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Research report

Virtual reality conditioned place preference using monetary reward

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HIGHLIGHTS

- We examined acquisition and extinction of a conditioned place preference for virtual rooms paired with monetary reward in healthy young adults.
- Participants showed a preference for (spent more time in) a virtual room paired with high monetary reward over one paired with low monetary reward.
- Participants reported that they preferred the room paired with high monetary reward and liked it more than the room paired with low monetary reward.
- The behavioral and subjective place preferences were transient; participants did not exhibit a preference for the high reward room 24 h later.

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ABSTRACT

Computerized tasks based on conditioned place preference (CPP) methodology offer the opportunity to study learning mechanisms involved in conditioned reward in humans. In this study, we examined acquisition and extinction of a CPP for virtual environments associated with monetary reward ($).

Healthy men and women (N = 57) completed a computerized CPP task in which they controlled an avatar within a virtual environment. On day 1, subjects completed 6 conditioning trials in which one room was paired with high $ and another with low $. Acquisition of place conditioning was assessed by measuring the time spent in each room during an exploration test of the virtual environments and using self-reported ratings of room liking and preference. Twenty-four hours later, retention and extinction of CPP were assessed during 4 successive exploration tests of the virtual environments.

Participants exhibited a place preference for (spent significantly more time in) the virtual room paired with high $ over the one paired with low $ ($p = 0.015$). They also reported that they preferred the high $ room ($p < 0.001$) and liked it significantly more than the low $ room ($p < 0.001$). However, these preferences were short-lived: 24 h later subjects did not exhibit a behavioral or subjective preference for the high $ room.

These findings show that individuals exhibit transient behavioral and subjective preferences for a virtual environment paired with monetary reward. Variations on this task may be useful to study mechanisms and brain substrates involved in conditioned reward and to examine the influence of drugs upon appetitive conditioning.

1. Introduction

Conditioned place preference (CPP) is a paradigm that has been used for many decades to study mechanisms of drug reward and aversion in rodents [1]. In the model, two distinct environments are paired separately with administration of drug or placebo. After several pairing (conditioning) sessions, rats are given the opportunity to explore both environments. With drugs known to produce pleasurable effects in humans, laboratory animals tend to exhibit a preference for (spend more time in) the environment paired with that drug. Conversely, with drugs known to produce disagreeable effects in humans, rodents tend to exhibit an aversion to (spend less time in) the environment paired with that drug. Although widely used, the utility of the model has been questioned, in part because it is not known what aspects of the drug stimulus or environment become conditioned, and in part because it is not clear how the model is related to drug use in humans. Recently, the CPP paradigm has been translated to humans [2–4] in an attempt to provide answers to some of these questions. However, the equivalent human model requires sufficient space (at least 2 separate

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rooms) and considerable time commitment (6–10 separate visits). Thus, investigators have sought to establish more convenient paradigms using computer tasks based on CPP methodology using virtual environments.

In the first published virtual reality CPP study [5], individuals exhibited a conditioned place preference for i.e., spent more time in, a house associated with pleasant consonant music versus a house with static noise. Further, the investigators showed that individuals avoided a house associated with unpleasant dissonant music versus a house with static noise. Astur and colleagues [6,7] went on to show that individuals exhibited a conditioned place preference for a virtual environment associated with food over one without food. They also showed that the strength of place preference was greater after food deprivation and greater in women who were dieting. Most recently, Astur and colleagues [8] extended their model to show that individuals exhibited a CPP for an environment associated with points, or secondary reinforcers with no intrinsic value. Finally, Radell et al. [9] used a modified virtual reality CPP task with contingent delivery of secondary reinforcers (golden eggs) to show that individuals with a preference for familiarity over unpredictability exhibited a bias toward a room associated with a high probability of reward. Together these studies have demonstrated that it is possible to establish preferences for virtual environments associated with music, food and secondary reinforcers. A prime utility of these virtual reality approaches, aside from their ease of implementation in the human laboratory, is that they may be conducted in the scanning environment e.g. FMRI, PET, in order to study the brain substrates involved in learning a CPP.

