Response-independent outcome presentation can leave instrumental R-O associations intact

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Three experiments investigated the impact on instrumental response–outcome (R–O) associations of arranging for O to occur independently of R. In each experiment, that arrangement resulted in reduced responding. But a transfer test with a separately trained stimulus revealed the continued strength of the R–O association. That stimulus augmented equally an R with which it shared an O, whether or not that R had been decremented by independent presentations of O. These results suggest that response-independent outcome presentation decrements responding by means other than modifying the R–O association.

There is now a good deal of evidence demonstrating that instrumental training results in the formation of an association between the response (R) and reinforcing outcome (O). In prior reports from this laboratory, two techniques for this purpose have been described: devaluation and transfer. For instance, Colwill and Rescorla (1985) trained rats to make two instrumental responses (lever press and chain pull) with each earning a particular outcome (solid pellet and liquid sucrose). Subsequent devaluation of one outcome by repeated pairings with LiCl resulted in a highly specific decrease in the likelihood of the response that had earned that outcome. Similarly, Colwill and Rescorla (1988) reported that after such two-response and two-outcome training, each R was selectively augmented by a stimulus that had elsewhere been trained with a third response earning its outcome. Both of these results imply the formation of highly specific R–O associations during instrumental training.

The present paper explores the fate of those previously formed R–O associations when the relation between the response and outcome is disrupted. They exploit the ability to detect the presence of specific R–O associations in order to separate changes in the R–O association from other potential causes of performance loss. Previous reports (e.g., Rescorla, 1991) have explored the impact on R–O associations of simple nonreinforcement of R and of replacement of the original O with a novel outcome. Those reports found that neither procedure, both of which might have been expected to undermine the R–O association, had a substantial effect on it. Simple extinction led, of course, to a decrease in the likelihood of the response, whereas substitution of a new outcome yielded continued performance without the continuation of the original outcome. But when the state of the original R–O association was assessed by transfer techniques, there was little evi-

dence that either procedure had attenuated that association. In the experiments reported here, another potential decremental technique was explored: delivery of the outcome independently of the response.

Making the outcome become independent of responding is of interest for several reasons. First, it is a natural procedure for disrupting the R/O relation without changing the frequency of the O per se. Indeed, such a noncontingent R/O arrangement has been suggested as a technique that might be superior for the study of extinction and that might be especially likely to yield associative loss (see, e.g., Rescorla & Skucy, 1969).

Second, there have been various reports that related procedures in Pavlovian conditioning can yield little associative change in some preparations (e.g., Lindblom & Jenkins, 1981; Rescorla, 1989). In some instances, making a stimulus irrelevant to the outcome produced little change in behavior (e.g., Rescorla, 1989). In others, it generated reduced performance, which recovered when the outcome was removed entirely (Lindblom & Jenkins, 1981). Although a random R/O relation does produce decrements in instrumental behavior, there have been few attempts to determine precisely the state of the R–O association after such a procedure.

Third, use of a noncontingent R/O decremental procedure may help address an issue left unsettled by our previous studies with simple extinction. An alternative interpretation of the demonstrations of R–O associations can be given in terms of a two-process theory that emphasizes instead O–R associations (see, e.g., Overmier & Trapold, 1972). For instance, reinforcing a lever with a pellet might result in Pavlovian conditioning of the anticipation of the pellet to the situational stimuli. Then the lever press might be reinforced in the presence of that anticipation, resulting in O–R associations. Extinction carried out on the lever press would then also result in the extinction of the situation–outcome (S–O) association. Should that Pavlovian association extinguish rapidly, O would no longer be anticipated, and consequently, nonreinforcement of R would no longer take place in the pres-

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ence of O. Hence, extinction might leave any O-R associations relatively intact and therefore available to be exposed by a transfer assessment. One advantage of using a random R/O extinction procedure is that it guarantees continued anticipation of O during the period when R no longer produces O. Hence, it should be especially powerful in destroying any associations between R and O, whether they be of an R-O or an O-R form.

