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Transfer between anticipatory and consummatory tasks involving reward loss

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ABSTRACT

Does recovery from reward devaluation or partial reinforcement (PR) involve the counterconditioning of frustration? Transfer among tasks involving reward loss was used to uncover frustration counterconditioning. In Experiment 1, Phase 1 training in consummatory successive negative contrast (cSNC; 32-to-4% sucrose devaluation) eliminated Phase 2 iSNC in one-way avoidance (40-to-3 s safety-time reduction), but the opposite sequence generated no detectable transfer. In Experiment 2, transfer from Phase 1 cSNC to Phase 2 autoshaping extinction after continuous reinforcement increased lever pressing in previously downshifted animals relative to unshifted controls. However, Phase 1 training in autoshaping under partial reinforcement (PR) had no effect on Phase 2 cSNC. Transfer from PR to cSNC also failed when sucrose pellets were used in autoshaping (Experiment 3), when autoshaping acquisition was extended from 100 to 300 trials (Experiment 4), and when preshift training in cSNC was extended from 10 to 20 sessions (Experiment 5). In Experiment 6, Phase 1 training in PR for licking enhanced Phased 2 cSNC, also involving licking, and in Experiment 7 Phase 1 PR training in autoshaping enhanced Phase 2 cSNC after a 22-to-4% sucrose downshift. Whereas prior exposure to cSNC (consummatory task) increased resistance to extinction in autoshaped lever pressing, prior training in one-way avoidance, PR in autoshaping, or PR in taste conditioning (all anticipatory tasks) either had no effect or they enhanced the cSNC effect. Frustration counterconditioning developed during these tasks, but the type of transfer effect depends on task sequence.

1. Introduction

Animals tend to reject rewarding outcomes when their incentive value is lower than expected. This phenomenon, called successive negative contrast, occurs in anticipatory instrumental responses (iSNC) and in consummatory responses (cSNC), and with magnitude and quality reward devaluations (Flaherty, 1996). Rejection of the devalued, small reward is transient; when sufficient training is provided, behavior returns to the level of unshifted controls reinforced always with the small reward. A contributing factor to SNC is the aversive emotion resulting from the negative discrepancy between received and expected reward magnitudes (Papini, Fuchs, & Torres, 2015). This aversive emotion has been traditionally referred to as frustration—a hedonically aversive internal state that suppresses goal approach and induces drive or attention (Amsel, 1962, 1992). The transient nature of the SNC effect implies that frustration is reduced in the course of experience with the devalued reward, but by what mechanisms?

Fig. 1 shows the two hypothesized mechanisms of recovery from SNC: memory update and frustration counterconditioning (Papini, 2003). Reward devaluation combined with food deprivation generates an approach-avoidance conflict. The relatively low

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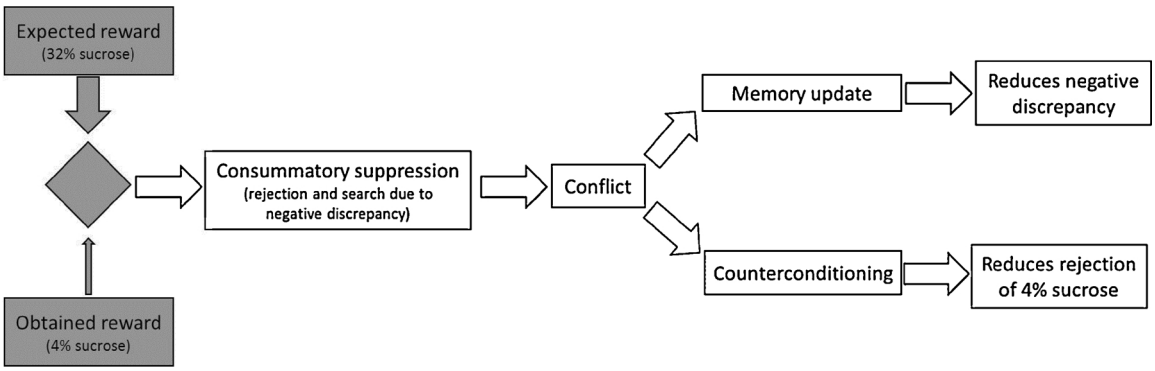

