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Learned Irrelevance: No More Than the Sum of CS and US Preexposure Effects?

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In the 1st experiment, 1 group of rats (Group Learned Irrelevance [LIRR]) experienced uncorrelated presentations of a noise and shock; a 2nd group (Group Control [CON]) experienced noise and shock in separate phases of training. Six conditioning sessions followed, each consisting of a single noise–shock pairing. Group LIRR conditioned to the noise more quickly than Group CON. The 2nd experiment was identical to the 1st, except that rats were given 6 noise–shock pairings in each conditioning session. In this experiment, Group LIRR learned more slowly than Group CON. These results suggest that learned irrelevance is in part the product of context specificity of latent inhibition, in which the context is the aftereffect of shock presentation. The implications of this for theories of learned irrelevance are discussed.

Classical conditioning of an association between a conditioned and an unconditioned stimulus (CS and US, respectively) can be greatly retarded if the animal has experienced uncorrelated presentations of those stimuli prior to the conditioning stage (e.g., Baker & Mackintosh, 1977; Kremer, 1971; Mackintosh, 1973). This effect has been called *learned irrelevance* (e.g., Mackintosh, 1973). It has been suggested that uncorrelated presentations of the CS and US allow the animal to learn that CS and US are specifically unrelated to each other. For example, Mackintosh (e.g., 1973, 1975) has argued that the associability of the CS for that particular US falls as a result of their uncorrelated presentations. Alternatively, Baker (e.g., 1976) has suggested that the animal might learn explicitly about the absence of a correlation between the two stimuli and that this interferes with subsequent learning about a positive correlation between them. Both of these proposals are interesting because they suggest that learned irrelevance is the product of a type of learning not anticipated by current theories.

Before introducing a special process to explain learned irrelevance, it is, however, necessary to demonstrate that the effect is not to be explained in terms of simpler mechanisms. For example, preexposure to a CS will retard conditioning to that stimulus, the phenomenon known as *latent inhibition* (e.g., Lubow, 1973; Lubow & Moore, 1959). Preexposure to the US can also retard subsequent conditioning (e.g., Kremer, 1971; Mis & Moore, 1973; Randich & LoLordo, 1979). It is incumbent, therefore, on those who postulate the existence of a mechanism for learning about irrelevance to demonstrate that the phenomenon is not simply the sum of these CS and US preexposure effects (e.g., Baker & Mackintosh, 1977). The evidence on this matter is not compelling. It has been demonstrated on a number of occasions that learned irrelevance training produces a greater retardation of conditioning than exposure to either CS or US alone (e.g., Baker & Mackintosh, 1977; Mackintosh, 1973), but this does not bear directly on the claim that learned irrelevance is more than the sum of the two effects. Of the few studies that have addressed this question (Baker & Mackintosh, 1979; Bennett, Maldonado, & Mackintosh, 1995; Matzel, Schachtman, & Miller, 1988), perhaps the most convincing was that recently reported by Bennett et al. (1995). They compared two groups of animals, one of which was given learned irrelevance training. The control group received the same total exposure to the CS and the US, but experienced those events in separate blocks of sessions. Both then received CS–US pairings in a subsequent training stage, and the rate of conditioning was compared in the two groups. As the control group received the same total exposure to CS and US as did the experimental animals, the retardation of learning produced by latent inhibition and the US preexposure effect should have been the same in the two groups. It is unlikely, on the other hand, that the control animals could learn specifically about the absence of a relationship between the CS and the US. Thus, if learned irrelevance is more than the sum of the CS and US preexposure effects, the irrelevance group should condition worse than the control group. This was just the effect that was observed.

Although this result is consistent with the suggestion that animals can learn that two stimuli are unrelated, it is open to an alternative interpretation. Latent inhibition is known to be context specific. If a CS is preexposed in one particular context, subsequent conditioning to that stimulus will be slow if it takes place in the preexposure context, but this latent inhibition effect will be attenuated if conditioning occurs in some other context (e.g., Channell & Hall, 1983;

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Hall & Channell, 1986; Lovibond, Preston, & Mackintosh, 1984). Although context is usually taken to mean the apparatus in which the CS is presented, it could refer to other aspects of the environment. For example, reinforcer presentation is a motivationally significant event that will elicit a complex of behavioral and emotional responses in the animal. This state produced by the reinforcer might be a salient enough stimulus to act as a contextual cue, so that the latent inhibition accruing in the presence of such a cue might become dependent on its presence (cf. Bouton, Rosengard, Achenbach, Peck, & Brooks, 1993). It has been suggested that such an analysis could explain learned irrelevance (e.g., Baker & Mackintosh, 1979; Hall, 1991). During irrelevance training CSs and USs are preexposed in the same session, so that latent inhibition to the CS could become conditional on the aftereffects of the US; the same will not be true in a standard latent inhibition procedure, in which the CS is preexposed in the absence of the US. As the conditioning procedures used to detect learned irrelevance typically use multiple conditioning trials per session (Baker & Mackintosh, 1977, 1979; Bennett et al., 1995; Mackintosh, 1973; Matzel et al., 1988), CS–US pairings will also usually occur in the presence of US aftereffects. It follows that the transition from preexposure to conditioning will be accompanied by a context change for animals given standard latent inhibition training, but not for animals given irrelevance training. This will result in slower conditioning in animals given irrelevance training than in those given latent inhibition training.

