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Appetitive conditioning to specific times of day

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ABSTRACT

Human laboratory studies have shown that eating desires are easily learned through classical conditioning: after a few pairings of an initially neutral stimulus (e.g., a box) with the intake of palatable food (e.g., chocolate), the stimulus elicits increased eating expectancies and eating desires (acquisition). After repeated non-reinforced presentations of the chocolate-associated stimulus, eating expectancies and desires decrease again (extinction). It is commonly assumed that eating desires in daily life are acquired and extinguished in a similar manner, but to date, this has not been empirically tested. In two studies, we examined whether the repeated consumption of chocolate at a specific time of day elicits increased eating expectancies and eating desires over a period of 5 days (study 1) or 15 days (study 2), and relative to a time of day not paired with chocolate intake. Further, it was tested whether acquired responding diminishes again during extinction (study 1). Ecological momentary assessment was used to carry out the studies in daily life. Results showed that eating expectancies were acquired in both studies. Only in study 2, eating desires were also successfully learned. It is concluded that eating expectancies and eating desires can be conditioned to ecologically valid cues and under real-life circumstances. This highlights the importance of associative learning processes in the experience of eating desires in daily life.

1. Introduction

Overweight and obesity prevalence have increased dramatically over the past decades (Ogden, Carroll, Kit, & Flegal, 2014). Experts agree that the 'obesogenic' environment plays an important role in this: it is characterized by an abundance of stimuli that signal the availability of palatable high-calorie foods, and exposure to these food cues can result in psychological and physiological changes that promote overeating (Jansen, 1998). One important psychological component of this so-called reactivity to food cues is a heightened wish or urge to consume the food, i.e., an increased desire to eat (Jansen, 1998; Kavanagh, Andrade, & May 2005). As cue-elicited eating desires primarily concern high-calorie foods and can occur even when sated, they might easily contribute to excessive weight gain (Ferriday & Brunstrom, 2011; Havermans, 2013; Jansen, Havermans, & Nederkoorn, 2011). This highlights the importance of investigating the etiology of eating desires.

Cue-elicited eating desires likely have a learned component. In theory, food cues have once become associated with intake through repeated pairings of a stimulus (conditioned stimulus or CS) with eating (unconditioned stimulus or US) (Jansen, 1998). Upon exposure, conditioned food cues elicit conditioned appetitive responses (CRs) including a heightened desire to eat. Any cue may come to function as CS, including the sight or smell of food (Blechert, Testa, Georgii, Klimesch, & Wilhelm, 2016), a certain emotion (Bongers & Jansen, 2017), or a specific situation or context (van den Akker, Jansen, Frentz, & Havermans, 2013). For example, when a person repeatedly consumes chocolate (US) in the evening, "evening time" may become a predictor (CS) for intake, subsequently eliciting an increased desire to eat (CR) (Jansen, 1998; Wardle, 1990; see also; Woods et al., 1977). Similarly, when a CS is no longer followed by the US, conditioned eating desires are expected to extinguish, and (over)eating should become less likely (Jansen et al., 2011). Findings of human laboratory conditioning studies are in line with this learning-based interpretation of cued eating desires (e.g., Bongers, van den Akker, Havermans, & Jansen, 2015; van den Akker, Havermans, Bouton, & Jansen, 2014; Van Gucht, Vansteenwegen, Van den Bergh, & Beckers, 2008). These studies also suggest that eating desires are readily acquired. After only a few pairings of a stimulus (e.g., a box, vase, or tray) with the intake of food (the US; e.g., chocolate), this stimulus (CS+) usually increases eating desires relative to a stimulus not paired with food (CS-), though awareness

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of the CS-US association is likely necessary for this (i.e., reporting heightened expectancies to receive the US when presented with the CS+; van den Akker et al., 2013; Hogarth & Duka, 2005; Birch, McPhee, Sullivan, & Johnson, 1989). During extinction, in which the CSs are repeatedly presented but no USs are provided, US expectancies and desires both diminish - although it seems that a complete extinction of acquired eating desires is difficult to achieve (van den Akker, van den Broek, Havermans, & Jansen, 2016; Van Gucht, Vansteenwegen, Beckers, & Van den Bergh, 2008).

Laboratory conditioning studies are very useful to investigate the basic learning processes underlying appetitive responses to food cues. Their ultimate aim, however, is to model real-life situations. Based on the finding that arbitrary stimuli (e.g., boxes) can quickly come to function as CSs that promote eating desires, one would expect similar effects in case of more "natural" stimuli in daily life (e.g., specific times of day) that have been paired with palatable food intake. However, laboratory findings do not necessarily translate to real-life circumstances, as conditioning studies differ from everyday life in many potentially important respects. For instance, in contrast to the complex real-life world, laboratory studies are usually relatively simple and highly controlled: the participants' attention is directed to the CSs in an environment that contains very few distractors. Laboratory studies also typically use very brief intervals between subsequent CS presentations (i.e., several seconds or minutes), unusually small US sizes (e.g., one small bite of chocolate), and relatively novel cues that have received little prior exposure (e.g., a novel box). All of these factors are known to potentially affect the acquisition and extinction of conditioned responses and might decrease the ecological validity of the paradigm.

