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Research report

Pavlovian conditioning to hedonic food cues in overweight and lean individuals ☆

Monica D. Meyer [a,b], Victoria B. Risbrough [c,d], June Liang [b,c], Kerri N. Boutelle [b,c,*]

[a] Alliant International University, San Diego, CA, USA
[b] Department of Pediatrics, University of California San Diego, USA
[c] Department of Psychiatry, University of California San Diego, USA
[d] Center of Excellence for Stress and Mental Health, Veterans Affairs

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ABSTRACT

Obese individuals develop heightened reactivity to environmental cues associated with hedonic foods through Pavlovian conditioning. This study examined differences between overweight (n = 16) and lean (n = 17) 18–26 year-olds in their acquisition of a swallowing response to visual cues paired with chocolate milk, tasteless water and no taste stimulus. We hypothesized that, compared to lean participants, overweight participants would demonstrate a heightened conditioned swallowing response to the visual cue paired with chocolate milk as well as a resistance to extinction of this response. Results showed that overweight participants swallowed more in response to the visual cue previously paired with chocolate than the cue previously paired with tasteless water ($t(15) = -3.057$, $p = .008$) while lean participants showed no cue discrimination ($t(16) = -1.027$, $p = .320$). The results evaluating the extinction hypothesis could not be evaluated, as the lean participants did not acquire a conditioned response. In evaluating the conditioned swallow response of overweight participants only, results indicated that there was not a significant decrease in swallowing to cues paired with chocolate milk or water, but overall, overweight participants swallowed more to cues paired with chocolate than cues paired with water. These are the first results to show differential acquisition of Pavlovian conditioned responding in overweight individuals compared to lean individuals, as well as differential conditioning to cues paired with hedonic food stimuli compared to cues paired with neutral stimuli.

Introduction

The modern environment is full of highly palatable foods. A heightened responsiveness to environmental cues that predict food intake has been implicated as one of the mechanisms that promote overeating, and by extension, weight gain in some individuals (Stice, Yokum, Burger, Epstein, & Small, 2011; Volkow, Wang, & Baler, 2011). When palatable food consumption is repeatedly paired with previously neutral cues in the environment, those cues come to elicit the same set of responses that were elicited by the food itself, such as salivation (Pavlov, 1927). Pavlovian conditioning plays an important role in motivating and maintaining food consumption (Woods & Kuskosky, 1976). This study evaluates differences between overweight and lean individuals in their acquisition and extinction of conditioned swallowing responses to visual cues paired with hedonic and neutral taste stimuli.

Through a process of Pavlovian conditioning, cues that typically predict food intake can trigger cue reactivity, a motivational state that may be experienced as an urge to eat and therefore increase the probability of food intake (Jansen, 1998). Several studies have demonstrated that exposure to the sight and smell of food increases subjective craving, desired portion size, and actual food intake (Fedoroff, Polivy, & Herman, 1997; Ferriday & Brunstrom, 2008; Sobik, Hutchison, & Craighead, 2005). Exposure to the sensory qualities of food also elicits physiological forms of cue reactivity (cephalic phase responses), including salivation. Cephalic phase salivary response has been observed in humans (Mattes, 1997; Nederkoorn, Smulders, & Jansen, 2000) and can also be elicited by neutral, non-food stimuli after repeated pairings with food. Early researchers in this field demonstrated a conditioned salivary response in normal weight humans in response to a tone previously paired with citric acid (Brown & Katz, 1967; Feather, Delse, & Bryson, 1967).

More recently, Van Gucht and colleagues (Van Gucht, Baeyens, Vansteenwegen, Hermans, & Beckers, 2010; Van Gucht et al., 2008) developed a paradigm testing Pavlovian acquisition, extinction and renewal in normal weight individuals. In this paradigm, two neutral

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* Corresponding author.
E-mail address: kboutelle@ucsd.edu (K.N. Boutelle).

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stimuli (serving trays, CSs) are repeatedly presented, one of which (CS+) is consistently paired with chocolate consumption (US) while the other (CS–) is never paired with eating chocolate. In this model, craving and expectancy to eat chocolate, as well as indirect measures of approach and avoiding tendencies are measured. Self-reported craving is reliably acquired using this paradigm; however, to date, the subsequent extinction paradigm consistently fails to reduce the acquired differential craving. It is possible that previous learning histories about trays or other cues may have influenced these responses. Furthermore, this model also includes operant conditioning (picking up the chocolate and eating it) and conditioned cephalic phase responses were not examined.

