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Preexposure to situational cues and shock intensity in two-way avoidance learning

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Four groups of rats (n = 16) received 65 two-way avoidance learning trials. The groups differed with respect to the amount of exposure (0 or 4 h) to the situational cues of the apparatus prior to avoidance learning and the intensity of shock (.3 or 1.6 mA) during learning. Superior avoidance performance with weak as compared to strong shock was obtained in the nonpreexposed groups. This inverse relationship between avoidance performance and shock intensity, typical of two-way avoidance learning, was eliminated in the preexposed groups. Presumably, a latent inhibition effect occurred in the strong-shock group, which resulted in a retardation of the conditioning of fear to the situational cues and a consequent improvement in performance. The results are consistent with the effective reinforcement theory, which emphasizes in aversive learning the detrimental effect of large amounts of fear remaining following a response.

The use of strong shock as opposed to weak shock has consistently been found to degrade signaled two-way avoidance (e.g., McAllister, McAllister, & Dieter, 1976; McAllister, McAllister, & Douglass, 1971; Moyer & Korn, 1964). This finding poses a difficulty for all theories of avoidance learning including the traditional two-process theory. According to the latter theory (e.g., Mowrer, 1947), fear which is classically conditioned to the conditioned stimulus (CS) is assumed to serve as motivation and its reduction as reinforcement for the instrumental avoidance response. Because more fear is conditioned with strong than with weak shock, a direct relationship between shock intensity and avoidance performance would be predicted.

Recently, however, an elaboration of two-process theory which emphasizes the role of fear conditioned to situational stimuli has been proposed to account for the inverse relationship (McAllister et al., 1976; McAllister et al., 1971). According to this position, the amount of effective reinforcement for an avoidance response is directly related to the amount of fear reduction occurring with the termination of fear-arousing stimuli (CS and/or situational cues) and negatively related to the amount of fear elicited by the stimuli present after a response. That is, it is not simply the amount of fear reduction which determines the amount of reinforcement, but rather it is the amount of fear reduction relative to the amount of fear remaining after a response. In the two-way task, in which the subject moves back and forth between two identical compartments, fear is conditioned to the situational cues of both compartments. Therefore, an avoidance response does not remove the subject from fear-arousing situational cues. Although a greater amount of fear reduction occurs with CS termination when shock is strong than when it is weak, the theory assumes that this increase in reinforcement is more than offset by the greater amount of situational-cues fear that remains after the response. Thus, two-way avoidance performance is degraded with strong, as compared to weak, shock. This position receives some support from the escape conditioning data of Campbell and Kraeling (1953), which show that rats exhibit superior escape performance if trained to run from a 200 to a 100-V shock than from a 400 to a 200-V shock.

The emphasis which the effective reinforcement theory places on the role of fear of situational cues as an influence on two-way avoidance learning implies that decreasing the amount of fear from this source after a response will improve performance. Support for this implication is provided by Kruger, Galvani, and Brown (1969), who reported facilitation of two-way avoidance performance when the compartment to be entered after a response contained walls, floor, and ceiling which were different from those of the starting compartment. Also, McAllister et al. (1976) demonstrated that with .3-mA shock, avoidance performance was significantly improved when the visual fear-arousing situational cues were removed after a response. Manipulations of situational-cues fear following a response should also alter the relationship between shock intensity and two-way avoidance learning. This expectation is consistent with the data of Modaresi (1975), which

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indicate that the inverse relationship is eliminated in the two-way task when the tactual cues of the grid are not present after the response. Presumably, the inverse relationship would have been reversed if Modaresi had also removed visual fear-arousing cues.

The present study investigated the role of shock intensity in the two-way avoidance task under a condition in which the amount of fear conditioned to all of the situational cues, both to the tactual cues of the grid and to the visual cues, would be minimized or at least reduced early in training. The procedure used was suggested by the latent inhibition phenomenon, which refers to the retardation of classical conditioning that occurs when a subject receives nonreinforced exposure to a stimulus prior to its use in the conditioning situation (e.g., Lubow & Moore, 1959; Rescorla, 1971). In the two-way task, preexposing subjects to the situational cues (tactual and visual) should retard the acquisition of classically conditioned fear to those cues during subsequent avoidance conditioning and thereby increase effective reinforcement and improve avoidance performance. Some support for this expectation is provided by the studies of Grant and Grant (1973) and Grant and Young (1971), who trained mice in a one-way avoidance task with identical start and safe compartments. Preexposure to the situational stimuli resulted in better avoidance performance than did nonpreexposure, presumably because latent inhibition decreased the amount of fear elicited in the safe box after a response.

