Cravings in a virtual reality room paired with chocolate predict eating disorder risk

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ABSTRACT

Pavlovian conditioning is a major factor in drug and food addictions. Previously, we have shown in humans that we can reliably establish a conditioned place preference to a virtual reality (VR) room that is paired with real life food reward. We examined whether the strength of this conditioned place preference is related to eating disorder risk. 31 food-restricted female undergraduates were recruited and placed into a VR environment consisting of 2 visually distinct rooms connected by a hallway. Participants underwent 6 pairing sessions in which they were locked into one of the two rooms and explored the VR environment. Room A was paired with real-life M&Ms for 3 sessions, and Room B was paired with no food for 3 sessions. After the conditioning, a test session was given in which participants were given free access to the entire VR environment with no food present. Additionally, participants completed a standard assessment of eating disorder risk, the Eating Attitudes Test (EAT-26). We observed a conditioned place preference only for the participants who were in the top 50 percentile for hunger. Self-reported hunger rating was significantly correlated with amount of time in the room paired with food. In regards to the eating attitudes, we observed that the higher the eating disorder risk, as evidenced by higher scores on the dieting subscale, and as evidenced by higher total risk scores, the lower they rated the room paired with no food. This suggests a unique conflict whereby stimuli that are not food associated are rated as less enjoyable, particularly the higher the risk for an eating disorder. Hence, novel measures and associations from a brief conditioning paradigm predict eating disorder risk and may suggest some implicit conflicts and processes involved in people with eating disorders. Future studies will examine people with eating disorders more directly as well as will examine whether these measures can direct treatment strategies and predict treatment success.

1. INTRODUCTION

The conditioned place preference (CPP) task is a standard behavioral model widely used in nonhuman research to assess the rewarding and aversive effects of a substance. Although the task differs along several dimensions, generally it involves two compartments joined by a connecting tunnel. The two compartments are contextually distinct across many modalities including visual, auditory, tactile and olfactory cues. Procedurally, the animal is confined to one of the two compartments and is given a rewarding substance for a fixed amount of time. In a separate session, the animal is confined to the other contextually distinct compartment and receives a placebo substance for an equal amount of time. To strengthen the relationship between context and presence or absence of the rewarding stimulus, these pairings are often repeated. Following the pairing sessions, a test session is given in which the animal receives unrestricted access to both compartments without any reward or placebo. It is frequently observed that animals demonstrate a strong preference for the room in which the reward was previously paired despite the reward no longer being present (van der Kooy et. al, 1983). While this preference can be seen with a variety of drugs (Mattson et. al, 2003), it can also be seen with natural reinforcers such as food, water, copulatory opportunity, and opportunity for social interaction (Tzschentke, 1998). Pavlovian conditioning is the most widely accepted explanation for the CPP. Essentially, the context paired with the reinforcer becomes a conditioned stimulus that predicts the presence of the reinforcer (CS+). Conversely, conditioned place aversions can also be observed if a context is paired with an aversive stimulus (Prus et. al, 2009).

While food is typically considered a rewarding stimulus, eating disorders, such as Anorexia Nervosa (AN), have been associated with food avoidance resulting in relentless restrictive eating and severe emaciation (Frank et.al, 2012). Disorders like AN and Bulimia Nervosa (BN) pose a unique challenge for clinicians since they are complex, of undetermined etiology, and are sometimes theorized as being culturally pressured by ideals of thinness (Strober,1995). However, while culture and societal pressures may exist, it is now recognized that a biological basis to these disorders may exist (Bulik, 2004). Moreover, eating disorders are believed to have commonalities of dysfunction in brain areas associated with reward. For example, data from animal models of eating disorders have demonstrated alterations in dopamine, acetylcholine, serotonin, and opioid reward systems (Avena et. al, 2011).

We are interested in whether the CPP task can be useful to predict eating disorder risk as well as treatment success. We previously have demonstrated that food-deprived undergraduates display a strong CPP for a room previously paired with chocolate reward using both implicit as well as explicit measures (Astur et al, in press).

Our current aim is to determine whether there is an association between eating disorder risk and CPP strength. We hypothesize that the higher the eating disorder risk, the less the amount of time spent in the chocolate-paired room on the test day.

