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Renewal, resurgence, and alternative reinforcement context

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ABSTRACT

Resurgence, relapse induced by the removal of alternative reinforcement, and renewal, relapse induced by a change in contextual stimuli, are typically studied separately in operant conditioning paradigms. In analogous treatments of operant problem behavior, aspects of both relapse phenomena can operate simultaneously. Therefore, the purpose of this study was to examine a novel method for studying resurgence and renewal in the same experimental preparation. An alternative source of reinforcement was available during extinction for one group of rats (a typical resurgence preparation). Another group experienced an operant renewal preparation in which the extinction context was distinguished via olfactory and visual stimuli. A third group experienced alternative reinforcement delivery in the new context, a novel combination of typical resurgence and renewal preparations. Removal of alternative reinforcement and/or a change in context induced relapse relative to an extinction-only control group. When alternative reinforcement was delivered in a novel context, the alternative response was less persistent relative to when extinction of the alternative response took place in the context in which it was trained. This methodology might be used to illustrate shared (or distinct) mechanisms of resurgence and renewal, and to determine how delivering alternative reinforcement in another context may affect persistence and relapse.

1. Introduction

Extinction, or removal of reinforcement that was previously contingent upon an operant response, can be an effective means of response suppression. On the other hand, the suppression of an operant response during extinction can be transient, and relapse of the response can occur when conditions change. For example, operant renewal is a relapse phenomenon that occurs when contextual stimuli present during the extinction of an operant response are changed. In animal studies of renewal, contextual stimuli can consist of a flashing versus steady operant chamber illumination (Podlesnik and Shahan, 2009), a distinctive scent (e.g., Bouton et al., 2011), stripes on the side of the operant chamber (e.g., Todd et al., 2012), and/or a combination of multiple such olfactory and visual stimuli (Bouton et al., 2011; Todd et al., 2012). For example, a rat might be trained to press a lever to receive a food pellet in one context (context A), but moved to a novel context (B) where no food is available for the target response (i.e., extinction). Even when the target response decreases to low levels, renewal of the operant response can occur despite continued extinction if the rat is returned to context A, or placed in a novel context (C). Understanding renewal is important because the phenomenon suggests that even when there is successful reduction of operant problem behavior, such as a period of abstinence from drugs while in a treatment facility, operant behavior may be susceptible to relapse with a change in context, such as returning home from treatment.

Operant relapse can also occur when alternative reinforcement introduced during extinction is removed, a phenomenon called resurgence (e.g., Leitenberg et al., 1970; Leitenberg et al., 1975; Winterbauer and Bouton, 2010; Winterbauer and Bouton, 2012; Winterbauer et al., 2013; Sweeney and Shahan, 2013a; Sweeney and Shahan, 2013b). After training an operant target response (e.g., a lever press), extinction is introduced for the target and alternative reinforcement is introduced for a different response (e.g., a chain pull or a press to a different lever). During target extinction plus alternative reinforcement, target response rates decrease and alternative response rates increase. When alternative reinforcement is removed via extinction of the alternative response, resurgence of the target response often occurs. Alternative reinforcement is an important aspect of many behavioral interventions (e.g., Lloyd and Kennedy, 2014; Petscher et al., 2009; DeFulio et al., 2009).

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Therefore, empirical work that tests potential predictors of resurgence is important to pursue.

Although typically studied separately in animal studies of relapse, it may be useful to consider the renewal and resurgence phenomena together. In analogous treatments of operant problem behavior, predictors of both relapse phenomena are often operating simultaneously. For example, an outpatient child with intellectual or developmental disability may receive differential reinforcement of alternative behavior (DRA) treatment that successfully reduces problem behavior in a school or clinic setting (e.g., Volkert et al., 2009). Following treatment, the child may not only be subject to lapses in treatment integrity where alternative reinforcement is removed or reduced (i.e., resurgence), but also to the change in contextual stimuli that are associated with moving from the clinic to the home, which may trigger renewal. In light of this, the purpose of this study was to examine a novel method for studying resurgence and renewal in the same experimental preparation in order to provide richer analysis of the potential contributors to relapse of operant responding that may occur in clinical settings.