In the present experiment, two preexposed and two nonpreexposed groups were trained in the two-way avoidance task. Within each exposure condition, one group was trained with weak and the other with strong shock. The usual inverse relationship between shock intensity and two-way avoidance performance was expected for the nonpreexposed groups, whereas it was expected that the inverse relationship would be either reversed, eliminated, or reduced in the preexposed groups, depending on the extent to which the conditioning of fear to the situational cues was retarded by the preexposure treatment.

METHOD

Subjects and Design

The subjects were 64 naive female hooded rats, 111-120 days of age, from the departmental colony. They were randomly paired and then assigned at random to one of the two shock intensity treatments (.3 or 1.6 mA). Within each pair, one subject was assigned at random to the preexposure (P) condition; the other, to the nonpreexposure (NP) condition. Thus, the design of the experiment was a 2 by 2 factorial (16 subjects per group) with the factors being Preexposure (P vs. NP) and Shock Intensity (.3 vs. 1.6 mA). One additional subject was discarded for failing to escape within 60 sec on 10 consecutive trials (.3 mA-NP group). The subjects were housed in pairs during the experiment and received food and water on an ad lib basis.

Apparatus

The two-way apparatus was 444 mm long × 165 mm wide × 152 mm high and contained two identical compartments. The compartments were separated by a 25-mm partition containing a guillotine door 57 mm wide × 89 mm high, which rested on a hurdle 63 mm high. The compartments were constructed of metal, painted white, and the guillotine door was black bakelite. Each compartment had a grid floor, hinged to serve as a floor switch, made of 18 stainless steel rods of 3-mm diameter spaced 13 mm apart. Scrambled shock was delivered through the grid floor by a Grason-Stadler shock generator, Model 700. Hinged to the top of each compartment was a separate box which served as a cover and which contained light sources. The bottoms of these covers consisted of hardware cloth, 86 mm above which was a pane of ground glass. The holding boxes used for the NP treatment were 20 cm long × 20 cm wide × 19 cm high. They were constructed of wood and painted gray. Hinged to the top of each box was a cover consisting of hardware cloth placed in a wooden frame which was painted gray. The floors of the holding boxes were covered with Litter Green.

Procedure

The experimental procedures required 5 days for each subject. On Days 1-4, the subjects were treated in pairs, one in the P condition and the other in the NP condition. The treatment on each day began with a 5-min handling period, during which the subjects were alternately picked up and petted and placed on a table to explore. Immediately after handling, the subject in the P condition was confined for two 15-min periods in each of the two compartments, with the periods of confinement alternating between the compartments. Thus, on each of the 4 days, the subject received 1 h of exposure to the apparatus, yielding a total exposure of 4 h. The guillotine door was closed during the exposure treatment. To control for handling and the amount of time spent in the experimental room, the subject in the NP condition received a treatment identical to that received by the subject in the P condition, except that the 15-min periods were spent in holding boxes placed adjacent to the apparatus.

On Day 5, each subject received 65 avoidance training trials in the two-way apparatus with either .3 or 1.6 mA (nominal values) discontinuous shock (.75 sec on, 2.00 sec off). The CS for all groups was a compound consisting of an increase in illumination from approximately 32 lx (intertrial illumination) to approximately 1,175 lx and the presentation of white noise, which raised the ambient sound level within the apparatus from approximately 51 to 53 dB. The noise component of the CS was provided by a Grason-Stadler white-noise generator, Model 901B. Each avoidance trial began with the presentation of the compound CS simultaneously with the opening of the guillotine door separating the compartments. Shock (US) was administered if the subject did not trip the floor switch in the opposite compartment within 5 sec following the onset of the CS. A response occurring within the 5-sec CS-US interval resulted in the CS termination and the avoidance of shock and was recorded as an avoidance response. Responses following shock onset resulted in both CS and US termination and were recorded as escape responses. After a response, the subject remained for a 30-sec intertrial interval (ITI) in the compartment it had entered. If an escape did not occur within 55 sec of initial shock onset, the guillotine door was closed, the CS and US were terminated, a latency of 60 sec was recorded, and the next trial was begun in the same compartment after the 30-sec ITI. Only five such no-escape trials occurred during the course of the experiment. Latencies were measured in .01-sec units with a Hunter Klockounter from the opening of the guillotine door and CS onset to the depression of the floor in the opposite compartment. The CS-US interval and the duration of the on and off periods of discontinuous shock were controlled by Hunter timers.

