Context-Specific Conditioning in the Conditioned-Emotional-Response Procedure

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In 3 experiments, rats were used to investigate the conditions that influence the transfer of a conditioned emotional response from 1 context to another. The subjects experienced training in 2 contexts on each day. In Experiment 1, subjects received a single conditioning trial with a different target stimulus in each of the 2 contexts. Conditioned responding was found to be more vigorous when the target was presented subsequently in the context in which conditioning had taken place than when it was presented in the other context. Experiments 2 and 3 confirmed these results and also showed that neither the unconditioned response evoked by the target stimulus nor the conditioned response acquired after multiple training trials showed evidence of context specificity. Possible reasons for the difference in outcome between single-trial and multitrial conditioning procedures are discussed.

It has often been suggested that contextual cues influence the retrieval of information about Pavlovian associative relationships (see, e.g., Bouton & Bolles, 1985; Medin, 1976; Miller & Schachtman, 1985; Spear, 1973). A prediction that follows from some versions of this suggestion (although not from associative treatments of the context's role; see Wagner, 1981) is that conditioned responding should be less vigorous when those contextual cues that were present during acquisition are absent at the time of testing. Several investigators have sought evidence for context specificity by using the conditioned emotional response (CER) paradigm; some have failed to detect any such effect (e.g., Bouton & King, 1983), and those studies that have found conditioned responding to be context dependent (e.g., Balaz, Capra, Hartl, & Miller, 1981; Balaz, Capra, Kasprow, & Miller, 1982) have proved susceptible to alternative explanations. In particular, as Lovibond, Preston, and Mackintosh (1984) pointed out, a loss of conditioned responding might occur simply because a change of context causes the conditioned stimulus (CS) to suffer generalization decrement. A novel test context will also (unlike the training context) have no associations with the unconditioned stimulus (US) and, to the extent that such associations contribute to the magnitude of the observed conditioned response (CR), some loss of responding might be expected on these grounds too.

Hall and Honey (1989; Experiment 3) conducted a CER experiment in which they attempted to eliminate the various complications noted by Lovibond et al. (1984). Rats initially received conditioning with one CS (X) in one context (A) and with a second CS (Y) in another context (B). This procedure ensured that the associative strengths of the two contexts would be equated. Subjects were then presented with, for example, Stimulus X either in Context A (the training context) or in Context B. This test revealed that the CR (the suppression of food-reinforced instrumental responding) was just as likely to occur in Context B as in Context A; that is, the CR showed no context specificity (see also Lovibond et al., 1984, Experiments 1c and 2). The absence of any effect in this experiment confirms what previous work had indicated (Hall & Honey, 1989, Experiment 1), that the particular stimuli used in this experiment do not suffer generalization decrement when presented in one context rather than the other.

Although the results just discussed are far from encouraging, it would be premature to reject entirely the suggestion that contextual cues can act to modulate the retrieval of associative information. Hall and Honey (1989) also reported the results of two experiments (Experiments 2 and 4) that were formally identical to the CER study just described, differing only in that an appetitive conditioning procedure was used. The CR (of approaching the site of food delivery) was much less vigorous when the test occurred in a context different from that used for initial training. Having ruled out alternative explanations, Hall and Honey (1989) concluded that, at least with their appetitive training paradigm, contextual cues aid the retrieval of associative knowledge acquired in their presence.

It now becomes necessary, therefore, to explain why no context specificity is found in studies using the CER paradigm. Our current theories for the effect provide no grounds for supposing that it will occur only with an associative training procedure; indeed, Bonardi, Honey, and Hall (in press) have recently provided evidence for context specificity in flavor-aversion learning. It seems possible, therefore, that the CER might be, in principle, as dependent on contextual cues as other conditioned responses but that some as yet undetected feature of the procedure might be acting to prevent the development or obscure the expression of this dependence. Accordingly, we conducted a series of experiments in which the standard CER procedure was modified in various ways. In our initial studies, we attempted to match as closely as possible (e.g., in trial duration, trial spacing, pretraining procedure) the CER procedure to that used in the appetitive conditioning experiments that were successful in revealing
context specificity. None of these manipulations resulted in the CER's showing context specificity. Accordingly, in the experiment to be described next, we adopted a quite different approach.