2. METHOD

2.1 Participants

Thirty-one University of Connecticut female undergraduates (avg. age = 19.3 yrs; SD = 1.57) were recruited from Introductory Psychology classes for this experiment via the university participant pool. Participants were required to abstain from eating for six hours 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.

2.2 Apparatus

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

2.3 Procedure

Food-deprived participants arrived at approximately 9:30 A.M., and consent was obtained. The participant was seated at a computer and was guided through a brief tutorial on how to interact with the virtual environment using a joystick. Participants received a 90 second practice session in which they were placed into an empty VR room. Throughout the practice session and in the experimental sessions, to encourage exploration, a coin appeared periodically in random locations, and participants were required to locate and collide with the coin. Additionally, an M&M was dispensed during the practice session, and participants were instructed that throughout the experiment, they are to eat the M&Ms as they are dispensed. Participants were allowed to ask questions at any time.

After finishing the practice session, each participant completed six six-minute experimental pairing sessions in a virtual environment. A short, 1- minute break followed each session. The environment consisted of two visually distinct rooms connected by a neutral hallway (see Fig 1). 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 opposite 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. Between 50-60 M&Ms total were dispensed during conditioning, which is approximately the amount in a regular 47.9g single size bag of M&Ms. After all six sessions were completed, a 10-min break was given before the test session.

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 six minute session. M&Ms were not dispensed on the test day. 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, and how much they enjoy chocolate on a scale of 0-100. Lastly, participants were also asked to complete Eating Attitude Test – 26 (EAT-26; Garner et al, 1982), which is a brief questionnaire designed to assess eating disorder risk. The EAT-26 consists of 3 subtests, Dieting, Bulimia, and Oral control, which are combined to obtain a Total score. After filling this out, participants were then offered snacks, debriefed, and dismissed.

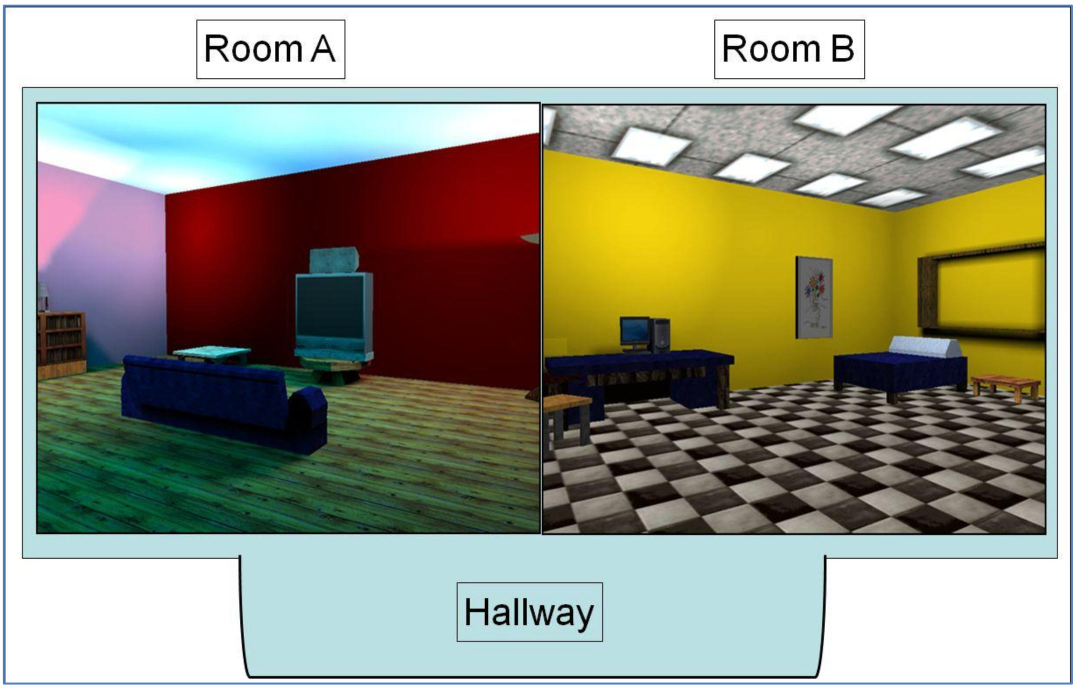

Figure 1A. *Both rooms were identical in shape, but contained different items, colors, patterns, etc.*

