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The Effect Of Diazepam On Escape Behavior In Helpless And Naive Rats

Louis Cotterell
Carroll College

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THE EFFECT OF DIAZEPAM ON ESCAPE BEHAVIOR IN HELPLESS AND NAIVE RATS

A THESIS SUBMITTED TO
THE FACULTY OF THE DIVISION OF BIOLOGY
FOR THE RECOGNITION OF HONORS

BY
LOUIS COTTERELL
HELENA, MONTANA
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This thesis for honors recognition has been approved for the Department of Biology.

Director: Dr. J. J. Manion

Reader: Dr. Jean Smith

Reader: Tom Carlin

March 30, 1979
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In previous research it was shown that diazepam, a benzodiazepine derivative, alone or with amphetamine, facilitated shuttle-box avoidance behavior in naive, male mice (Sansone 1975). Other research showed that high doses of diazepam (30 mg/kg) produced a significant decrement in response rate in rats trained on a fixed ratio schedule of lever pressing for food reward (Edmonds, Stack, and Albertson 1975).

The purpose of the present research was to show that the systemic administration of diazepam would affect the acquisition of an escape behavior in helpless and naive rats. The data indicated that diazepam significantly facilitated escape behavior in helpless rats but not naive rats.

The experiment was conducted in two parts. In part 1 two groups of rats were made helpless, helplessness defined as 15 inescapable shocks of 15 second duration with an extinction of escape behavior. After the animals were helpless, one group received diazepam the other saline and then the learning trials of escape behavior began. In part 2 two groups of rats were not given inescapable shock, but one group was given diazepam the other saline and then each group was given the same type of learning trials of escape behavior as the groups in part 1.

Method

The subjects were twenty Sprague-Dawley female rats (250 gm average weight). The rats were housed in standard cages with food and water ad lib throughout the duration of the experiment.

The apparatus was a shuttle-box designed by the experimenter. Its dimensions were 12X24X14 inches high. A plexiglass sheet served as a cover for the box, and a light (50W) was positioned over this and used as the conditioned stimulus. The floor of the box was a grid composed of 1/8 inch steel rods spaced with the center of one rod 1/2 inch from the center of the next rod. The grid was electrified by batteries delivering 270 volts D.C. at 2 milliamps.
The shock was used as the unconditioned stimulus. The use of an electrified grid is the best procedure for delivering shock to a freely moving organism. When doing so, however, the polarity of the grid bars must be continuously changed so that the subject cannot avoid being shocked by straddling bars of the same polarity. A shock scrambler was built in a similar fashion to the one developed by Hoffman and Fleshler (1962) to accomplish the task of changing the polarity of the grid-bars.

The experimental design was a Solomon Four-Group Design (Matheson, Bruce, and Beauchamp 1978). This design took into account that two of the groups had some previous treatment. The presentation form for this design is in Table 1.

**TABLE 1**

PRESENTATION FORM FOR SOLOMON FOUR-GROUP DESIGN

<table>
<thead>
<tr>
<th>Groups</th>
<th>Before Treatment</th>
<th>Treatment</th>
<th>Post Treatment Learning Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Helpless</td>
<td>Diazepam</td>
<td>Time of Trial</td>
</tr>
<tr>
<td>II</td>
<td>Helpless</td>
<td>No Diazepam</td>
<td>Time of Trial</td>
</tr>
<tr>
<td>III</td>
<td>-</td>
<td>Diazepam</td>
<td>Time of Trial</td>
</tr>
<tr>
<td>VI</td>
<td>-</td>
<td>No Diazepam</td>
<td>Time of Trial</td>
</tr>
</tbody>
</table>

Note.— Only four rats were in group I.

Five rats were randomly assigned to each of four groups: a helpless-diazepam group (I); a non-helpless-diazepam group (III); and two control groups, a group that was not helpless and no diazepam (IV) and a group that was helpless and no diazepam (II). With the exception of either helplessness or diazepam all the groups were treated identically.

**Part 1**

**Helplessness**

Rats in group I and group II received 15, 15-sec. inescapable shocks over a 25 min. period. The procedure for delivering the shock was as follows: the conditioned stimulus (CS) was turned on. Five seconds later the unconditioned stimulus (US) was turned on in conjunction with the CS. After 15 seconds both the CS and the US were simultaneously terminated. By this procedure light was
present for 20 seconds and shock present for the last 15 seconds together with the light. An intertrial time of 15 to 25 seconds followed the termination of the shock and light.

**Learning trials**

Twenty-four hours after the helplessness session the rats were subjected to ten trials of escape learning per day for ten days with a total of 100 trials for each rat. Each day three hours before the trials were to begin, the rats in group I received an injection interperitonially of diazepam (2 mg/kg of body weight). The rats in group II received an injection interperitonially of isotonic saline (0.1 ml).