Experiment 1

A feature of the CER procedure, particularly when training is prolonged and relatively mild electric shocks are used (as in the experiments just described), is that the degree of suppression evoked by the CS increases to an asymptote and then declines (e.g., Schachtman, Channell, & Hall, 1987; Zielinski, 1966). Inspection of a variety of appetitive conditioning studies that have been performed in our laboratory (e.g., Channell & Hall, 1983; Hall & Honey, 1989) reveals that no equivalent effect is found when an appetitive conditioning procedure is used. One may speculate about the reasons for this difference (and we shall do so later in the General Discussion) but for now its significance is that it implies that prolonged CER training causes some new process to come into play that has no apparent equivalent in our appetitive conditioning procedures.

If this interpretation is correct, then it suggests that the strategy used in the previous experiments (of equating the aversive and appetitive procedures in as many ways as was feasible) might be inappropriate for detecting context specificity in the aversive case. Rather, we should perhaps concentrate on investigating the context specificity of the aversive CR that occurs early in training, before the processes responsible for the postasymptotic decline in suppression begin to exert their effect. Thus, rather than endeavoring to match in the aversive case the number of training trials used in the appetitive experiments, we should use the minimum number of trials capable of generating conditioning. Accordingly, in Experiment 1, we used the same general procedures as were used by Hall and Honey (1989, Experiment 3) but gave only one conditioning trial in each context. The magnitude of the US was increased to 0.75 mA to ensure that conditioned responding was established on this trial.

Subjects were given training sessions in each of two contexts on each day of the experiment. After baseline training, all subjects received a single presentation of Stimulus X followed by the delivery of shock in Context A and a single presentation of Stimulus Y followed by shock in Context B. In the test phase of the experiment, half of the subjects, those constituting Group S (same), were given nonreinforced test trials with Stimulus X in Context A and Stimulus Y in Context B. The rest of the subjects, those in Group D (different), received test trials with Stimulus X in Context B and Stimulus Y in Context A. If the conditioning generated by this training procedure shows context specificity, the subjects in Group D should show less profound suppression than those in Group S.

Method

Subjects

The subjects were 16 experimentally naive male hooded (Lister) rats, with a mean ad lib weight of 402 g (range = 385–420 g). The animals were maintained at 80% of their ad lib weights throughout the experiment by being given a restricted amount of food on each day.

Apparatus

Two pairs of identical standard Skinner boxes, supplied by Campden Instruments Ltd., were used. Each box had three walls of sheet aluminum, a grid floor, a transparent plastic door as the fourth wall, and a white translucent plastic ceiling. One wall, adjacent to the door, contained a recessed food tray, the opening to which measured 6 cm high by 5 cm wide and was guarded by a transparent plastic flap. This flap also measured 6 cm by 5 cm and was hinged to the top of the opening to the food tray. Pushing the flap inward from its vertical resting position allowed subjects to gain access to the food tray; such movements of the flap activated a microswitch, and each closing of the switch was recorded as a single response. The flap returned to its resting position when the rats removed their snouts from the food tray. Responses to this flap constituted the baseline operant response. Response levers that were fitted alongside the food tray were retracted throughout the experiment. Each of the boxes was housed in a sound- and light-attenuating shell and was brightly lit by a 30-W striplight (rated for 240 V but operated at 100 V) located above the ceiling. A speaker fitted to the rear wall of the box allowed presentation of auditory stimuli. The grid floor of the chamber could be electrified by means of a Campden Instruments shock generator (Model 521C) and scrambler (Model 521S).

The two pairs of boxes were differentiated in a number of ways. One pair was housed in a large experimental room, and a small amount of eucalyptus oil was added to the tray below the grid floor to provide a distinctive odor. For the other pair, the odor was that produced by the addition of iso-amyl acetate to this tray. The latter pair of boxes was housed in a smaller room in a different part of the laboratory. They were made visually distinctive by the addition of black and white checkered wallpaper to two walls of the box, the wall provided by the door and the rear wall of the box.

Two stimuli were available as CSs. One was the offset of the striplight for 30 s, and the other was a 30-s presentation of a 20-Hz train of clicks at an intensity of 82 dB (A). The two stimuli and the contexts were identical to those that were used by Hall and Honey (1989).

Procedure

On each day of the experiment, the animals received two training sessions—one in each of the contexts. These sessions were separated by approximately 4 hr. The context experienced in the morning will be referred to as Context A, and the context that was experienced in the afternoon will be referred to as Context B. Half of the subjects in each group experienced a given pair of boxes as Context A, and half experienced them as Context B. All sessions were 40 min in duration unless otherwise specified.

