterconditioning as an alternative procedure to reduce cue-induced craving, in a non-clinical population. We found that a cue, initially paired with chocolate consumption, did not cease to elicit craving for chocolate after extinction (repeated presentation of the cue without chocolate consumption), but did so after counterconditioning (repeated pairing of the cue with consumption of a highly disliked liquid, Polysorbate 20). This effect persisted after one week. Counterconditioning moreover was more effective than extinction in disrupting reported expectancy to get to eat chocolate, and also appeared to be more effective in reducing actual cue-elicited chocolate consumption. These results suggest that counterconditioning may be more promising than cue exposure for the prevention of relapse in addictive behavior.

Keywords: craving, human appetitive conditioning, extinction, counterconditioning, relapse

Counterconditioning Reduces Cue-Induced Craving and Actual Cue-Elicited Consumption

Both obesity and addiction are highly prevalent health problems with a great societal impact. Important similarities exist between disturbed eating behavior and addictive behavior (e.g., Cooper, 1989; Rogers & Smit, 2000), e.g., both are characterized by strong craving and preoccupation with the substance (food or drug). Cue-elicited craving (i.e., craving elicited by cues that have been paired with food or drug consumption) is considered to be an important factor in both the maintenance of the disorders and relapse (e.g., Drummond, Tiffany, Glautier, & Remington, 1995; Jansen, 1998). Therefore, it is important to gain insight into the processes that underlie cue-elicited craving and to develop ways to reduce it. Given that chocolate craving is highly prevalent and (unlike for example alcohol dependency and binge eating) largely unconfounded by psychiatric co-morbidity (Jansen, 1998), it constitutes a good testing ground to experimentally investigate cue-elicited craving and craving reduction techniques in a relatively pure manner and in easily accessible populations (Weingarten & Elston, 1991).

One technique that is applied to reduce addictive behaviors and binge-eating is cue exposure. In essence, cue exposure entails repeatedly presenting a patient with cues that have been paired with food or drug consumption in the past (e.g., the sight of a chocolate bar), without allowing actual consumption, much like an extinction procedure in classical conditioning consists of repeatedly presenting a conditioned stimulus (CS; here, the chocolate bar) in absence of the unconditioned stimulus (US; here, eating chocolate). In classical conditioning, an extinction procedure typically reduces or abolishes the conditioned reaction (CR; e.g., craving) (Pavlov, 1927). Therefore, associative learning models of craving (for an overview and other approaches, see Van

Gucht et al., 2008a) suggest that cue exposure should be an effective technique to reduce craving. However, a meta-analysis of Conklin and Tiffany (2002) shows that the efficacy of cue exposure in the treatment of addictions is low. Conklin and Tiffany (2002) argue that in the application of cue-exposure treatment, recent empirical findings on extinction have not been sufficiently taken into account. Research has shown that extinction does not necessarily involve the destruction of a previously acquired CS-US association, but rather reflects the learning of a new, contextually controlled association, which temporarily inhibits the previously learned association (e.g., Bouton, 2002). A change of context after extinction can remove this inhibition, leading to a return of the conditioned reaction, i.e., renewal (Bouton & Bolles, 1979).

We recently developed a differential conditioning paradigm that allows to systematically investigate the acquisition, extinction and return of conditioned appetitive responses in humans (Van Gucht, Vansteenwegen, Beckers, & Van den Bergh, 2008b; Van Gucht, Vansteenwegen, Van den Bergh, & Beckers, 2008c). In this paradigm, in a first phase (acquisition), two neutral stimuli are repeatedly presented (two different serving trays), one of which (CS+) is consistently paired with chocolate consumption (US) while the other (CS-) is never paired with eating chocolate. In a subsequent extinction phase, both CSs are repeatedly presented without the US. Extinction may be performed either in the same context (A) in which acquisition took place, or in a different context (B).