This analysis can explain the results reported by Bennett et al. (1995). They argued that because uncorrelated presentations of CS and US produced a more profound retardation of conditioning than separate CS and US preexposure, the uncorrelated presentations must allow the animal to learn that CS and US are unrelated. The analysis outlined above, however, suggests a simpler explanation. Animals given uncorrelated CS and US presentations during preexposure were both preexposed and conditioned in the presence of US aftereffects. As preexposure and conditioning to the CS occurred in the same context, these animals would be expected to show a profound latent inhibition effect. In contrast, animals in the control condition were given CS and US preexposure in separate blocks of sessions and were therefore preexposed to the CS in the absence of the US, but conditioned in the presence of US aftereffects. This context change would be expected to attenuate latent inhibition to the CS and so could explain the superior acquisition that was observed in this group.

The aim of the present experiments was to discriminate between these two interpretations of Bennett et al.'s (1995) results. In Experiment 1, we followed Bennett et al.'s procedure in that one group of animals received learned irrelevance training, and the other experienced the same number of CS and US presentations, but in separate blocks of sessions. Our procedure differed from theirs in the test phase, in which we gave animals only one conditioning trial per session, so that each conditioning trial occurred in the absence of US aftereffects. We anticipated that all animals would become latently inhibited to the CS, and that this latent inhibition would become conditional on the presence of US aftereffects in the irrelevance group. However, because in our experiment conditioning occurred in the absence of US aftereffects, animals in the irrelevance group were preexposed in the presence of US aftereffects and conditioned without them. They should have therefore experienced a greater change of context than animals in the control group, who were both preexposed and conditioned in the absence of US aftereffects. It follows that the irrelevance group should have shown a greater attenuation of latent inhibition, and hence better learning, than the animals in the control group. In contrast, if animals in the irrelevance group could learn that CS and US are unrelated during the preexposure phase, this should be manifested as retarded conditioning regardless of the number of trials per session delivered during conditioning. In summary, the context-specificity account predicts the reverse of the learned irrelevance account—better conditioning in the irrelevance group than the control group. The first experiment was designed to examine this prediction.

Experiment 1

In Experiment 1, we used two groups of rats that were preexposed to both a noise CS and a shock US. All animals experienced the same number of noises and of shocks during this phase, but the manner in which these events were scheduled differed in the two groups. One group of rats (Group Learned Irrelevance [LIRR]) received standard irrelevance training. Thus, for these animals noise and shock were presented, explicitly uncorrelated, in the same sessions. Another group of rats (Group Control [CON]) provided a control for CS and US preexposure effects; these animals were first given a number of sessions of CS preexposure and then the same number of US preexposure sessions. Then all animals were conditioned with a single noise–shock pairing per session, and the rate of conditioning was compared in the two groups.

Method

Subjects

The subjects were 16 naive male hooded Lister rats (*Rattus norvegicus*) with a mean ad-lib weight of 394 g (range = 350–444 g) that were housed in pairs in plastic tub cages with sawdust bedding. The colony rooms were lit from 8 a.m. to 10 p.m.; the rats were tested during the light portion of the cycle. Before the start of training they were reduced to 80% of their ad-lib weights and were maintained at this level for the rest of the experiment by being fed a restricted amount of food at the end of each session.

Apparatus

The apparatus consisted of four Campden Instruments (Loughborough, England) operant chambers. Each of the boxes had three walls of sheet aluminum, a transparent plastic door as the fourth wall, and an aluminum ceiling. Each of the boxes contained a recessed food tray to which 45-mg mixed-composition food pellets could be delivered; this was situated in the center of one of the walls, adjacent to the door. Access to this food tray was by means of a rectangular aperture 6 cm high × 5 cm wide, which was covered by a transparent plastic flap of the same dimensions. A speaker was mounted on the wall of the chamber through which an 80-dB(A) white noise could be delivered from a Campden Instruments noise generator. The floor was constructed from stainless-steel rods 0.5 cm in diameter and 1.5 cm apart; these could be electrified by a Grason-Stadler (W. Concord, MA) shock generator. The boxes were housed in sound- and light-attenuating shells; masking noise was provided by the operation of ventilating fans contained in these shells. The apparatus was controlled by a microcomputer programmed in a version of BASIC.

Procedure

Baseline training. In the first 40-min session, animals were trained to retrieve pellets from the food tray; pellets were delivered according to a variable time 60-s schedule during this session. In the second session, animals were rewarded for pressing the magazine flap according to a continuous reinforcement schedule until they had made a total of 75 responses.

All subsequent sessions were 40 min in duration. In the third session, flap pressing was reinforced according to a variable-interval (VI) 30-s schedule. In the remaining four sessions of this stage and throughout the remainder of the experiment, flap pressing was rewarded according to a VI 60-s schedule.

