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Research report

Pavlovian conditioning to food reward as a function of eating disorder risk

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HIGHLIGHTS

- We examined how eating disorder risk affects food-based conditioned place preference strength.
- Conditioned place preferences for a virtual room previously paired with chocolate are evident.
- Increased dieting behaviors predicted stronger place preferences.
- Increased dieting behaviors predicted lower ratings of a place never paired with food.

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ABSTRACT

The aim of this experiment was to examine the extent to which eating disorder risk affects the strength of food-reward conditioning. Eighty food-restricted undergraduates were placed into a VR environment consisting of two visually distinct rooms. Participants underwent multiple pairing sessions in which they were confined into one of the two rooms and explored a VR environment. Room A was paired with real-life M&Ms for three sessions, and Room B was paired with no food for three sessions. After a short delay, a test session was administered, and participants were given free access to the entire VR environment for 5 min. Participants also completed the Eating Attitudes Test (EAT-26; [11]), which is a standard screening tool of eating disorder risk. Participants displayed a significant conditioned place preference for the VR room previously paired with food, and they displayed a significant explicit preference for the M&M-paired room in a forced-choice test. There was a significant positive correlation between place preference strength and scores on the dieting subscale of the EAT-26. Additionally, ratings of the no-food room were significantly lower as dieting scores increased. This suggests that components of eating disorder risk can influence basic conditioning strength to places associated with food reward. For both males and females, additional correlations between eating disorder risk subscales and conditioning variables are discussed, and implications for future research are proposed in hopes of understanding how conditioning paradigms can provide insight into treating and preventing eating disorders.

Whereas it is undeniable that food functions as a primary reward, it is unclear whether food-related disorders such as obesity or eating disorders are directly related to food reward dysfunction. For example, some studies show that obese persons are more motivated to eat than non-obese persons, suggesting that obese persons find food more rewarding [14,19]. On the other hand, eating disorders, such as anorexia nervosa (AN), have been associated with food avoidance resulting in restrictive eating and severe emaciation [10]. Nonetheless, some researchers argue that all eating disorders share dysfunction in reward and inhibition, and differences in these extremes result in the varying types of disorders [26]. Despite the fact that eating disorders are sometimes theorized as being culturally pressured by ideals of thinness [21], it is now recognized that a biological basis to these disorders may be responsible for negative attitudes toward eating [6].

Studies by [3] suggest that eating disorders have commonalities of dysfunction in brain areas associated with reward and demonstrate alterations in dopamine, acetylcholine, serotonin, and opioid

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reward systems using animal models of eating disorders. It has been suggested that AN and bulimia nervosa (BN) are two stages of the same disorder since a majority of BN patients start with a brief period of starvation and AN patients report incidences of binging and purging [20]. However, while there are some commonalities between the two eating disorders, the division between them is clinically important as their subdivisions differ in terms of treatments and prognosis [24].

Several nonhuman studies have shown heightened neuronal dopamine-related reward response in rats associated with food restriction and weight loss [2]. The downregulation of D2 receptors, on the other hand, results in overconsumption of food [15]. These animal studies propose that sensitization occurs with food restriction, while excessive food intake may desensitize brain reward pathways. Furthermore, human brain imaging studies show that obese individuals demonstrate reduced brain response to receiving food [12], as well as reduced dopamine receptor terminals [25]. Brain-imaging studies on those with eating disorders show that AN individuals were more responsive than controls to images of thin bodies in the ventral striatum, an area believed to be associated with dopamine and reward [8]. In BN patients, researches have reported low dopamine metabolite concentrations in cerebrospinal fluid associated with the frequency of binge episodes [13]. Studies have also shown decreased striatal DA neurotransmission in patients with BN relative to controls [16], as well as reduced activity in anterior cingulate cortex, an area that is believed to be involved in error monitoring but also in the anticipation of reward [9]. Collectively, these experiments suggest alterations in the reward circuitry across food-related disorders.

