Animal Learning & Behavior
1978, 6 (2), 155-159

Inescapable shock interferes with the acquisition of an appetitive operant

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This article reports the reinforcer generality of the interference effect resulting from exposure to inescapable shock. In Experiment 1, rats that received inescapable shock showed weak interference with the acquisition of an appetitive operant compared to animals exposed either to escapable or no shock. In Experiment 2, the response-reinforcer contingency was degraded by introducing a 1-sec delay of reinforcement on the appetitive task. Inescapable shock produced much stronger interference with the acquisition of the operant response than in Experiment 1. The results demonstrate reinforcer generality of the debilitating effects produced by inescapable shock.

Exposure to inescapable shock produces strong interference with a dog's or rat's ability later to learn a novel response to escapable shock (Maier, Albin, & Testa, 1973; Overmier & Seligman, 1967; Seligman & Beagley, 1975). However, animals given an equivalent amount of escapable shock or no shock at all, usually show no difficulty in learning the novel escape response. This learned helplessness phenomenon has also been obtained in a number of other species (cf. Seligman, 1975).

Maier and Seligman (1976), Maier, Seligman, and Solomon (1969), and Seligman, Maier, and Solomon (1971) have proposed that this deficit results from the animal's learning during its exposure to inescapable shock, that its responses and reinforcement are independent. This learning is held to reduce the incentive for initiating responding and to interfere proactively with the subsequent learning that now reinforcement is contingent on responding. Thus, the animal exposed to inescapable shock subsequently fails to learn the response required to terminate shock or learns it more slowly than controls.

This learned helplessness hypothesis suggests that the animal acquires a fairly general expectancy about the consequences of its behavior. Such an expectancy may not be exclusively specific to the stimulus, response, or reinforcer situation where it was acquired. Thus, it might be more difficult for such an animal to learn subsequently that its responding can produce reinforcement in a variety of different situations. And, indeed, some recent studies suggest that this phenomenon is somewhat general (Braud, Wepmann, & Russo, 1969; Rosellini & Seligman, 1975) in that it does at least transfer across different aversive training and testing conditions. Braud, Wepmann, and Russo (1969) found inescapable shock to interfere with the learning of a response to escape from a cold-water maze. Rosellini and Seligman (1975) reported that inescapable shock interferes with the learning of a hurdle-jump response to escape from frustration. Recently, Goodkin (1976) found that exposure to noncontingent food interferes with the acquisition of a response to escape/avoid shock.

Although these findings are supportive of an expectancy analysis of the learned helplessness phenomenon, research is needed to delineate further the generality of the interference produced by exposure to uncontrollable aversive events. If the learning deficit is indeed due to the animal's learning that its responses are ineffective in producing reinforcement, then it might be expected that the deficit would not be limited to an aversive situation.

EXPERIMENT 1

The present experiment investigates whether the effects of exposure to inescapable shock transfer to an appetitive context and interfere with the acquisition of a free appetitive operant. Different groups of rats were exposed to either escapable, inescapable, or no shock. Subsequently, they were tested for their ability to learn to leverpress to produce food. If the effects of inescapable shock transfer to the appetitive context, the inescapably shocked rats should show a

This research was supported by Postdoctoral Fellowship MH-00980 from the National Institute of Mental Health to the author and Grant MH-19604 from the National Institute of Mental Health to Dr. Martin E. P. Seligman. The author wishes to express his appreciation to Drs. Martin E. P. Seligman, Martin T. Orne, and Richard L. Solomon for their constructive criticism during the preparation of this manuscript and Max Bazerman for assistance in the execution of this research. Requests for reprints should be sent to Robert A. Rosellini, Department of Psychology, State University of New York at Albany, 1400 Washington Avenue, Albany, New York 12222.

deficit in the appetitive situation. This deficit might be evidenced as either a complete failure to learn the barpress response or as a retardation in learning that response in comparison to the escapable shock or no-shock groups.