Results show that at the end of the acquisition phase, participants reliably report stronger craving to the CS+ than to the CS-. Remarkably, subsequent extinction consistently fails to reduce the craving elicited by the CS+, even though it does effectively reduce other conditioned responses such as the expectancy to get to eat chocolate upon presentation of the CS+. Upon return to the original acquisition context

A, a renewal effect in US-expectancies is observed, if extinction was performed in a different context B (Van Gucht et al., 2008b, 2008c).

There thus seem to be at least two potential sources for relapse: Relapse cannot only be promoted by a return of cue-elicited anticipatory reactions (e.g., return of US-expectancy after a context switch) but also by lingering cue-elicited craving. Research on relapse should therefore tackle both aspects, on the one hand by developing methods to reduce the return of successfully abolished cue-elicited reactions, and on the other hand by investigating techniques to counter extinction-resistant cue-elicited craving. This last issue forms the topic of the present study.

Cue-elicited craving is not the only instance of acquired responding that is relatively insensitive to extinction treatment. Evaluative conditioning research has shown that acquired likes and dislikes, established by pairing initially neutral cues with positively or negatively evaluated stimuli, are quite resistant to extinction as well (see De Houwer, Thomas, & Baeyens, 2001 for a review). For example, once a like or dislike for a picture of a neutral face (CS) has been established by repeatedly pairing the presentation of that picture with the picture of a clearly liked or disliked face (US), repeated presentations of the neutral face without the liked or disliked face do not appear to affect the evaluation of the CS (De Houwer, Baeyens, Vansteenwegen, & Eelen, 2000). Some have argued that, unlike conditioned preparatory responses, conditioned evaluative responses do not serve to prepare an organism to deal with an upcoming US and are not based on the actual expectancy of the US's occurrence, but on the mere activation of the representation of the US in memory. Since the conditioned evaluative response to the CS is not based on US-expectancy, contradiction of US-expectancy during extinction training does not affect it, hence the insensitivity of evaluative conditioning to extinction (Baeyens, Vansteenwegen, Hermans, & Eelen,

2001). Perhaps, like conditioned evaluative responses, conditioned subjective craving responses are also based on mere activation of the US-representation in memory, not on actual US-expectancy; indeed, some authors have even suggested that craving may be strongest when the US is unavailable (e.g., Tiffany, 1999).

In fear conditioning, even when US-expectancy ratings show complete extinction, the acquired dislike of a CS paired with shock remains unaffected by extinction training (e.g., Hermans, Crombez, Vansteenwegen, Baeyens, & Eelen, 2002; Vansteenwegen, Francken, Vervliet, Declercq, & Eelen, 2006), again in parallel with our observations of divergence between subjective craving and US-expectancy in appetitive conditioning. It thus seems that both in appetitive and in aversive conditioning, distinct response systems do not necessarily behave in synchrony with each other during extinction. Craving, (dis)liking and US-expectancy may go hand in hand during the acquisition. However, subsequent extinction may have more impact on US-expectancies and response systems that prepare an organism to process and deal with the impending US than on response systems that assign evaluative/hedon(ist)ic value (De Houwer et al., 2001).

Since craving and liking appear to be relatively unaffected by an extinction procedure, it may be worthwhile to try to reduce them through a different procedure. In evaluative conditioning, a counterconditioning procedure, unlike extinction, does seem effective in changing the valence of a stimulus (Baeyens, Eelen, Van den Bergh, & Crombez, 1989). In such a procedure, after the acquisition phase the CS is repeatedly paired with a US having a valence opposite to that of the US that was used for acquisition. It should be noted that counterconditioning has not proven more successful than extinction in the treatment of fear in humans so far (de Jong, Vorage, & van den Hout, 2000): In spider phobics, counterconditioning (by pairings spiders with tasty

food-items while playing the subjects' favorite music) was only as effective as regular exposure in changing the affective valence of spiders and in long-term treatment efficacy. However, counterconditioning may bear more promise for the treatment of unwanted behavior in the appetitive domain, as it turns out easier to change evaluations from positive to negative than inversely (a phenomenon called positive-negative asymmetry or negative learning bias; Lewicka, Czapinski, & Peeters, 1992; Rozin & Royzman, 2001).

