Reexposure to a Conditioned Reinforcer Following Outcome Elevation and Devaluation

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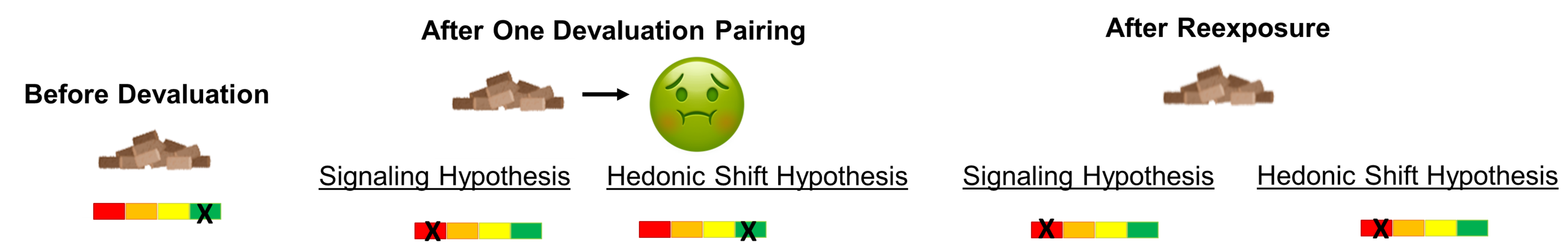
Introduction

- In an outcome devaluation procedure, a primary reinforcer (e.g., food) is paired with an aversive outcome (e.g., illness), which results in a reduction of the response (e.g., a lever press) that previously led to the reinforcer (Adams & Dickinson, 1981).
- The behavioral change seen following devaluation (i.e., the devaluation effect) could be the result of the animal learning that the food *signals* illness (i.e., the signaling hypothesis) after devaluation, and thus the behavioral suppression reflects the animal avoiding a predicted aversive outcome (Balleine & Dickinson, 1991).
- In contrast, the hedonic shift hypothesis posits that the devaluation procedure results in a change in the *affective value* of the reinforcer itself (i.e., the actual taste; Balleine, 2011).
- Whereas the signaling hypothesis predicts that a reduction in the response following *a single devaluation pairing* can occur, hedonic shift requires an *additional trial* in which the animal is *reexposed* to the outcome (e.g., the food) following devaluation, during which the animal is able to react to the changed value of the outcome (i.e., avoidance responses to the now devalued food).

