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Effects of occasional reinforced trials during extinction on the reacquisition of conditioned responses to food cues



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ABSTRACT

Background and objectives: Successful long-term dieting appears to be difficult, and part of its difficulty might be explained by processes related to classical appetitive conditioning. Increasing the speed of extinction of appetitive responses to food cues and decreasing the magnitude of returns of these responses could help increase the long-term effectiveness of weight loss attempts. Two extinction techniques hypothesized to slow down rapid reacquisition of conditioned appetitive responses were investigated: the provision of 1) occasional reinforced extinction trials (OR) and 2) unpaired unconditioned stimuli (USs) during extinction (UNP).

Methods: After acquisition, participants (N = 90) received one of three extinction trainings: OR, UNP, or normal extinction (control), followed by a reacquisition phase. Their desire to eat, US expectancy, and salivation were measured. Effects of impulsivity on different phases of appetitive conditioning were also assessed.

Results: It was found that both extinction techniques were successful in reducing the rate of reacquisition of US expectancies. Participants in the OR condition also demonstrated a slower extinction of US expectancies and desires to eat. However, the reacquisition of conditioned desires was not affected by either extinction technique. Impulsivity did not moderate responses during acquisition or extinction, but appeared to slow down the reacquisition of conditioned desires.

Limitations: US expectancies and eating desires were not completely extinguished, and a few differences in baseline responses caused difficulty in interpreting some of the findings.

Conclusions: It is concluded that the provision of occasional reinforced extinction trials and unpaired USs seem promising techniques to slow down reacquisition, but that additional studies are needed.

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1. Introduction

Over the past decades, the prevalence of overweight and obesity has been continually increasing. Around 70% of the US population is currently overweight, of which half qualifies for obesity (Ogden, Carroll, Kit, & Flegal, 2012). Attempts to lose the excess weight are common: approximately 40% of all US adults have engaged in weight loss practices in the previous year (Weiss, Galuska, Khan, & Serdula, 2006). However, successful long-term weight loss appears difficult. Only one in five dieters is able to lose at least 10% of their

initial weight and maintain the loss for at least one year (Wing & Phelan, 2005).

Conditioning models propose roles for learning processes in explaining the difficulty to chronically adhere to restrictive diets. In response to an (initially neutral) stimulus (conditioned stimulus, CS) that has become associated with eating palatable food (unconditioned stimulus, US), cue reactivity is elicited (Jansen, 1998). Any stimulus could become associated with food intake, such as the sight or smell of food, emotions, or environments (Jansen, 1998; Van den Akker, Jansen, Frentz, & Havermans, 2013). Cue reactivity includes preparatory responses of the body and a subjective experience of craving, urge or desire to eat (Jansen, 1998; Power & Schulkin, 2008), and higher levels of cue reactivity are thought to be associated with an increased difficulty to abstain from eating (Jansen, 1998; Jansen, Havermans, & Nederkoorn, 2011). Therefore, chances to successfully lose weight might be increased by

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diminishing reactivity – for instance, through extinction. During extinction, one is repeatedly exposed to a food cue (CS) without eating (US) to learn that the CS no longer predicts the US. Consequently, cue reactivity should diminish (Jansen et al., 2011). Extinction of cue reactivity is essentially practiced when being on a restrictive diet: a person attempts not to reinforce certain food cues to which he is exposed. However, extinction may take a while, and as long as a CS promotes a relatively high degree of cue reactivity (e.g., desires to eat), dieting efforts are easily undermined. Indirect support for the idea that cue reactivity and dieting success are related stems from a study showing formerly obese successful dieters to be less cue reactive than their unsuccessful counterparts (Jansen, Stegerman, Roefs, Nederkoorn, & Havermans, 2010), suggesting that their food cue reactivity was successfully reduced (presumably extinguished). Additionally, food cue exposure therapy (during which an individual is repeatedly presented with “forbidden” foods without eating) seems to be effective in decreasing eating in the absence of hunger in obese children (Boutelle et al., 2011), and in reducing the desire to eat and the number of binges in binge eaters (Jansen, Broekmate, & Heymans, 1992). Thus, to maintain weight loss in the long run it might be necessary to extinguish cue reactivity to certain food cues (CSs).

It is known that extinction results in inhibitory learning that is highly dependent on context, rather than erasure of the CS–US relationship (Bouton, 2002). This is why conditioned appetitive responses can suddenly re-emerge after extinction, promoting “relapse” and limiting the effectiveness of extinction treatments (e.g., Havermans & Jansen, 2003). There are several conditioning phenomena that can explain such returns of conditioned responses, one of which being rapid reacquisition (for an overview see Bouton, 2011). Rapid reacquisition is characterized by a quick return of responding when a CS is again paired with the US after extinction, and it presumably occurs because of contextual similarities to the original acquisition context (Bouton, 2011). Translated to dieting, rapid reacquisition could cause a “lapse” in the diet (i.e., a re-reinforced CS after extinction) to trigger a quick return of appetitive responding to a food cue (Bouton, 2011). This quick return of food cue reactivity after a period of successfully abstaining from eating tasty high-calorie foods could easily end up in a full-blown return of appetitive responses, resulting in a failure to maintain dietary restriction and weight loss.