To summarize, the goal of the present study was to investigate whether counterconditioning, in contrast to extinction, would prove effective in reducing cue-elicited craving. We compared the degree of both subjective craving and US-expectancy elicited by a cue paired with chocolate consumption between three groups, an acquisition-only group, an extinction group, and a counterconditioning group. In the latter group, the cue that was first paired with chocolate was subsequently paired with the consumption of a Polysorbate 20 solution, a bitter-tasting compound. We additionally measured the degree to which the CS+ elicited actual chocolate consumption, by recording the number of pieces of chocolate eaten by the participant in the presence of the CS+ while carrying out a filler task. Finally, we also collected liking ratings, to see whether we could replicate the evaluative conditioning findings of Baeyens et al. (1989). To assess the robustness of the effects of extinction and counterconditioning, we collected additional measurements after one week.

Method

Participants were randomly allocated to one of three groups: (1) an acquisition-only group (A), (2) an extinction group (E) or (3) a counterconditioning group (C). In a first session, all groups received the same acquisition training. After this, in group A a 15-min break followed, whereas in group E an extinction procedure and in group C a

counterconditioning procedure was implemented. One week later, all participants returned and were tested.

Participants

Undergraduate psychology students ($n = 73$, 93.15% female¹) at the University of Leuven participated in return for course credit. They were between 17 and 25 years old ($M = 18.27$; $SD = 0.93$; age data missing for three participants).

Settings

The experiment took place in a small and largely empty room. It only contained a chair for the experimenter, a simple couch for the participant adjacent to a little table and a second table with a pc on it. Two small lights -and no central lighting- were turned on during the experiment. There were no other lights, no windows and the floor was covered by wall-to-wall carpet.

Measures

Three subjective (craving for chocolate, US-expectancy, liking) and one behavioral measure (number of pieces of chocolate missing) were recorded in this experiment.

Craving. Self-reported craving for chocolate was assessed on a 100-mm VAS. The scale was accompanied by the following question (all instructions and questions were presented in Dutch but are translated here): “When presented this tray, how strong is your craving for chocolate now?”, ranged from *no craving at all* to *extremely strong craving* and did not contain any other anchors.

US-expectancy. Participants reported their US-expectancies on a 100-mm VAS stating “How strongly do you now expect to be invited to eat chocolate?” and ranging from *certainly not* to *certainly* (the scale did not contain any other marks or labels).

Liking. Participants were asked to indicate to what extent they liked or disliked both trays on 100-mm VASs. For each tray, the following question was asked: “To what extent did you find the white(green) tray pleasant/unpleasant?”. The VASs ranged from *very unpleasant* to *very pleasant*, without any other labels.

Number of pieces of chocolate missing. At the end of the first session, the experimenter told a cover story and left the participant alone in the room with eight pieces of chocolate, presented on the CS+ tray, to carry out a filler task. The number of pieces of chocolate that was missing afterwards was recorded.

Materials

Two serving trays (one round and green, the other rectangular and white) were used as CSs. One tray was the CS+, the other one the CS-, counterbalanced across participants.

On the basis of information gathered prior to the experiment, we prepared for every participant individually packed (in aluminium foil) pieces of his/her favorite brand and kind of chocolate. One piece of chocolate was approximately 2 cm². In total there were 12 pieces for each participant (four for the acquisition phase and eight to use during the filler task, see below).

For participants in group C, eight cups of 25 ml water each mingled with 0.075 ml of a highly disliked liquid (Polysorbate 20 or ‘Tween’) were prepared.

Procedure

The experiment consisted of two sessions (the first lasting 1 hr, the second 10 min) with on average one week between sessions. Participants were instructed to abstain from chocolate and other candies 24 hr prior to participation.

