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Effect of the passage of time on the contribution of initial response–outcome associations to instrumental performance

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Abstract

The effect of the passage of time on the contribution of initial response–outcome associations to subsequent instrumental performance was explored in three experiments with rats using outcome devaluation. Experiments 1 and 2 showed that a response that had been trained first with one outcome and then given identical training with a second outcome was more sensitive to devaluation of the second outcome than the first if the two training episodes were separated in time. Experiment 3 showed that inserting a delay between training with the second outcome and testing after outcome devaluation appeared to mitigate this effect of temporally separating first and second outcome training. Inserting this delay also made a response slightly more sensitive to devaluation of the first outcome than the second when there was no delay between the two training episodes. These results suggest that the passage of time can shift the balance between the contributions of first and second trained outcomes to instrumental performance.

Keywords: Instrumental learning; Outcome devaluation; Multiple outcomes; Passage of time; Decision-making; Rats; Memory; Discounting

There is considerable evidence from studies using outcome devaluation and transfer techniques that learning about the identity of the outcome routinely occurs during the course of instrumental training (e.g., Adams and Dickinson, 1981; Colwill and Rescorla, 1985a, b, 1988). This evidence is consistent with the view that a basic constituent of instrumental learning is the formation of an association between representations of the response and the outcome (e.g., Colwill, 1994; Colwill and Rescorla, 1986). One aspect of the response–outcome (R–O) association that has been carefully documented in studies using post-conditioning devaluation of the outcome is its resistance to a variety of response-elimination procedures. Despite a depressive effect on instrumental responding, extinction procedures involving nonreinforcement, noncontingent outcome presentations and negatively correlated outcome presentations have all been shown to leave the association between a response and its outcome intact (Colwill, 1994, 2001; Rescorla, 1992, 1993).

Colwill (1994, 2006) has extended this analysis of decremental operations on the R–O association to include an examination of the effect of the passage of time. In one study using a within-subjects design (Colwill, 2006, Experiment 1), two responses were initially trained with different outcomes (R1–O1 and R2–O2). Several weeks later, another pair of responses was trained with those outcomes (R3–O1 and R4–O2). Then, one of the outcomes was devalued. In a subsequent extinction test with each pair of responses, performance of the devalued response was reduced relative to that of the valued response. The magnitude of this devaluation effect appeared to be comparable for both pairs of responses suggesting that the memory for R–O associations remains robust over time.

The purpose of the present studies was to pursue an examination of the effects of the passage of time on the contribution of initially established R–O associations to subsequent instrumental performance involving those responses. Interference between sequentially presented learning episodes has generally been observed in the classic retroactive and proactive interference paradigms (e.g., Bouton, 1993; Underwood, 1957). In the former case, learning that takes place second interferes with retrieval of information from the first learning episode; in the latter case, learning that takes place first interferes with retrieval of information from the second learning episode. The effect of the passage of time on proactive interference has been examined by manipulating two temporal intervals; the one between the two learning episodes (T_1–T_2) and the one between the second learning episode and retention testing (T_2-test).

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It has long been thought that the memory of the first-learned association becomes progressively more available as the T_2-test interval increases (Spear, 1967). A good example of this comes from an experiment conducted by Kehoe (1963) with pigeons. In one of the interference conditions, subjects were first trained to peck one color (e.g., red) in a 5-color display and then a different color (e.g., green) in that display. After a T_2-test interval of 1, 10 or 30 days, the first problem was retrained. That retraining proceeded faster, the longer the T_2-test interval. Rescorla (1996b, 1997b) has also shown recovery in the performance of an instrumental response trained sequentially with two outcomes when a delay followed training with the second outcome. Similar results have been reported in studies using sequentially trained Pavlovian associations (Bouton and Peck, 1992; Rescorla, 1997a). One reason the first trained association is thought to become more accessible with time is due to the dissipation of an outcome-independent inhibitory process generated by omission of the first outcome during learning of the second outcome.