Pretraining. The rats were given 2 days of magazine training in which 45-mg food pellets were delivered on a variable-time 60-s schedule. During Day 1, the plastic flap covering the entrance to the food tray was fixed in a raised position, making it easier for the subjects to retrieve the food pellets. The flap was returned to its vertical resting position on Day 2, making it necessary for subjects to move the flap to gain access to the food tray when a food pellet had been delivered. On the next day, the rats were trained to press the flap to obtain food pellets on a continuous reinforcement schedule. After 75 reinforcers had been earned, the animal was removed from the box. Responding to the flap was reinforced on the next day according to a variable-interval 30-s (VI-30) schedule and on the final
day of pretraining according to a VI-60 schedule. This schedule remained in force throughout the rest of the experiment.

**Training and testing.** On the next day, subjects received a single conditioning trial with Stimulus X in Context A and a single trial with Stimulus Y in Context B. This trial was presented 10 min after the beginning of each of the sessions. The shock intensity was 0.75 mA, and its duration was 0.5 s. Following conditioning, there was a single baseline-recovery day during which subjects responded on a VI-60 schedule. On the next day, which was the test day, subjects received three nonreinforced trials with each stimulus. The interval between the onset of successive trials was 10.5 min, and the first trial occurred 10 min after the beginning of the session. Subjects in Group S received nonreinforced presentations of Stimulus X and Stimulus Y in Contexts A and B, respectively, and subjects in Group D were given presentations of Stimulus X in Context B and Stimulus Y in Context A. For one half of the subjects in each group, the click served as X and darkness served as Y, and for the remainder this arrangement was reversed.

Conditioning and test performance were assessed using a suppression ratio that took the form \( a/(a + b) \) in which \( a \) represented the number of responses made during the CS, and \( b \) represented the number of responses made during a period that immediately preceded the onset of the CS and was the same duration as the CS.

**Results and Discussion**

The data points of the left-hand side of Figure 1 represent the mean level of unconditioned suppression that was shown by subjects in Groups S and D on the conditioning trial. Inspection of the performance shown by subjects to the two stimuli, the click and the darkness, revealed that there were no systematic differences dependent on stimulus type. Similarly, there were no differences dependent on the contexts designated as A and B. Therefore, the data were pooled across stimulus type, and the contexts that were designated as A and B. It is clear from the figure that the groups did not differ in the level of unconditioned suppression on the conditioning trial. This impression was supported by statistical analysis (\( F < 1 \)). The rates of response during the prestimulus periods, with means of 23.12 rpm (responses per minute) for Group S and 21.87 rpm for Group D, also did not differ (\( F < 1 \)).

The scores on the right-hand side of Figure 1 represent the level of suppression on the three test trials. It is clear that suppression was greater following conditioning and that Group S showed a greater level of suppression than did Group D—a difference that was particularly marked on the first test trial. Statistical analysis largely confirmed these impressions. An analysis of variance (ANOVA) conducted with group and trials as factors revealed an effect of group, \( F(1, 14) = 3.14, p < .05 \) (one-tailed), an effect of trials, \( F(2, 28) = 3.46, p < .05, \) and no interaction between these two factors (\( F < 1 \)). Because the largest numerical differences between the groups was on Trial 1, we sought further statistical support for the apparent difference between Groups S and D by conducting a one-way ANOVA on this trial in isolation. This revealed a significant difference between the groups, \( F(1, 14) = 6.17, p < .05 \). The rates of responding during the prestimulus periods, with means of 24.38 rpm for Group S and 27.66 for Group D, did not differ significantly (\( F < 1 \)).

These results demonstrate, therefore, that CER conditioning can, in certain circumstances, show context specificity. The experimental design was formally identical to that used in previous CER experiments that have found nearly perfect transfer of the CR between training and test contexts. The effect observed here must depend, therefore, on the use of a procedure in which just one rather than many (Hall & Honey, 1989, Experiment 3 gave 24 trials with each stimulus) conditioning trials were given.

Before turning to more complex interpretations of these results, consideration should be given to the role of generalization decrement. If a change of context causes a change in the way that a CS is perceived, then a loss of suppression in Group D might be anticipated. We have already argued that such generalization decrement does not occur with the stimuli and contexts used in this experiment. But earlier studies that failed to reveal evidence of generalization decrement involved giving the subjects multiple exposures to the stimuli before the test session. If for some reason a change of context following just a single exposure was especially effective in inducing generalization decrement, then a reduction in the CR might be expected on this basis alone. It was necessary, therefore, to investigate directly the extent to which the training procedures of Experiment 1 resulted in generalization decrement. This was one of the issues taken up in the next experiment.