Method

Subjects. The subjects were 24 male Holtzman rats approximately 90 days of age at the start of the experiment. One week before the experimental treatment, all rats were placed on an 85% adjusted-body-weight deprivation schedule (Weinstock, 1972). They were maintained on ad-lib water and were run during the light phase of the 12-h dark/12-h light cycle.

Apparatus. Four experimental chambers were used for shock training. Each chamber was 24 cm long, 21 cm high, and 20 cm wide. The side walls and the ceiling were constructed of clear Plexiglas and the front and back walls of stainless steel. The top half of the front wall could be retracted out of the chamber, thereby creating a shelf 10 cm high and 9.5 cm deep, 11 cm above the grid floor of the chamber. The floor was constructed of stainless steel rods, 0.47 cm in diameter and spaced 1.30 cm apart. Shock was delivered to the chambers by a constant-current shock source. Shock pulsated at a rate of 5 Hz. A safety-pin electrode entered through the ceiling of the chambers and was attached to a safety-pin electrode mounted subcutaneously in the rat's upper back. The shock circuit was completed through the grid floor of the chamber. Each chamber was enclosed in a sound-attenuating container supplied with white noise and a houselight.

Four operant chambers were used for the appetitive test. Each chamber was 30.5 cm long, 27.9 cm high, and 25.5 cm wide. The two side walls were of clear Plexiglas. The front and back walls were of aluminum, and the floor, of stainless steel rods 0.32 cm in diameter, spaced 1.30 cm apart. A 5 × 1.3 cm lever was centered on the front wall, 10 cm above the grid floor, and protruded 1.9 cm into the chamber. A 5 × 3.8 × 2.5 cm food cup was located directly beneath the lever and rested on the grid floor. A stainless steel water spout was 3.8 cm to the right of the food cup and protruded 1.9 cm into the chamber. Each chamber was housed in a sound-attenuating container which was equipped with a white-noise speaker, a houselight, and a ventilating fan. The shock chambers and the operant chambers were housed in different rooms. All programming and recording equipment was housed in a separate room.

Procedure. Seven days after the beginning of deprivation, the 24 rats were assigned to the three treatment groups on the basis of their ad-lib body weights so that all groups were approximately equal in mean body weight (range 381-391 g). A subcutaneous safety-pin electrode was mounted in each rat's upper back. The back of the animal was shaved to prevent attenuation of shock in the event the animal rolled on its back.

Shock training. On the first day of the experiment, the three groups were given differential shock training. This procedure was similar to that used by Seligman and Beagley (1975). The first group (N = 8) was trained to escape shock (Group E). Training consisted of one session of 80 trials of up to 60 sec of 1.0-mA shock, which could be terminated by jumping onto a platform. Escape trials were presented on a variable-time 1-min schedule with a range of 5-115 sec. The shock session was approximately 90 min long.

On each trial, unsignaled shock delivery and retraction of the top portion of the front wall of the chamber, making the platform available, occurred simultaneously. All animals in Group E learned to jump onto the platform to terminate shock. Each animal in the second group (Group I) was yoked to an animal in the escape group. Thus, each pair of animals received an identical pattern and duration of shock. However, the shock for Group I rats was inescapable, since its termination was not contingent upon their behavior but on the behavior of the Group E animals. Group I animals also had equal access to the platform. But, for these animals, the platform was electrified and jumping did not terminate shock. The animals in the third group were used as controls (Group C). They were placed in the training chambers for a yoked duration of time, but were never exposed to shock.

Appetitive test. Twenty-four hours following the shock training, the appetitive test was conducted. Each animal was placed in an appetitive chamber where it could depress the lever to produce food (one 45-mg Noyes food pellet) on a continuous reinforcement schedule (CRF). On the first session of the test, 10 food pellets were placed in the food cup of each chamber. Testing was conducted for a maximum of five sessions or until the animal earned 100 pellets. Each daily test session was 120 min in length. The time elapsing between the animals being placed in the chambers and the emission of the first barpress and all subsequent interresponse times (IRT) were recorded.

Results

Shock training. All rats in Group E learned to jump onto the platform to terminate shock. No failures to escape were observed for any of these animals on the last 20 trials of training. The mean amount of shock received by this group, and therefore Group I, was 575.45 sec, with a standard deviation of 231.36.