This classical conditioning interpretation of unsuccessful dieting predicts that dieters can benefit from interventions that reduce or prevent the return of appetitive responses caused by, for instance, rapid reacquisition. While rodent studies, human fear conditioning studies, and a few human appetitive conditioning studies have identified an array of potentially effective techniques (Bouton, 2002; Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014; Laborda, McConnell, & Miller, 2011; MacKillop & Lisman, 2008; Van Gucht, Baeyens, Hermans, & Beckers, 2013; Van Gucht, Baeyens, Vansteenwegen, Hermans, & Beckers, 2010), no studies have examined ways of tackling rapid reacquisition of appetitive responses in humans. In rats, one procedure that has been shown to be very effective in slowing down the reacquisition of appetitive responses after extinction is the presentation of some CS–US pairings during extinction (Bouton, Woods, & Pineño, 2004). During this procedure, after acquisition, a food cue (CS) is occasionally followed by the intake of food (US) during extinction. In a subsequent reacquisition phase, renewed CS–US pairings elicit *less* responding compared with rats that received a regular extinction training (never a US after the CSs), i.e. the reacquisition of appetitive responses was less rapid. It has been suggested that occasional reinforced trials during extinction enable reinforced trials to be associated with extinction trials, leading to a greater generalization between the extinction and reacquisition context and a slowing

down of reacquisition (see Bouton et al., 2004; Woods & Bouton, 2007). If humans can similarly associate one reinforced CS–US pairing (e.g., eating chocolate once in response to a CS) with no subsequent reinforcements (not eating chocolate during subsequent CS presentations), the effectiveness of extinction training on the long-term could be increased by preventing a full-blown relapse. An eating binge could be prevented using occasional reinforcements as well, by learning to associate consuming one small snack (the CS) with no further (over)eating (US) (Bouton et al., 2004).

Another technique that remarkably slows down reacquisition in rats also involves occasional US presentations during extinction, but in this technique the US is not presented in contingency with its CS; rather, it is not paired with a cue. Unpaired USs during extinction may slow down reacquisition through a mechanism similar to the one described for occasional reinforced extinction: a US may come to signal upcoming extinction trials, slowing down reacquisition (Bouton et al., 2004; Woods & Bouton, 2007; see also Rauhut, Thomas, & Ayres, 2001; Vervliet, Vansteenwegen, & Hermans, 2010). Thus, while animal studies show that extinction procedures that include occasional reinforcements and unpaired US presentations reduce reacquisition of appetitive responses, these techniques have yet to be studied in humans.

Some individuals may be predisposed to reacting stronger to food cues and/or reacting differently to the learning and extinction of appetitive responses. Having an impulsive personality has been related to increased food cue reactivity, overeating, obesity, and reduced dieting success (Guerrieri, Nederkoorn, & Jansen, 2008; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Nederkoorn, Jansen, Mulken, & Jansen, 2007; Tetley, Brunstrom, & Griffiths, 2010). Additionally, some evidence was found for impulsivity to be related to slower extinction of food reward expectations, and to potential differences in acquisition and reacquisition rates (Van den Akker, Jansen, Havermans, & Bouton, 2014; but see Papachristou, Nederkoorn, Beunen, & Jansen, 2013). Several authors have proposed mechanisms that may underlie a possible influence of impulsivity during different stages of appetitive conditioning (Corr, 2001, 2002; Corr, Pickering, & Gray, 1995; Dawe, Gullo, & Loxton, 2004; Franken, van Strien, Nijs, & Muris, 2008; Gorenstein & Newman, 1980; Patterson & Newman, 1993; Zinbarg & Mohlman, 1998). For instance, impulsivity may be associated with greater changes in emotional states and increased arousal in appetitive situations, which could strengthen conditioning (Corr, 2001). Increased rash impulsiveness (as measured by the BIS-11) may be related to extinction deficits through worse functioning of the orbitofrontal cortex, which is involved in learning under conditions of changing reward contingencies (see Dawe et al., 2004; McDannald, Jones, Takahashi, & Schoenbaum, 2014). Based on these models and on previous findings, it may be expected that impulsivity facilitates the acquisition and slows down the extinction of appetitive responses.

In the present study, a differential conditioning paradigm was used in which two different (initially non-food related) boxes served as CSs. During an acquisition phase, one box (the CS+) was repeatedly paired with consumption of chocolate mousse (US), while another box (the CS–) served as within-subject control and was never paired with consumption. Consequently, the CS+ should elicit heightened expectancies to receive the US and an increased desire to eat, compared with the CS–. After acquisition, participants received one of three extinction trainings. Effects of occasional reinforced extinction and unpaired US presentations during extinction on the speed of extinction and reacquisition of appetitive responses to a food CS were examined. It was hypothesized that both techniques would slow down reacquisition relative to a normal extinction procedure, and that occasional reinforcements

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