RESULTS

Mean Percentage of Avoidance

Figure 1 presents the mean percentage of avoidance responses plotted against blocks of five trials for each of the groups. In the left portion of the figure, the typical inverse relationship can be seen under the NP condition; that is, two-way avoidance performance was superior with weak as compared to strong shock. For the P condition, shown in the right portion of the figure, it can be seen that the difference in performance between the two shock conditions is much reduced. These data are replotted in Figure 2 so that the effect of the preexposure treatment on avoidance performance at each shock level is more clearly depicted. The right portion of Figure 2 shows that avoidance performance with a 1.6-mA shock is markedly superior following preexposure to the situational cues as compared to nonpreexposure. This superiority appears at the outset and persists throughout the 65 training trials. The left portion of the figure suggests that the preexposure treatment had relatively little effect upon performance under the .3-mA condition, although a slight trend toward better performance with preexposure is exhibited over the first 50 trials.

These observations were evaluated with a repeated measures analysis of variance with shock intensity and preexposure as the between-subjects factors and trial blocks as the within-subject factor. The interaction between trial blocks and shock intensity, $F(12,720) = 2.74$, $p < .005$, and the triple interaction, $F(12,720) = 1.98$, $p < .05$, were significant. Because of these interactions, simple effects analyses were performed for each shock level and for each of the preexposure conditions. The repeated measures analyses for each shock level yielded a significant preexposure effect under the 1.6-mA shock condition, $F(1,30) = 9.26$, $p < .005$, indicating better performance with preexposure, but no effect ($p > .20$) under the .3-mA condition. In neither case did preexposure interact significantly with trial blocks, but the latter factor was significant in each instance ($ps < .001$). The repeated measures analyses for each of the preexposure conditions yielded a significant effect of shock intensity under the NP condition, $F(1,30) = 7.24$, $p < .025$, indicating better performance with weak shock. Although shock intensity and trial blocks did not interact under the NP condition, they did interact under the P condition, $F(12,360) = 2.89$, $p < .005$. Further simple effects analyses of the data from the P condition revealed a significant effect of shock intensity only for the fifth trial block, $F(1,30) = 4.83$, $p < .05$, with the weak-shock group outperforming the strong-shock group on that trial block.

In summary, the data show that preexposure facilitated avoidance performance under the 1.6-mA, but not under the .3-mA, shock condition, and that

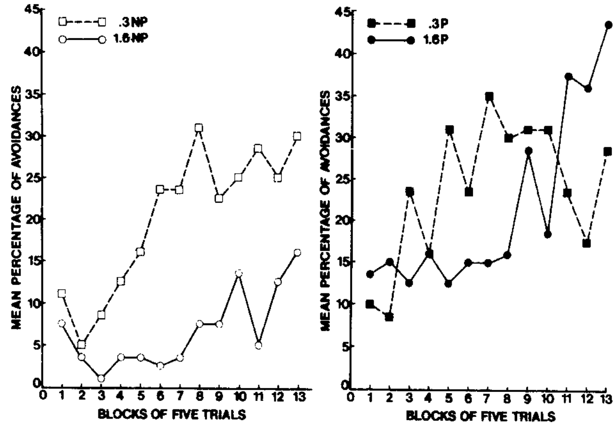

Figure 1. Mean percentage of avoidances as a function of blocks of five trials for the nonpreexposed (NP) groups (left portion of figure) and for the preexposed (P) groups (right portion of figure) with weak (.3 mA) and strong (1.6 mA) shock.

performance was superior with weak as compared to strong shock under the NP condition but not, except for one trial block, under the P condition.