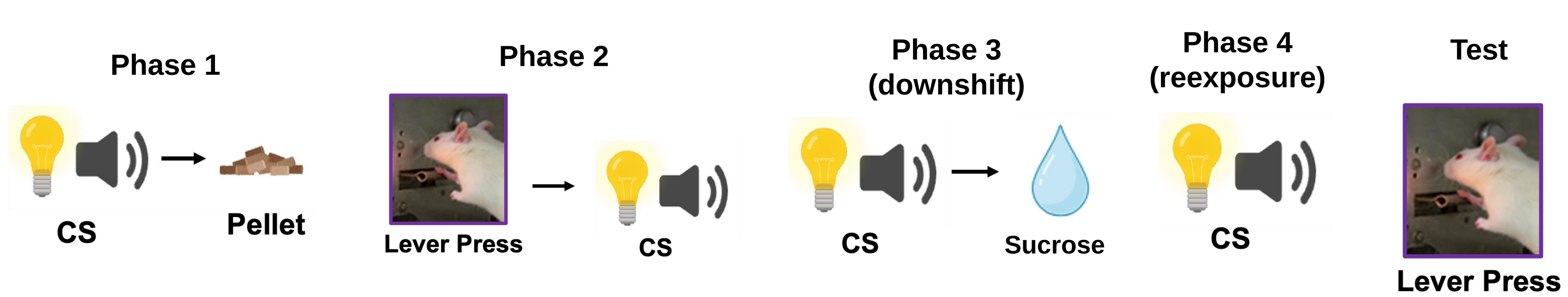


- Previous research has found evidence that reexposure is necessary to see a reduction in responding, which supports the hedonic shift hypothesis (Balleine & Dickinson, 1991; Balleine, 2001; Balleine & Dickinson, 1998; Balleine, Garner, Gonzalez & Dickinson, 1995; Lopez, Balleine & Dickinson, 1992).
- In addition to the devaluation of primary reinforcers, stimuli that have a history of being paired with reinforcement (i.e., a conditioned reinforcer, CDR) can also be devalued. To establish a CDR, animals first receive Pavlovian pairings of a conditioned stimulus (CS; e.g., a light) with an unconditioned stimulus (US; e.g., food). Once animals acquire a conditioned response (CR; e.g., entering the magazine), then the CS alone can serve as a reinforcer for an operant response (e.g., a lever press) in the absence of any primary reinforcer.
- Stahlman, Elliott, and Leising (2021) examined whether reexposure was required following the devaluation of a CDR via a mild foot shock. They found that rats that rats that were not reexposed to the CDR and rats that received a CDR → shock pairing separated in time (unpaired) showed a similar amount of lever pressing for the CDR. In contrast, rats that were reexposed, either by virtue of a second CS-shock pairing (group two-paired) or in a subsequent reexposure session, had similar reduced levels of lever pressing. Overall, these results suggest that reexposure to a devalued reinforcer is necessary even when the devalued reinforcer is not a primary reinforcer.
- In addition to devaluation by shock and taste aversion, there are procedures that can test for sensitivity to a change in the value of an outcome by elevating the appetitive value of an outcome. In a typical contrast procedure, the value of a reward is shifted to either a lower quality reward (i.e., a reward downshift) or to a higher quality reward (i.e., a reward upshift; Annicchiarico et al., 2016; Papini et al., 2001; Weber et al., 2015).
- The current experiment aimed to extend the findings of Stahlman, Elliott, and Leising (2021) by examining whether devaluation or elevation of a CDR could occur with reexposure.

Method

Subjects: Twenty-four experimentally-naïve male and female Long-Evans rats, with eight rats per group.
Apparatus: All tests occurred in a standard operant chamber which included two retractable levers with a food dispenser capable of delivering a sucrose solution and chocolate-flavored pellets

Group	Magazine Training	Phase 1 (10 Trials)	Phase 2 (60 Trials)	Phase 3 (1 Trial)	Phase 4: Reexposure (1 Trial)	Test (30-min)
Pell-Suc	Sucrose/Pellet (4:1)	CS → Pellet	LP_{Active} → CS	CS → Sucrose	CS-	LP_{Active} –
Suc-Pell		CS → Sucrose	$LP_{Inactive}$ –	CS → Pellet		$LP_{Inactive}$ –
Suc-Suc				CS → Sucrose		



Results

Training

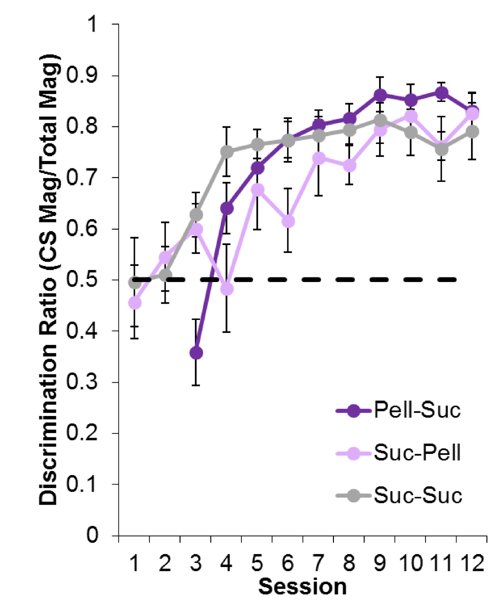


Figure 1. Due to the low value of the 12% sucrose solution compared to the chocolate pellet, rats that received CS-sucrose pairings (groups Upshift and Upshifted) began Phase 1 two sessions prior to group Downshift. An ANOVA was performed on discrimination ratio with session (3-12) as the within-subjects factor and group (Pell-Suc, Suc-Pell, and Suc-Suc) as the between-subjects factor. There was a main effect of session, $F(1, 17) = 35.38$, $p < .001$, and a session by group interaction, $F(2, 17) = 3.90$, $p = .04$, but no main effect of group, $F(2, 17) = 1.31$, $p = .30$. Follow-up tests using a Bonferroni adjustment were performed on the interaction. The results revealed that within the Pell-Suc group, session 3 (i.e., their first session of Phase 1) differed significantly from all sessions, $ps < .002$, with no significant differences from session 2 onward, $ps > .24$. Within group Suc-Pell, session 4 differed significantly from sessions 8, 9, 10, and 12, $ps < .05$, and session 6 differed marginally from session 10, $p = .07$, and significantly from session 12, $p = .05$. All other comparisons were nonsignificant, $ps > .16$. Lastly, no differences were found across sessions 3-12 in group Suc-Suc, $ps > .37$.