Sample Testing for one participant						
Day 1 Conditioning Sessions						Day 2 Test Session
Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Test Session
Room A	Room B	Room B	Room A	Room B	Room A	Free Access
No Food	M&Ms	M&Ms	No Food	M&Ms	No Food	No Food

Figure 1B. *A sample testing order for one participant. Across participants, testing order and M&M/Room pairings was counterbalanced.*

3. RESULTS

Data analysis: Times spent in rooms on the test day were compared using a paired Student's t-test. Correlations between variables in the CPP task and with the EAT-26 were calculated using Pearson bivariate correlations. An alpha level of 0.05 was used in all analyses.

During the test session, participants did not display a CPP, in that there is no significant difference between dwell time in the room previously paired with M&Ms compared to the No Food room, $t(30) = 0.74$, $p > 0.1$. However, anecdotally, some participants seemed reluctant to each the M&Ms as the experiment progressed, and we hypothesized that they were becoming satiated with M&Ms during the conditioning sessions which occur immediately prior to the test session. Additionally, we know from previous experiments in our lab that hunger is necessary for a place preference to be evident (Astur, et al, in press). To address this, we performed a median split on self-reported hunger level. When examining participants in the upper 50% of hunger ratings, we see a significant CPP in that participants spent 70% of their time in the M&M room compared to 30% of their time in the no food room, $t(14) = 3.31$, $p = 0.005$, Figure 2. There is no significant place preference for those in the bottom 50% of hunger ratings, $t(15) = 1.36$, $p > 0.1$.

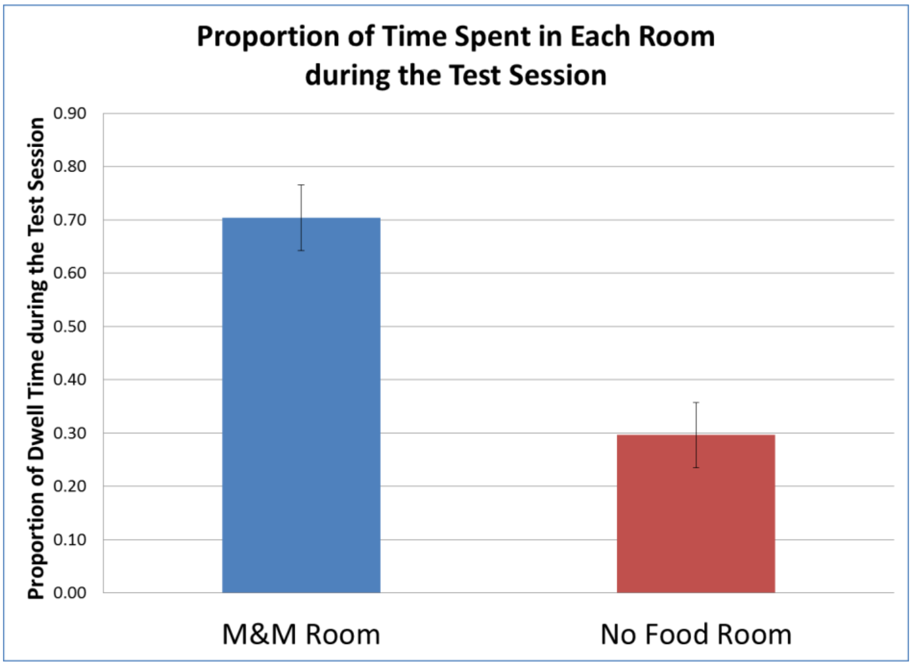

Figure 2. *There was a significant place preference for the room that was previously paired with M&Ms (p = 0.005) for the people who were in the upper 50 percentile for self-reported hunger levels. For those who were in the bottom 50 percentile for hunger, there is no significant place preference.*

