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Reinstatement of instrumental actions in humans: Possible mechanisms and their implications to prevent it☆

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ABSTRACT

The study of post-extinction recovery effects in humans has received significant attention. For instance, research on reinstatement has increased in the last decade. However, most of the studies focus on the return of fear responses. In the present experiments, we used a videogame task to explore the reinstatement of operant behavior in human participants. In Experiment 1, after participants learned to shoot at enemies, they received an extinction procedure that eliminated the shooting behavior. However, the mere reintroduction of the outcome reinstated the original response. Experiment 2 showed that the reinstatement of instrumental behavior is contextually modulated. Finally, in Experiment 3 we found that presenting a reminder for extinction attenuated the response recovery effect. The overall pattern of results suggests that reinstatement of voluntary actions in humans could be explained by an interference memory framework. In addition, the present data suggest that therapies that use brief reminders of therapeutic intervention could help prevent the reinstatement of unhealthy instrumental behaviors.

1. Introduction

It is widely accepted that learned behaviors such as overeating and cigarette smoking are linked to human diseases (Houben & Jansen, 2011; Schroeder, 2007). It is also accepted that those behaviors involve instrumental conditioning (e. g., eating a midnight snack [instrumental response] is reinforced by its high palatability). Although cognitive behavior therapies successfully reduce unhealthy behaviors, several data show that those behaviors are not eliminated (e. g., Craske & Mystkowski, 2006) and reappear relatively easily (Kirshenbaum, Olsen, & Bickel, 2009). Given that instrumental extinction (i. e., response decrement when reinforcers are withdrawn) is involved in many clinical procedures that eliminate behaviors, some authors have proposed that the study of instrumental extinction could provide some insights for the development of more enduring therapeutic strategies that prevent or reduce relapsing (e. g., Bouton, Winterbauer, & Todd, 2012).

Instrumental extinction is not permanent (e. g., Todd, Vurbic, & Bouton, 2014). For instance, in spontaneous recovery, an extinguished behavior reappears after introducing a retention interval (Rescorla, 1997; after a period of abstinence the urge to seek a beer might return), whereas testing the subject outside the extinction context *renews* the original performance (e. g., Bouton, Todd, Vurbic, & Winterbauer, 2011; Nakajima, Tanaka, Urushihara, & Imada, 2000; the background provided by a family party may produce the craving for drinking soda). Finally, free delivery of reinforcers *reinstates* the instrumental performance (e. g., Reid, 1958; a person who recently quit smoking might begin smoking again after she smells someone else's cigarette). Because it has been suggested that those effects might explain the high rates of relapse after having a therapeutic treatment (e. g., Crombag, Bossert, Koya, & Shaham, 2008), several researchers have proposed the development of new behavioural ways to prevent relapse of unhealthy voluntary actions based on the study of the aforementioned response recovery effects (e. g., Bouton et al., 2011; Crombag, Grimm, & Shaham, 2002).

Although there is evidence of renewal (e. g., Vila, Romero, & Rosas, 2002) and spontaneous recovery (e. g., López-Romero, García-Barraza, & Vila, 2010) of instrumental responses in humans, to the best of our knowledge all the available data about reinstatement of instrumental behavior has been conducted with nonhuman animals (e. g., Bouton, Winterbauer, & Vurbic, 2011). Hence, exploring the effect in humans seems necessary in order to: a) to aid the research field to fully understanding the mechanisms underlying the reinstatement of voluntary responses, b) to provide a potential explanation for why individuals relapse and c) to improve behavioural techniques that thwarts relapse

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after psychological therapy.

Thus, the main goal of this experimental series was to study the reinstatement of voluntary behaviors in healthy humans. In Experiment 1, we explored whether the reinstatement of instrumental actions could be found using a videogame task with college students. The purpose of the second experiment was to assess whether the context used during the re-exposure of the outcome had any impact on reinstatement. Finally, in Experiment 3 we explored whether the reinstatement of instrumental actions was attenuated in the presence of the cue that accompanied the extinction of the action.

2. Experiment 1

Since its very first report with dogs (Pavlov, 1927), reinstatement has been observed using Pavlovian (e. g., Bouton & Bolles, 1979; Rescorla & Heth, 1975; Schachtman, Brown, & Miller, 1985; Westbrook, Iordanova, McNally, Richardson, & Harris, 2002), and instrumental procedures with rats (e. g., Baker, 1990; Delamater, 1997; Rescorla & Skucy, 1969). In humans, this phenomenon has been found in contingency judgment tasks (García-Gutiérrez & Rosas, 2003a, 2003b; Vila & Rosas, 2001), fear conditioning procedures (e.g., Dirikx, Hermans, Vansteenwegen, Baeyens, & Eelen, 2004; Hermans et al., 2005; LaBar & Phelps, 2005) and in a conditioned suppression task (Neumann, 2008). To this date, no evidence of reinstatement of instrumental responses in human participants has been reported. As we previously stated, this response recovery effect has been reported with rats (e.g., Rescorla & Skucy, 1969). For example, Baker, Steinwald, and Bouton (1991) trained two groups of hungry rats to press a lever for food (Response, R). Following the extinction of the instrumental response, both groups were exposed to the experimental chambers with no levers. During that day, only rats in Group Food received non-contingent food presentations (Outcome, O). On the next day, all rats were tested with the levers present. Baker et al. (1991) found a reinstatement of the lever-pressing behavior because rats in Group Food showed the most response recovery.