Fig. 1. Amsel's (1992) frustration theory applied to cSNC. When obtained rewards are less valued than expected rewards (represented by the thickness of the arrows converging on the comparator), then consummatory behavior is suppressed. The ensuing conflict involves approaching the devalued reward, which is still rewarding because of food deprivation, versus rejecting/avoiding the devalued reward because it is not as large as expected. Recovery from this conflict is hypothesized to involve two mechanisms (Papini, 2003). Memory update adjusts the reward expectation until it matches the obtained reward, thus eliminating the negative discrepancy. Counterconditioning resulting from pairings of anticipatory frustration with the devalued reward reduces rejection and avoidance.

incentive value of the devalued reward induced rejection and avoidance of the outcome, but food deprivation instigates approach to the outcome. Thus, presession feeding attenuates the approach response and prolongs cSNC (Cuenya et al., 2015). Moreover, presession anxiolytics (e.g., ethanol and benzodiazepines; Flaherty, Grigson, & Rowan, 1986; Kamenetzky, Mustaca, & Papini, 2008) and opioid agonists (Rowan & Flaherty, 1987; Wood, Daniel, & Papini, 2005; Wood, Norris, Daniel, & Papini, 2008) reduce cSNC by attenuating the rejection/avoidance response. According to this analysis, recovery from reward devaluation requires conflict resolution.

As the animal experiences the devalued reward it is also learning to anticipate it—a memory-update process (Papini, 2003). Memory update reduces the negative discrepancy until eventually there is no basis for negative emotion because the obtained reward matches the expected reward. Memory update has been tested with postsession administration of chlordiazepoxide, a benzodiazepine that has memory-interfering effects (e.g., Silva & Frussa-Filho, 2000). Immediate, but not delayed, administration of chlordiazepoxide after the first downshift session prolongs the cSNC effect in subsequent sessions (Ortega, Glueck, Daniel, White, & Papini, 2014). Control experiments indicate that this drug effect requires reward devaluation to occur. A retardation of recovery from cSNC is consistent with interference with the acquisition of a new memory about the devalued reward. Thus, one way to reduce the conflict is to adjust the comparison memory to the new reward magnitude so as to reduce negative discrepancy. The experiments reported in this article relate to the second mechanism of recovery: the counterconditioning of frustration.

Counterconditioning was first described by Pavlov (1927) in an experiment in which a dog received pairings of an electric shock with food. Pavlov noticed that after a few pairings, defensive responses gave way to salivary secretion when the shock was administered. Similarly, Amsel (1992) argued that the pairing of anticipatory frustration with reward weakened the tendency to evoke outcome avoidance and replaced it with a tendency to induce outcome approach. In Amsel's (1992) theory, counterconditioning is a major mechanism to account for increased response persistence in extinction after training with partial reinforcement (PR) relative to continuous reinforcement (CR). In the SNC situation, counterconditioning would result from pairings between anticipatory frustration and the devalued reward. The devalued reward is still a reward given the high motivational state derived from food deprivation. A key property of counterconditioning is that it supports transfer across situations, responses, and motivational states. Ross (1964); see also Mellgren, Hoffman, Nation, Williams, & Wrather, 1979; Nation, Wrather, Mellgren, & Spivey, 1980) reported an experiment in which rats received training in three phases, under different conditions, that provided support for transfer across situations. In Ross' experiment, six groups of rats received training in either PR (3 groups) or CR (3 groups) during Phase 1. Pairs of PR—CR groups differed in the response requirement (running, climbing, or jumping), but were all food deprived, food reinforced, and trained in a short, black, wide box. In Phase 2, all animals received CR training for running in a long, narrow, white runway, while water deprived, and to collect water in the goal box. Finally, in Phase 3, all animals received extinction of the running response trained in the previous phase. Ross argued that the counterconditioning of frustration in Phase 1 would reinstate the associated response during extinction in Phase 3. Such reinstatement would either facilitate extinction when that response was incompatible with running (such as climbing), but it would induce persistence when the responses were compatible (such as with running and jumping). Ross confirmed these counterintuitive predictions. Animals exhibited transfer of counterconditioned frustration to a novel context, under a different motivational state, and working for a different reward. Such transfer occurred even if no opportunity for counterconditioning was provided in Phases 2–3 when only CR training was administered. Transfer was hypothesized to be based on anticipatory frustration induced during the extinction of running in Phase 3.

Recent experiments have used this strategy to determine whether transfer attributable to frustration counterconditioning could be detected with mixed results. Cuenya et al. (2015) investigated the role of transfer across cSNC and iSNC tasks in inbred Roman strains of rats. Roman rats have been selectively bred since the 1960 s to exhibit either fast (Roman high-avoidance strain, RHA) or slow (Roman low-avoidance strain, RLA) avoidance learning in the two-way active avoidance situation. Strains also differ in a variety of