Appetitive test. All animals quickly acquired the barpress response to obtain food on the CRF schedule, as indexed by their low IRTs after the 10th response of the test. The mean IRT for the 11th to the 20th responses for Groups E, I, and C was 0.61, 0.69, and 0.71 min, respectively [$F(2,21) < 1$]. Asymptotic performance was reached by the 50th response with a mean IRT of 0.17, 0.23, and 0.19 min for Groups E, I, and C, respectively [$F(2,21) < 1$]. However, during the initial part of the test (0-10th response), the animals exposed to inescapable shock (Group I, mean = 25.78 min) showed substantially longer IRTs than rats given either escapable (Group E, mean = 7.65 min) or no shock (Group C, mean = 8.89 min). Figure 1 shows the mean IRTs for each of these three groups on each of the first 10 responses of the test. Groups E and C show approximately equal IRTs throughout this part of the test, while Group I shows considerably longer IRTs for the first five responses with a subsequent decrease to the level of the other groups by the sixth response. A 3 by 10 analysis of variance showed the differences between

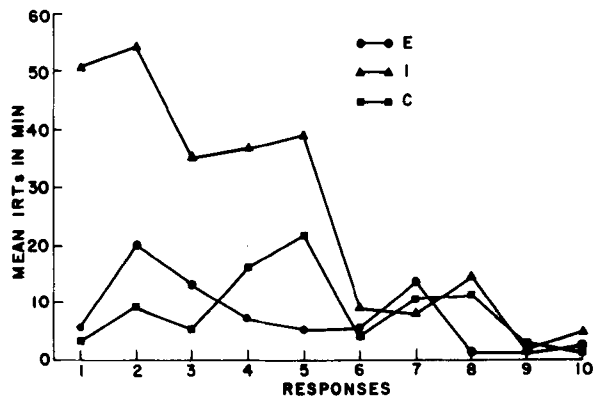

Figure 1. Mean interresponse times (IRTs) in minutes for the escape (E), inescapable (I), and control (C) groups on the first 10 responses of the appetitive test in Experiment 1.

groups to be significant [$F(2,21) = 4.05$, $p < .05$]. Newman-Keuls post hoc tests showed Group I to have longer IRTs than either Group E or Group C ($p < .05$), which did not differ from each other ($p > .10$).

No reliable correlation was obtained between amount of shock received during training by either Group E or Group I and mean IRTs from the 0 to the 10th response [$r(6) = 0.21$ and 0.18, $p > .10$, respectively].

Discussion

The initially longer interresponse times shown by the animals exposed to inescapable shock as compared to the IRTs seen in Groups E and C are suggestive. This difference shows that inescapable shock affects acquisition of an appetitive operant. Usually, prior exposure to inescapable shock results either in the failure to learn a novel response or at least in a substantial interference with the learning of a response to terminate an aversive stimulus (cf. Maier, Albin, & Testa, 1973; Rosellini & Seligman, 1975; Seligman, Rosellini, & Kozak, 1975). However, in the present appetitive test, only a slight interference with the acquisition of the barpress response was obtained. Methodological differences in the aversive and appetitive test situations may be responsible for the differential effects obtained.

One potentially important difference may be the type of contingency employed in the test. Maier, Albin, and Testa (1973) and Seligman and Beagley (1975) found no deficit in the acquisition of an escape response following exposure to inescapable shock if a single response was required to produce immediate shock termination. However, if the animal was required either to cross from one side of a shuttlebox to the other and back (FR2) or to depress a lever three times (FR3) to terminate shock, a large deficit was obtained. In addition to increasing the physical response requirement, this manipulation also degrades the response-reinforcer contingency by effectively introducing some delay between the first member of the response chain and shock termination. Maier and Testa (1975) found the nature of the contingency between the response and reinforcement to be an important determinant of the deficit obtained following exposure to inescapable shock, even when the physical response requirement was held constant. A deficit could be obtained using an FR1 shuttle response if the contingency was degraded by introducing a delay between the response and shock termination.