Experiment 1 aimed to test whether the recovery of an extinguished instrumental behavior can be observed in a reinstatement procedure with healthy humans. In a within-subject design, participants played a computer game (Gámez & Rosas, 2005, 2007) in which they were requested to defend Andalusia against invasion by shooting missiles at tanks or planes by clicking on their respective pictures (i. e. R1 or R2 counterbalanced). The explosion of the enemies (tanks, O1 or planes, O2) served as reinforcer for the shooting behavior (i. e., instrumental response). Then, both responses (shooting at tanks or at planes) underwent extinction (the shooting did not produce the destruction of any enemies). After the last extinction trial, participants saw only one enemy destroyed by an ally (e. g., the tanks). It was hypothesized that reinstatement of the extinguished instrumental response would be observed only for shooting at tanks (R1). It should be noted that all participants experienced all responses, stimulus, and reinforcers throughout the experiment, so, it would seem more likely that the difference between R1 and R2 during testing should be attributed to the reinstatement effect (i. e., watching the destruction of the enemy) than to any other factor (i.e, differences between participants, preferences for a particular enemy or response).

2.1. Method

2.1.1. Participants

Sixteen undergraduate students from the Universidad de Cádiz participated in this experiment in exchange for course credit (12 women, 4 men; M_{age} = 21.81 years; age range = 21–28 years). They had no previous experience with this task. All individuals participated voluntarily and gave their informed consent before starting the experiment, being free to abandon the task at any point of the process, although it did not happen.

2.1.2. Apparatus and stimuli

Participants were trained individually in ten adjacent cubicles. Each cubicle had a Pentium PC on which the task was presented. The procedure was implemented using the SuperLab Pro (Cedrus Corporation) software. The task was similar to the one used by León, Abad, and Rosas (2010). Participants played a computer game in which they had to defend Andalusia from air and land attacks. The main screen represented a viewer simulating a participant's view from a hypothetical bunker in which they were supposed to be. Contexts were presented within the viewer's viewing area. Scenes of different beaches in Andalusia, Puerto Banús (urban beach) and Tarifa (natural beach) were counterbalanced as contexts A and B. The two attackers were a plane and a tank. The plane was presented in the sky, at the top right area of the context, while the tank was presented on the sand, at the bottom left area of the context. Both attackers could appear in one of two different positions within their respective areas on the context so that it would give the impression of movement to the participant. The instrumental response consisted of clicking on either the plane or the tank (R1 and R2, counterbalanced). The destruction of the tank and the plane was counterbalanced asoutcomes O1 and O2 across participants.

2.1.3. Procedure

The instructions and all the necessary information were presented in participants' native language (Spanish) on the computer screen. Participants interacted with the computer using the mouse (left button). Instructions were presented in three screens using a black Times New Roman 26 bold font against a light-yellow background to emulate the appearance of an old document. To advance through the instruction screens, participants had to click on a button labeled as “next” placed on the bottom right corner of the screen. Each participant was initially asked to read the following instructions:

> “(Screen 1) Andalusia is being attacked. Different parts of Andalusia are being assaulted by land and air. You are placed in the only bunker able to face the attackers. Use the mouse to launch missiles at the targets. Your goal is to destroy the attackers before they take over Andalusia. (Screen 2) The monitor represents the bunker's viewer, in which the different attackers you should facewill appear. To shoot, click the left button on the mouse while the pointer is on top of the target. Your technology and weapons are older than theirs, so you will need to shoot several times to be able to destroy them. (Screen 3) The battle begins! You have to destroy tanks and planes before they take the Andalusian coast. We are in your hands! GOOD LUCK!”

In each trial the tank or the plane was presented. Giving the appropriate response (i.e., clicking on the plane) was reinforced with the destruction of the attacker (outcome) on a variable interval (VI) 2-s schedule in which the availability of reinforcement varied randomly between 1 s and 3 s. So, in each trial the participant should make multiple clicks on the enemy to destroy it. The trial ended only after the participant gave the correct response and, hence, the enemy was destroyed (O1 or O2).

The experiment was conducted in four phases (see the experimental design in the first row of Table 1).

2.1.3.1. Acquisition. A screen displaying the message “Your detachment has been posted to… (name of the beach where the battle continued)” was presented for 2 s before starting training in each context. Participants received 10 training trials with each attacker. R1-O1 trials were conducted in two blocks of 5 trials in Context A, whereas R2-O2 trials were conducted in two blocks of 5 trials in Context B. Trial order within each context was random. Context order for half of the participants was ABAB and BABA for the other half.

2.1.3.2. Extinction. After the acquisition phase, all participants received 30 extinction trials with duration of 4 s, identical to the