To examine the relation between the place preference and EAT-26, we conducted a number of Pearson bivariate correlations. We observed that there was a significant positive correlation between reported hunger level and amount of time spent in the M&M room on the test day, $r = 0.52$, $p < 0.01$. Additionally, there was a significant positive correlation between the explicit rating of how much participants liked the M&M room with the amount of time spent in the M&M room on the test day, $r = 0.39$, $p < 0.05$. In regards to the EAT-26, we observed that there was a significant negative correlation with the EAT-Diet score and the explicit rating of how much the participants liked the non-M&M room, $r = -0.53$, $p < 0.01$. Similarly, there was a significant negative correlation with the EAT-Total score and the explicit rating of how much the participants liked the non-M&M room, $r = -0.47$, $p < 0.01$. That is, the higher their eating disorder risk (as determined by EAT-Diet and EAT-Total), the lower they rated the room that never contained any M&Ms. Lastly, the higher their eating disorder risk, as determined by EAT-Oral Control, the higher they rated that they enjoyed chocolate, $r = 0.44$, $p < 0.05$.

4. CONCLUSIONS

The results indicate that as a group, there is no place preference evident on the test day. Previously, we reported that we were able to elicit strong place preferences in hungry undergraduates (Astur et al, in press). However, in the current paradigm, the conditioning and the test session are on the same day, whereas our previous paradigm was a 2-day study, with the conditioning and the test session being on separate days. Accordingly, whereas participants were food-restricted prior to starting the current experiment, by the time they were given the test session, they had already consumed approximately 50 M&Ms, and numerous participants were less than enthusiastic about consuming M&Ms at this stage in the experiment. Hence, given that our test session was after eating these M&Ms, many participants were not hungry when the test session was presented, and we previously have shown that if participants are not hungry, there will be no place preference. To address this, we performed a median split on self-reported hunger levels, and we observed that those in the upper 50% of hunger show a strong and significant place preference, whereas those in the bottom 50% do not show any place preference. Collectively, these data again indicate the importance of hunger in observing a place preference to food in female undergraduates.

In fact, when we conducted a number of correlations, we also observed that the hungrier that participants reported that they were, the stronger the place preference that they displayed on the test session. Again, this supports the idea that hunger is a critical factor in observing a conditioned place preference for food. Additionally, the higher the amount of time in the M&M room on the test day, the higher participants rated that room, suggesting that implicit measure and explicit measures of place preference are tapping into the same or similar constructs.

In regards to the eating attitudes, we observed that the higher the eating disorder risk, as evidenced by higher scores on the dieting subscale, and as evidenced by higher overall risk scores, the lower they rated the room paired with no food. This is an intriguing finding in that there is no relation between eating disorder risk and the rating of the room that contained M&Ms. Rather, these significant negative correlations suggest that the room that does not contain food has some negative valance about it, particularly to people with higher risk for eating disorders. It may be that because this room is never paired with a rewarding food, it takes on aversive properties, perhaps because of frustration with the inability to obtain food when in this room. Alternatively, it could be that there is a rewarding process underlying abstaining or controlling food intake, and this process is removed or greatly diminished when in the no food room; accordingly, it takes on aversive qualities. Lastly, it was observed that the higher their eating disorder risk as evidenced by the oral control subscale, the higher that participants rated their enjoyment of chocolate. Again, this is interesting in that it again suggests an internal conflict that some participants are engaging in control of their food intake, and yet, they rate chocolate more favorably than those who do not engage in such oral control. Perhaps this type of oral control involves chocolate being a rare and restricted food item, and hence, it becomes more desirable. Future studies might aim to decipher this by inquiring about frequency and quantity of chocolate consumed.

In this study, we recruited undergraduates without any specific restrictions besides the necessity to eat chocolate. Of our 31 females, there were 5 who had scores on the EAT-26 that would suggest that they were at risk for an eating disorder, and follow-up assessment would be necessary to corroborate and characterize this risk. Hence it is possible that we actually were testing two distinct populations in our study (1) those with an unhealthy relationship with food; (2) those with a healthy relationship with food. And, it could be that these 5 at-risk participants were disproportionately influencing our correlations. Our future studies will specifically target individuals at either high risk or low risk for eating disorders, so that we can obtain a better understanding of how these two groups display preferences for contexts where rewarding food is present. Hopefully, this will launch new avenues of research aimed at understanding reinforcement, addiction, relevant brain structures, and the contributing factors.

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