Standard instrumental training procedures with rat subjects were used in all of the experiments reported here. Instrumental responding was established for lever pressing and chain pulling, with pellets and sucrose as the outcomes. Then the outcomes were made independent of the responses in order to produce behavioral decrement. Finally, the state of the R-O associations was assessed by presenting stimuli with which the animal had been trained to make another response (nose poking) to produce either pellets or sucrose. The known outcome-specific effect of that stimulus was used to determine the strength of the original R-O associations.

The experiments differed among themselves in two ways. First, they had somewhat different designs, in a repeated attempt to detect any associative decrement. Second, they had different procedures for producing similar behavioral levels for responses that had and had not received decrement. If one is to compare the state of the R-O association for responses that vary in the degree to which they have been subjected to a decremental procedure, it is important to have the response rates per se be at reasonably comparable levels. This was accomplished in different ways in the various experiments.

EXPERIMENT 1

The design of this experiment was straightforward, as can be seen in Figure 1. Initially, two stimuli (S1 and S2) served as signals that a common response (nose poking) would be followed by a particular outcome (O1 or O2). This established the stimulus-outcome (S-O) associations to be used in the eventual transfer test. Then the animals were trained with the two responses of interest (R1 and R2), each of which earned one outcome. One of those responses was subsequently made random with respect to the outcomes. Both outcomes were used during this

phase in order to equate overall frequency of experience with the two outcomes. Finally, both responses were tested in the presence of the two stimuli.

As a result of this design, each of two responses was tested with a stimulus that had signaled the same outcome and a stimulus that had signaled a different outcome. For the nondecremented response, this allows us to document the outcome-specificity of the transfer previously reported. For the decremented response, this yields information about the degree to which the R-O association has remained intact.

Method

Subjects and Apparatus

The subjects were 16 male Sprague-Dawley rats about 90 days old. They were housed in individual cages and maintained on a food deprivation regime that kept them at 80% of ad-lib body weight. They had free access to water in the home cage.

The apparatus consisted of eight operant chambers measuring $22.9 \times 20.3 \times 20.3$ cm, identical to those described in previous reports (e.g., Colwill & Rescorla, 1985). The two end walls of each chamber were aluminum; the sidewalls and ceiling were clear Plexiglas. Each chamber had a recessed food magazine in the center of one end wall. A small metal cup measuring 1.25 cm in diameter and 1.5 cm deep was sunk in the floor of each food magazine. To the left of the magazine was a lever and to the right was a chain suspended from a microswitch mounted on the lid of the chamber. Located directly above the food magazine was a 2-cm opening, behind which was an aluminum plate that activated an attached microswitch when displaced by a nose poke. Access to these manipulanda could be blocked by covering the lever with a metal shield, retracting the chain through a hole in the ceiling, and covering the nose-poke opening with a jeweled lens. The floor of the chamber was composed of 0.48-cm stainless steel rods, spaced 1.9 cm apart. Each chamber was enclosed in a sound- and light-resistant shell. Mounted on the inside wall of this shell was a speaker that permitted the presentation of a white noise measuring approximately 76 dB re $20 \mu\text{N/m}^2$ against a background level of 62 dB. Also mounted on that wall was a 6-W bulb that could be illuminated to provide a light stimulus during the otherwise dark session. The outside ceiling of the shell supported a solenoid-operated gravity feed valve that was connected via plastic tubing to the cup in the food magazine. This system permitted the presentation of .3 ml of an 8% sucrose solution. Also attached to that food magazine was a dispenser containing 45-mg pellets (Noyes, Formula A). A third outcome was also available during some portions of the experiment, a 5% w/v solution of polyucose, delivered in the same manner as the sucrose. This substance is highly attractive to rats and is readily discriminated from pellets and sucrose.

Experimental events were controlled and recorded automatically by relays and microprocessors located in an adjoining room.