Despite these potentially important manners in which laboratory studies differ from more natural situations, to our knowledge, no published studies have investigated appetitive conditioning in daily lives and using ecologically valid cues. Therefore, the aim of the present studies was to test whether acquisition (study 1 and 2) and extinction (study 1) of conditioned appetitive responses can be established under real-life circumstances. In the studies, a within-subject conditioning paradigm was implemented over the course of 17 (study 1) and 15 (study 2) days, using two specific times of day as CS+ and CS-. A smartphone application was used for ecological momentary assessment of US expectancies and eating desires at these time points. It was expected that differential US expectancies and eating desires would increase during an acquisition phase, and decrease again during a subsequent extinction phase.

2. Study 1

2.1. Methods and materials

2.1.1. Participants

27 participants completed the study. Before conducting the study, a sample size calculation on the post-acquisition differentiation in desires to eat between a CS+ and a CS- of a previous study (Cohen's $d = 0.69$; van den Akker, Havermans, & Jansen, 2015). This calculation indicated that using an alpha of 0.05 and to achieve a power of 0.80, N = 19 participants would be needed. Before participation, a screening questionnaire was filled in. Participants were eligible to participate in the study if they were female undergraduate students, aged between 17 and 25, owned a well-functioning Android smartphone, were not currently dieting, had no allergies/intolerances for, and indicated to like, chocolate and caramel. As a cover story, participants were told the study would be about "cacao and cognitive performance". Participants received course credit or a monetary voucher worth € 50, - for participation. The study was approved by the local ethical committee.

2.1.2. Stimuli

US: Two handmade Belgian chocolates with a caramel filling (Rousseau chocolade; approximately 30 g/140 kcal) were used as US. To highlight their novelty to participants, they were introduced as "Chokito's" (this name was made-up by the researchers). Each pair of chocolates was wrapped in a non-transparent bag.

CS: Two specific times of day were used as conditioned stimuli. Prior to attending the first session, participants were asked to identify two specific times of day between 10:30 and 18:00 during which they were usually not eating or otherwise busy, and which were at least 2.5 h apart (e.g., 14:00 and 16:30). Whether a participant's earlier or later time point served as CS+ (chocolate-associated) or CS- (control) was counterbalanced across participants.

2.1.3. Measurements

US expectancy and desire to eat: 100 mm-Visual Analogue Scales (VAS) were used to assess the expectancy to be allowed to consume the US *("How strongly do you expect to be allowed to eat Chokito's, at this moment?")* and the desire to eat the US *("Pay attention to the current time of day. How strong is your desire for Chokito's, at this moment?")*, ranging from 0 *(I certainly do not expect it/no desire at all)* to 100 *(I certainly expect it/very strong desire).*

US liking: 100 mm-VAS was used to assess liking of the taste of the US *("How much did you like the Chokito's?")*, ranging from 0 *(not at all)* to 100 *(very much).* A 7-point Likert scale was used to assess liking of the US size *("What did you think about the size of the Chokito's?")*, "1" reflecting *far too little,* "4" reflecting *exactly right,* and "7" reflecting *far too much.*

Compliance: a semi-structured interview was conducted to assess the participant's compliance in following the instructions. Participants were asked whether they had eaten the USs whenever asked to, and whether they had always carried at least one US during each time of day. Participants were also required to return any USs that they had not consumed. These were counted and then returned to the participant.

Revised Restraint Scale (RS; Polivy, Herman, & Howard, 1988*)*: To check for levels of dietary restraint (i.e. the intention to restrict food intake) the 10-item RS was used. Scores range from 0 to 35, a higher score indicating increased intentions to restrain intake.

2.1.4. Smartphone app and trial sequence

On all participants' mobile phones the application movisensXS, version 0.4 2469 (movisens GmbH, Karlsruhe, Germany) was installed. This application was personalized for each participant, triggering an auditory alarm (lasting up to 5 min) on the two times of day selected by the participant. When the alarm was answered, a trial started.

2.1.5. Design and procedure

Participants were individually seen on two laboratory sessions, and the conditioning procedure took place in between these sessions. The personalized app was created prior to session 1.

2.1.5.1. Session 1. On the first session, the participant gave written consent, after which she was provided with detailed oral and written instructions she was required to adhere to during the study period. On the two selected times of day, she had to make sure the sound on her phone was turned on, and she needed to have sufficient time to complete the questionnaires and to precisely follow all instructions given in the application. The participant was also required not to be eating anything or being otherwise occupied during the two times of day. Besides this, she was instructed to follow her usual eating pattern. She also had to have access to at least one Chokito package during each time of day (she thus had to