Behavioural Processes 142 (2017) 64–69

Contents lists available at ScienceDirect

Behavioural Processes

journal homepage: www.elsevier.com/locate/behavproc

Effects of extinction in multiple contexts on renewal of instrumental responses

Rodolfo Bernal-Gamboa[a], Javier Nieto[a,*], Metin Uengoer[b,*]

[a] Universidad Nacional Autonoma de Mexico, Mexico
[b] Philipps-Universität Marburg, Germany

ARTICLE INFO

Keywords:
Instrumental conditioning
Extinction
Multiple contexts
Rats
Renewal

ABSTRACT

In two experiments with rats, we investigated the effects of using multiple contexts during extinction on renewal of lever-pressing behavior. During the first phase of both experiments, rats were reinforced to press a lever for food in Context A. Then, responses underwent extinction. For half of the animals, extinction sessions were conducted in a single context, whereas the other half received extinction in three different contexts. In Experiment 1, we observed that extinction in multiple contexts eliminated ABC renewal, but had no detectable impact on ABA renewal. Experiment 2 revealed that conducting extended extinction training in multiple contexts attenuated ABA renewal. Theoretical and clinical implications of the present findings are discussed.

1. Introduction

The study of instrumental (operant) conditioning is an important approach for our understanding of voluntary or goal-directed behaviors (e.g., de Wit and Dickinson, 2009; Laurent and Balleine, 2015). When a response (e.g., a lever-press) leads to a desirable outcome (e.g., food pellets), the likelihood of performing the response increases. In instrumental extinction, reinforced responses are decreased by withdrawal of the reinforcing outcome. Instrumental extinction can be considered as an animal model for the suppression of unhealthy or problematic voluntary behaviors such as overeating and gambling (see Bouton, 2011; Todd et al., 2014), and drug abuse (e.g., Crombag et al., 2008; Zironi et al., 2006).

Extinguished responses are not permanently lost, but can reappear under certain conditions. One example is provided by the renewal effect (Bouton, 2004) referring to a recovery of an extinguished response after changing the context. For instance, when animals are trained to press a lever for food in Context A, and then responding is extinguished in a second Context B, the extinguished lever-pressing behavior can renew when tested again in the initial acquisition Context A (ABA renewal; e.g., Nakajima et al., 2000). Extinguished responses can also reappear when acquisition, extinction and test occur in three different contexts (ABC renewal; e.g., Todd, 2013) or when acquisition and extinction take place in the same context, but testing in a second one (AAB renewal; e.g., Bouton et al., 2011).

Some researchers have suggested that the study of renewal of instrumental performance could have important implications for the understanding of relapse after behavior therapy (e.g., Bouton et al., 2012; Marchant et al., 2013). Therefore, investigating methods that attenuate renewal might be helpful to clinicians interested to implement therapeutic strategies that thwart the return of unwanted behaviors.

One method for reducing renewal that received considerable empirical attention is conducting extinction in multiple contexts. However, most of the studies have evaluated the impact of multiple-contexts extinction using classical conditioning procedures with aversive outcomes such as fear conditioning in rats (e.g., Bouton et al., 2006a; Gunther et al., 1998), and in humans (e.g., Bandarian Balooch and Neumann, 2011; Neumann et al., 2007; see also Vansteenwegen et al., 2007), and conditioned taste aversion in rats (Chelonis et al., 1999). Therefore, the main goal of the present experiments was to investigate the effectiveness of conducting extinction in multiple contexts on renewal of instrumental responses involving appetitive outcomes.

In Experiment 1, we directly compared the impact of extinction in multiple contexts on the strengths of ABA and ABC renewal. To our knowledge, only two previous studies took this approach, but revealed diverging results. Using a predictive learning task with humans, Bustamante et al. (2016, Experiment 2) reported that multiple-contexts extinction reduced ABC renewal, but was ineffective in case of ABA renewal. On the other hand, Neumann (2006, Experiment 3) trained human participants with a conditioned suppression task and observed that extinction in multiple contexts abolished both ABA and ABC

* Corresponding authors at: Facultad de Psicología, División de Investigación y Estudios de Posgrado, Universidad Nacional Autónoma de México, Cubículo 16, Edificio D, 1er Piso, Mexico/Ciudad Universitaria, Coyoacán, Ciudad de México, CP 0451, Mexico.
E-mail addresses: janigu@unam.mx (J. Nieto), uengoer@staff.uni-marburg.de (M. Uengoer).

http://dx.doi.org/10.1016/j.beproc.2017.06.003
Received 14 January 2017; Received in revised form 17 May 2017; Accepted 8 June 2017
Available online 10 June 2017
0376-6357/

Table 1
Experimental Design.

Experiment	Group	Acquisition	Extinction	Test	
				Extinction Renewal	Condition Condition
1	ABA-1	A: 6R-O	B: 3R-	B: 1R-	A: 1R-
	ABA-3	A: 6R-O	B: 1R- C: 1R- D: 1R-	B: 1R-	A: 1R-
	ABE-1	A: 6R-O	B: 3R-	B: 1R-	E: 1R-
	ABE-3	A: 6R-O	B: 1R- C: 1R- D: 1R-	B: 1R-	E: 1R-
2	ABA-1	A: 6R-O	B: 3R-	B: 1R-	A: 1R-
	ABA-3	A: 6R-O	B: 1R- C: 1R- D: 1R-	B: 1R-	A: 1R-
	ABA-1e	A: 6R-O	B: 12R-	B: 1R-	A: 1R-
	ABA-3e	A: 6R-O	B: 4R- C: 4R- D: 4R-	B: 1R-	A: 1R-

Note: A, B, C, D and E are five different contexts. "R-O" means that pressing the lever was reinforced. "R-"means that pressing the lever was not reinforced. The numbers before the letters refer to the number of sessions conducted in each context.

renewal.