**Experiment 2**

The purpose of this experiment was twofold. First, it seemed important to attempt to replicate the central finding of Experiment 1, because this is, as far as we are aware, the only adequately controlled demonstration of context specificity in the CER paradigm. Accordingly, the training conditions for
Groups S and D matched those received by the groups with
the same designations in Experiment 1. Subjects in Group S
were given a single conditioning trial with Stimulus X in
Context A and with Stimulus Y in Context B; they subse-
quently received test trials with the stimuli presented in the
same contexts in which training had been given. Group D
subjects were given the same training regime but were tested
with Stimulus X presented in Context B and Stimulus Y in
Context A. On the basis of the results of Experiment 1, we
expected that Group S would exhibit a more vigorous CR
during the test trials than Group D.

The second purpose of the experiment was to address the
issue of generalization decrement. A further pair of groups,
Group S- and Group D-, was given the same training and
testing procedures as Groups S and D with the exception that
the training trials with Stimuli X and Y were nonreinforced.
The results reported by Hall and Honey (1989; Experiment
1) show that a single exposure to the events used as X and Y
stimuli results in the habituation of the unconditioned re-
se (UR) of suppression that they elicit. If, however, a
change in context results in generalization decrement, then
subjects will experience rather different stimuli on the test
trials from those to which they received habituation training.
A return of the UR should thus be evident in Group D-.
It would then be possible to argue that any loss of suppression
evident in Group D on the test session might also be a
consequence simply of generalization decrement.

Method

The subjects were 32 experimentally naive male hooded (Lister)
rats with a mean ad lib weight of 444 g (range = 400–495 g). They
were maintained in the same way as subjects in the previous experi-
ment.

Instrumental baseline training proceeded in the same way as in
Experiment 1. Subjects in Groups S and D were then given a single
conditioning trial; those in Groups S- and D- were given a single
nonreinforced presentation of Stimulus X in Context A and of
Stimulus Y in Context B. All of the subjects then received a baseline
recovery session in each of the contexts, during which they responded
on a VI-60 schedule. Subsequently, a series of three nonreinforced
test trials were given in Contexts A and B. For Groups S and S-,
the stimulus presented in Context A was X and that presented in Context
B was Y. In Groups D and D-, subjects were given presentations of
Stimulus X in Context B and Stimulus Y in Context A. Other details of
the procedure that have not been specified were identical to those
used in Experiment 1.

Results

The isolated points on the left side of Figure 2 represent the
mean level of unconditioned suppression shown by each of
the four groups during initial conditioning (or nonrein-
forced exposure for Groups S- and D-). As before, the scores
for the X and Y trials were pooled to produce the result shown
in the figure. It is clear that the groups did not differ in the
extent of unconditioned suppression shown on the condition-
ing trials. One of the animals in Group S- failed to respond
during the prestimulus periods and was therefore excluded
from statistical analysis. An unequal- n ANOVA conducted
on the suppression scores revealed no effect of group assign-
ment (F < 1). An equivalent ANOVA conducted on the rates
of response during the prestimulus periods (with means of
27.62 rpm for Group S, 26.00 for Group D, 20.28 for Group
S-, and 20.25 for Group D-) showed that these rates did not
differ, F(3, 27) = 1.76, p > .17.

The data points on the right side of Figure 2 represent the
mean level of conditioned suppression shown by Groups S
and D and the mean amount of unconditioned suppression
shown in Groups S- and D- across the three test trials. It is
apparent that the groups that had received reinforced pres-
entations of the target stimuli tended to show more suppres-
sion than the groups that had been given nonreinforced
training trials with these stimuli. There was little difference
between Groups S- and D- in the degree of unconditioned
suppression observed, but Group S exhibited substantially
more conditioned suppression on each of the three test trials
than did Group D.