Preexposure. At this point the rats were randomly assigned to one of two groups and preexposed to the noise and the shock. All noise presentations were of 1-min durations. In the first session in which shocks were presented, the shock intensity was 0.3 mA and in all subsequent sessions 0.4 mA. This gradual increase was to help maintain the animals' baseline responding. The duration of the shock was 0.5 s throughout the experiment.

Noise and shock presentations for Group LIRR were scheduled in the following manner. The first 40-min session of preexposure was divided into 1-min bins, and noise presentations were programmed to occur in six random bins over the course of the session, with the constraint that noises could not occur in consecutive bins. This process was repeated for the remaining seven sessions of preexposure received by these rats. Shock presentations were programmed in exactly the same way, but with the additional constraint that there should be a total of eight noise–shock pairings over the course of the eight preexposure sessions. This was to ensure that the conditional probability of shock presentation was not greater in the absence of the noise than in its presence. Shock presentations occurred in an added 0.5 s after the bin in which they were programmed to occur. Thus the shock could occur immediately before or after, but not during, the noise. In the preexposure stage, rats in Group LIRR received eight sessions of baseline training followed by eight sessions of preexposure in which they received the uncorrelated schedule of noise and shock presentations just described. Group CON received exactly the same schedule of shock delivery as Group LIRR and exactly the same schedule of noise presentations. However, for these rats noise and shock were presented in separate sessions. Thus, in the first eight sessions of preexposure, rats in this group received preexposure to the noise, and in the second eight sessions they received preexposure to the shock.

Baseline recovery. At this point all rats were given two sessions with no noise or shock presentations, in order to allow recovery of baseline responding.

Conditioning. Each of the six conditioning sessions consisted of one conditioning trial. Each trial comprised a 60-s presentation of the noise followed immediately by a 0.5-s, 0.4-mA shock. This trial occurred in a random bin during the session, with the constraint that it was preceded by a 60-s pre-CS period (see below).

Data treatment. In both experiments, flap pressing was recorded during each CS presentation and during the pre-CS period, the 60-s bin that immediately preceded the onset of the CS. In order to evaluate the conditioned fear commanded by the CS during conditioning, conditioned suppression was computed using a suppression ratio of form $a/(a + b)$, in which b was the pre-CS score and a was the CS score, for that session. Two rats, one in each group, failed to make any responses during the pre-CS period in one of the six conditioning sessions. The appropriate group mean was substituted for these rats' scores in the analyses that were performed. Inspection of the data revealed that there were sometimes differences in suppression according to the box in which the rats were trained. Accordingly, box, which was fully counterbalanced across all groups, was included as a factor in the analyses of this and the following experiments. Finally, a significance level of $p < .05$ was adopted throughout.

Results and Discussion

Responding during the conditioning sessions for the two groups is shown in Figure 1. Responding on the first trial of conditioning is of interest as it reflects the effect of the preexposure treatments on suppression to the noise. It is clear that the noise did not command suppression in either group, but actually elevated responding to some extent, and this effect was slightly greater in Group LIRR. An analysis of variance (ANOVA) with group and box as factors revealed that this apparent difference was not significant ($Fs < 1$). However, this conclusion is complicated by the fact that the rate of pre-CS responding was greater in Group CON than in Group LIRR. The pre-CS response rates for

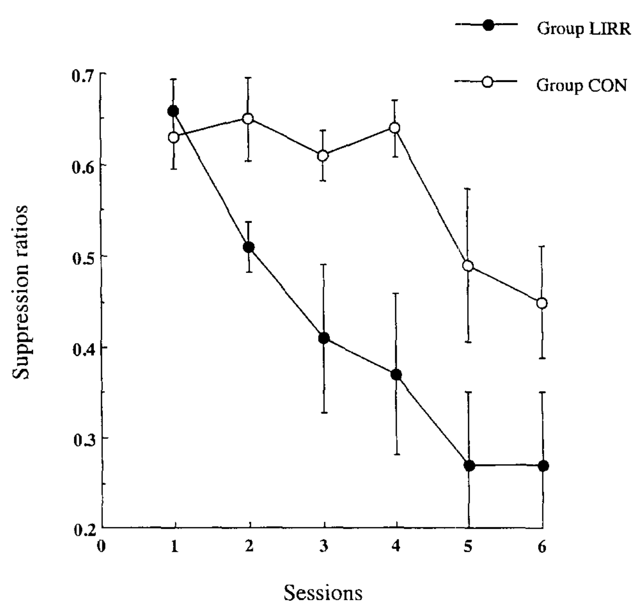

Figure 1. Mean suppression ratios for Group LIRR and Group CON, in the six test sessions of Experiment 1. The bars show standard errors. LIRR = learned irrelevance; CON = control.

this trial were 7.88 responses per minute (rpm) for Group LIRR and 16.75 rpm for Group CON. An ANOVA with box and group as factors revealed that these scores differed significantly, $F(1, 8) = 8.80$; nothing else was significant, largest $F(3, 8) = 1.83$.

