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Unblocking in a runway discrimination problem produced by a surprising reduction in S− reward magnitude at the beginning of compound stimulus training

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The effects of a surprising reduction in S− reward magnitude on the blocking of the acquisition of stimulus control by brightness cues following prior acquisition of discriminative control by internal cues were investigated here in an instrumental discrimination problem in the runway. Blocking groups received large reward (L) in S+ and nonreward (N) in S− during Phase 1 and failed to learn about brightness when brightness cues were added as redundant, relevant discriminanda in Phase 2 and the reinforcement conditions remained the same as in Phase 1. Control groups received training with internal cues and brightness cues simultaneously and equally relevant either in Phases 1 and 2 or only in Phase 2. Brightness cues acquired substantial discriminative control in both control groups. Two unblocking groups received small reward (S) in S− in Phase 1, but otherwise were trained as the blocking groups were. The shift from S in S− to N in S− at the beginning of compound stimulus training attenuated the blocking effect in both unblocking groups.

Blocking refers to the observation that a group that first learns to respond to some stimulus, A, and then experiences another stimulus, X, only as a redundant source of information, that is, as part of an AX compound, learns less about X than does a control group given training only with the AX compound. In Pavlovian conditioning experiments on blocking, a surprising increase in unconditioned stimulus (US) intensity coincident with the beginning of AX training results in learning about X that otherwise would have been blocked (e.g., Kamin, 1969; Mackintosh & Turner, 1971), a phenomenon referred to as unblocking. Unblocking in Pavlovian conditioning also has been produced by the surprising addition of a second US or the omission of an expected, second US (Dickinson, Hall, & Mackintosh, 1976), by a change in US locus (Stickney & Donahoe, 1983), and by a memory reactivation treatment (Balaz, Gutsin, Cacheiro, & Miller, 1982; Schactman, Gee, Kasprow, & Miller, 1983).

The very considerable interest in treatments that produce unblocking is largely due to the fact that theoretical explanations of the blocking effect differ most with regard to predictions about conditions under which blocking will fail to occur. Thus, Wagner, Mazur, Donnegan, and Pfautz (1980) reported that a surprising decrease in US intensity at the beginning of AX training failed to produce unblocking, a result consistent with the Rescorla-Wagner model (e.g., Rescorla & Wagner, 1972), but at variance with theoretical formulations proposed by Logan (1977), Mackintosh (e.g., 1975), and Pearce and Hall (1980).

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The blocking effect has been demonstrated in instrumental conditioning in both the operant chamber (e.g., Miles, 1970; Neely & Wagner, 1974; Seraganian & vom Saal, 1969) and the runway (Capaldi, Verry, & Nawrocki, 1982; Haddad, Walkenbach, Preston, & Strong, 1981; Haggbloom, 1981), but there is no unequivocal evidence for unblocking in instrumental conditioning. Feldman (1971) and Neely and Wagner (1974) reported the only previous investigations of unblocking in an instrumental task. Neely and Wagner provided evidence that the unblocking effects obtained by Feldman and in two of their own experiments were due to generalization decrement brought about by a change in internal, reward-produced stimuli (Capaldi, 1967) accompanying the reward shifts.

Haggbloom (1981) reported that rats trained on a runway discrimination problem in which internal, reward-produced, and intertrial-interval(ITI)-related cues were relevant discriminanda and brightness cues were irrelevant discriminanda in Phase 1 failed to learn about brightness when brightness cues were added as redundant, relevant discriminanda in Phase 2. The experiment reported here investigated whether a surprising decrease in S− reward magnitude at the beginning of Phase 2 would produce unblocking in the task employed by Haggbloom (1981). The operation of reducing S− reward in a discrimination problem is viewed here as analogous to increasing US intensity in Pavlovian conditioning. The present study does not distinguish among the several alternative theoretical explanations of blocking and unblocking effects, but it does bear on the generality of the unblocking effect and on the applicability of those theories, developed largely in the context of Pavlovian conditioning, to instrumental conditioning situations.

There were six groups in the present experiment. Two blocking groups and a control group were trained as comparable groups employed by Haggbloom (1981) had been. A second control group received training in both Phases 1 and 2, with internal cues and brightness cues being relevant in both phases. Finally, two unblocking groups experienced a surprising reduction in S− reward magnitude at the beginning of compound stimulus training.

METHOD

Subjects

The 60 male rats used as subjects were bred in the laboratory from Holtzman stock.

Apparatus

The apparatus consisted of two black and white runways fully described elsewhere (Haggbloom, 1981). The alleys were divided into three sections over which running times were recorded (respectively, start, run, and goal time). Start times were recorded from the opening of the startbox door, which triggered a .01-sec clock, to a point 30 cm into the alley. Run and goal times were recorded over the next 40 and 30 cm, respectively. The offset of the first clock and the operation of the remaining clocks were controlled by photoelectric circuitry.