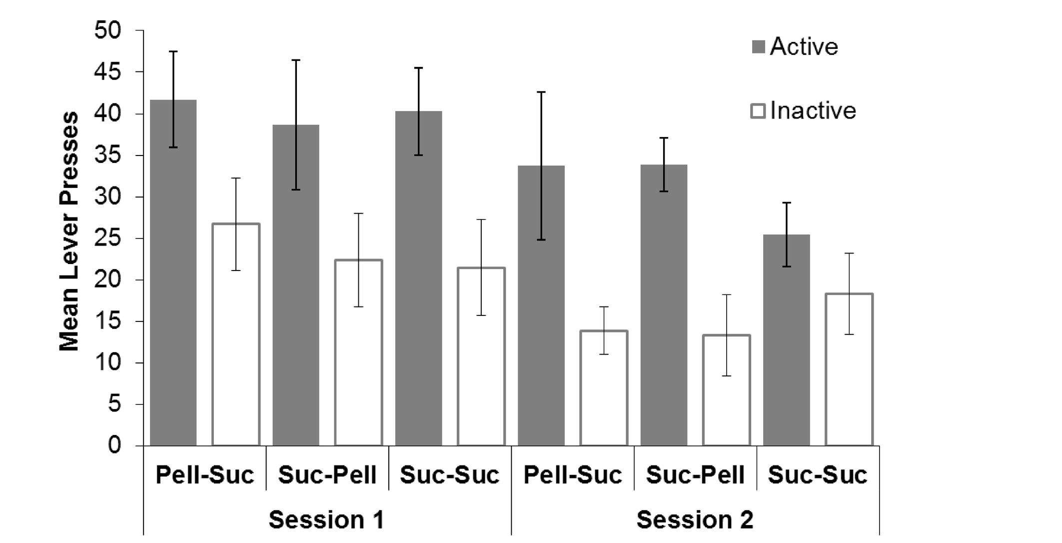


Figure 2. An ANOVA performed on mean lever presses in Phase 2 with lever (active vs. inactive) and session (1 vs. 2) as the repeated measures with group (Pell-Suc, Suc-Pell, and Suc-Suc) as the between-subjects factor revealed a main effect of session, $F(1, 17) = 15.29$, $p = .001$, and a main effect of lever, $F(1, 17) = 20.\ 30$, $p = .001$. The main effect of group and interactions were nonsignificant, $Fs < 1$.

Test

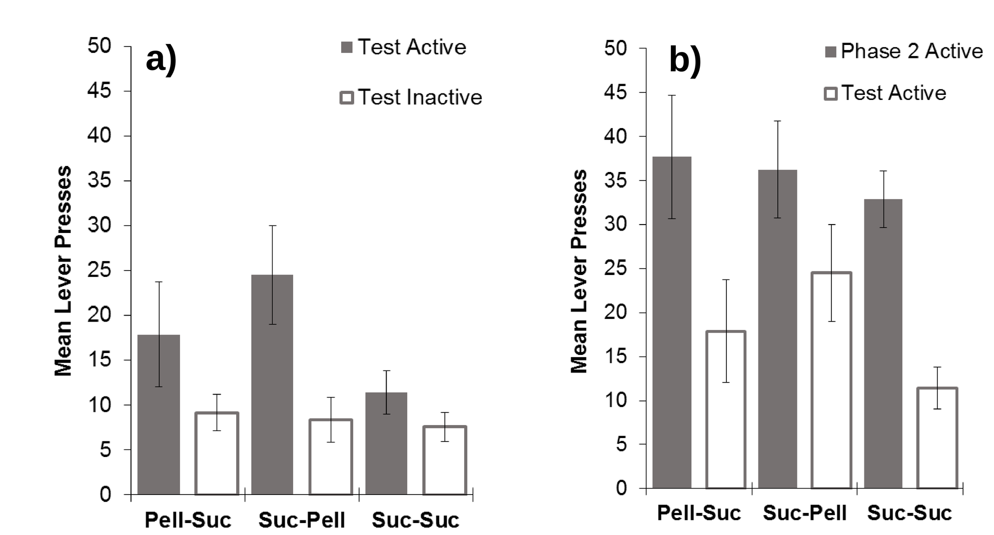


Figure 3. (a) An ANOVA was performed on mean lever presses (LPs) at test with lever (active vs. inactive) as the within-subjects factor and group (Pell-Suc, Suc-Pell, and Suc-Suc) as the between-subjects factor. The results revealed a main effect of lever, $F(1, 17) = 8.65$, $p = .01$, but no main effect of group and no interaction, $Fs < 2.11$, $ps > .12$. (b) An ANOVA performed on mean active lever presses with phase (Phase 2 vs. Test) as the repeated measure and group as the between-subjects factor revealed a main effect of phase, $F(1, 17) = 26.20$, $p = .001$, but no main effect of group and no phase by group interaction, $Fs < 1.00$, $ps > .39$.