Procedure

Initial training. On the 1st day, the animals received two 20-min magazine training sessions, the first containing 20 pellet deliveries and the second containing 20 sucrose deliveries. Over the next 2 days, all animals were trained to lever press and chain pull. Each training session allowed responding to earn 25 deliveries of the appropriate outcome on a continuous reinforcement schedule. Half the animals received one session in which lever pressing led to pellets and one in which chain pulling led to sucrose; for the other half of the animals, the contingencies were reversed. On the next 2 days, all animals were trained to nose poke. In the first session, they earned 25 pellets; in the second, they earned 25 sucrose deliveries. On each of the next 2 days, all animals received two 20-min sessions, during each of which the nose poke was reinforced on a variable

Discrimination	Training	Decrement	Retraining	Test
L: Rc--O1	R1--O1	R1/O1,O2	R1--O3	L, N: R1
N: Rc--O2	R2--O2	R2/O1,O2	R2--O3	L, N: R2

Figure 1. Design of Experiment 1. Two responses (R1 and R2, lever press and chain pull) were each trained with a particular outcome (O1 and O2, sucrose and pellets). Then, during the decrement phase, one response received independent presentations of both outcomes. After retraining with O3 (polyucose) to match response levels, both responses were tested with light (L) and noise (N), which had signaled that a common response (Rc, nose poke) would yield differential outcomes.

interval (VI) 60-sec schedule. In one session the outcome was pellets; in the other it was sucrose. Throughout this initial training, individual shaping was used if necessary for a particular R-O combination.

Discrimination training. On each of the next 10 days, the animals received discrimination training sessions with nose poking. Each session contained sixteen 30-sec trials with the light and sixteen 30-sec trials with the noise. During these stimuli, nose poking resulted in reinforcements according to a VI 30-sec schedule. In a manner counterbalanced with regard to previous treatments, light signaled pellets and noise signaled sucrose for half the animals; the reinforcement contingencies were reversed for the other half of the animals. The intertrial interval (ITI) was variable around means of 45, 60, and 90 sec for the first 3 days of training, respectively. Thereafter the mean ITI was 120 sec.

Target response training. On each of the next 4 days, the animals received VI 60-sec training with both lever pressing and chain pulling. Each of two 20-min sessions, spaced about an hour apart, contained one manipulandum; the outcomes were those used in initial response training.

Target response decrement. On each of the next 8 days, all animals received two decremental sessions in which reinforcers were made random with respect to one of the responses. These sessions were exactly like those of VI training, except that the outcomes were delivered in response-independent fashion on a variable time (VT) 60-sec schedule rather than a VI 60-sec schedule. One session of each day contained each outcome; in both sessions, the same response was available. The alternative manipulandum was not available to the animal during this phase of the experiment.

Target response retraining. In order to assure that the actual rate of responding would be comparable for decremented and non-decremented responses, all animals then received 2 days of retraining with a polycose reinforcer. This phase was exactly like the original target response training except that the common outcome, polycose, was used with both responses. Prior work (e.g., Rescorla, 1991) has shown that this procedure elevates the response likelihood by the addition of new R-O associations but without apparent adverse effects on the original R-O associations.

Discrimination retraining. On the next 2 days, all animals received retraining on the original light/noise discrimination. This was done to ensure that the associations between those stimuli and their outcomes would be fully functional at the time of test.

Test. On the next day, each animal received two 8-min extinction sessions, one with the lever and one with the chain. The intention of this procedure was to reduce responding to allow the discriminative stimuli to elevate behavior on the subsequent test (see Colwill & Rescorla, 1988). On the next day, the animals received two 8-min test sessions. Each session contained four 30-sec presentations each of light and noise, given in counterbalanced order with an ITI of 30 sec. During the first session, the chain was present; during the second, the lever was present.

Results and Discussion

Initial response and discrimination training proceeded smoothly. On the final day of discrimination training, the mean responses per minute were 22.3, 22.1, and 2.5 during the light, noise, and ITI, respectively. Responding rapidly reached stable levels on the lever and chain. On the final day, the mean responses per minute were 9.2 and 7.8, for the lever press and chain pull, respectively.

Responding dropped rapidly with the introduction of random reinforcement, so that by the final day of that training, the mean responses per minute were 1.1 and 1.0 for the lever press and chain pull, respectively. The adverse effects of random reinforcement were still evident at the beginning of retraining with polycose. Over the first

5-min period of the initial session, the mean responses per minute were 3.9 and 7.1 for the responses that had and had not been subjected to random reinforcement, respectively [$T(16) = 9.5$, $p < .01$]. For the second retraining session, the mean rate of responding was 4.5 per minute. As in past studies, polycose maintained a lower overall level of behavior than did sucrose or pellets.