Mean Trials to First Avoidance

The mean trials to the first avoidance are plotted for each group in Figure 3. It can be seen that the first avoidance response occurred later with strong than with weak shock under the NP condition, whereas there was no effect of shock intensity under the P condition. Also, an effect of preexposure treatment is apparent under the strong-shock but not under the weak-shock condition. These observations were evaluated by a factorial analysis of variance. The interaction between shock intensity and preexposure was found to be significant, $F(1,60) = 8.17$, $p < .01$. Subsequent simple effects analyses of variance were performed in which the error term from the original analysis was used. The preexposure treatment was significant under the 1.6-mA, $F(1,60)$

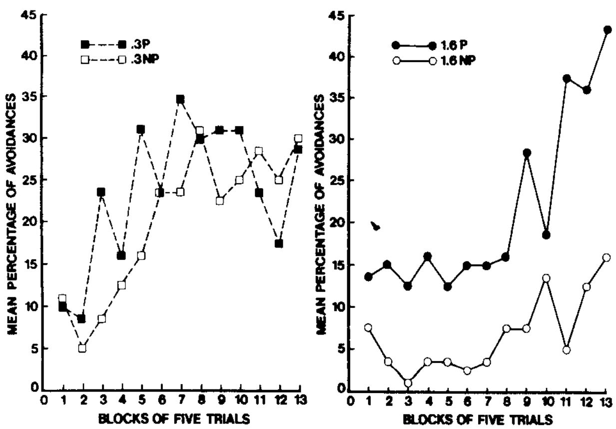

Figure 2. Mean percentage of avoidances as a function of blocks of five trials for the weak-shock (.3 mA) groups (left portion of figure) and the strong-shock (1.6 mA) groups (right portion of figure) with preexposure (P) and nonpreexposure (NP).

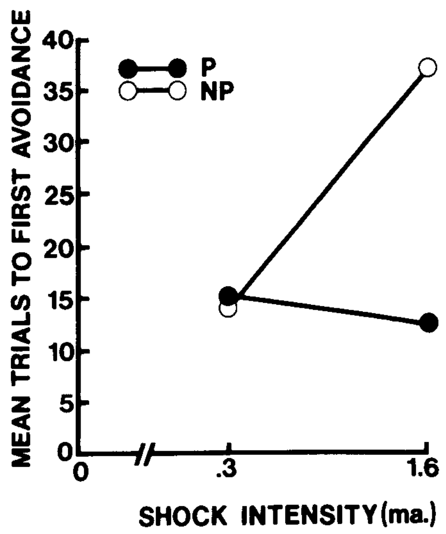

Figure 3. Mean trials to the first avoidance for the preexposed (P) and the nonpreexposed (NP) groups with weak (.3 mA) and strong (1.6 mA) shock.

= 15.16, $p < .001$, but not under the .3-mA shock condition ($p > .20$) and shock intensity was significant under the NP, $F(1,60) = 13.08$, $p < .001$, but not under the P condition ($p > .20$).

DISCUSSION

In the present experiment, the typical inverse relationship between shock intensity and two-way avoidance performance was replicated in the groups which were not preexposed to the situational cues of the apparatus and was eliminated in the groups which were preexposed to these cues. These results provide support for the effective reinforcement theory, which attributes the inverse relationship to the large amount of fear that is conditioned to the situational cues when strong shock is used and remains after the instrumental response is made. Presumably, a latent inhibition effect resulting from the preexposure treatment reduced the amount of fear that was conditioned to the situational cues during two-way avoidance training in the strong-shock group. As a consequence, although the amount of fear reduction from CS termination was the same with or without preexposure, the decrease in the amount of fear present after a response in the preexposed strong-shock group increased effective reinforcement, thus eliminating the inverse relationship. Even with weak shock, preexposure should, because of the latent inhibition effect, have increased effective reinforcement. Although there was a trend for better performance with preexposure than without preexposure, the difference in performance between the groups was not significant. On the surface, this finding appears contradictory to that reported by McAllister et al. (1976). They found a significant improvement in two-way avoidance performance with weak shock when the visual, fear-arousing, apparatus cues were removed after a response, indicating that the amount of fear present after a response can play an important role when shock is weak. It should be noted, however, that the present study and the McAllister et al. study differed with respect to the absolute amount of fear reduction that could occur following an avoidance response. The preexposure treatment used in the present study presumably reduced the amount of fear present both before and after a response; hence, the absolute amount of fear reduction was produced only by CS termination and was the same with and without preexposure. In the McAllister et al. study, the fear-arousing visual apparatus cues were removed after a response, but these cues were present before the response. Consequently, a greater absolute amount of fear reduction occurred when these cues were removed after a response than when they remained. The implication from all of these data is that the absolute amount and the relative amount of fear reduction play important roles in two-way avoidance performance.

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