Consistent with the findings of Bustamante et al. (2016), our first experiment revealed that extinction in multiple contexts eliminated ABC renewal, but had no detectable impact on ABA renewal. In Experiment 2, we investigated whether it is possible to reduce the strength of ABA renewal by multiple-contexts extinction when the amount of extinction training is extended (e.g., Laborda and Miller, 2013; Thomas et al., 2009).

2. Experiment 1

The design of Experiment 1 is shown in the upper part of Table 1. Initially, all rats were trained to press a lever for food in Context A. Then, lever pressing was extinguished. For Groups ABA-1 and ABE-1, extinction was conducted in Context B, while for rats in Groups ABA-3 and ABE-3 extinction took place in three different contexts (B, C and D). Finally, rats were tested for response recovery either in the initial acquisition Context A (Groups ABA-1 and ABA-3) or in a novel Context E (Groups ABE-1 and ABE-3). If extinction in multiple contexts reduces renewal, then rats in Groups ABA-3 and ABE-3 should show lower levels of response recovery than those in Groups ABA-1 and ABE-1, respectively.

2.1. Method

2.1.1. Animals

Forty-eight female three months old experimentally naïve Wistar rats (12 per group) weighting in average 253 g were used. They were individually housed in methacrylate cages (21 × 24 × 46 cm, H × W × D) inside a room maintained on a 12–12 h light-dark cycle. All subjects were maintained with ad libitum access to water but were food-deprived to 83% of their initial body weights throughout the experiment.

2.1.2. Apparatus

Twelve identical chambers manufactured by MED Associates (model ENV-008) measuring 29 × 22 × 24 cm (H × W × D) were used. Each chamber was enclosed in a sound-attenuating chamber. The sidewalls and ceiling were made of clear acrylic plastic, while the front and rear walls were made of stainless steel. The floor of the chamber consisted of sixteen 0.5 cm diameter stainless steel rods spaced 1.5 cm apart. A recessed 5 cm × 5 cm food magazine in which 45 mg Noyes A/I pellets could be delivered was centered on the front wall. Each chamber had one retractable lever which was positioned to the left of the food tray. These levers were 4.8 cm long and positioned 6.8 cm above the floor. A 28 Vdc bulb was placed 4.2 cm above the lever, which served as a general house light. The chambers were connected to a PC that controlled and recorded the events.

The chambers were set up to provide five different sets of contextual cues. Two chambers provided one context consisting of one sidewall and the ceiling covered with white and black horizontal lines. The floor consisted of sixteen 0.5 cm diameter stainless steel rods spaced 1.5 cm apart. Two more chambers provided another context where a white vinyl acetate sheet covered the floor and the sidewalls were covered with large dark dots. Two additional chambers provided another context where a clear acrylic sheet covered the floor. Another context was provided by two more chambers where sidewalls were covered with dark green paper and the floor was covered with fiber paper egg trays. The contexts were counterbalanced as B, C, D and E across rats. Four chambers provided Context A for all rats where sandpaper sheet covered the floor and one side-wall was covered with wide black and white diagonal lines.

2.1.3. Procedure

The present experimental protocol was approved by the Ethical Committee of the Faculty of Psychology of the National University of Mexico. Sessions were conducted on successive days at the same time each day. Prior to acquisition, rats were exposed to all contexts. At the first day, rats were exposed to Contexts A, B and C. On the next day, rats were exposed to Contexts D and E. Sessions were separated by 1 h. During the sessions food pellets were delivered approximately 65 times at a variable time (VT) 30 s schedule. The lever was retracted. Each session lasted 30 min.

2.1.3.1. Acquisition. For six days, rats were trained to press the lever for food on a variable interval (VI) 30 s schedule in Context A. Each session lasted 30 min.

2.1.3.2. Extinction. All rats received one daily extinction session for three days. For Groups ABA-1 and ABE-1, all extinction sessions were conducted in Context B, while rats in Groups ABA-3 and ABE-3 experienced extinction successively in Contexts B, C and D. No pellets were delivered. Each session lasted 30 min.

2.1.3.3. Test. Rats received a single 10 min test session in both the extinction and renewal conditions. Each session was separated by 60 min. The order of testing contexts was fully counterbalanced across rats. Thus, half of the rats were tested first in Context B (extinction condition) and then received testing in Context A (Groups ABA-1 and ABA-3) or Context E (Groups ABE-1 and ABE-3). The opposite was true for the other half. No pellets were delivered.

2.1.4. Statistical analysis

For this and the subsequent experiment, mean responses per minute were compared using analyses of variance (ANOVA). The rejection criterion was set at $p = .05$, and effect sizes were reported using partial eta-squared (ηp^2).

2.2. Results and discussion

The left panel of Fig. 1 shows the mean responses per minute for each group during each session of acquisition. The figure indicates that all rats acquired lever pressing similarly and that responding increased as acquisition progressed. This was confirmed by a 4 (Group) × 6 (Session) ANOVA conducted with the data of acquisition. The analysis found a significant main effect of session, $F(5, 220) = 180.08$, Mean Square Error (MSe) = 12.9, $p = .001$, $\eta p^2 = .80$. Neither the main