Although the two groups seemed not to differ on the first trial, it is clear from the figure that thereafter Group LIRR conditioned faster than Group CON. This impression is supported by the results of an ANOVA with group, box, and sessions as factors. This revealed a significant effect of group, $F(1, 8) = 7.41$, and of sessions, $F(5, 40) = 7.38$; nothing else was significant, largest $F(5, 40) = 1.56$. The mean pre-CS scores for the test sessions are shown in Table 1. An ANOVA with group, box, and sessions as factors revealed no effect of group ($F < 1$). However, there was a significant main effect of box and of sessions, $F(3, 8) = 7.25$ and $F(5, 40) = 7.05$, respectively, and a significant Group × Sessions interaction, $F(5, 40) = 2.60$. Nothing else was significant, largest $F(15, 40) = 1.36$. Simple main effects performed on the Group × Sessions interaction revealed that pre-CS rates differed marginally in significance on Session one, $F(1, 29) = 4.13$, $p = .051$, but not on any other session, largest $F(1, 29) = 1.97$. The results of this analysis suggest that the difference in suppression between the two groups was not an artifact of differences in pre-CS responding.

The results of this first experiment support the predictions of the context-specificity interpretation of learned irrelevance by showing that Group LIRR learned faster than Group CON. This is consistent with our suggestion that the latent inhibition accruing to the CS in Group LIRR is conditional on the presence of US aftereffects, whereas that in Group CON is not. In our experiment, the CS was conditioned in the absence of such aftereffects, so that Group LIRR experienced a context change between preexposure and conditioning, whereas Group CON did not. Thus, latent inhibition would have been selectively attenuated in Group LIRR, producing the faster conditioning that was observed. The traditional irrelevance account would, in contrast, be constrained to predict worse conditioning in this group.

This experiment did not include any rats for whom both CS and US were novel during the conditioning stage, and so we have no direct evidence that our irrelevance training procedure retarded the acquisition of conditioned responding compared with such a control. We did not include this control condition because our account does not require that it should differ from a group given irrelevance training. Our reasoning is that rats given irrelevance training experience a substantial change of context when they are subsequently conditioned with one trial per session, and in principle it is possible that latent inhibition is completely eliminated by this context change. Nevertheless, as rats given irrelevance training are also exposed to the US, this might still result in a retardation of conditioning by means of the US preexposure effect (e.g., Kremer, 1971; Mis & Moore, 1973; Randich & LoLordo, 1979). But the US preexposure effect is also, in part, specific to the context in which preexposure occurs (Matzel, Brown, & Miller, 1987; Randich & LoLordo, 1979). Thus, if the US aftereffects that serve as the effective context for latent inhibition training also serve as part of the context in which the US is preexposed, then the context change produced by the switch to the one-trial conditioning procedure could eliminate the US preexposure effect as well as latent inhibition. We would, therefore, have no difficulty in explaining the observation that the irrelevance group conditioned as fast as rats given no preexposure at all.

There is an alternative interpretation of our results. A proponent of the irrelevance account might argue that the schedule of uncorrelated CS and US presentations that we used did not allow the rats to learn about the absence of a relationship between the CS and US, but instead simply made the noise slightly excitatory compared with that in the control group. This would also tend to make conditioning faster in Group LIRR. We think it unlikely that this is an appropriate explanation of our data. At the start of conditioning there was no sign in either group that the noise had any excitatory strength; on the contrary, the rats responded slightly more during the noise than in its absence. Moreover, this elevation effect was, if anything, more profound in Group LIRR than in Group CON. Still, it is possible that responding on the first trial of conditioning was not a sufficiently sensitive measure of conditioning to the noise, particularly in view of the fact that the pre-CS response rates differed on this trial. Therefore, Experiment 2 was in part designed to provide evidence against this interpretation.

Table 1
Group Mean Pre-CS Response Rates in the Six Test Sessions of Experiment 1

Group	Session 1	2	3	4	5	6
Learned irrelevance	7.88	11.38	27.38	16.50	21.00	21.13
Control	16.75	14.13	21.88	15.25	14.88	18.63

Note. CS = conditioned stimulus.

Experiment 2

One aim of Experiment 2 was to replicate the results of Experiment 1. Thus, two groups of rats were again preexposed to noise and shock. For Group LIRR-ONE these events were presented uncorrelated in the same sessions, whereas for Group CON-ONE they were presented in separate sessions. These rats were then conditioned, as in Experiment 1, with one trial per session. Two further groups, LIRR-MULTI and CON-MULTI, were treated identically to the one-trial groups during preexposure, but were given multitrial sessions of conditioning during the test phase.

According to the context-specificity account, the more similar the preexposure and conditioning contexts, the more latent inhibition will be able to transfer, and so the slower conditioning will be. As we have seen, this account predicts that conditioning will be more rapid after learned irrelevance training when each conditioning session comprises only one trial. But when conditioning sessions involve multiple trials, the conditioning trials will occur in the presence of US aftereffects, so that the conditioning context will resemble the preexposure context more in Group LIRR than in Group CON. Thus, this account predicts slower conditioning in Group LIRR with the multitrial procedure, but faster conditioning in this group with the one-trial procedure. The irrelevance account, in contrast, must predict slower learning in the irrelevance group regardless of the conditioning procedure used.

Method

Subjects and Apparatus

The subjects were 32 naive female hooded Lister rats (*Rattus norvegicus*) with a mean ad-lib weight of 198 g (range = 185–225 g). They were housed and maintained exactly as in Experiment 1. The apparatus was the same as that used in Experiment 1.