This description of the data was supported by statistical
analysis. The data were subjected to an ANOVA, the factors
being whether the test context was the same as (Groups S and
S-) or different from (Groups D and D-) that used in
training, whether training had been reinforced (Groups S and
D) or nonreinforced (Groups S- and D-), and trials. This
analysis showed there to be an effect of reinforcement, F(1,
28) = 64.79, p < .01, an effect of context change, F(1, 28) =
8.01, p < .01, and an interaction between these two factors,
F(1, 28) = 4.99, p < .05. There was also an effect of trial, F(2,
36) = 13.06, p < .01. There were no other significant inter-
actions (F < 1).
A parallel analysis of the prestimulus response rates (means of 24.2 rpm for Group S, 31.16 for Group D, 28.12 for Group S−, and 26.5 for Group D−) revealed no significant main effects and no interaction among the factors (Fs < 1). The interaction of reinforcement history and context revealed in the analysis of the suppression scores was explored using the Duncan multiple-range test. This analysis showed that Groups S− and D− did not differ from one another but that both differed from Groups S and D on each of the three trials (largest p < .05). The analysis also showed that Groups S and D differed on each of the test trials: ps < .01 on Trials 1 and 2, and p < .05 on Trial three.

Discussion

The results of this experiment confirm the reliability of those of Experiment 1: Subjects that received training and testing in the same context (Group S) showed a more vigorous CR than did subjects that were trained and tested in different contexts (Group D). We have contrasted this success in demonstrating context-specific aversive conditioning following a single conditioning trial with a number of failures to demonstrate such context dependence when a multiple-trial conditioning procedure has been used (cf. Hall & Honey, 1989, Experiment 3; Lovibond et al., 1984, Experiments 1c and 2). One interpretation offered for this pattern of results was that generalization decrement might be especially likely when just one training trial is given. The results of Groups S− and D−, groups that received nonreinforced exposure to the target stimuli, provide no support for this analysis. Both groups showed initial unconditioned suppression in response to the target stimuli, but both showed habituation of this UR in that neither showed suppression on the test trials. Had a change of context produced generalization decrement, a return of the UR might be expected in Group D−, but group D− subjects were no more likely to show dishabitation of the UR following a single trial than were Group S− subjects.

The finding that habituation will transfer readily from one context to another is a result of some theoretical significance (see Hall & Channell, 1985, and Mackintosh, 1987, for a discussion of this issue) and, accordingly, we felt it worthwhile to conduct a further, small-scale, experiment to confirm its reliability and generality. Two further groups of 8 rats each (Groups S− U and D− U) were trained according to the procedures used for Groups S− and D− but with the following modification. On each of the preexposure sessions, a single shock was given 20 min after the start of the session and thus 10 min after the presentation of the target stimulus. The use of this unpaired procedure should preclude conditioning but allow us to assess habituation in animals given a treatment more closely matched to that of the conditioning groups.

The results for the new groups, S− U and D− U, turned out to be almost identical to those for Groups S− and D−. On the preexposure session, the mean suppression score was 0.33 for both Group S− U and Group D− U. Habituation was evident in that there was less suppression on the test day, but the two groups did not differ in this respect. The mean suppression scores for the three test trials for Group S− U were 0.46, 0.56, and 0.55; for Group D− S the scores were 0.45, 0.41, and 0.55. An ANOVA revealed no significant main effect of group and no interaction (Fs < 1). It may be added that the results of these unpaired groups demonstrate that the CS–US pairing experienced by Groups S and D was necessary for them to show suppression on the test and rules out the possibility that the effect seen in these groups was a consequence of shock-induced sensitization rather than true conditioning.

Experiment 3

The results of Experiments 1 and 2, combined with those of our previous work (both published and unpublished), point to the conclusion that the CER will show context specificity after one-trial conditioning but not with a multitrial procedure. Before starting to speculate on the reason for such a difference, we thought it important to confirm, in a single experiment, that the number of training trials (or some procedural concomitant of the number of trials) is indeed critical in determining whether context specificity will be observed.

Accordingly, the present experiment included four groups. The training conditions for Groups Single-S and Single-D matched those experienced by the S and D groups of Experiment 2. The second pair of groups (designated Multi-S and Multi-D) received training that was, insofar as possible, just the same as that given to the single-trial groups. The detailed procedures for the multitrial groups were the same as those used by Hall and Honey (1989) in their Experiment 3. If the results of this latter experiment are replicated, we can expect to find no difference in the test performance of Groups Multi-S and Multi-D. The single-trial groups, on the other hand, should differ, with Group Single-D showing less suppression on test than Group Single-S.