In the first session, participants were first asked to fill out an informed consent form. Next, they were shown the craving and US-expectancy VASs and were explained

what the concepts stand for. Then, they received the following introduction from the experimenter: “Here you see two different serving trays. I will present you those trays in a randomized order, determined beforehand on the basis of coin tosses. One tray will sometimes be followed by me asking you to eat or drink something, the other tray not”. All groups then received the same acquisition procedure. In the acquisition phase, eight trials were presented (four for the CS+, four for the CS-) in a randomized order, based on coin tosses, with the restriction that no more than two successive trials were of the same type. A trial proceeded as follows: The experimenter presented the tray to the participant and asked him/her to pay attention to the tray and his/her feelings and thoughts. After 30 s, the participant was asked to fill out the craving and US-expectancy VASs (the order of these scales was counterbalanced across participants). In case of a CS+ trial, the participant was then given a piece of chocolate (which was kept out of sight of the participant behind a carton board at all other times) and asked to eat it, after which the tray was removed from the participant’s sight. In case of a CS- trial, after filling out the VASs, the tray was simply removed. Trays were kept in a large shopping bag, which was placed behind the chair of the experimenter. After a trial, a tray was always put back in the bag, even if the next trial required using the same tray. The next trial started 30 s later.

After the acquisition phase, participants in group A had a 15-min break, during which they remained waiting in their couch in the same room (the length of this break corresponded to the length of the extinction/counterconditioning procedures), whereas in group E an extinction procedure and in group C a counterconditioning procedure was implemented. The extinction procedure consisted of 16 trials, eight for the CS+ and eight for the CS-, randomized as before. A trial proceeded similarly as in acquisition, apart from the fact that no chocolate consumption followed the CS+ presentations. In

the counterconditioning procedure, 16 trials were also presented. The only difference here was that the CS+ was now consistently paired with the consumption of a highly disliked liquid (the cups containing the liquid were kept out of sight of the participant at all other times).

After the break-extinction-counterconditioning phase, all groups performed a computerized reaction time task—a behavioral measure which allows to measure implicit approach and avoid tendencies (i.e., an adapted version of the task developed by Mogg, Bradley, Field, & De Houwer, 2003). Previous results obtained with this task showed that conditioned craving cues can elicit an automatic approach tendency (Van Gucht et al., 2008c). However, in the current experiment, no significant effects were obtained (no overall acquisition effect could be detected, with no differences between groups), most likely because of procedural problems². Accordingly, the specifics and data from this task will not be reported.

Following the reaction-time task, participants filled out a questionnaire with a few demographic questions and the liking VASs. In total 50 min of the first session had now passed, and because participants were required to be present for one hour in order to gain course credit, the experimenter told them that there was still some time left, in which they could help out a colleague of the experimenter by performing a short task on the pc. While the experimenter was explaining this, she placed eight pieces of chocolate on the CS+ tray (which was left on purpose on the little table adjacent to the couch at the end of the last trial) and told the following cover story: “I made a mistake when preparing your chocolate, I thought you were supposed to be in a different condition, so I have prepared too much. Feel free to take some if you like. When you are ready with the task on the computer, the experiment is finished and you can leave this room, I will be waiting outside”. The experimenter left the room and waited outside for the

participant to leave, then said goodbye and reminded her/him about attending the second session. She then went back in the room and counted the pieces of chocolate that were missing from the CS+ tray.

One week later, participants returned for the second session and were tested in the same context and under exactly the same conditions as the preceding session. They were presented both the CS+ and CS- and were asked to fill out the craving and US-expectancy VASs (without consumption of either chocolate or Tween). Afterwards, they performed the aforementioned reaction-time task for a second time.