The relatively mild interference obtained in the present experiment may be partly due to the nature of the test contingency employed. Each response produced immediate delivery of a food pellet. It seems possible, then, that if the response-food delivery contingency was degraded, a larger deficit would be obtained in the acquisition of the appetitive operant.

EXPERIMENT 2

The present experiment was aimed at testing this line of reasoning. Like the Maier and Testa (1975) study, the appetitive test contingency was degraded by introducing a temporal delay of reinforcement in the CRF schedule (cf. Grice, 1948).

Method

Subjects. The subjects were 24 male Holtzman rats, approximately 90 days old at the beginning of the experiment. Housing conditions and deprivation procedures were identical to those described above.

Apparatus. The appetitive testing chambers and the shock escape training chambers were those used in the above experiment.

Procedure. The animals were again assigned to groups ($N = 8$) on the basis of their ad-lib body weights so that the groups were approximately equal in mean body weight (range 342-354 g).

Shock training. This phase of the experiment was identical to that of Experiment 1. Group E rats were trained to jump onto the platform to terminate shock. Group I rats were yoked to Group E rats and therefore received an equal amount of shock, but inescapably. Group C rats were simply placed in the training chambers for a yoked amount of time but were not exposed to shock.

Appetitive test. On Day 2, the appetitive test was begun. All testing procedures were identical to those reported above, with two important exceptions. A 1-sec delay of reinforcement was superimposed on the CRF schedule. Each barpress again produced a food pellet. However, a 1-sec delay was introduced between the emission of the response and the delivery of the reinforcer. The amount of time elapsing between the animal's being placed in the appetitive chamber and its ingestion of the first food pellet located in the food cup was recorded. The appetitive test was again conducted for a maximum of 5 days with a 2-h daily session or until the animal had earned 100 food pellets. IRTs were recorded for each animal.

Results

Shock training. All rats in Group E learned the jump-up escape response. No failures to escape were observed in this group during the last 20 training trials. The mean amount of shock received throughout training by Group E and therefore Group I was 605.70 sec, with a standard deviation of 142.88.

Appetitive test. No differences were observed between Groups E, I, and C in the latency to ingestion of the first pellet after being placed in the appetitive chambers [$F(2,21) < 1$]. The mean latency on this measure for Groups E, I, and C was 2.75, 2.13, and 1.30 min, respectively.

More importantly, however, Group I showed longer IRTs than either Group E or Group C for a relatively large number of responses during the early part of testing. Figure 2 shows the IRTs for these three groups averaged across 5 responses for the first 50 responses of the appetitive test. Both Group E and Group C showed a slight increase in IRTs for the first three blocks of responses, a subsequent sharp decrease on the next two blocks, and asymptotic IRTs

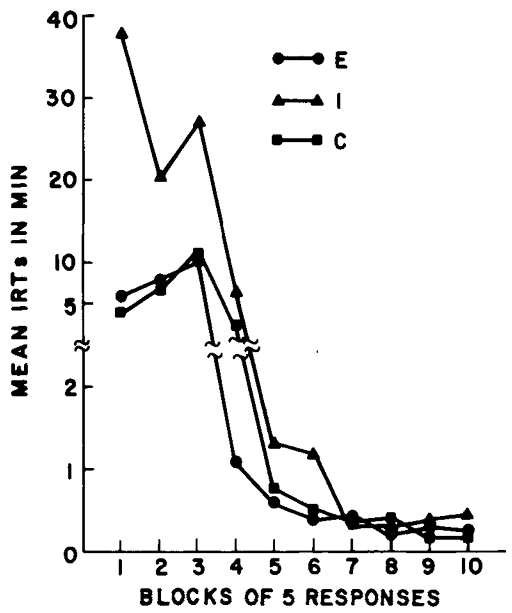

Figure 2. Mean interresponse times (IRTs) in minutes for the escape (E), inescapable (I), and control (C) groups in blocks of 5 responses in the appetitive test of Experiment 2.

by the sixth block of responses. Group I showed long IRTs on the first three response blocks, a sharp decrease on the following three blocks, and asymptotic performance by the seventh response block. A Group (3) by Block (10) analysis of variance showed both main effects to be significant [$F_{Groups}(2,21) = 6.33$ and $F_{Blocks}(9,189) = 9.96$, $p < .01$], as was the Group by Blocks interaction [$F(18,189) = 2.89$, $p < .01$]. Newman-Keuls post hoc tests showed Group I to have significantly longer ($p < .05$) IRTs during the first three response blocks than Group E or Group C, which did not differ from each other ($p > .10$).