Procedure

The rats were housed in individual cages and had free access to water throughout the experiment. A food-deprivation schedule consisting of 12 g of Wayne Lab Blox per day was begun 14 days prior to the beginning of training. The deprivation schedule continued throughout the experiment; the amount of food consumed in the runway was subtracted from the daily ration. On each of Days 12-14 of deprivation, the rats were handled in squads of three for 3 min per squad. After being handled on each day, the rats received 10 45-mg Noyes food pellets in a small dish placed in their home cages. Phase 1 discrimination training began on Day 15 of deprivation.

A trial was initiated when the startbox door was opened approximately 3 sec after the rat had been placed in the startbox and regardless of the rat's orientation. A maximum time of 30 sec was allowed in each section of the alley. If 30 sec was exceeded in any alley section, the additional time was added to the time score of the next section forward. If the animal did not enter the goalbox within 90 sec, it was placed in the goalbox.

The rats were run in squads of five (Phase 1) or six (Phase 2 and test phase); each squad consisted of one rat from each group. All rats within a squad received Trial 1 each day before any rat received Trial 2, and so on. The squad-rotation procedures resulted in approximately a 4-min ITI between Trial 1 and Trial 2 and between Trial 3 and Trial 4. The ITI between Trial 2 (S+) and Trial 3 (S−) was 20 min. S+ reward consisted of 10 45-mg Noyes food pellets; small reward (S) in S− consisted of 2 pellets. On all reward trials, the rats were removed from the goalbox after the food had been consumed. On nonreward trials, the rats were confined to the unbaited goalbox for 20 sec.

Design

Phase 1. Groups C-I/N and V-I/N received two consecutive large-reward (L) trials separated by a 4-min ITI and followed 20 min later by two consecutive nonreward (N) trials separated by a 4-min ITI (LL ... NN sequence) daily. Groups C-I/S and V-I/S were trained like groups C-I/N and V-I/N, respectively, except that they received S on Trials 3 and 4 each day (LL ... SS sequence). One-half of the rats in Groups C-I/N and C-I/S received all of their Phase 1 trials in the black runway; the remaining rats in both groups received all of their Phase 1 trials in the white runway. In this way, brightness was made a constant-irrelevant (C-I) cue in Groups C-I/N and C-I/S. One-half of the rats in Groups V-I/N and V-I/S received their S+ trials (Trials 1 and 2 each day) in the black runway and their S− trials (Trials 3 and 4 each day) in the white runway on odd-numbered days; those conditions were reversed on even-numbered days. The counterbalanced condition held for the remaining rats in both groups. In this way, brightness cues were varied-irrelevant (V-I) in Groups V-I/N and V-I/S in Phase 1.

In all four groups, internal reward-produced cues and certain ITI-related cues were relevant in Phase 1. The S+ discriminanda consisted of ITI-related cues uniquely associated with the first trial of the day (Capaldi & Morris, 1974), which always predicted L on that trial, and the memory of large reward, S^L, occasioned on Trial 1, which always predicted L on Trial 2. The S− discriminanda consisted of within-day ITI-related cues accompanying Trial 3 (see Haggbloom, 1979), which predicted N for Groups C-I/N and V-I/N and S for Groups C-I/S and V-I/S on that trial; and the memory of nonreward, S^N (or small reward, S^S) occasioned on Trial 3, which always predicted N (or S) on Trial 4 in Groups C-I/N and V-I/N (or Groups C-I/S and V-I/S). A fifth group, Group E-CONTROL, received the LL ... NN sequence daily, with all L trials occurring in one runway and all N trials in the opposite runway so that both internal cues and brightness cues were relevant in Phase 1. There were 12 days of training in Phase 1.

Phase 2. Phase 2 training was identical to that given all five groups in Phase 1; a sixth group, Group CONTROL, began its training in Phase 2. Each group received the LL ... NN sequence daily, with all L trials occurring in one runway brightness and all N trials in the opposite runway. Thus, Groups C-I/S and V-I/S experienced a reduction in S− reward from S in Phase 1 to N in Phase 2. Both internal cues and brightness cues were relevant in Phase 2 for each group. Haggbloom (1981) reported that the blocking effect in the C-I condition was independent of whether the newly introduced brightness cue was added to the S+ or the S− stimulus compound. The newly introduced brightness cue became part of the S− compound in the C-I groups in the present experiment. Phase 2 lasted 8 days.