Results

Self-reported craving ratings

To assess the presence of *acquisition*, a 3 (Group: A vs. E vs. C) x 2 (CS-type: CS+ vs. CS-) x 2 (Trial: first acquisition trial vs. last acquisition trial) ANOVA was performed on the subjective craving scores with Group as between-subjects variable and CS-type and Trial as within-subjects variables. Across groups we saw an increase in differentiation between the CS+ and CS- ratings going from the beginning to the end of the acquisition phase as shown by a CS-type x Trial interaction across groups, $F(1, 67) = 39.89, p < .001$ (see Figure 1). There was no difference between groups in terms of acquisition, Group x CS-type x Trial interaction, $F < 1$.

To evaluate the effects of the *extinction* and *counterconditioning* procedure, we calculated a 2 (Group: E vs. C) x 2 (CS-type: CS+ vs. CS-) x 2 (Trial: first vs. last extinction/counterconditioning trial) ANOVA. The 3-way interaction was significant, $F(1, 45) = 8.13, p < .01$, indicating a difference between the extinction and counterconditioning procedure. As can be seen in Figure 1, the *extinction* procedure did not reduce the acquired differentiation in craving, CS-type x Trial (first vs. last extinction trial) interaction, $F < 1$. However, the *counterconditioning* procedure did

prove effective, as shown by the CS-type x Trial (first vs. last counterconditioning trial) interaction, $F(1, 45) = 10.92, p < .01$. The difference between CS-types on the last counterconditioning trial was totally abolished, $F < 1$, whereas the difference between CSs on the last extinction trial remained, $F(1, 45) = 14.95, p < .001$, also reflected by a significant interaction between groups on this last trial, $F(1, 45) = 11.78, p < .01$. Note that it is not the CS- that increases from the first to the last counterconditioning trial, $F(1, 45) = 1.64, p = .21$, but the CS+ that decreases from the first to the last counterconditioning trial, $F(1, 45) = 4.79, p < .05$.

To test whether the effect would still be present a week later at *follow up*, responding on the first acquisition trial was compared to the follow-up test trial one week later by means of a 3 (Group: A vs. E vs. C) x 2 (CS-type: CS+ vs. CS-) x 2 (Trial: first acquisition vs. test trial) ANOVA on the subjective craving scores with Group as between-subjects variable and CS-type and Trial as within-subjects variables. The overall 3-way interaction failed to reach significance, $F(2, 67) = 2.23, p = .12$. Planned comparisons were conducted to evaluate the effects at follow-up in each group. In both group A and group E, the CS-type x Trial (first acquisition vs. test trial) interactions were significant, indicating that the differentiation observed at the end of acquisition was still observed after one week, $F(1, 67) = 16.11, p < .001$, and $F(1, 67) = 5.67, p < .05$, respectively. In group C, differentiation remained absent, CS-type x Trial (first acquisition vs. test trial) interaction, $F(1, 67) = 1.16, p = .28$. Groups A and C moreover differed significantly, Group (A vs. C) x CS-type x Trial interaction, $F(1, 67) = 4.45, p < .05$.

US-expectancy ratings

To assess the presence of *acquisition*, a 3 (Group: A vs. E vs. C) x 2 (CS-type: CS+ vs. CS-) x 2 (Trial: first vs. last acquisition trial) ANOVA was performed on the

US-expectancy ratings, with Group as between-subjects variable and CS-type and Trial as within-subjects variables. Across groups, participants learned to expect to get to eat chocolate more in the presence of the CS+ than in the presence of the CS- tray, as indicated by a significant CS-type x Trial interaction across groups, $F(1, 67) = 282.80, p < .001$ (see Figure 2) with no differences between groups, as reflected by a non-significant Group x CS-type x Trial interaction, $F < 1$.

