Effects of inescapable shock in the rat: Learned helplessness or response competition

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A new procedure for alleviating the effects of inescapable shock (preshock) on subsequent learning was attempted. It consisted of introducing trials in a straight alley between preshock and escape/avoidance learning designed to countercondition an approach response to fear cues. The success of the procedure in reducing the interference effect supported a response-competition interpretation of the effect. However, performance of a control group that received only preshock led to consideration of other explanations of the results.

Recent experiments in aversive conditioning have shown that exposure to inescapable and unavoidable shock (preshock) often leads to an "interference effect," the impaired acquisition of a subsequently trained escape-avoidance response. On the basis of this experimental work, Maier, Seligman, and Solomon (1969) offered an explanation in terms of learned helplessness, that is, the organism develops the expectancy during preshock that its responses are independent of the onset, duration, and intensity of shock. The interference effect is therefore interpreted as a reduced incentive to initiate escape-avoidance responses. An alternative, though not necessarily incompatible, hypothesis is that each subject reduces certain psychophysical properties of preshock by means of some specific motor response. This hypothesis concedes that while, by definition, responses during preshock cannot affect the onset or duration of shock, these responses may affect perceived shock intensity. Some responses to shock, relative to others, are more effective in reducing the level of shock-induced pain, and it is these responses, because of their relationship to perceived intensity, that tend to be repeated in other situations that involve aversive stimuli (Kimmel, 1971; Perkins, 1968). Consequently, when escape or avoidance of shock is made contingent on a particular response, rate of learning depends on the similarity of the response acquired during preshock to the designated escape-avoidance response: if the two responses are incompatible, acquisition will be retarded.

There are several possible strategies for testing accounts of the interference effect based on reduced incentive and on competing motor response. For example, if the interference is due to some form of response competition, it should obviously be possible to train an escape response that would interfere with the learning of a subsequent escape-avoidance response. The degree of interference in the escape group should equal that of a group administered the same amount of shock in the absence of an escape contingency. An incentive position might predict that, because the first-learned

response is not inescapable, helplessness should not result, and there should be no interference effect in the second-learned response. Maier (1970) conducted an experiment with dogs along these lines and found evidence for a transient interference effect in a group trained to perform a response presumed to be incompatible with a hurdle-jump response.

A second strategy in testing the incentive and competing response positions, whether one assumes that an unspecified competing response or reduced incentive is acquired during inescapable preshock, is to introduce between preshock and shuttlebox test an "alleviation" treatment that reduces or even eliminates the interference with later escape learning. In one such technique, the "helpless" dog is dragged back and forth across the barrier in the shuttlebox to escape or avoid shock (Seligman, Maier, & Geer, 1968). This treatment reduces the interference effect. Both hypotheses can readily account for these findings: Maier et al. (1969) point out that, under such conditions, subjects again become sensitive to the contingency between responding and shock termination. A response-competition position maintains that the improved shuttlebox performance is the result of counterconditioning fear from an incompatible to a compatible response.

The experiment we report uses an alleviation procedure based on the work of N. E. Miller (1960), and others, that counterposes the incentive and response competition hypotheses. It has been shown in a number of studies (e.g., Feirstein & Miller, 1963; Miller, 1960) that rats trained to run for food will continue to approach a goalbox that contains food and a painful electric shock if the intensity of shock was originally very low and has been incremented gradually. Miller and others (e.g., Wagner, 1966) argue that under such conditions, the organism learns to approach the goalbox in the presence of fear cues, which would normally result in withdrawal or avoidance. Instead, through counterconditioning, these cues become part of the stimulus complex that maintains approach to the goalbox. Our expectation was that interposing such

Figure 1. Mean response latency during shuttlebox test. FR 1 was in effect in Block 1; FR 2 in Blocks 2-4.

counterconditioning between inescapable shock treatment and shuttlebox performance would reduce the interference effect. The helplessness hypothesis would not seem to account for the possible effectiveness of such an alleviation procedure since it involves presentation rather than termination of shock.

METHOD

Subject

Thirty-two naive male albino rats, obtained from Holtzman Company, Madison, Wisconsin, at approximately 90 days of age, were housed individually with water continuously available.

Apparatus

Preshock was administered in 16 identical boxes (20 x 12.5 x 15 cm) constructed of clear Plexiglas sides with a grid floor of stainless steel rods (3 mm diam) spaced 1.2 cm apart center to center. The grid floors were wired in parallel and scrambled shock was delivered simultaneously to each cage from a shock generator (Grason-Stadler, Model 700). The boxes were suspended from the top in a standard Wahmann animal rack.

The components of the runway, all with internal dimensions of 7.6 x 7.6 cm, were a startbox 27 cm long, a 92-cm runway, and a 30-cm goalbox. Photocell circuitry and Standard Electric timers recorded the time to the nearest .01 sec for subjects to traverse each of three equal 30.7-cm distances in the runway. A semicircular sheet metal trough, located 3.5 cm beyond the last photobeam, served as the foodcup. A pair of L-shaped aluminum strips, separated by a 2-cm gap which extended the length of the goalbox floor, formed the walls and floor of the goalbox and permitted delivery of footshock. The remainder of the apparatus was painted flat black and covered with clear Plexiglas.

An 8 x 12 x 10 cm box constructed of aluminum sides and floor with a 2-cm gap separating the shocking surfaces served as the control cage. Footshock could be delivered to the floor from the shock source described previously. The cage was housed in a larger sound- and light-attenuating box.