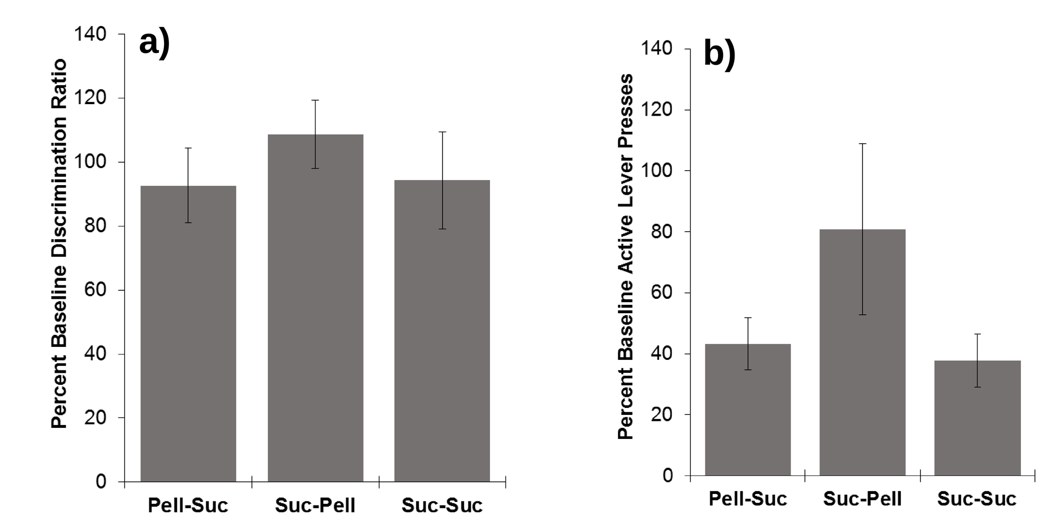


Figure 3. (a) Percentage of baseline (Phase 2) discrimination ratio (DR; number of active LPs/total LPs) at Test (Test DR/Mean Phase 2 Active LPs*100) for each group. An ANOVA performed on percent baseline DR as a function of group (Pell-Suc, Suc-Pell, and Suc-Suc) revealed no main effect of group, $F < 1$. A series of *t*-tests performed on percent baseline DR against a constant (100%) revealed that none of the three groups differed significantly from 100%, $ts < .81$, $ps > .46$. (b) percentage of baseline (Phase 2) active lever presses at Test (Test Active LPs/Mean Phase 2 LPs) for each group. An ANOVA performed on percent baseline active lever presses as a function of group revealed no main effect of group, $F(2, 17) = 2.00$, $p = .17$. A series of *t*-tests performed against a constant (100%) revealed that whereas the percent baseline LP for animals that were downshifted (Pell-Suc) or unshifted (Suc-Suc) was significantly below 100%, $ts(6) > 6.64$, $ps < .001$, the percent baseline LP for the upshifted did not differ from 100%, $t(5) = .68$, $p = .53$.

Discussion

- All groups acquired the conditioned response in Phase 1 regardless of the value of the outcome (the low-value 12% sucrose vs. the high-value chocolate-flavored pellet) and no group differences were found in the last six sessions of Phase 1.
- The results of Phase 2 revealed that all rats lever pressed less on the second session of lever press training than they did on the first. In addition, all rats pressed the active lever that resulted in the conditioned reinforcer more than the inactive lever that did not, suggesting that the audiovisual CS served as an effective reinforcer to support the acquisition of the lever press response regardless of whether it was previously paired with 12% sucrose or the chocolate-flavored pellet.
- At test, all groups continued to respond more to the active lever than to the inactive one and their percent baseline (Phase 2) discrimination ratios (DR; number of active lever presses divided by total lever preferences) did not differ from 100%, suggesting no change in DR from Phase 2 to Test.
- Although rats continued to show evidence of discriminating between the two levers at Test, the number of active lever presses at Test was lower than the number of active lever presses in Phase 2, indicating some extinction.
- When looking at the percent baseline (Phase 2) active lever presses at test, although no group differences were found, the percent baseline active lever presses in the upshifted group did not differ from 100%, but both the downshifted and unshifted groups were significantly below 100%, suggesting that the upshift pairing may have slowed extinction.

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