The results of most interest, from the test sessions in which light and noise were presented while either the chain or the lever was available, are shown in Figure 2. That figure displays the mean responses per minute separately for the response that had been decremented and for that which had not. Responding is shown in the absence of any stimulus (ITI), and in the presence of a stimulus that had signaled the same outcome as, or a different outcome from, that originally used with the response.

The data at the left, from the response not subjected to a decremental procedure, confirm earlier findings with this transfer technique. Responding was greater during the same-outcome stimulus than during the different-outcome stimulus [$T(16) = 14.5$, $p < .01$], indicating the presence of relatively specific R-O associations. Moreover, presentation of the same-outcome stimulus elevated responding over that in the ITI [$T(16) = 4$, $p < .01$], whereas presentation of the different-outcome stimulus failed to do so [$T(16) = 39.5$, n.s.].

The data at the right show a similar pattern for the response subjected to a decremental procedure. The same-outcome stimulus elevated responding relative both to that during the different-outcome stimulus [$T(16) = 7$, $p < .01$], and to that during the ITI [$T(16) = 4$, $p < .01$]. However, unlike the case of the control response, the response subjected to random treatment was also elevated by the different-outcome stimulus [$T(16) = 16.5$, $p < .01$]. This may indicate that random exposure to the alternative outcome produced some association between it and the response. This possibility is addressed in the General Discussion.

Figure 2. Results of the test session of Experiment 1. Responding is shown for the decremented and nondecremented response in the intertrial interval (ITI) and in the presence of a stimulus that elsewhere signaled the same or a different outcome.

The retraining with polycose was reasonably effective in producing similar levels of overall responding for the decremented and nondecremented response. Although the former showed a numerically lower response level overall, that proved not to be reliable for either the individual or the overall comparisons. Consequently, one may compare the behavior to the decremented and nondecremented responses with reasonable confidence. Such direct comparisons provide no evidence that the random treatment attenuated the R-O associations. The selectivity of the effect of the different stimuli on the responses was not reliably different whether measured in terms of difference scores or ratios.

These data thus suggest that random delivery of the outcomes during extinction undermines performance, but does not undermine the R-O association.

EXPERIMENT 2

In Experiment 1, two responses with individual outcomes were paired; one of the responses then underwent decrement through noncontingent presentation of both outcomes. This permitted a between-response comparison of R-O associations that had and had not been subjected to noncontingent reinforcement. Experiment 2 employed the converse strategy of training a response with *both* outcomes but then arranging for noncontingent presentations of one. Prior work has shown that a response trained with two outcomes can concurrently retain both R-O associations with minimal interference between them (Rescorla, 1991). The question is then whether noncontingent presentations of one outcome would have a specific decremental effect on the R-O association with which it is involved. This experiment thus provides a within-response comparison of two R-O associations, one of which has been subjected to the noncontingent decremental procedure and one of which has not. Because the same response is involved in the assessment of both associations, no special measures are needed to assure comparable overall response levels at the time of the test.

In other regards, this experiment is like Experiment 1. Initial discrimination training was given with two different stimuli signaling that a common response yielded different outcomes. Then each of two target responses earned both pellets and sucrose. After each of those responses had been present during noncontingent deliveries of one of its outcomes, the responses were tested in the presence of the stimuli. If noncontingent presentation of an outcome has a decremental effect on its R-O association, the stimulus that signals that O should be less successful than the other stimulus in the test.

Method

Subjects and Apparatus

The subjects were 16 male rats of the same sort and maintained in the same manner as in Experiment 1. The apparatus was that from Experiment 1.

Procedure

Initial training. Magazine training was conducted in the same manner as in Experiment 1. Then each animal received 6 days of continuous reinforcement training, 2 each with the lever press, chain-pull, and nose-poke manipulanda. In each session, the animal was allowed to earn 25 outcomes. On the 1st day with each manipulandum, the outcome was pellets; on the 2nd day, it was sucrose. On each of the next 2 days, all animals received two 20-min VI 60-sec sessions with nose poking, spaced about an hour apart. In one of those sessions, the earned outcome was pellets; in the other, it was sucrose.