Method

The subjects were 32 experimentally naive male hooded Lister rats with a mean ad lib weight of 333 g (range = 290–370 g). They were maintained as were the rats in the previous experiments. The experiment lasted for 15 days. The 16 animals assigned to the multitrial groups received training every day in Contexts A and B. Over the first 5 days, the operant baseline response was established according to the procedures described for Experiment 1. There followed 8 days of aversive conditioning, each consisting of a three-trial session with Stimulus X in Context A and a three-trial session with Stimulus Y in Context B. The interval between successive trials was 10.5 min. The shock duration was fixed at 0.5 s but, following Hall and Honey (1989), the intensity was increased over the course of training from 0.1 mA on Days 1 and 2, to 0.15 mA on Days 3 and 4, and to 0.2 mA for the final 4 days of conditioning. The 16 subjects in the single-trial groups received no special training (apart from being handled and weighed daily) over the first 7 days of the experiment. Their 5 days of operant baseline training began on Day 8 of the experiment; conditioning (which consisted of exactly the same procedures as described for Experiment 2) thus occurred on Day 13, the final day of conditioning for the multitrial subjects. All subjects then received a baseline recovery day followed by the test day. The detailed procedures were just as described for Experiments 1 and 2, with one half of the subjects in each of the main groups (single and multitrial) being assigned to the S condition for the test and one half being assigned to the D condition.
Results and Discussion

Figure 3 shows the group mean suppression ratios for the last trial of conditioning (the only conditioning trial for the single-trial groups) and for the three test trials. As before, data were pooled across stimulus type and context type. The scores for the conditioning day for the single-trial groups represent unconditioned suppression evoked by the stimuli when first presented; those for the multitrial groups are the product of the previous 23 conditioning trials. Animals in the multitrial condition showed, on average, more suppression than those in the single-trial condition. In both of these conditions, however, the D group showed somewhat more suppression than the corresponding S group, presumably a chance occurrence because each pair of S and D groups had received identical treatment until this stage. Statistical analysis confirmed that the effect was unreliable. A factorial ANOVA of the suppression ratios (the factors being multitrial vs. single, and S vs. D) revealed no significant effect of the number of trials, F(1, 28) = 1.34, no significant effect of whether the subjects were to be assigned to the same or different test condition, F(1, 28) = 1.29, and no significant interaction (F < 1). Perhaps not surprisingly, because they had more extensive baseline training, animals in the multitrial condition had higher baseline response rates than those in the single-trial condition. The mean prestimulus response rates were 39.87 rpm in Group Multi-S, 45.12 rpm in Group Multi-D, 27.62 rpm in Group Single-S, and 27.25 rpm in Group Single-D. A factorial ANOVA showed there to be a significant effect of the number of trials, F(1, 28) = 10.35, p < .01; no other effect was significant (Fs < 1).

We were aware when designing the experiment that the different amounts of baseline training given to the single- and multitrial groups might result in differing baseline response rates. Giving extra training to the single-trial groups, however, would have entailed giving them extensive experience of the contexts in the absence of conditioning trials. We decided to avoid this latter complication and to allow for the possibility that baseline rates would differ.

The test data, shown in Figure 3, replicate for the single-trial groups the effect demonstrated in Experiments 1 and 2. Thus, Group Single-D showed less suppression than Group Single-S, and this was in spite of the fact (numerically at least) that the degree of unconditioned suppression evoked by the test stimuli tended to be greater in Group Single-D than in Group Single-S. (One animal in each of the single-trial groups failed to emit the baseline response during the test, and the mean scores shown in the figure are based on the remaining 7 subjects.) The test performance of the multitrial groups, by contrast, simply reflected directly on the degree of suppression evident on the last day of conditioning, with Group Multi-D continuing to show somewhat more suppression than Group Multi-S.

An unequal-n ANOVA was conducted on the Figure 3 test data. The factors were amount of training (single or multitrial), test context (S or D), and trial. There was a significant effect of test trial, F(2, 52) = 5.63, p < .01, reflecting the loss of suppression that occurred in all groups over the course of the test, a significant effect of amount of training, F(1, 26) = 10.19, p < .01, and, more important for our present concerns, a significant interaction between amount of training and whether the context was S or D, F(1, 20) = 5.01, p < .05. This interaction reflects the fact that for the single-trial groups, Group S showed more suppression than Group D, whereas for the multitrial groups the difference was, if anything, reversed. No other main effect or interactions were statistically reliable, all Fs < 1.