Test. A single opposed-cue test day, on which brightness cues were reversed for each of the six groups, followed Phase 2. Except for the reversal of brightness cues, procedures on the test day were identical to those in Phase 2.

RESULTS

All times in each alley section for each subject were converted to speeds in centimeters per second. Only total speeds, which are representative of responding in individual alley sections, are reported here. Because one subject in each of Groups V-I/S, C-I/S, and CONTROL died, all analyses are based on nine subjects per group for those groups.

Phase 1

Each of the five groups given Phase 1 training eventually ran slower in S− than in S+ by the end of Phase 1 (data not shown). As expected, discriminative responding was more pronounced in groups given N in S− than in groups given S in S−. The mean differences between S+ and S− speeds (in centimeters per second) on the last day of Phase 1 were 46.35 in Group C-I/N, 44.0 in Group V-I/N, and 66.16 in Group E-CONTROL, compared with 27.29 in Group C-I/S and 12.36 in Group V-I/S. An analysis of variance (ANOVA) with groups (5) and brightness (2) as between-subjects factors and discriminanda (2) and trials (2) as within-subjects factors was applied to speeds on the last day of Phase 1. Subsequent simple effects of discriminanda at each group showed that, for each group, S+ speeds were reliably faster than S– speeds [smallest $F(1,38) = 4.12$, $p < .05$, for Group V-I/S].

Phase 2

Haggbloom (1981) reported that the introduction of a novel brightness cue into the S– stimulus compound at the beginning of Phase 2 produced a marked reduction in S– speeds, a difference that gradually abated over the next several days of training, even though responding to the novel stimulus was never reinforced. A similar response decrement was obtained here in Groups C-I/N and C-I/S. Mean S– speeds in groups C-I/N and C-I/S decreased by 29.58 and 16.05 cm/sec, respectively, between the last day of Phase 1 and the 1st day of Phase 2. In contrast, S– speeds in Groups V-I/N and V-I/S showed little or no change (–6.16 and 4.82 cm/sec, respectively).

Phase 2/Test Phase

The difference between each subject's mean speed in S+ and S– was calculated for both the last day of Phase 2 and the test day. Figure 1 shows the mean of those difference scores on both days for Groups C-I/N and C-I/S and for the two control groups in the left panel, and for Groups V-I/N and V-I/S and the same two control groups in the right panel.

As can be seen in Figure 1, Groups E-CONTROL, C-I/N, C-I/S, and V-I/S attained substantial and comparable levels of discriminative behavior, and were discriminating somewhat better than Groups V-I/N and CONTROL, by the end of Phase 2. That brightness cues exercised substantial control over the discrimination in Groups E-CONTROL and CONTROL was indicated by the marked reduction in discriminative responding in those groups when brightness cues were reversed. The reversal of brightness cues had much less of an effect on discriminative responding in Group C-I/N and virtually no effect on behavior in Group V-I/N, suggesting that, as in comparable groups employed by Haggbloom (1981), the acquisition of stimulus control by brightness was substantially blocked in those groups by the prior acquisition of control by internal cues. The blocking effect in both the C-I and V-I conditions was attenuated by the reduction in S– reward at the beginning of Phase 2, as indicated by the intermediate level of performance of those groups on the test day.

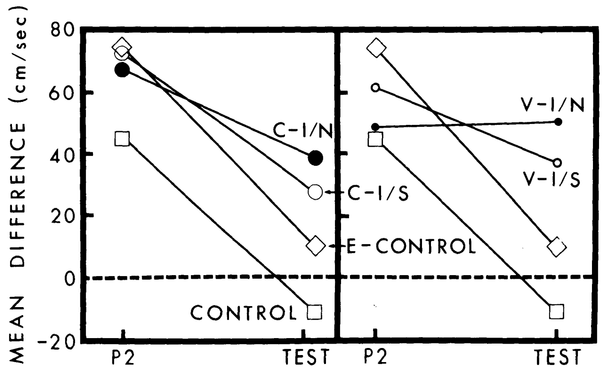

Figure 1. Mean difference between speeds in S+ and S– on the last day of Phase 2 (P2) and the test day (test) for the two control groups and the two groups in the C-I condition in the left panel and for the same two control groups and the two groups in the V-I condition in the right panel.

Separate ANOVAs with six levels of groups, but otherwise identical to the one applied to the data from the last day of Phase 1, were applied to speeds on the last day of Phase 2 and on the test day. Subsequent simple effects of discriminanda at each group showed that all groups ran reliably faster in S+ than in S– on the last day of Phase 2 [smallest $F(1,45) = 6.12$, $p < .05$, for Group CONTROL]. On the test day, Groups CONTROL ($F < 1$), E-CONTROL ($F < 1$), and C-I/S [$F(1,45) = 3.06$] all failed to run reliably faster in S+ than in S–. In the remaining groups, S+ speeds were faster than S– speeds [smallest $F(1,45) = 5.39$, $p < .05$, for Group V-I/S].