In the current experiment, we aimed to establish appetitive conditioning using a virtual reality CPP task with monetary reinforcement. Money is a generalized conditioned reinforcer that has been used extensively in behavioral tasks and maintains a diverse range of behaviors [10]. As a reinforcer, money is a robust reward. It is relatively independent of deprivation state, is easily quantified, is scalable, and does not interfere with ongoing behavior. Thus, establishing a virtual task with monetary reinforcement will optimize the versatility of the virtual CPP paradigm. The first aim of the study was to establish a preference for a virtual environment by pairing it with delivery of high monetary reward. We hypothesized that individuals would exhibit a subjective preference for the high reward room, as measured by ratings of room liking and preference as well as an objective preference as measured by time spent in the room. The second aim of the experiment was to assess retention of the preference for an extended period during a return visit to the laboratory 24 h later. At this visit, we also tested persistence of the preference across several unrewarded tests. We hypothesized that individuals would retain their subjective and objective preference for the room previously paired with high monetary reward at the second visit and that it would diminish across repeated tests without reward.

2. Methods

2.1. Design

Men and women (aged 18–45) participated in this two-site study conducted at the University of Chicago and University of Illinois at Chicago. The study was approved by the Institutional Review Committees at each site and all subjects gave written informed consent before participation. Subjects were told that the purpose of the study was to investigate how people learn relationships. Subjects completed two experimental sessions conducted on consecutive days, in the laboratory. At the first session on day 1, subjects completed a virtual reality conditioning program in which high and low monetary reward were associated with distinct virtual environments. At the second experimental session on day 2, subjects completed the virtual reality task to assess retention of the learned association.

2.2. Virtual conditioning task

The virtual reality conditioning task was presented to participants on a Dell Optiplex computer with a 15" × 15" monitor and accessory speakers for auditory feedback. The task was developed locally, based on the design of [6]. The virtual environment consisted of two distinct rooms (A and B) connected by a hallway (Fig. 1). The rooms were equally sized and contained a similar number and variety of immobile, non-interactive objects (television, sofa, table, and bookcase) but were visually distinct in terms of the color of the walls, carpet and sofa, pictures on the walls, location and design of furniture. The computer screen presented subjects with a first-person view of the virtual environments and they navigated about the virtual space using the keyboard arrow keys and mouse.

The task consisted of a Conditioning phase and a Testing phase. During the conditioning phase, subjects completed six separate conditioning trials (2-min each). During each trial subjects were confined to just one of the rooms (each trial began with the subject already in the room), thus 3 trials took place in each room (in counterbalanced order, ABBAAB or BAABBA). Subjects were told that their task was to move about the rooms and to collect balloons as they appeared, signaled by text instructions on the screen "a balloon has appeared". They collected balloons by approaching the balloon and jumping beneath it to touch it. They were also told that they could earn money during the task which would be paid to them at the end of testing that day. They were told that their earnings were dependent on interactions with the environment and would be displayed on a counter at the bottom of the screen. In fact, monetary rewards were delivered randomly (signaled by an auditory cue) in $0.15 increments regardless of subjects' movements within the virtual rooms or collection of balloons, and all subjects accumulated $14.85 throughout conditioning which was paid to subjects ($15.00 in total) at the end of testing on day 1. During the trials, monetary reward accrued at a greater rate in one of the rooms, designated the High Reward Room ($4.35 delivered during each conditioning trial, total = $13.05, approximate reward rate = $0.15 every 4 s), in comparison to the other room, the Low Reward Room ($0.60 delivered during each conditioning trial, total = $1.80, approximate reward rate = $0.15 every 30 s). The High and Low Reward rooms were assigned in a counterbalanced order. During the testing phase, subjects completed preference tests (1-min each) in which they could explore both rooms moving freely between them. Subjects were told that they would have 1-min to explore both of the virtual rooms. Preference tests began in the hallway and subjects were instructed to enter the rooms, after which they could not re-enter the hallway, but could move between the two rooms via an interconnecting doorway (see Fig. 1). No monetary rewards were delivered during preference tests and no balloons were presented.

2.3. Procedure

Fig. 1 shows a timeline of procedures conducted at each experimental session.

Day 1: At the first experimental session, subjects began with a 60-s practice trial (P). This practice trial took place within a gray virtual space with no distinguishing features and served to acclimate subjects to the controls and moving within the virtual environment. Balloons also appeared during the practice trial so that participants could practice collecting them. Subjects then completed the six 2-min conditioning trials (C). At the end of the last trial, they