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Asymmetrical effects of posttraining outcome revaluation on outcome-selective Pavlovian-to-instrumental transfer of control in human adults

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ABSTRACT

In outcome-selective Pavlovian-to-instrumental transfer (PIT), stimuli that are predictive of particular outcomes prime instrumental responses that are associated with these outcomes. Previous experiments with humans obtained evidence that a strong posttraining devaluation of the associated outcome abolishes outcome-selective PIT. The present study extends this research to an upvaluation of outcomes. Adults learned in a stock market paradigm to relate particular stimuli and responses with particular monetary outcomes. Participants preferred responses associated with the same outcome as that predicted by the Pavlovian cue in a first transfer test. Before a second test, one currency was devalued, while the value of another currency was increased. In two experiments, outcome devaluation reduced specific PIT, while the upvaluation had no effect. Thus, a downward shift in the reward value was more effective than an equidistant upward shift for a change of PIT.

1. Introduction

The motivation to work for a reward is altered by the presence of external stimuli and their particular reward history. Numerous studies showed that stimuli predictive of a specific outcome augment responses working for that outcome—a phenomenon that was termed *outcome-selective Pavlovian-to-instrumental transfer of control* (specific PIT). In a typical demonstration, relations between stimuli and differential outcomes (Pavlovian learning: S1-O1,S2-O2) and relations between responses and outcomes (instrumental learning: R1-O1, R2-O2) are first established in separate training sessions. In a transfer test, both responses are then made available in extinction and the preference for a specific response is measured in the presence of each Pavlovian cue (i.e., S1: R1 vs. R2; S2: R1 vs. R2). A typical result is a preference for the response whose outcome was signaled by the Pavlovian cue (for reviews see Holmes, Marchand, & Coutureau, 2010; Urcuioli, 2005).

Researchers have studied the underlying knowledge structures of specific PIT effects with a reinforcer devaluation treatment, for instance, by prefeeding rats with one of the rewards to satiety before a PIT test. Several rat experiments (e.g., Colwill & Rescorla, 1990; Holland, 2004; Rescorla, 1994) and studies with human adults (e.g., Hogarth, 2012; Hogarth & Chase, 2011; Watson, Wiers, Hommel, & de Wit, 2014) concluded that PIT is unaffected by a devaluation of the shared outcome after the training. In those experiments, working for a devalued reinforcer was still augmented by the presentation of an associated Pavlovian cue (relative to an unrelated cue), although the devaluation treatment decreased both baseline responding and

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consumption of the devalued reinforcer. Furthermore, lesion studies with animals and human brain imaging studies suggest that the neural circuits underlying PIT tendencies and outcome devaluation on instrumental performance are mediated by anatomically and neurochemically distinct processes (Bray, Rangel, Shimojo, Balleine, & O'Doherty, 2008; Corbit & Balleine, 2005; Talmi, Seymour, Dayan, & Dolan, 2008). In combination, these studies argue that the cue-instigated response tendency is insensitive to the current incentive value of the associated outcome and therefore habitual.

A few studies however obtained positive evidence for an influence of posttraining reinforcer devaluation on outcome-selective transfer effects. In one study, human adults learned in a stock market paradigm to associate particular symbols and responses with particular money currencies (Allman et al., 2010Allman, DeLeon, Cataldo, Holland, & Johnson, 2010). In a first PIT test, participants preferred responses associated with the same outcome as that predicted by the presented Pavlovian cue (i.e., they exhibited specific PIT). Immediately before a second PIT test, participants were informed verbally that one of the currencies is now worthless. This devaluation treatment reduced responding to those stimuli associated with the devalued currency, eliminating the PIT effect for that particular currency. Responding for the nondevalued currency was still elevated by presentations of symbols associated with that currency. Eder and Dignath (2016) recently extended this line of research to a devaluation of primary reinforcers. After devaluation of a lemonade with bad-tasting Tween20, PIT was eliminated for the devalued lemonade. The Pavlovian cue paired with the devalued lemonade ceased to excite responses producing that outcome, indicating that posttraining devaluation does affect the strength of PIT tendencies in certain conditions. For an explanation of their findings, Eder and Dignath (2016) suggested that the strength of reinforcer devaluation critically determines whether cue-instigated responding after training is sensitive to devaluation or not. With a strong aversive outcome after the devaluation treatment, the instrumental response procuring that outcome is inhibited relative to other available responses (Frankel, 1975). Activation of the aversive outcome by an associated Pavlovian cue intensifies the inhibition of the devalued response (Bouton & Bolles, 1980; Dayan & Seymour, 2009), which explains why the response rate was reduced most in the presence of those cues.

While most revaluation studies studied effects of posttraining devaluation on PIT tendencies, much less research is available on effects of a posttraining upvaluation treatment. In fact, we found in our literature search not a single published study that used an upvaluation procedure in a PIT paradigm. A pronounced increase in the reward value after training may have a capacity to strengthen PIT, revealing symmetrical revaluation effects on outcome-selective transfer effects. Alternatively, it is also possible that value decrements and increments have asymmetrical effects on instrumental performance in a PIT paradigm. Many studies showed that losses loom larger than gains for motivational choice even with equidistant value changes (Tversky & Kahneman, 1991). Moreover, behavioral inhibition of a devalued response and behavioral activation of an upvalued response may be mediated by distinct motivational systems that affect PIT tendencies differently (Corr, 2013; Eder, Elliot, & Harmon-Jones, 2013; Gray & McNaughton, 2000). Accordingly, it is unclear whether and how PIT changes when a reward is increased after the training.

2. Experiment 1

A stock market paradigm similar to that used by Allman et al. (2010) was used. Participants were informed that they were to play the role of an investment banker who trades with three different African currencies at a simulated stock market. It was made clear to participants that the money earned in fictitious African currencies will be exchanged in real money (Euros) with identical exchange rates (50 Dollars = 1 Euro). Participants first learned in a "Pavlovian phase" to associated different companies (represented by specific symbols) with particular African currencies. In a subsequent "instrumental phase" they were able to earn their own money in an African currency with repeated key presses. In a first transfer test phase, the company symbols (Pavlovian cues) were presented again and participants were free to respond at will. Outcome-selective transfer was measured by the extent to which a company symbol increased the rate of the instrumental response working for the same currency (i.e., the number of key presses). After retraining of the Pavlovian and instrumental contingencies, a revaluation treatment followed that informed the participant about important changes in the exchange rates of currencies: Participants were told that one African currency had lost its value (to worthless), while another currency had doubled its value. The value of a third currency was not changed. Subsequently, a second transfer test was administered. PIT tendencies working for the different currencies could hence be compared before and after the revaluation treatment.

2.1. Method

2.1.1. Participants

Thirty-three volunteers (25 women, 1 left-hander, mostly students) with an age between 18 and 54 years ($M = 25.6$) participated in exchange for payment. Three participants did not pass the Pavlovian contingency tests (see Section 2.1.4 below). Additional data of three participants were lost due to computer failures. The experiment was approved by an ethics committee and all participants provided written consent.

2.1.2. Design

The experiment had a 2 (transfer test: before revaluation vs. after revaluation) × 4 (Pavlovian relation: Currency 1 vs Currency 2 vs Currency 3 vs. no currency) × 3 (instrumental relation: Currency 1 vs Currency 2 vs Currency 3) repeated-measures design. Each participant worked through two transfer tests, one before and one after the revaluation treatment.