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Extinction Can Reduce the Impact of Reward Cues on Reward-Seeking Behavior

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Reward-associated cues are thought to promote relapse after treatment of appetitive disorders such as drug-taking, binge eating, and gambling. This process has been modelled in the laboratory using a Pavlovian-instrumental transfer (PIT) design in which Pavlovian cues facilitate instrumental reward-directed action. Attempts to reduce facilitation by cue exposure (extinction) have produced mixed results. We tested the effect of extinction in a recently developed PIT procedure using a natural reward, chocolate, in human participants. Facilitation of instrumental responding was only observed in participants who were aware of the Pavlovian contingencies. Pavlovian extinction successfully reduced, but did not completely eliminate, expectancy of reward and facilitation of instrumental responding. The results indicate that exposure can reduce the ability of cues to promote reward-directed behavior in the laboratory. However, the residual potency of extinguished cues means that additional active strategies may be needed in clinical practice to train patients to resist the impact of these cues in their environment.

Keywords: extinction; reward; Pavlovian instrumental transfer; addiction; expectancy

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THERE IS GOOD EVIDENCE that reward cues can modulate behavior directed towards obtaining that reward, both for natural rewards such as food and manmade rewards such as addictive drugs. For example, patients who return to drug use after abstinence often report that their relapse was precipitated by exposure to reward cues. These cues might include visual or olfactory stimuli, places, time of day or mood states, or a complex combination, such as attending a party in the case of smokers (Niaura et al., 1988). Controlled exposure to reward cues can elicit craving and physiological reactivity (Carter & Tiffany, 1999). Conversely, cues that are negatively associated with reward can dampen craving (Dar, Rosen-Korakin, Shapira, Gottlieb, & Frenk, 2010). The majority of these cues are not innate, so they must have acquired their control over behavior via some form of associative learning.

We know that extinction—the repeated presentation of a predictive cue without the outcome it previously signaled—is an effective way to reduce associatively based behavior. Therefore, it is natural that clinicians have been keen to apply extinction to reduce the impact of reward cues. However, the initial results of such "cue exposure" techniques in clinical practice have been largely disappointing. For example, a review by Conklin and Tiffany (2002) found no consistent evidence for the efficacy of cue-exposure treatment, and we are not aware of any subsequent positive findings. Interestingly, laboratory research confirms that extinction may be surprisingly ineffective in reducing the impact of reward cues on goal-directed behavior.

The most commonly used laboratory procedure for studying the effect of reward cues is known as Pavlovian-instrumental transfer, or PIT. In this procedure, arbitrary cues (conditioned stimuli or CSs) are paired with a reward and the participants are separately trained to perform an instrumental response to obtain the same reward. In the critical transfer test phase, the Pavlovian CSs are presented while the instrumental response is available. The typical result is that a CS trained as a predictor of reward will facilitate instrumental responding for that reward, relative to a nonpredictive control CS (see Holmes, Marchand, & Coutureau, 2010, for a review). Using this approach, animal PIT studies have shown that a CS for food or sucrose continues to produce selective facilitation of an instrumental response for the same reward despite intervening Pavlovian extinction (Delamater, 1996; Holmes et al., 2010). A similar result has been reported in the only two studies we know of that have tested the effect of Pavlovian extinction on PIT in humans (Hogarth et al., 2014; Rosas, Paredes-Olay, García-Gutiérrez, Espinosa, & Abad, 2010). Together, these results suggest that the ability of a reward cue to promote reward-directed behavior may survive simple extinction.

However, the existing evidence base is not large, and there is a need for further studies with humans. Such studies would allow an examination of the role of cognitive processes such as expectancy and contingency awareness, which have been shown to play a critical role in human associative learning (e.g., Mitchell, De Houwer, & Lovibond, 2009) and in reward-based behavior specifically (e.g., Hogarth, Dickinson, Wright, Kouvaraki, & Duka, 2007; Hogarth & Duka, 2006). Furthermore, most contemporary animal and human PIT studies have used a selective PIT design with two rewards and two response options, in which high motivation effectively renders the test phase a forced choice procedure. Although this design has played an important role in establishing the selectivity of PIT effects, it is not necessarily optimal for testing the absolute ability of a reward-related CS to instigate instrumental action for that reward. To our knowledge there has been no published study of Pavlovian extinction in a "simple" PIT procedure in which participants are free to perform (or not perform) a single instrumental response.

Accordingly, in the present study we employed a procedure we have recently developed (Lovibond & Colagiuri, 2013) with a single reward and a single instrumental response, and absolute response rate as the primary measure. We see this procedure as providing a laboratory model of the modulation of goal-directed behavior by reward-related cues in real-world settings. An advantage of this procedure is that it uses a natural high-value reward, chocolate, rather than an abstract or symbolic reward such as points or money. We recorded online reward expectancy in a subset of participants to assess the relationship between Pavlovian expectancy and modulation of instrumental behavior. We used a within-participant design in which one CS was paired with reward, a second CS was paired with reward but subsequently extinguished, and a third CS was never paired with reward. At test, all three CSs were presented to measure their impact on instrumental responding for the reward. To further investigate the role of cognitive processes in PIT, we assessed Pavlovian contingency knowledge by a postexperimental questionnaire and analyzed the data according to the degree of contingency awareness.

Method

PARTICIPANTS

Participants were 90 students (48 female, mean age 20.5 years) from the University of New South Wales (UNSW). Of these, 35 responded to an advertisement and received A$15 compensation for their time, and 55 participated in partial fulfillment of a course requirement. A further sample of 27 students (19 female, 16 paid, mean age 21.6) was tested with an additional expectancy rating requirement (see Procedure). Of the 117 participants across both samples, 39 described their ethnicity as Caucasian, 28 as Chinese, 19 as South East Asian, 17 as Indian, and 14 as Other. To be eligible for the study, participants had to meet the same criteria as in Lovibond and Colagiuri (2013) regarding chocolate liking and consumption, not being on a diet or allergic to chocolate, and not having eaten chocolate for the preceding 24 hours. However, participants were required not to have eaten any food for 3 hours, rather than the 2 hours used in that study. An additional 17 participants were tested but their data were not included due to failure to earn the required number of rewards during instrumental training (see Procedure). The study was approved by the UNSW Human Research Ethics Committee (approval number HC13026) and all participants provided written informed consent.

Materials

The test room and equipment were the same as described in Lovibond and Colagiuri (2013). In brief, participants were tested individually in a separate room from the experimenter and control equipment, wearing headphones to attenuate external sounds. They sat at a desk with a computer monitor, a box with 6 colored lights, a response button and a Med Associates M&M's® chocolate