It is important to evaluate these processes in both overweight and normal weight individuals, to further our understanding about cue reactivity and Pavlovian learning, to begin to develop interventions to directly address putative abnormal or hyperactive cue-reactivity in this population. Jansen's cue reactivity model (Jansen, 1998) proposes that those with a history of overeating, such as binge eaters and overweight individuals, exhibit heightened cue reactivity as a function of their history of eating large amounts of food in the presence of certain cues. Cue reactivity research with these populations supports this hypothesis (Epstein, Paluch, & Coleman, 1996; Jansen et al., 2003; Sobik et al., 2005; Temple, Giacomelli, Roemmich, & Epstein, 2007; Tetley, Brunstrom, & Griffiths, 2009). Overeaters and overweight individuals are thought to develop increased cue reactivity through disparate learning histories related to food intake. Recent studies suggest that obese individuals may anticipate and experience abnormal reward processing of hedonic food (Davis & Fox, 2008; Epstein et al., 2007; Stice, Spoor, Bohon, & Small, 2008; Stice et al., 2011; Wang et al., 2001). Furthermore, some of these abnormalities in reward processing may predate obesity while others may be a consequence of habitual overeating (Bello, Lucas, & Hajnal, 2002; Stice et al., 2011).

To date, no group has studied acquisition and extinction of markers of food cue responsivity to hedonic food cues (such as those in our environment today) in overweight and normal weight individuals. Thus, the purpose of this study is to examine differences in Pavlovian acquisition and extinction of behavioral responses (swallowing) to food cues in overweight and non-overweight college students. We hypothesized that overweight participants would demonstrate a stronger conditioned swallowing response to the visual stimulus repeatedly paired with a hedonic taste stimulus compared to lean participants. Secondly, we hypothesized that the conditioned swallowing responses of overweight participants would be more resistant to extinction than those of lean participants.

Methods

Overview of the study

This study used a mixed quasi-experimental design with one between subjects factor (weight group) and two within subjects factors (cue type and trial block). Overweight and normal weight college students were recruited to complete surveys and participate in a laboratory conditioning paradigm. The conditioning paradigm consisted of the presentation of three visual cues on a computer screen (conditioned stimuli (CS)) repeatedly paired with the delivery of 1 ml of chocolate milk (Hershey's chocolate syrup with equal parts whole milk and half and half), Evian water, or no taste cue (unconditioned stimuli (US)). Both the water and no taste USs were included to distinguish between conditioned swallowing elicited by cues predicting presentation of hedonic food cue (chocolate milk) vs. presentation of liquid (water) in the mouth. The acquisition phase consisted of 27 CS–US pairings and the extinction phase consisted of 27 presentations of the visual cues with no US presentations. Swallowing was measured via electromyograph (EMG) during each visual cue presentation at baseline (before cues were paired with US) and during three blocks (of 9 trials) of extinction (total 27).

Participants

Forty-five college students who report liking sweets were recruited for participation through flyers posted in common high-traffic areas on San Diego college campuses, and through Internet resources, including student web forums, e-mail list serves, and Craigslist. The 45 total participants were divided into two groups based on Body Mass Index (BMI). The overweight group consisted of 25 participants (BMI ≥28) and the lean group consisted of 20 participants (BMI ≤24). Prospective participants contacted the researcher via phone or e-mail and took part in an initial phone screen to determine eligibility.

The inclusion criteria included being between the ages of 18 and 26 years old, BMI ≥28 or ≤24, self-reported liking chocolate, and a willingness to participate in a lab paradigm. Participants were excluded from this study due to self-reported dairy or wheat food allergies, self-reported color blindness, self-reported history of any serious psychiatric condition or eating disorder, a score of 16 or greater on the Center for Epidemiological Studies Depression Scale (CES-D), suggesting clinically significant depression, self-reported medical conditions that could affect weight or eating and self-reported current use of any medications that could affect weight or appetite.

Procedure

Eligible participants completed a series of surveys, signed consent forms and then took part in a laboratory conditioning paradigm lasting approximately 1½ hours. Participants were instructed to refrain from eating during the four hours prior to their laboratory appointment.

Participants were seated in a Whisperroom™ in a reclining chair with a computer screen in their view. The CSs were presented on the computer screen (see Fig. 1). Participants received both the experimental hedonic unconditioned stimulus (US) (high-fat chocolate milk) and the neutral US (Evian water) through a gustometer. The gustometer was composed of two computer-controlled programmable syringes that dispensed liquid through Tygon beverage tubing, ensuring consistent volume, rate and timing of taste delivery.

Because the US delivery interferes with accurate assessment of swallowing, we limited measurement of swallowing to two minute test trials either immediately before acquisition training (Baseline) or during the extinction (Block 1, 2 and 3) session. During the acquisition phase, the CS+ was paired with the delivery of one mL of chocolate milk and the $CS-_1$ was paired with the delivery of one mL of Evian water. The $CS-_2$ was presented with no US delivery during the acquisition phase. During the extinction phase, all three CSs were presented without any US delivery. Each participant received the same set of visual cues in the same order; however, CS–US pairings were randomized across participants such that half of the participants received chocolate milk with the blue circle and half received it with the red square. The yellow triangle was always presented with no US delivery. CS–US pairings were not made explicit to participants at any point in the instructions. The acquisition phase consisted of nine presentations of each CS–US pairing in a semi-randomized order for a total of 27 acquisition trials. No CS–US pairing was presented more than two consecutive times. Each acquisition trial lasted 10 seconds and began with a 7.5 second CS presentation followed by 2.5 seconds of US delivery. Each acquisition trial was followed by a 20 sec ITI trial in which the computer monitor was black.

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