Discrimination training. On the next 12 days, the animals received discrimination training with light and noise signaling the availability of an outcome for a nose-poke response. That training was conducted in exactly the same manner as in Experiment 1, so that for half the animals light signaled pellets and noise signaled sucrose, whereas for the other half, the contingencies were reversed.

Target response training. On each of the next 8 days, the animals received VI 60-sec training with both lever pressing and chain pulling. Each of two 20-min sessions, spaced about an hour apart, contained one manipulandum. Half of the sessions with each manipulandum contained pellets as the outcome; the other half of the sessions contained sucrose.

Response decrement. On each of the next 10 days, the animals received two 20-min sessions, during which one of the manipulanda was available. During those sessions, either pellets or sucrose was scheduled on a VT 60-sec schedule. For half the animals, pellets were scheduled in the presence of the lever and sucrose was scheduled in the presence of the chain; for the other half of the animals, the outcomes were interchanged. The treatments were arranged to be orthogonal to the stimulus-outcome relations that obtained during discrimination training.

Discrimination retraining. In order to ensure the effectiveness of the associations between the light and noise stimuli and the differential outcomes, two additional discrimination training sessions were given with the nose-poke manipulandum. These were identical to those given during the previous discrimination training phase.

Test. On each of the next 2 days, the animals received two test sessions, one with lever press and one with chain pull. During each of those sessions, they received four 30-sec presentations each of light and noise, spaced 30-sec apart. The question of interest was whether the exposure to a response in random relation to one of its outcomes would reduce its sensitivity to the presentation of a stimulus with which it shared that outcome.

Results and Discussion

Initial response and discrimination training proceeded without incident. On the final day of discrimination training with nose poking, the mean responses per minute were 19.8, 15.3, and 2.7 during the noise, the light, and the ITI, respectively. On the final day of training, the mean responses per minute were 10.3 and 11.1 for the lever press and chain pull, respectively. Over the course of exposure to the VT schedule, responding declined, so that on the final day of that treatment the mean responses per minute were 1.9 and 1.6 for the lever press and chain pull, respectively.

The data of most interest, from the test sessions, are shown in Figure 3. Because there were no systematic differences as a result of stimulus, response, or outcome identity, the data have been combined. Responding is shown separately in the absence of any stimulus (ITI), in the presence of a stimulus that had signaled the out-

Figure 3. Results of the test session of Experiment 2. Responding is shown during the intertrial interval (ITI) and in the presence of a stimulus that elsewhere signaled either the outcome with which the response was decremented or the alternative outcome.

come with which the response had received noncontingent treatment, and in the presence of a stimulus that had signaled the other outcome. It is clear that both stimuli elevated responding compared with that during the ITI and that they did so to about the same extent. The elevation was reliable in both cases [$T_s(16) = 0$, $p_s < .01$], but the difference between the stimuli was not.

These results suggest that when a response has associations with two outcomes, arranging for it to then receive noncontingent presentations of one of those outcomes has little detectable decremental effect on the R-O association. Certainly the noncontingent presentation resulted in an overall decrement in performance, but that decrement is apparently not attributable to differential effects on the R-O associations.

It is worth mentioning that Experiment 2 has been replicated with the sole difference that during the decremental procedure any outcome programmed to occur within 10 sec of a prior response was delayed until that 10 sec had expired. The results of this somewhat negative contingency were virtually identical to those of the random treatment. During the decrement, responding declined to .9 responses per minute. During the test, responding was at 4.7, 4.5, and 2.8 per minute during the stimulus signaling the nondecremented, decremented, and ITI, respectively. The elevation relative to the ITI was reliable [$T_s(16) < 14$, $p_s < .01$] for both stimuli but not differential [$T(16) = 61$].