The shuttlebox (40 x 20 x 18 cm) had metal ends painted black and clear Plexiglas sides with photocells positioned 3.7 cm above the floor and 7 cm to either side of a 7-cm-high sheet metal hurdle that bisected the apparatus. The photocells were wired such that latencies from tone onset on one side of the chamber to breaking the photobeam on the other side were recorded. The tone (85 dB, 4,000 Hz) was delivered via two 7-cm speakers attached to the ceiling of the shuttlebox. The entire apparatus was housed in a sound-attenuating wooden box. Presentation of stimuli and recording of responses were controlled by a Grason-Stadler PDP-8i computer and SCAT system.

Procedure

Ad-lib food conditions were in effect for the first 5 days after receipt of the rats from the vendor. They were then placed on a

food deprivation schedule of two daily feedings which maintained them at approximately 80% of their ad-lib weights.

Preshock Treatment

Subjects were randomly assigned to one of four equal-sized groups. In Phase I, three groups were treated with inescapable shock (IS). Each of the five 90-min sessions conducted twice per day included presentation of 30 1.2-mA 5-sec footshocks according to an irregular temporal schedule. The fourth group (NS) was placed in the shock cages for the same amount of time as IS but received no shock.

Runway Training

In Phase 2, two IS groups and the NS group were trained in a runway under continuous reward (single 500-mg pellet, P. J. Noyes Co.) conditions. Sessions of four trials were conducted twice daily. Intertrial interval was 20 min. Beginning with the 11th runway session, one shock (IS-RS) and the no-shock (NS-RS) group received shock in the runway. For these groups, a brief, .75-sec footshock was delivered on a random 75% of the trials in the goalbox when the subject interrupted of the final photobeam. Shock intensity was gradually increased from .05 to 1.0 mA over Runway Sessions 11 to 22. The second shock-control group (IS-SC) was never shocked in the goalbox but received an amount and intensity of footshock equivalent to the RS groups in the control cage following each session of runway training. The final shock group (IS-HC) remained undisturbed in their home cages during Phase 2.

Shuttlebox Test

Phase 3, which began 12 h after the final runway session, consisted of a 5-min adaptation period to the shuttlebox apparatus in the absence of tone and shock which was followed immediately by 20 trials of signaled escape-avoidance training. For the first five trials, the criterion response was a single hurdle crossing (FR 1), while on the remaining 15 trials, two hurdle crossings (FR 2) were required to escape or avoid shock. If the criterion response was not completed within a 5-sec interval following onset of the tone, scrambled shock (1.3 mA) was delivered to the grid floor until the response occurred or until 30 sec of shock had elapsed. The tone and shock were coterminous. Intertrial interval in both sessions averaged 90 sec. Latency to avoid or escape shock was recorded. Maier, Albin, and Testa (1973) reported that such a procedure produces an interference effect in rats.

RESULTS AND DISCUSSION

Response latencies from CS onset in the shuttlebox are presented in Figure 1. Analysis of variance performed separately on the FR 1 and the FR 2 data revealed that no differences ($p > .10$) existed between the groups when a single hurdle cross was required to escape or avoid shock which confirms the findings of Maier et al. (1973). The analysis of FR 2 latencies indicated that the groups effect was highly significant ($F = 4.82$, $df = 3/28$, $p < .01$); planned comparisons between Group IS-RS and each of the other groups indicated that IS-RS performed significantly better in the shuttlebox than did IS-SC and NS-RS ($ps < .05$), but no differently from IS-HC (means 8.9 and 9.3, respectively).

It will be recalled that the prediction from the response competition hypothesis was that interpolating a counterconditioning treatment between inescapable

shock and shuttlebox test would reduce the interference effect. While the IS-RS treatment did result in better escape-avoidance learning than IS-SC or NS-RS, these differences are difficult to interpret within a response-competition framework because the group given inescapable shock alone (IS-HC) did not differ from IS-RS; that is to say the control IS group was no different from the group in which IS was followed by counterconditioning.

One explanation of these data depends on recent evidence that the interference effect is only transient and dissipates almost completely in 48 h (Weiss, Glazer, & Pohorecky, 1974). Since approximately 120 h intervened between inescapable shock and shuttlebox test, this can account for the rapid acquisition of shuttle responding in the IS control group. To account for the differences among the remaining three groups, however, one must assume that under IS-SC and NS-RS conditions, exposure to brief periods of shock during the retention interval is sufficient to maintain (or produce) the interference effect, while the combination of inescapable shock and the counterconditioning treatment reduces the interference effect.

However, a second factor might also be considered: the method of preshock administration. Since preshock was delivered through floor grids, and the subjects were not restrained, vigorous jumping occurred during the 5-sec shock presentation. It is therefore conceivable that jumping rather than some form of immobility became the dominant escape response. If jumping transferred to the shuttlebox in the preshock groups, IS-RS and IS-HC acquired the shuttle response relatively quickly because they had previously learned to escape shock by jumping and moving about; NS-RS did not benefit from such positive transfer. The performance of the IS-SC group might indicate that transfer of the jumping response can be greatly reduced if shock treatment interpolated

between preshock and test occurs in a small enclosure in which activity is restricted. Without additional control groups, it cannot be determined from the present experiment: (a) whether the counterconditioning treatment by itself enhanced escape/avoidance acquisition, or (b) the degree to which, under these procedures, preshock enhanced acquisition. Research is necessary to determine the appropriateness of these alternative explanations.

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