Procedure

Baseline training. This was identical to that in Experiment 1.

Preexposure and baseline recovery. Both these phases were the same as in Experiment 1 with the exception that, because of problems with the apparatus, we turned the shock up by 0.1 mA in one of the chambers. On the first session with shock delivery, the shock was therefore 0.4 mA in this chamber and in the remaining sessions 0.5 mA.

Conditioning. At this point both Group LIRR and Group CON were divided into two further groups. One of each pair, Group LIRR-ONE and CON-ONE, received one-trial conditioning exactly as in Experiment 1. The other two subgroups, Groups LIRR-MULTI and CON-MULTI, were given multitrial conditioning. For the multitrial groups there were six trials per session, each consisting of a 60-s noise presentation immediately followed by shock. These trials occurred at random intervals during the session, with the constraints that the onset of one trial did not occur less than 3 min after the offset of the previous one, and that each CS was preceded by a 1-min pre-CS period. There were six sessions in this stage.

Results and Discussion

Responding during the first trial of conditioning was examined separately to permit an evaluation of the effect of the preexposure treatments on suppression to the noise. The mean suppression ratio on this trial was 0.63 for Group LIRR-ONE and 0.52 for Group CON-ONE. The corresponding means for Groups LIRR-MULTI and CON-MULTI were 0.58 and 0.59, respectively. Thus, the noise tended to produce a slight elevation of responding in all groups. The two multitrial groups did not differ substantially in this respect, but in the one-trial groups, animals responded slightly more during the noise in Group LIRR. However, statistical analysis revealed that none of these effects were significant. An ANOVA with conditioning (one-trial or multitrial), preexposure (irrelevance or control), and box as factors revealed no significant effects or interactions, largest $F(3, 16) = 1.76$. The rates of pre-CS responding on this first trial were 20.5 rpm for Group LIRR-MULTI, 17.25 rpm for Group CON-MULTI, 17.75 rpm for Group LIRR-ONE, and 22.50 rpm for Group CON-ONE. An ANOVA performed on these data with preexposure, conditioning, and box as factors revealed a significant main effect of box, $F(3, 16) = 7.07$. No other effects or interactions were significant, largest $F(3, 16) = 2.75$. Thus, the difference in baseline rates that was observed on the first trial of Experiment 1 was no longer present in this experiment. This suggests we can be confident that the various groups were responding similarly to the noise at the start of conditioning. We may therefore conclude that any effect observed during the test may be unambiguously attributed to differences in conditioning among the various groups.

Responding during the conditioning sessions for the one-trial groups is shown in Figure 2 and for the multitrial groups in Figure 3. First, consider the rats conditioned with one trial per session. Although on the first trial Group LIRR-ONE responded slightly more than Group CON-ONE, on the second this pattern had reversed and, except during session 4, Group LIRR remained more suppressed than Group CON for the rest of conditioning. This replicates the finding of Experiment 1: If conditioning is conducted using a one-trial procedure, rats given irrelevance training will condition faster than controls.

Now consider Figure 3, which depicts the corresponding data for the rats given multitrial conditioning. In the first session there was no difference between the two groups, but a difference emerged in Session 2, in which Group LIRR-

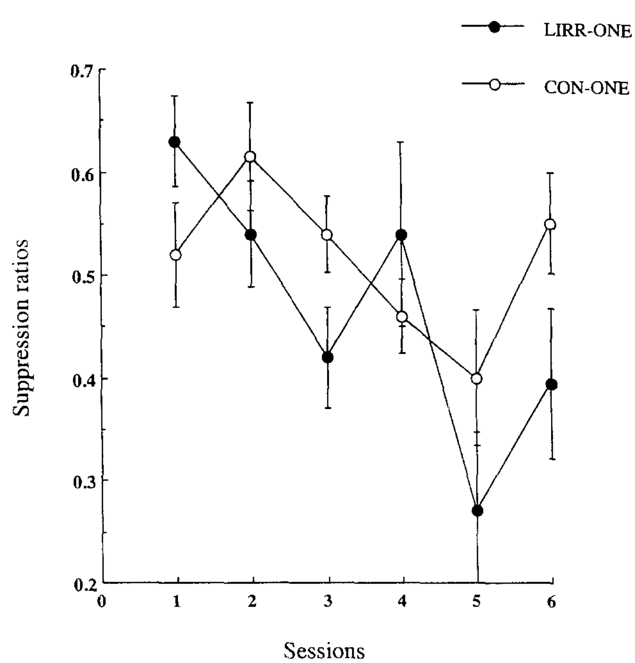

Figure 2. Mean suppression ratios for Group LIRR-ONE and Group CON-ONE, in the six test sessions of Experiment 2. The bars show standard errors. LIRR = learned irrelevance; CON = control.