Substantially less is known, however, about the effect of lengthening the T_1–T_2 interval on proactive interference in these Pavlovian and instrumental sequential learning procedures. Based on the results of Colwill (1994, 2006) demonstrating the longevity of R–O associations, increasing the T_1–T_2 interval might be expected to have negligible impact on proactive interference. Such a finding would be consistent with many of the results from studies of short-term memory showing that the accuracy of matching to sample performance is unaffected across a range of T_1–T_2 values (Grant and Roberts, 1973; Medin, 1980). On the other hand, outcomes that are more distant in time might be discounted or given less weighting relative to more recent outcomes (Devenport, 1998; Devenport et al., 1997). Evidence that proactive interference declines as the T_1–T_2 interval increases would be consistent with the studies of short-term memory for individual events that have reported improved accuracy as the T_1–T_2 interval is increased (Henson, 1998; Pontecorvo, 1983). It would also fit with recent work demonstrating that the magnitude of spontaneous recovery is reduced by increasing the temporal distance between training and extinction (Rescorla, 2004).

Three experiments used the outcome devaluation technique to evaluate the influence of the passage of time on the associations between a response and its first trained and second trained outcomes. Experiment 1 examined the effect of an extended passage of time between training with the first and second outcomes. Experiments 2 and 3 examined the effects of relatively shorter temporal intervals inserted between or after the two training episodes.

1. Experiment 1

Experiment 1 was designed to investigate the effect of inserting a delay between training a response with its first outcome and training with its second outcome on the sensitivity of that response to a change in the value of either the first trained or second trained outcome. Two responses (R1 and R2) were trained with different outcomes (O1 and O2) in phase 1 such that one response earned pellets and the other earned liquid sucrose. Then, in phase 2, each response was given the same amount of training with the other outcome. For one group (Imm), phase 1 training ended the day before the start of phase 2 training; for another group (Del), phase 1 training ended 270 days before the start of phase 2 training. Immediately following the end of phase 2 training, one of the outcomes was devalued and the responses were tested in extinction. The basic design is outlined in Table 1. The question of interest was how, if at all, the temporal distance between phases 1 and 2 would affect the sensitivity of the responses to devaluation of the outcome earned in phase 2. Evidence that responses were indifferent to devaluation of the first or second outcome when a delay of about 9 months separated the two training episodes would provide particularly credible support for other studies alleging the persistence of R–O associations over time.

Table 1
Basic between-subjects design of Experiment 1

	Phase 1	Phase 2	Devaluation	Test
Group Imm	R1–O1 R2–O2	R1–O2 R2–O1		
			O1+, O2−	R1−, R2−
Group Del	R1–O1 R2–O2	R1–O2 R2–O1		

R1 and R2 are instrumental responses, lever press and chain pull. O1 and O2 denote pellets and sucrose. + denotes pairing with LiCl. For Group Imm, phase 2 training began the day after the end of phase 1 training; for Group Del, phase 2 training began 270 days after the end of phase 1 training.

A potential advantage of this design for assessing the strength of R–O associations as a function of time is that the same response is interrogated for its associations with both a remote and a recent outcome. This feature eliminates the difficulty of making comparisons between recently trained responses which tend to have lower overall rates and those trained remotely which tend to have relatively higher overall rates (Colwill, 1994, 2006). It may also provide a more sensitive assessment because it ensures equivalent contact during testing with the response manipulanda that have undergone training with both recent and remote outcomes.

2. Method

2.1. Subjects

The subjects were 32 experimentally naive Sprague–Dawley male rats (Harlan Co.) about 90 days old at the start of the experiment. They were housed individually and maintained at 80% of their ad lib weight by regulating their daily intake of food. Water was freely available in the home cage.

2.2. Apparatus

The apparatus consisted of eight identical Skinner boxes measuring 22.9 × 20.3 × 20.3 cm. The two end walls of the chamber were aluminum, and the side walls and ceiling were made of clear Plexiglas. The floor of the chamber was composed of 0.48 cm stainless steel rods spaced 1.9 cm apart. Each chamber