No significant correlation was obtained between amount of shock received during training and the mean IRT averaged across the 10 response blocks for either Group E or Group I [$r(6) = 0.42$ and 0.31, $p > .10$, respectively].

GENERAL DISCUSSION

Inescapable shock interferes with learning an appetitive operant. In Experiment 1, only a slight interference was obtained which dissipated by the sixth exposure to the response-reinforcer contingency. In Experiment 2, however, a stronger interference was seen. Animals exposed to inescapable shock showed long interresponse times for at least the first 15 responses of the test. This deficit is specifically attributable to the uncontrollability of the shock during training, since animals exposed to identical amounts of *escapable* shock acquired the appetitive response at the same rate as nonshocked controls.

The more profound deficit obtained in Experiment 2 indicates that the nature of the response-reinforcer contingency employed in the test is an important determinant of the magnitude of the deficit seen after exposure to inescapable shock. This finding is in agreement with results reported from the aversive test situation. Maier, Albin, and Testa (1973) and Seligman and Beagley (1975) found inescapable shock to produce no interference with the subsequent learning to escape shock if an FR1 shuttle or barpress response-shock termination contingency was in effect during the test. But substantial interference was obtained with an FR2 shuttle or FR3 barpress-shock termination contingency. Similarly, in the present study, inescapable shock produced weak interference with the learning of an appetitive barpress response when reinforcement was presented on a CRF schedule. But a much stronger interference was obtained when the response-reinforcer contingency was degraded by imposing a delay of reinforcement on the CRF schedule.

It might be argued that the present deficit could be due to a neophobia effect (Barnett, 1963, p. 28). Animals exposed to inescapable shock may simply take a longer period of time to approach and consume a novel food. This possibility, however, does not seem tenable, since no differences were obtained in time-to-approach and begin-to-consume the novel food. In addition, observation of the animals throughout testing showed all animals to consume rapidly the pellets earned by barpressing. It should be emphasized that the interference obtained in these experiments is considerably weaker than that usually obtained with an aversive test. The differential effect may be due partly to the different testing procedures employed in these two situations. The typical shock-escape test for learned helplessness may be more conducive to obtaining large deficits than the appetitive test. In the shock test, each time the animal fails to escape, it is essentially exposed to an additional trial of inescapable shock. This additional exposure should, if anything, strengthen the effect of the prior exposure to inescapable shock. However, in the appetitive operant test, a failure to respond has no consequences. In addition, each time the animal does respond, it is exposed to the response-reinforcer contingency. Seligman, Rosellini, and Kozak (1975) have shown that repeated exposure to the response-reinforcer contingency in the aversive situation does reverse the debilitating effects of prior exposure to inescapable shock. Thus, it might be expected that each exposure to the response-food delivery contingency may to some extent weaken the effect of prior inescapable shock. Further research must be conducted to determine whether the debilitating effects of inescapable shock can be reversed by exposure to an appetitive response-reinforcer contingency.

In conclusion, these experiments show the reinforcer generality of the interference effect produced by exposure to uncontrollable shock. Although these findings are certainly congruent with the learned helplessness hypothesis, they do not provide a critical test between this hypothesis and alternative hypotheses such as learned inactivity (Glazer & Weiss, 1976a and 1976b) or competing response (Bracewell & Black, 1974; Miller & Weiss, 1969), which can also account for effects of exposure to uncontrollable aversive events.

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(Received for publication June 3, 1977;
revision accepted October 19, 1977.)