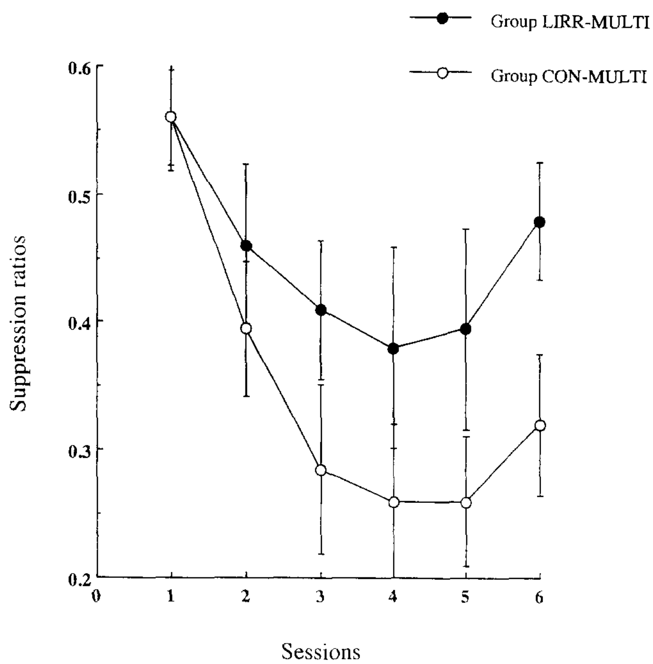

Figure 3. Mean suppression ratios for Group LIRR-MULTI and Group CON-MULTI, in the six test sessions of Experiment 2. The bars show standard errors. LIRR = learned irrelevance; CON = control.

MULTI was less suppressed than Group CON-MULTI, and this difference was sustained for the rest of conditioning. Conditioning proceeded relatively slowly in these rats. By the end of training, suppression was very similar in the one-trial and multitrial groups, despite the fact that the multitrial groups had received six times as many conditioning trials as the one-trial rats. This difference may have arisen because, with some procedures, classical conditioning occurs more rapidly with longer intertrial intervals (e.g., Gibbon & Balsam, 1981). Perhaps the considerably longer intertrial interval in the one-trial rats was sufficient to offset the smaller number of trials they received.

Our description of the data was supported by the results of an ANOVA with conditioning (one-trial or multitrial), preexposure (irrelevance or control), box, and session as factors. This revealed a main effect of conditioning, $F(1, 16) = 12.99$; of box, $F(3, 16) = 12.69$; and of session, $F(5, 80) = 12.57$. There was also a significant interaction between conditioning and preexposure, $F(1, 16) = 8.31$; conditioning and session, $F(5, 80) = 2.49$; and most critically, a three-way interaction between conditioning, preexposure, and session, $F(5, 80) = 3.17$. Nothing else was significant, largest $F(3, 16) = 2.08$. The significant three-way interaction suggested that the preexposure treatments had different effects on the one-trial and multitrial groups, and that this effect varied over the course of training. Consequently, separate analyses with preexposure, conditioning, and box as factors were conducted on the data from each of the six training sessions.

These analyses revealed significant interactions between conditioning and preexposure in Sessions 3, 5, and 6. Analyses of the remaining sessions revealed only a main effect of conditioning in Sessions 2 and 4, $F(1, 16) = 8.35$ for Session 2, and $F(1, 16) = 7.01$ for Session 4. Nothing else was significant in these sessions, largest $F(3, 16) = 2.52$.

In Session 3, there was a significant main effect of conditioning, $F(1, 16) = 9.31$; of box, $F(3, 16) = 4.17$; and a significant Preexposure × Conditioning interaction, $F(1, 16) = 7.67$. Nothing else was significant, largest $F(3, 16) = 1.88$. The interaction was examined further with an analysis of simple main effects which revealed that the LIRR and CON groups did not differ in either one-trial or multitrial conditions, $F(1, 16) = 3.60$ and 4.07, respectively. However the *ps* for both comparisons were less than .1.

In Session 5, there was a significant main effect of box, $F(3, 16) = 15.81$, which interacted with conditioning, $F(3, 16) = 3.36$. The Preexposure × Conditioning interaction was significant, $F(1, 16) = 12.36$, and this also interacted significantly with box, $F(3, 16) = 3.77$. Nothing else was significant, largest $F(3, 16) = 1.24$. The Preexposure × Conditioning interaction was examined further with an analysis of simple main effects, which revealed that the LIRR and CON groups differed in both the one-trial condition, $F(1, 16) = 6.07$; and the multitrial condition, $F(1, 16) = 6.30$. The three-way interaction with box deserves comment, but probably does not interfere with our conclusions. Examination of the means separately for each of the boxes revealed that, of the multitrial rats, Group LIRR was less suppressed than Group CON in all boxes. For the one-trial rats, Group LIRR was more suppressed than Group CON in three of the four boxes.

In Session 6, there was a significant main effect of box, $F(3, 16) = 6.99$, and a significant Preexposure × Conditioning interaction, $F(1, 16) = 13.29$. Nothing else was significant, largest $F(1, 16) = 2.78$. The interaction was examined further with an analysis of simple main effects, which revealed that the LIRR and CON groups again differed in both one-trial or multitrial conditions, $F(1, 16) = 6.34$ and 6.96, respectively. It should be noted that the three-way interaction with box was not significant in this session, $F(3, 16) = 1.25$. This suggests that the significant results observed in Session 5 were not an artifact of the three-way Preexposure × Conditioning × Box interaction that was observed in that session.