Within nonhuman research, the conditioned place preference (CPP) task is a hallmark paradigm used to assess the rewarding effects of a substance. Generally, the task involves two contextually distinct compartments joined by a connecting tunnel. The two compartments may differ across modalities such as visual, auditory, tactile and olfactory cues. During the task, the animal is confined to one of the two compartments for a fixed amount of time, and then given a rewarding substance, such as food or drug. Later, in a separate session, the animal is confined to the other compartment and receives a placebo for an equal amount of time. These pairings are then repeated to strengthen the relationship between context and presence or absence of the reward. Following the pairing sessions, a test session is given in which the animal receives unrestricted access to both compartments without any reward or placebo. Typically, the animals demonstrate a strong preference for the room in which the reward was previously paired despite the reward no longer being present [23]. This conditioned place preference can be elicited by a wide variety of drugs [18] as well as a number of natural reinforcers like food, water, copulatory opportunity, and opportunity for social interaction [22]. Pavlovian conditioning is the most widely accepted explanation for the CPP since it is believed that the context paired with the reinforcer becomes a conditioned stimulus that predicts the presence of the reinforcer.

We previously have demonstrated that food-deprived undergraduates display a strong CPP for a virtual reality room previously paired with a chocolate reward [4]. Given the success of the CPP task is assessing basic reward mechanisms in nonhumans, we were interested in assessing whether this task could lend insight into basic reward mechanisms in eating disorders. Accordingly, the aim of this experiment is to examine whether there is an association between eating disorder risk and CPP strength, suggesting that basic Pavlovian mechanisms may be dysfunctional when food is the reward. We hypothesize that the higher the eating disorder risk, the weaker the CPP for the room previously paired with chocolate.

1. Method

1.1. Participants

Eighty University of Connecticut undergraduates (avg. age = 19.7 yrs; SD = 2.66; 51 females) were recruited from introductory psychology classes. Participants were required to abstain from eating for 6 h prior to the experiment. It was also required that participants were willing to eat chocolate for the purposes of this experiment. Participants received class credit for their participation. Approval for this study was obtained from the University of Connecticut Institutional Review Board.

1.2. Apparatus

An IBM-compatible computer with a SVGA color monitor was used for testing. Participants seated at the computer navigated through the virtual environments by manipulating a joystick. A speaker connected to the computer was used to provide auditory feedback and a Med Associates Inc. ENV-203IR pellet dispenser was used to dispense M&Ms into a tray for the participant to consume.

1.3. Procedure

Food-deprived participants arrived at approximately 9:30 A.M., and consent was obtained. Participants were asked to complete a brief demographics questionnaire consisting of questions regarding age, sex, when the participant last ate, and items like level of hunger on a 1–10 scale (1 being “not at all”). After being guided through a brief tutorial on how to interact with the virtual environment using a joystick, participants received a 90-s practice session in which they were placed in an empty VR room. To encourage exploration in both the practice and experimental sessions, a coin appeared periodically in random locations and participants were required to locate and collide with the coin. Additionally, M&M’s were dispensed during the practice session, and participants were instructed that throughout the experiment they are to eat the M&Ms as they were dispensed. Participants were allowed to ask questions at any time.

After completing the practice session, each participant completed 6, 7-min experimental pairing sessions in a virtual environment. A short, 1-min break followed each session. The environment consisted of two visually distinct rooms connected by a neutral hallway (see Fig. 1A). In each of the six experimental sessions, the participants were confined into one of the two rooms and were to explore the environment using the joystick. One room was paired with real M&Ms for three sessions, while the opposing room was paired with no food for three sessions. The room paired with M&Ms and the orders of the pairing sessions were counterbalanced. One M&M was dispensed periodically into a cup next to the participant during the M&M sessions, and the participant was instructed to eat the M&Ms as they were dispensed. Specifically, an M&M was dispensed every 21 s ± 5 s. Between 50 and 60 M&Ms total were dispensed, which is approximately the amount in a regular 47.9 g single size bag of M&Ms. After all six pairing sessions were completed, a 10-min break was given before the test session (see Fig. 1B for a sample testing sequence).

For the test session, participants were placed in the same virtual environment and started in the neutral hallway. They had access to both rooms for the entire 6-min session. M&Ms were not dispensed on the test session. After the test, participants were given a survey. Questions asked which of the two rooms they preferred, how much they enjoyed each room on a scale of 0–100 (0 being “not at all”), and how much they enjoy chocolate on a scale of 0–100 (0 being “not at all”).