EXPERIMENT 3

Previous investigation of the potential decremental effect of nonreinforcement on an R-O association made use of an especially powerful comparison (Rescorla, 1991). A response was first trained with one outcome, then extinguished, and then trained with a second outcome. Then the strength of the two R-O associations was compared, using a transfer technique like that employed here. With that paradigm, the same response is tested for two associations but one of those associations was trained and then

extinguished before the second was ever trained. Although one might think that such a procedure would be especially likely to detect the detrimental effects of extinction, in fact no differences were observed. That provides particularly compelling evidence for the resistance of the R-O association to change by nonreinforcement. Experiment 3 made the same comparison for a decremental treatment in which the outcome was made random to the response. In some ways, this can be thought of as a replication of Experiment 2 with the order of the various R-O relations given sequentially rather than in intermixed fashion. Otherwise, the same general procedures were used.

Method

Subjects and Apparatus

The subjects were 16 male rats of the same sort and maintained in the same manner as in Experiment 1. The apparatus was that from Experiment 1.

Procedure

Initial training. Magazine and initial response training were conducted in the same manner as in Experiment 1. The animals were trained to lever press and chain pull, with each response leading to a particular outcome. Then they received training to nose poke for both outcomes, first on a continuous reinforcement schedule and then on a VI schedule.

Discrimination training. Discrimination training to nose poke during light and noise was conducted for 12 days in a manner exactly like that in Experiment 1.

Response training, Phase 1. The animals were then given 4 days of VI training with the lever press and chain pull. Each day contained two 20-min sessions, during which reinforcement was available on a VI 60-sec schedule. In a fashion orthogonal to the stimulus-outcome relations of discrimination training, half the animals had lever pressing earn pellets and chain pulling earn sucrose, whereas the other half of the animals had the outcomes interchanged.

Response decrement. On each of the next 12 days, the animals received a single 20-min session with only one manipulandum available. During that session, the outcome which that manipulandum had previously earned was now presented in a response-independent fashion on a VT 60-sec schedule. For half the animals, in each of the prior treatments, the response so treated was the lever press, whereas for the other half of the animals it was the chain pull. As a result of this training, one of the two responses had been subjected to a decremental procedure with its training outcome, whereas the other response had been spared that treatment.

Response training, Phase 2. On each of the next 4 days, the animals received response training identical to that of Phase 1, except that the reinforcers for the two responses were interchanged. As a result, responding was retrained, but with the alternative reinforcer from that used in initial training and decrement.

Discrimination retraining. On each of the next 2 days, the animals received retraining on the discrimination, in a manner identical to that used previously.

Test. On the next day, the animals received an 8-min extinction session with lever press and with chain pull. As in Experiment 1, this was done to reduce responding, in the interests of better exposing the elevation that the stimuli might produce. On the next day, the animals received two test sessions, one with the lever press and one with the chain pull. Each session contained four 30-sec presentations each of light and noise, spaced 30-sec apart. Each response had earned in turn two outcomes, but one of the responses had been decremented between the two types of training. Hence, one may use responding during a stimulus trained with an outcome to assess whether a response has a stronger association with its first-

or second-used outcome as a function of whether it had received decrement between the trainings.

Results and Discussion

Discrimination learning and response training were uneventful. By the final day of nose-poke discrimination training, the mean responses per minute were 19.2 and 16.5 during the noise and light, respectively. On the final day of the first phase of response training, the mean responses per minute were 7.8 and 7.6 for the lever press and chain pull, respectively. By the end of the noncontingent treatment, the mean responses per minute were .9 and .7 for the lever press and chain pull, respectively. Responding rapidly recovered with the introduction of the alternative reinforcers. By the final day of Phase 2 of response training, the mean responses per minute for the lever press and chain pull were 9.4 and 8.5, respectively.

The results of most interest, from the test of lever pressing and chain pulling in the presence of light and noise, are shown in Figure 4. That figure displays the response rate separately for the responses that had and had not been subjected to decrement. Responding is shown in the absence of any stimuli (ITI), and in the presence of stimuli that signaled the outcome with which each response was trained first (prior to decrement) and second (after decrement).

The set of bars to the left shows responding for the response not subjected to a decremental procedure. Those results are similar to the ones previously found for a comparably treated response in an extinction experiment (Rescorla, 1991). The stimulus elevated responding above that in the ITI, whether that stimulus signaled the first outcome [$T(16) = 6, p < .01$] or the second [$T(16) = 24.5, p < .05$]. Moreover, there was no reliable difference between the effects of those stimuli.