To evaluate the effects of the *extinction* and *counterconditioning* procedure, we performed a 2 (Group: E vs. C) x 2 (CS-type: CS+ vs. CS-) x 2 (Trial: first vs. last extinction/counterconditioning trial) ANOVA. The 3-way interaction was significant, $F(1, 45) = 7.51, p < .01$, suggesting a difference between groups E and C. As can be seen in Figure 2, the source of this interaction is different from that for the craving data. In both groups, the acquired differentiation in US-expectancy is reduced, as shown by a significant CS-type x Trial (first vs. last extinction trial) interaction in group E, $F(1, 45) = 73.32, p < .001$ and CS-type x Trial (first vs. last counterconditioning trial) interaction in group C, $F(1, 45) = 160.42, p < .001$. As can be seen in Figure 2, and as confirmed by the three-term overall interaction, in the latter group, the reduction in differentiation was even stronger than in group E. In group C, the difference between the CSs on the last (counterconditioning) trial was no longer significant, $F(1, 45) = 3.20, p = .08$, whereas it still was on the last (extinction) trial in group E, $F(1, 45) = 21.94, p < .001$.

To test whether the effect would still be present a week later at *follow up*, responding on the first acquisition trial was compared to the follow-up test trial one week later by means of a 3 (Group: A vs. E vs. C) x 2 (CS-type: CS+ vs. CS-) x 2 (Trial: first acquisition vs. test trial) ANOVA on the US-expectancy ratings with Group as between-subjects variable and CS-type and Trial as within-subjects variables. The 3-way interaction indicated differences between groups in the change (over time) in

differential CS+/CS- responding, $F(2, 67) = 4.17, p < .05$. We followed up on this analysis with planned comparisons for CS-type x Trial (first acquisition vs. test trial) interactions within each group. In all groups, we found significant interactions, indicating that a differentiation in US-expectancies was observed after one week, $F(1, 67) = 38.80, p < .001$; $F(1, 67) = 15.10, p < .001$; $F(1, 67) = 5.06, p < .05$, for groups A, E, C, respectively. Still, differentiation was reliable smaller in group C than in group A, $F(1, 67) = 8.29, p < .01$, with differentiation in group E not differing from either group C, $F(1, 67) = 1.43, p = .24$, or group A, $F(1, 67) = 2.77, p = .10$.

Self-reported liking ratings

To evaluate how acquisition, extinction and counterconditioning affected acquired evaluations of the CSs, we performed a 3 (Group: A vs. E vs. C) x 2 (CS-type: CS+ vs. CS-) ANOVA on the liking ratings with Group and CS-type as between-subjects variables. The analysis revealed a significant main effect of CS-type, $F(1, 70) = 14.75, p < .001$, qualified by a significant Group by CS-type interaction, $F(2, 70) = 43.27, p < .001$. As can be seen in Figure 3, the CS+ tray was rated more positively than the CS- tray both in group A and in group E, $F(1, 70) = 34.57, p < .001$ and $F(1, 70) = 36.23, p < .001$ respectively, with no reliable difference between both groups, $F < 1$. The pattern was reversed in group C, implying that the CS+ tray was consistently rated more negatively than the CS- tray, $F(1, 70) = 29.16, p < .001$. Consequently, the CS+/CS- differentiation was significantly different for group A vs. group C, $F(1, 70) = 63.67, p < .001$, and for group E vs. group C, $F(1, 70) = 65.26, p < .001$.

Number of pieces of chocolate eaten

To evaluate whether the different conditioning procedures also affected the capacity of the CS+ to elicit actual consummatory behavior, we performed a one-way ANOVA on the number of pieces of chocolate taken from the CS+ tray during the filler

task, with Group as between-subjects variable. The effect of Group was marginally significant, $F(2, 69) = 2.81, p = .07$. Figure 4 shows that participants in group A took more pieces of chocolate than those in group E, who in turn took more than those in group C, yielding a significant difference between groups A and C, $F(1, 69) = 5.60, p < .05$.