Finally, the mean pre-CS scores for the test sessions are shown in Table 2. An ANOVA performed on these data with conditioning, preexposure, box, and sessions as factors revealed a significant main effect of box, $F(3, 16) = 10.19$; and a significant Preexposure × Sessions interaction, $F(5, 80) = 2.40$. Nothing else was significant, largest $F(3, 16) = 2.60$. This suggests that the differences in conditioned suppression that we observed cannot be attributed to differences in pre-CS responding.

The results of the present experiment replicate those of Experiment 1, demonstrating that with a one-trial conditioning procedure, rats given irrelevance training condition faster than controls. Although this difference was significant in both experiments, there were some differences between the two sets of results, most notably that in the

Table 2
Group Mean Pre-CS Response Rates in the Six Test Sessions of Experiment 2

Group	Session 1	2	3	4	5	6
Multitrial						
Learned irrelevance	19.52	18.00	21.48	19.21	17.29	18.77
Control	11.36	13.17	12.98	12.02	17.11	14.44
One-trial						
Learned irrelevance	17.75	14.43	28.50	15.50	17.88	16.13
Control	22.50	15.38	19.13	19.46	24.13	19.75

Note. CS = conditioned stimulus.

present experiment the effect actually reversed on Session 4. It is likely that this was the product of a random fluctuation, to which the small sample of behavior collected on a single trial would be especially susceptible, rather than an indication that the effect was unreliable. Further evidence in favor of this interpretation comes from the fact that we have conducted a further experiment, an exact replication of Experiment 1, the results of which are shown in Figure 4. There were 8 rats in each group, although 1 rat made no pre-CS responses in five of the six test sessions and was eliminated from the analyses. The resulting data are very similar to those of Experiment 1. On the first trial there was a slight difference between the two groups, but an ANOVA with group and box as factors revealed that this difference was not significant, largest $F(3, 7) = 1.04$. Nor did the pre-CS response rates (shown in Table 3) differ on this trial, largest $F(1, 7) = 3.92$. Thereafter Group LIRR conditioned faster than Group CON, an impression that was confirmed by an ANOVA, with group, box, and sessions as factors. This revealed a main effect of group, $F(1, 7) = 6.72$, and of sessions, $F(5, 35) = 2.61$. No other effects or interactions were significant, largest $F(3, 7) = 2.00$. An identical analysis on the pre-CS rates (see Table 3) revealed a significant main effect of sessions, $F(5, 35) = 2.59$, but nothing else was significant, largest $F(3, 7) = 3.75$. These results provide yet further evidence that the one-trial conditioning procedure can reverse the standard learned irrelevance effect.

The results of this experiment provide good support for our hypothesis. The rats that had been given irrelevance training in the preexposure phase conditioned more slowly than Group CON if they were given multitrial conditioning during the test phase, but rats given one-trial conditioning showed the opposite pattern of results. These differences were significant on Sessions 5 and 6, and almost significant on Session 3. It seems that learned irrelevance training produces a greater retardation of conditioning than training in which CS and US are presented separately only if conditioning is conducted with a multitrial procedure. These data also help to rule out the possibility that Group LIRR learned faster in the one-trial condition because our uncorrelated schedule made the noise slightly excitatory in this group. If this had been the case, then the rats given irrelevance training should also have conditioned faster than controls in the multitrial condition; this is the opposite of what was observed.

General Discussion

The results of these experiments confirm that relative to control rats experiencing equal numbers of CS and US presentations, rats given uncorrelated preexposures of a CS and US show retarded conditioning when the usual, multitrial test procedure is used. But if only a single conditioning trial is given in each test session, rats given irrelevance training actually condition faster than those in the control condition. Standard accounts of learned irrelevance cannot explain this finding. In contrast, an account that attributes the learned irrelevance effect to the sum of CS and US preexposure effects, and takes account of the fact that latent inhibition is highly dependent on context, can provide a good explanation for all our results and those reported by Bennett et al. (1995). Proponents of a special learned irrelevance effect could still argue that, although in our procedure context specificity of latent inhibition is a major contributor to performance, irrelevance training also produces explicit learning that CS and US are unrelated, and that this may be more apparent with other training procedures. It must be noted, however, that this is not the most parsimonious explanation, and that perhaps the most conservative interpretation of the present results is that context specificity of latent inhibition is the sole explanation of learned irrelevance effects.