We conducted an assessment of persistence and relapse across four groups of rats (1) resurgence, (2) renewal, (3) compound, and (4) control following equal baseline acquisition of the target response (a lever press). In the resurgence group, alternative reinforcement was introduced for a chain pull response during extinction of the target response and removed during the relapse test (i.e., typical resurgence). In the renewal group, wall stripes and pine scent were introduced during the extinction of the target response and removed during the relapse test (i.e., typical renewal). In the compound group, both alternative reinforcement and novel contextual stimuli were introduced during extinction of the target response and removed during the relapse test (combined resurgence and renewal). For the control group, extinction was introduced without alternative reinforcement or novel stimuli and nothing was altered during the relapse test.

By combining the variables that trigger renewal and resurgence together, we can examine the effects of alternative reinforcement and context change, and also assess how the delivery of alternative reinforcement in a novel context may affect the persistence and relapse of the target response. This design also compares the persistence of the alternative response when alternative reinforcement is delivered in the same context as it is removed (as in typical resurgence) relative to the persistence of the alternative response when alternative reinforcement was delivered in a different context. The assessment of resistance to change of the alternative response is practically important because the persistence of a desirable replacement behavior should be considered alongside any differences in relapse when choosing how to deliver alternative reinforcement.

2. Method

2.1. Subjects

The experiment used eight rats for each of four experimental groups, for a total of 32 experimentally naïve male Long-Evans rats (Charles River, Portage, MI, USA). This sample size is comparable to a similar between-groups resurgence study that detected a difference between groups using eight subjects per group (Sweeney and Shahan, 2013a). The animals were 71–80 days old when they arrived at the research facility. Rats were individually housed in a climate controlled colony room with a 12 h light cycle that began at 7:00 a.m. Rats were allowed ad libitum water access in their home cages and were maintained at approximately 80% of free feeding weight by food received in the session (Bio-Serv 45-mg dustless precision pellets) and daily post-session supplemental feedings (Harlan Teklad Rodent Diet 8604).

2.2. Apparatus

Experimental sessions occurred in one of four Colbourn modular operant chambers, the details of which have been described previously (Podlesnik et al., 2006). Two non-retractable response levers were located on the left and on the right of the food magazine where pellets were delivered. The response lever wall and opposite, rear chamber wall were both metal, and the two side walls were clear Plexiglas. When in place, the striped stimuli were attached to the outside of the two clear, Plexiglas walls. The laminated striped stimuli sheets were 25.4 cm wide by 17.8 cm tall. The stripes alternated between black and white, ran vertically, and were 2.5 cm wide. A small hole in the center of the ceiling allowed for a 30.5-cm metal response chain to be dropped into the operant chamber, which extended to approximately .64 cm above the grid floor.

2.3. Procedure

The experiment compared performance between groups across three phases, baseline acquisition of the target response (Phase I), extinction treatment in which reinforcement was no longer available for the target response (Phase II), and continued extinction of the target response with a manipulation expected to induce relapse in some groups (Phase III).

2.3.1. Pretraining

Because the rats were naïve, prior to the experiment proper, subjects were trained to eat from the food magazine in the operant chamber in two, 30-min training sessions where food was delivered on a variable-time (VT) 60-s schedule.

2.3.2. Phase I

Phase I was implemented identically for all rats, where a food pellet was delivered for pressing the target (right) lever on a variable-interval (VI) 45-s schedule of reinforcement for 10 daily, 25-min sessions. Presses to the inactive (left) lever were recorded but had no programmed consequences. There was no changeover delay in place during Phase I. Due to a software error, experimental data were not saved on the fifth session of Phase I for four rats, one from each experimental group. After Phase I, groups were randomly assigned, with the caveat that the groups should not differ in terms of mean target response rates for the last five sessions of Phase I.

2.3.3. Phase II

During Phase II, reinforcement for pressing the target lever was discontinued in all groups for a fixed length of 15 sessions. Other experimental manipulations implemented during Phase II differentiated the four experimental groups: resurgence, renewal, compound, and control. For the Resurgence group, extinction of the target response was accompanied by alternative reinforcement for pulling the chain. Alternative reinforcement, when delivered, was the same 45-mg pellet delivered during Phase I but on a VI 10-s schedule. There was a changeover delay in place such that chain pulls could not produce food if a target response had occurred during the last 3 s. For the renewal group, extinction of the target response occurred in a different operant chamber that had black and white vertical stripes stimuli on the wall and 10 mL of pine-scented cleaner on a paper towel beneath a blue guard under the chamber floor grid. The chain was introduced but pulling never produced food. In the Compound group, extinction occurred in a novel chamber with stimuli as in the renewal group, but chain pulling also produced alternative reinforcement. In the Control group, the chain was introduced but never produced food, and the rat remained in the same chamber as Phase I.