The learning trials consisted of the same procedure as above with the exception that the animals could now avoid or escape shock by moving from one end of the box to the other end and back again. If the rat moved from one end of the box and back again after the onset of the CS and before the onset of the US, the CS was terminated and shock was avoided. If the animal did not move back and forth until after the onset of the US but before the CS had been on for 20 sec., the CS and US were terminated when the animal completed the response and the animal escaped shock. To avoid and escape shock the animal had to complete the response within 20 seconds after the onset of the CS. If the animal failed to complete the response in 20 sec. the CS and US were terminated and a new trial started 25 seconds later.

**Part 2**

The animals in groups III and IV participated in part 2 of the experiment. The animals in these two groups were not given any in-escapable shock. Instead the rats in group III received diazepam at the same dose as group I and rats in group IV were given the same amount of isotonic saline as group II. These two groups were given only learning trials following the same procedure as in part 1.

**Results**

Each rat's time was recorded for each learning trial in the shuttle-box. Each day all the times for all the trials of that day were averaged to give one median time (median latency) for each group. These data are recorded in Figure 1.
FIG. 1. Median latencies of the four experimental groups.

The test statistic employed was a t Test For Two Means. A comparison of groups I and II's median latency times indicated a significant difference between the two groups with group I responding more quickly than group II (t=2.24; df=18; p<.025). Comparison of group III to group IV gave no significant difference. There was a significant difference between the two control groups, II and IV: (t=2.56; df=13; p<.025), indicating that group IV responded more quickly in the shuttle-box.

Discussion

When a naive rat is given inescapable shock, Seligman (1975) postulates that its motivation to respond in the face of later shock is reduced. Moreover, even if the rat does respond, and the response succeeds in producing relief, the rat has trouble learning that the response worked.
To explain this lack of motivation to respond Seligman used an elegant experimental design to show that it was not the shock itself but learning that shock was uncontrollable, that causes helplessness.

For the fifteen inescapable shocks in this experiment, the rats had no control over when the shock would come on or when the shock would stop. The typical behaviors of all the rats in the helplessness groups were defecation, urination and huddling in a corner of the box while shock was on.

Explaining why there is an interference of learning and inescapable shock is not easy. Hypotheses that were rejected are: (a) adaptation to shock, (b) sensitization to shock, (c) competing motor responses and (d) emotional exhaustion (Campbell and Church 1969). None of these hypotheses could adequately account for the interference effect.

The one hypothesis that does account for the lack of motivation is the helplessness hypothesis. The hypothesis, as stated by Seligman, is that animals acquire expectations about the outcomes of their acts. The animal learns that responding or not responding can produce reinforcement. In a situation where shock is inescapable or unavoidable the animal learns that his response is independent of shock termination. As Seligman puts it: "Nothing I do matters." (Campbell and Church 1969).

The data indicated a significant improvement in learning between helpless animals with diazepam and helpless animals without diazepam. How could this be explained?

It has been reported in other papers (Mowrer and Lamoueux 1945; Gray 1972) that a conditioned stimulus will produce a "fear reaction" in the animal. The animal subjected to a CS-US pairing will acquire a fear of the CS when it is presented because of anticipation of the noxious US. In this experiment the presentation of light caused all the animals to defecate or urinate after the animal had previously been exposed to the light-shock pairing either in learning trials or inescapable shock.

If we look at the situation of inescapable shock we can say that there was a total omission of reward for any response. Because of this lack of reward the state the animal is in is one of frustration (Gray 1971).
Gray also goes on to state the hypothesis that "frustration = fear." To take this hypothesis seriously, it must first be shown that frustrative non-reward shares properties with punishment. To define a punishment we can say that it is aversive and the animal will work to avoid or escape it. In helplessness the animal cannot do either, he is prevented or frustrated in his attempt.

This frustration = fear hypothesis can account then for a decrease in learning ability if taken as fear of the CS and punishment by the US. As Gray points out animals subjected to frustrative non-reward cease to respond.

To explain how diazepam works we could say that diazepam directly reduced fear in the animal. However, there are other ways of accounting for this finding. The drug could have produced sensory changes in the animal towards shock by making the shock less painful. This is inadequate because observation of animals receiving diazepam as compared to not receiving diazepam showed no difference in flinching and jumping movements. This leads to the conclusion than that diazepam could reduce the fear and frustration the animal experiences so the animal can better respond during learning trials. How diazepam does this is unknown at present and further study must be done to find the mechanism.
References


Seligman, M. E. P. Helplessness; on depression, development, and death. San Francisco: W. H. Freeman and Co., 1975