Discussion

Our paradigm again proved successful in installing differential acquisition of chocolate craving. After repeated pairings with actual chocolate consumption, the CS+ elicited more craving than the CS- at the end of the acquisition phase. US-expectancies were also easily acquired: Participants learned to expect to eat chocolate in the presence of the CS+ and not in the presence of the CS-. Also in line with our previous observations, we found that an extinction procedure (repeated presentation of the cue without chocolate consumption) did not make the CS+ cease to elicit craving for chocolate. Note that this is a robust and recurrent finding, demonstrated in multiple experiments, even after trying different manipulations (explicit instructions, different exposure procedure; Van Gucht et al., 2008b, 2008c). Like in our previous experiments, the extinction procedure did reduce the acquired differentiation in US-expectancy (Van Gucht et al., 2008b, 2008c).

Again, the extinction data suggest that conditioned craving differs from conditioned US-expectancies in its sensitivity to extinction. As we have noted earlier, conditioned craving might resemble conditioned likes, which have been found to be quite resistant to extinction as well (De Houwer et al., 2001). Because of this resemblance between conditioned craving and preferences with regards to extinction, and because of the observation that counterconditioning did alter preferences (Baeyens et al., 1989), we hypothesized that a counterconditioning procedure –in contrast to an

extinction procedure- would be effective in reducing craving. Indeed, our data replicate the effects reported by Baeyens et al. (1989): Evaluative conditioning was not affected by our extinction procedure, whereas the counterconditioning procedure (repeated pairing of the cue with consumption of a highly disliked liquid) did prove effective in changing the evaluative valences attributed to the trays. Second, and more importantly, in contrast to the extinction procedure, our counterconditioning procedure also proved effective to reduce craving: At the end of the counterconditioning phase, there was no difference in reported craving for chocolate whereas after the extinction procedure the difference in conditioned craving remained clearly present. Counterconditioning moreover was more effective than extinction in disrupting reported expectancy to get to eat chocolate, and also appeared to be more effective in reducing actual cue-elicited chocolate consumption.

In addition, one week later, the reduced craving effect still persisted in group C, whereas in group A and group E, a significant differentiation was present at follow up. Counterconditioning also appeared somewhat more effective than extinction when US-expectancies were concerned at follow up: Although some residual difference in reported expectancy to get to eat chocolate was present after one week, this difference was remarkably smaller in group C than in group A, although not significantly smaller than in group E.

The results presented here can provide useful suggestions for improving treatments in clinical practice since craving is considered an important factor in both the maintenance of the (eating/addictive) disorder and in relapse. One could think about implementing a clinical equivalent of counterconditioning to reduce or eliminate this craving. Decades ago, in nicotine research, treatments in the form of aversive smoking (rapid smoking, satiation and focused smoking) were found to yield promising results

(for a review see Piasecki, 2006). They have largely been abandoned because of safety issues and the introduction of nicotine-replacement products in the eighties (Piasecki, 2006). Nonetheless, if designed properly, counterconditioning as a procedure to reduce craving in the appetitive domain might well be worthwhile.

However, a number of issues still require our attention. First, further research with a better designed version of the reaction-time task should be conducted since in the current experiment no reliable effects could be obtained. Second, we should not forget that (lingering) craving is only one factor in the maintenance of the disorder and in relapse. With respect to the latter, earlier research demonstrated that relapse into disturbed eating behavior and addictive behavior can also be promoted by a return of preparatory reactions after successful extinction (e.g., renewal in US-expectancy, Van Gucht et al., 2008b, 2008c). In that respect, it is encouraging that counterconditioning did not only reduce craving, but also seemed more effective in reducing expectancy to get to eat chocolate than was extinction. Still, phenomena that thwart the endurance of extinction can similarly affect the effect of counterconditioning (Bouton, Woods, Moody, Sunsay, & Garcia-Gutiérrez, 2006). Like extinction, counterconditioning involves second learned information, which does not necessarily destroy the information that was learned first. Therefore, it is important to investigate whether counterconditioning is also sensitive to contextual control and thus renewal. To reduce the return of responding after extinction/counterconditioning, we can draw inspiration from techniques that have proven to be effective in human fear conditioning research (for an overview see Vansteenwegen, Dirikx, Hermans, Vervliet, & Eelen, 2006), such as carrying out extinction/counterconditioning in multiple contexts to reduce the context dependency (e.g., Chelonis, Calton, Hart, & Schachtman, 1999; Effting & Kindt, 2007; Gunther, Denniston, & Miller, 1998) or exploring the effect of a reminder cue (e.g.,

Brooks & Bouton, 1994; Collins & Brandon, 2002) presented during the extinction/counterconditioning and test phase.