The set of bars to the right shows a similar pattern for the response that was given the decremental treatment. Again, the stimulus elevated responding relative to that in the ITI both when it signaled the first-used outcome

[$T(16) = 4, p < .01$] and when it signaled the second-used outcome [$T(16) = 16.5, p < .01$]. Again, there was no reliable difference between the responses to the stimuli. None of the differences between the two responses proved reliable.

These results agree with those of Experiments 1 and 2 in suggesting that subjecting a response to a noncontingent relation with its reinforcer has little decremental impact on the R-O association. The present result is of special interest because it permits comparison of two associations that the same response has with two different outcomes, under conditions that document performance decrement in the presence of one. Despite the fact that the response was initially reinforced and then underwent decrement with one outcome prior to training with a second outcome, the R-O associations were of similar strength.

GENERAL DISCUSSION

The results of these transfer experiments suggest that repeated nonreinforced occurrence of a response does little to reduce the value of the R-O association, despite the noncontingent delivery of the outcome. In Experiment 1, a response reinforced with one outcome and then given noncontingent delivery of several outcomes continued to be augmented by discriminative stimuli trained with the initial outcome. In Experiment 2, a response reinforced with several outcomes and then given noncontingent delivery of one continued to show similar levels of augmentation by stimuli associated with each outcome. Finally, in Experiment 3, a response reinforced with one outcome, decremented with noncontingent delivery of that outcome, and then trained with a second outcome, showed evidence of similar associative strengths with the two outcomes.

The results of these experiments with noncontingent outcome delivery as a decremental procedure agree with those found previously for simple extinction and replacement of one outcome by another. Apparently, the noncontingent delivery of the outcome is no more successful than is simple extinction in reducing the original R-O association.

The conclusion that noncontingent outcome delivery and simple extinction may have similar consequences agrees with some earlier results. For instance, in an early study of the two procedures with instrumental training, Rescorla and Skucy (1969) concluded that they produce generally comparable results, although perhaps at different rates. Although some detailed differences have been reported for the two procedures (e.g., by Boakes & Halliday, 1975), by and large that conclusion has stood.

Challenges to that conclusion have apparently come from studies in which the decrement induced by noncontingent outcome delivery is reversed when simple extinction is instituted. Such a finding was first reported in the Pavlovian literature by Lindblom and Jenkins (1981). Using an autoshaping procedure with birds, they reported that making a previously trained CS random with regard to its US yielded initial response decrement. But that was followed by substantial recovery when the US was re-

Figure 4. Results of the test session of Experiment 3. Responding is shown for the decremented and nondecremented response during the intertrial interval (ITI) and in the presence of stimuli that signaled either the first-earned or the second-earned outcome.

moved in further testing. Apparently, a CS-US association not evident during the noncontingent procedure was revealed in subsequent extinction. However, a special feature of those experiments was their arranging for noncontingency by holding constant the rate of US occurrence during the CS while greatly increasing that in the absence of the CS.

A similar procedure was studied in instrumental learning by Dickinson and Charnock (1985). They used a schedule that permitted holding constant the likelihood of the outcome immediately after the response and achieving noncontingent delivery by increasing the outcome likelihood at other times. Although they found some recovery from the decremental effect of such a procedure when extinction was introduced, the recovery was quite small relative to the level of performance prior to noncontingent outcome delivery. In an earlier study by Rescorla and Skucy (1969), animals were trained on a VI schedule and subjected to an equal-valued VT schedule; responding was then tested in extinction. They found little evidence for recovery in extinction. Apparently, the simple removal of the noncontingent outcome has rather modest effects in instrumental training situations.

The present results provide a more specific assessment of the state of particular R-O associations. They suggest that however the noncontingent treatment and simple extinction may differ, they seem to be similar in leaving the original R-O association intact. This suggests that some other process, not specific to a particular outcome, is responsible for the decrement observed. A possibility suggested for the case of extinction is conditioned frustration. It has been common to argue that the nonoccurrence of an anticipated positive outcome produces an aversive frustrative reaction (e.g., Amsel, 1958). It is not implausible, then, that such a reaction could itself be conditioned to the response in the same way that a positive outcome becomes so conditioned. That frustration could then work, in a way that was independent of any particular positive outcome, to depress responding. Such a mechanism is also possible for the case of noncontingent outcome delivery. Although the continued response-independent delivery of an outcome might reduce the likelihood of such frustration's becoming conditioned to the situational cues, responding would still be followed by an outcome much less frequently than was the case during original training.