The effects of the reversal of brightness cues on the magnitude of discrimination on the test day were evaluated by a 6 (groups) x 2 (brightness) x 2 (phase) between-within ANOVA applied to the mean difference between each subject's speeds in S+ and S– on the last day of Phase 2 and on the test day. The ANOVA yielded a reliable groups x phase interaction [$F(5,45) = 4.89$, $p < .05$]. The simple effects of groups on both days revealed that there were no reliable differences among groups in discriminative behavior on the last day of Phase 2 [$F(5,45) = 1.78$], but that those group differences were highly reliable on the test day $F(5,45) = 5.13$, $p < .01$]. The change in discriminative behavior in each group from the last day of Phase 2 to the test day was evaluated by simple effects of phase at each group. These tests revealed a significant reduction in discriminative responding in each group [smallest $F(1,45) = 4.82$, $p < .05$, in Group V-I/S] with the exception of Group V-I/N ($F < 1$).

Planned comparisons between the mean difference scores of Groups CONTROL and E-CONTROL on the test day showed that the difference in magnitude of discriminative responding between those two groups was not reliable [$F(1,45) = 2.71$]. Subsequent planned comparisons between the mean difference score for each group and the pooled mean of the two control groups on the test day showed that the difference between Group C-I/S and the control groups was not reliable [$F(1,45) = 2.97$]. All other comparisons with the control groups were significant [smallest $F(1,45) = 5.20$, $p < .05$, for Group V-I/S]. The mean difference score in Group C-I/S on the test day did not differ from that in Group C-I/N ($F < 1$); the difference between Groups V-I/S and V-I/N, on the other hand, was reliable [$F(1,45) = 4.61$, $p < .05$].

DISCUSSION

The blocking effects obtained in Groups V-I/N and C-I/N in the present experiment are in complete agreement with those reported by Haggbloom (1981) in comparably trained groups. In both groups, given Phase 1 training in which internal cues were relevant and brightness was irrelevant, relatively little was learned about brightness in Phase 2 training in which brightness was added as a redundant, relevant cue, compared with the very substantial control exercised by brightness in both control groups.

Blocking was attenuated in Groups C-I/S and V-I/S. The reversal of brightness cues significantly disrupted discriminative responding in Group C-I/N as well as in Group C-I/S, but reliable discriminative responding was eliminated in Group C-I/S, and the mean difference score in that group did not differ from the pooled mean of the control groups on the test day. The reversal of brightness cues also disrupted discriminative responding in Group V-I/S, but did not do so in Group V-I/N. Moreover, the mean difference between S+ and S− speeds in Group V-I/S on the test day was reliably smaller than that in Group V-I/N. Thus, although the differences were not large, the reduction in S− reward appears to have resulted in unblocking in Groups C-I/S and V-I/S. This finding parallels the unblocking effect produced by a surprising increase in US intensity in Pavlovian conditioning (e.g., Kamin, 1969; Mackintosh & Turner, 1971).

As would be expected, the Phase 1 discrimination in Groups C-I/S and V-I/S was not as large as in groups given nonreward in S−. Nevertheless, internal cues clearly did acquire discriminative control over behavior in Phase 1 in those groups. Given the stimulus similarity between S^S and S^N (Capaldi, 1967), it was assumed here that control acquired in Phase 1 by S^S would readily generalize to S^N. It is, of course, possible that this did not happen and that unblocking here was due to generalization decrement brought about by a change in reward-produced cues (see Neely & Wagner, 1974). A generalization decrement explanation of the unblocking effects obtained here is discounted because the very substantial generalization decrement produced by the introduction of novel brightness cues in Group C-I/N here and in similar groups employed by Haggbloom (1981) did not prevent blocking. [Although the blocking effect here was smaller in Group C-I/N than in Group V-I/N, Haggbloom (1981) reported an equal blocking effect in those conditions]. Moreover, Group C-I/S experienced both stimulus-change conditions. If the attenuation of blocking due to the reward change were due to generalization decrement, greater control by brightness should have been acquired by Group C-I/S than by Group V-I/S. That, however, was not the case.

The reversal of brightness cues on the test day disrupted discriminative responding in Group E-CONTROL as much as in Group CONTROL. This result suggests that the blocking effects obtained here and in Haggbloom (1981) were not due to Phase 1 training per se or simply to extended training with relevant internal cues. Vom Saal and Jenkins (1970) similarly ruled out some nonspecific effect of Phase 1 training itself as a cause of blocking in instrumental conditioning.

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