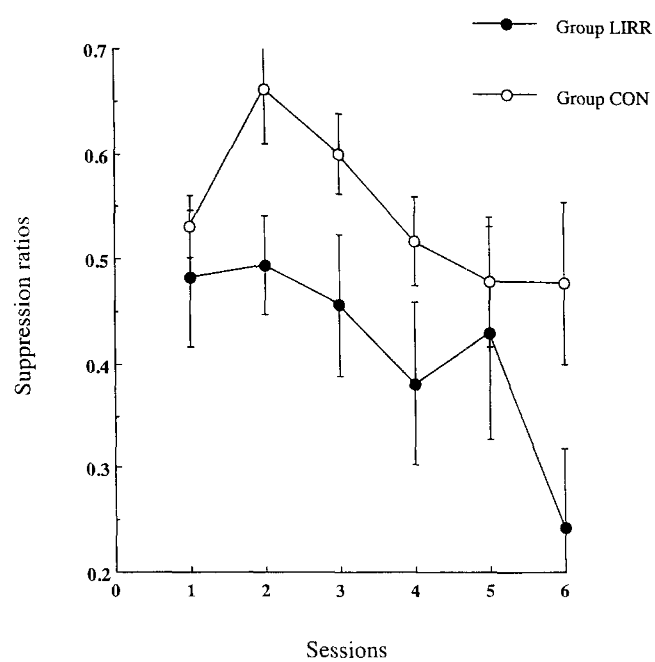

Figure 4. Mean suppression ratios for Group LIRR and Group CON, in six test sessions of replication of Experiment 1 (see text). The bars show standard errors. LIRR = learned irrelevance; CON = control.

Table 3
Group Mean Pre-CS Response Rates in the Six Test Sessions of Replication of Experiment 1

	Session					
Group	1	2	3	4	5	6
Learned irrelevance	19.25	25.63	30.25	43.75	28.87	43.13
Control	45.50	22.62	36.13	41.38	28.63	39.00

Note. CS = conditioned stimulus.

This account can also explain the results of other experiments that are taken to demonstrate learning that stimuli are unrelated. These studies have exploited the fact that certain manipulations are known to attenuate or abolish the CS and US preexposure effects. For example, Baker and Mackintosh (1979) demonstrated that irrelevance training produced poorer conditioning than CS preexposure alone. They argued that this was either due to a US preexposure effect or to specific learning about the absence of a relationship between CS and US. They attempted to rule out the former possibility by signaling the US with another cue during irrelevance training for one group of animals, a manipulation that they had demonstrated was capable of abolishing the US preexposure effect. They demonstrated that this had no effect on the learned irrelevance effect, and so concluded that their animals were learning about the absence of a relationship between CS and US. But this result may also be explained in terms of context specificity of latent inhibition. Baker and Mackintosh (1979) used a multitrial conditioning procedure in their test phase, so that for the irrelevance group both preexposure and conditioning occurred in the presence of US aftereffects. Thus, in their experiment, irrelevance training may indeed have produced slower conditioning than CS preexposure alone, but this may have been due to enhanced transfer of latent inhibition in the irrelevance group, rather than to the US preexposure effect. This would explain why the advantage of irrelevance training was not eliminated by signaling the USs, as these signals would have little influence on the critical US aftereffects. It is true, however, that if the USs were signaled during irrelevance training, the absence of this signal would introduce a change of context at the start of conditioning. But making the reasonable assumption that the signal is a far less salient stimulus than the US and its aftereffects leads to the conclusion that this context change will be relatively small, and would be unlikely to have much effect on subsequent conditioning. This was of course the result that Baker and Mackintosh (1979) observed.

A related strategy was adopted by Matzel et al. (1988), who outlined procedures capable of eliminating both CS and US preexposure effects, and then used them during learned irrelevance training. If learned irrelevance is no more than the sum of CS and US preexposure effects, then eliminating both of these effects should remove any retarding effect on conditioning. However, if learned irrelevance is more than the sum of the two effects, some effect on conditioning should remain. They presented converging evidence that learned irrelevance survived these treatments. For example, they succeeded in demonstrating retardation of conditioning after irrelevance training in which latent inhibition had been abolished by presenting a stimulus after the CS, and the US preexposure effect abolished by signaling the US. They also found retardation of conditioning after irrelevance training when both CS and US preexposure effects were abolished by a change of physical context before the conditioning stage. In both cases, the existence of a residual retardation of conditioning was taken as evidence for learning that CS and US were unrelated. The problem with these studies is that it is clearly critical that latent inhibition is completely eliminated; unfortunately, the evidence that this was the case came from normal latent inhibition training procedures. It is therefore possible that the stronger latent inhibition produced by irrelevance training, for the reasons we have outlined, was not completely abolished in these studies.

It seems, then, that all the evidence for the existence of specific learning about the absence of a correlation between CS and US can be explained in terms of a well-established phenomenon, the context specificity of latent inhibition. If this is the case, it would have implications for one other phenomenon with which learned irrelevance is related, that of preparedness. This refers to the notion that certain CSs become associated more readily with some USs than others (e.g., Foree & LoLordo, 1973; Garcia & Koelling, 1966). Some have argued that this may be an evolutionary bias that allows us to learn selectively about probable causes of significant environmental events (e.g., Seligman, 1970). Others, however, have argued that preparedness, rather than being independent of environmental experience, might be a manifestation of our ability to learn that events are unrelated. For example, Mackintosh (1973) has argued that preparedness may be, at least in part, the consequence of learned irrelevance. During learned irrelevance training the associability of a CS for a particular US falls, making it hard for an association to form between these two stimuli. If in their developmental history animals can learn which CSs are unlikely to predict a certain US, it follows that they will be more inclined to associate that US with CSs that are likely to predict its occurrence. This analysis clearly requires that associability is, at least in part, reinforcer-specific. The present results provide no support for this assumption.

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