Interpretation of the interaction is complicated by the fact that baseline response rates continued to be higher in the multitrial groups than in the single-trial groups. The mean response rates pooled over all test day prestimulus response periods were 44.17 rpm in Group Multi-S, 47.75 rpm in Group Multi-D, 20.42 rpm in Group Single-S, and 22.9 rpm in Group Single-D. An ANOVA showed a significant effect of amount of training, F(1, 26) = 18.12, p < .01, but no effect of the S versus D factor and no significant interaction between the factors (Fs < 1). Accordingly, separate analyses were conducted comparing the suppression scores (pooled over all test trials) for the pairs of groups (i.e., the two multitrial and the two single-trial groups) that had equivalent baseline rates. Groups Single-S and Single-D differed reliably, F(1, 12) = 5.20, p < .05, but there was no reliable difference between Group Multi-S and Group Multi-D, F(1, 14) = 1.99.

The results of this experiment allow the conclusion, already suggested by our previous work, that the CER will show context specificity when it has been established by a single conditioning trial but that it will transfer from one context to another when a multitrial procedure has been used in initial acquisition. Possible reasons for this difference are considered in the following General Discussion.
General Discussion

Hall and Honey (1989) presented a series of experiments investigating the notion that contextual cues influence the retrieval or use of associative information. These studies demonstrated that, other things being equal, evidence of a CS–food association was less likely when training and testing took place in different contexts than when they occurred in the same context. This finding is in accord with the suggestion that contextual cues modulate the efficacy of associative links. However, there was no indication that CS–shock associations were influenced by the context in which testing was given. The CR, conditioned suppression, was no more likely when the CS was presented in the training context than when it was presented elsewhere (see also Lovibond et al., 1984).

The present series of experiments demonstrates that there is no reason in principle why the CER procedure should fail to show contextual specificity. Although no effect was seen in the multitrial conditioning groups of Experiment 3 (replicating the results of previous studies), context specificity was observed when the procedure was modified so that the subjects were given just one conditioning trial with each of the target stimuli. We must now try to specify what feature of the single-trial procedure makes it susceptible to the effects of context change when the multitrial procedure is not.

There are many differences between the single-trial and the multitrial procedures, in addition to the number of conditioning trials per se. Thus, the multitrial groups of Experiment 3 received more exposure to the CSs and the contexts than did the single-trial groups and had much higher baseline response rates. Although the levels of suppression shown on the test trials were roughly equivalent, this was achieved by using a much weaker shock for the multitrial procedure than that used for the single-trial procedure. With the shock levels used here, recovery from suppression starts to occur by the end of training in the multitrial condition, something not possible with the single-trial procedure.

Which, if any, of these factors is responsible for the difference in context specificity can be determined only by further experimental work. Such work might start by concentrating on the implications of the last of these factors, because it is possible to devise some theoretical reason as to why it might influence context specificity. One possible interpretation of the loss of conditioned suppression observed with extended training is that repeated presentation of shock allows the development of some "slave" process ("relief") that opposes the state of "fear" that is evoked by shock (Solomon & Corbit, 1974). Late in training, the development of a CS–relief association would act to diminish the degree of suppression evoked by the CS–fear association. If it is assumed that these associations, like others (e.g., between CS and food), are context specific, it is possible that there will be little net change in the CR when a well-trained CS for shock is presented in a context different from that used for training. To the extent that the association with fear is less well retrieved, the animal will be less likely to show the CR of suppression; however, to the extent that the association of the CS with relief is also less readily available, the animal will be more likely to show the CR. There is one circumstance, however, in which context specificity might be observed, even with a shock as the US. Because the state of relief is assumed to be relatively weak early in training, the CR seen at this stage would be governed primarily by the CS–fear association. If very few conditioning trials are given, the only (relevant) effect of changing context will be to make the CS–fear association less effective, and thus a loss of conditioned suppression would result. This was, of course, the effect observed in our single-trial conditioning experiments.

No doubt, it will require further empirical evidence in its favor if the opponent-process account just outlined is to gain acceptance. But irrespective of the fate of this particular interpretation, the basic findings on which it is based will remain. They are, to summarize, that given appropriate conditions of training, CER conditioning can show contextual specificity that (a) cannot be explained away as an artifact of generalization decrement and (b) is most readily interpreted in terms of the suggestion that the contextual cues present during conditioning facilitate the retrieval of relevant information when they are also present on test.

References


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