The clinical equivalent of counterconditioning will not be suitable in every situation and can be met with aversion by patients; in that case an optimized exposure treatment (or a combination of exposure and counterconditioning) may be more suitable. It may also be worthwhile to try to identify yet alternative ways to alter cue-elicited craving. Research on evaluative conditioning suggests that, like counterconditioning, US revaluation is highly effective in changing conditioned likes and dislikes (Baeyens, Eelen, Van den Bergh, & Crombez, 1992; Walther, Gawronski, Blank, & Langer, 2009; for related research on reinforcer devaluation in animal appetitive conditioning, see e.g., Delamater, Campese, LoLordo, & Sclafani, 2006; Dwyer, 2005; Holland & Rescorla, 1975). In a US-revaluation procedure, the evaluative meaning of the original US is altered through instructions or through pairing of that US with a US of opposite valence (instead of directly pairing the CS with the latter US, as is done in counterconditioning). Given the effectiveness of such a procedure in altering acquired likes and dislikes, and given the parallel effects of extinction and counterconditioning on conditioned (dis)likes and conditioned craving, it seems worthwhile to also investigate the effectiveness of US revaluation in reducing cue-elicited craving.

To close, we showed that counterconditioning, in contrast to extinction, is a promising procedure to reduce craving, and it appears also effective in reducing actual cue-elicited chocolate consumption. These results suggest that counterconditioning may be more promising than cue exposure both as a treatment strategy, and for the prevention of relapse, in disturbed eating behavior and addictive behavior.

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Footnotes

¹ Although we failed to observe systematic effects of gender on conditioning of chocolate craving in our previous studies, the almost exclusive reliance on a female population may somewhat limit the generalizeability of the present results.

² In the present experiment, new pictures of the serving trays were used in the reaction-time task. In contrast to when using our previous version of the task (Van Gucht et al., 2008c), several participants now reported being unsure of the content of the pictures. This was of course unintended and most likely responsible for the absence of an acquisition effect.

Figure 1. Mean reported chocolate craving (+SE) on a VAS-scale ranging from 0 (*no craving at all*) to 100 (*extremely strong craving*) for the acquisition group (Group A, left panel), the extinction group (Group E, middle panel) and the counterconditioning group (Group C, right panel), by CS-type and trial. ACQ1 = acquisition trial 1; ACQ4 = acquisition trial 4; FU = follow-up test trial; EXT1 = extinction trial 1; EXT8 = extinction trial 8; COUNTER1 = counterconditioning trial 1; COUNTER8 = counterconditioning trial 8.

Figure 2. Mean reported US-expectancy (+SE) on a VAS-scale ranging from 0 (*certainly not*) to 100 (*certainly*) for the acquisition group (Group A, left panel), the extinction group (Group E, middle panel) and the counterconditioning group (Group C, right panel), by CS-type and trial. ACQ1 = acquisition trial 1; ACQ4 = acquisition trial 4; FU = follow-up test trial; EXT1 = extinction trial 1; EXT8 = extinction trial 8; COUNTER1 = counterconditioning trial 1; COUNTER8 = counterconditioning trial 8.

Figure 3. Mean reported liking (+SE) on a VAS-scale ranging from 0 (*very unpleasant*) to 100 (*very pleasant*) for the acquisition group (Group A, left panel), the extinction group (Group E, middle panel) and the counterconditioning group (Group C, right panel), by CS-type.

Figure 4. Mean number of pieces of chocolate missing (+SE) for the acquisition group (Group A), the extinction group (Group E) and the counterconditioning group (Group C).