Alternatively, random delivery of an outcome might establish competing responses that interfere with performance without reference to the original R-O associations. Certainly there is evidence that deliberate reinforcement of particular alternative responses can undermine performance without entirely removing the original learning (see, e.g., Leitenberg, Rawson, & Mulick, 1975). However, some evidence points to greater specificity of the decrement to the treated responses than would be anticipated on the basis of a competing response account. For instance, in the present Experiment 1, a response subjected to the noncontingent delivery of both outcomes showed slower retraining than did one not so treated. But there is little reason to anticipate that any competing re-

sponses would have differential impact on retraining of the different responses in the same situation. Nevertheless, competing responses may contribute to the present findings.

These results also suggest that the consequences of noncontingent presentation of an outcome are quite different for responses with and without prior associations with that outcome. A good deal of evidence suggests that outcomes that are noncontingent on responses from the outset do not support behavior. These results have been interpreted to mean that such a procedure does not support the development of R-O associations. Yet in the present experiments, previously established associations appear not to have been undermined by noncontingent delivery. This seems to mirror the situation for Pavlovian conditioning, wherein the same random CS-US relation fails to produce substantial CS-US associations but can nevertheless preserve previously established associations (see, e.g., Rescorla, 1989).

However, this conclusion must be tempered by the observation made in Experiment 1 that a response previously trained with one outcome and then made random with respect to a second outcome can be augmented by a stimulus trained elsewhere with that second outcome. That suggests that a response can develop something of an association with another outcome with which it is made random. Although this effect is relatively small, it may complicate analysis of this decremental procedure. It could mean that random outcome delivery fails to remove previously established associations because it is sufficient to establish weak associations of its own. That makes the results of simple random procedures like those used in Experiments 2 and 3 more difficult to interpret. However, it encourages the use of procedures like that used in Experiment 1, in which preservation of the original R-O associations is assessed after both outcomes occur during the decremental period.

It is worth noting that the outcome-specific transfer technique used here has clear advantages for assessing the associative basis of instrumental performance. Although conventional phenomena, such as spontaneous recovery, can help identify the failure of decremental procedures to remove fully previous learning, they rely on overall levels of responding. This greatly limits their ability to assess the state of particular associations. With the present transfer procedure, one can single out associations with a particular outcome for inspection. That can allow one to study the associative impact of various treatments with responses that are otherwise performed with similar frequencies. This may provide a means not only of identifying the presence of associations but also of comparing their relative strengths after different treatments. In the present application, the transfer technique suggests that previously established R-O associations are of similar strengths whether or not they are subjected to the response decrement engendered by noncontingent outcomes.

The present results are also of some help in addressing an alternative account of the previous extinction studies in terms of a two-process O-R association. According to

such a view, instrumental training results in O-R associations between the anticipation of a particular outcome and the response. That anticipation of O is a result of learned associations between situational stimuli and outcomes (S-O). It is possible that in simple extinction this S-O anticipation is rapidly lost, with the consequence that the opportunity for extinction of the O-R association is rather limited. Elevation of the response by a transfer stimulus would then simply make use of the nonextinguished O-R association. However, the noncontingent delivery of O during nonreinforcement of R should ensure the continued anticipation of O, ensuring ample opportunity for extinction of any O-R association. Consequently, the continued ability of a stimulus to augment responding after noncontingent outcome delivery is evidence for continued association between R and O, whether one views it as R-O or O-R.

When taken together with previous findings (Rescorla, 1991, 1992), these results suggest that the associations established during instrumental training are remarkably resistant to the effects of various decremental operations. An R-O1 association apparently remains intact when O1 is replaced by another outcome, removed altogether, or made random with regard to R. Similarly, an S-O1 association appears to be preserved when the O1 is replaced or removed. Whether the associations established in other than instrumental learning situations are equally resistant to decrement remains uncertain.

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