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The Disruption of Learned Behavior by Punishment in Highly Trained Rats: a Model for Neurosis Studies? [1, 2]

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Summary

In an attempt to disrupt normal, learned behavior, 15 highly trained rats were exposed in a shuttlebox to four strenuous sessions of an interpolated, inescapable shock program, while 15 other similarly trained rats served as the control group by concurrently receiving the final training program. Both groups were subjected afterwards to two further sessions under control conditions. The rats exposed to the inescapable shock program displayed, during the "normal trials" of these sessions, a marked decrease in avoidance reactions and a substantial increase in average response times. There was an overall return to pre-stress levels of performance, however, within the two sessions following termination of the stress, and no lasting effects were noted in any of these rats in subsequent studies.

There has been much literature concerned with the inhibiting effect of inescapable shocks, or "fear conditioning", on the subsequent learning of the avoidance response by previously naive animals. *Weiss, Krieckhaus* and *Conte* (1968), in addition to demonstrating that fear conditioning trials markedly impaired avoidance learning in rats, also showed that an avoidance decrement could be eliminated by training rats to a high level of shuttlebox performance prior to the presentation of inescapable shocks. In their experiments, "fear conditioning" consisted of four 5 sec. shocks spaced 10 min. apart, on each of 2 consecutive days, with each shock being preceded by a 10 sec. CS-US interval. In contrast to these results, *Storms, Baroczi* and *Broen* (1963) demonstrated various degrees of disruption of operant behavior (modified Skinner box) performance by shock punishment in trained rats, depending upon the strain tested. Several other workers, including *Jones* (1969) and *Domjan* and *Rowell* (1969) have also measured avoidance and escape behavior during the presentation of short, inescapable shocks, but also with rats trained on operant behavior programs.

The present experiment was designed to measure the influence on highly trained rats of several much more prolonged, strenuous sessions of inescapable shocks than had been previously attempted with the shuttlebox. The object was to determine if a disruption of learned behavior could be obtained by this method, and if this disruption would remain in evidence after termination of the inescapable shock sessions long enough to provide a possible model for eventual studies related to human anxiety and neuroses.

Method

30 male albino rats, about 3 months old, were used. Each of the 4 training sessions, as well as all experimental and "follow-up" sessions, were conducted at exactly 7-day intervals for each animal. At the conclusion of training, the rats were divided into two equally performing groups of 15 each, designated as control (A) and "inescapable shock" (B) groups.

The standard, 2-way shuttlebox used in all sessions has been previously described in detail (*Bättig,* 1957). The conditioned stimulus (CS) consisted of a synchronized light and buzzer signal, and the unconditioned stimulus (US) of a stabilized AC current of 60 V, delivered through the copper grid floor of the occupied side of the shuttlebox. In addition to counting the total numbers of avoidance reactions, the length of time elapsing between the onset of the CS and the termination of the response (when the rat passed through the door into the other chamber as far as the base of its tail), was also recorded for every trial. This procedure provided two parameters of measurement

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throughout the experiment, those being % of avoidance reactions (PAR) and average response times (ART).
During the first 3 training sessions, each session consisted of 100 consecutive trials with a CS-US interval of 3 secs. ($^5/_{100}$ min.). The intertrial interval (between response termination and onset of the next CS) was 30 sec. during the first 30 trials and 15 sec. during the next 70 trials. The fourth training session for each rat was identical to the other 3, except that the intertrial interval was 15 sec. throughout.
After the completion of training, group A was exposed to the identical (fourth session training) program for 4 more sessions. Group B, however, was exposed to 4 sessions of a randomized inescapable shock program as shown in fig. 1. The 70 empty squares represent "normal" trials (runs) with a CS-US interval of 3 sec., in which escape or avoidance reactions were possible. The 30 crossed squares represent trials (runs) with a CS-US interval of 3 sec., this being followed by a 27 sec. period in which electric current was delivered to the grid on both sides of the shuttlebox, regardless of the response of the animal. When the rats failed to respond during normal trials, the electric current was also discontinued after 27 sec., with the total CS time of 30 sec. being recorded.
For the last 2 sessions of the experiment, groups A and B were both exposed to the fourth training session program.

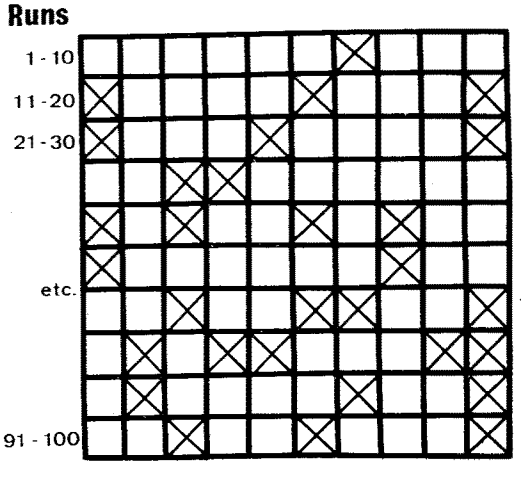

Fig. 1 Inescapable shock program (sessions 5—8) for group B rats.

Results

The results for all sessions, in terms of the two parameters used, are shown in fig. 2 and 3. The values shown for group B during the inescapable shock sessions (5—8 in both figures) refer to the behavior of these animals during the 70 "normal" trials of these sessions only. The results of these 70 trials were extrapolated to 100 trials in order to facilitate comparison with group A. An obvious disturbance of behavior in group B,

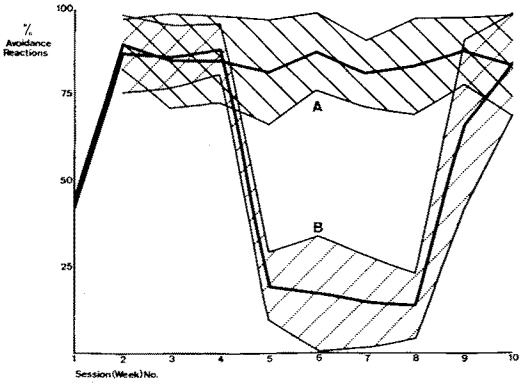

Fig. 2 PAR results for all sessions (1—4 = training phase, 5—8 = experimental phase, and 9—10 = recovery, or "follow-up" phase). A = control group, B = "inescapable shock" group. The thick, solid lines represent the means for each group, shaded areas represent the standard deviations.

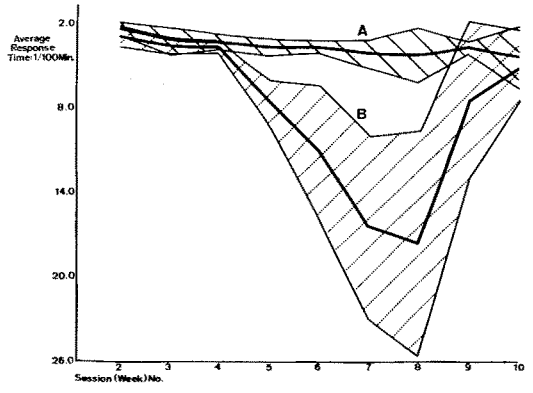

Fig. 3 ART results (reversed in order to facilitate comparison with fig. 2).

caused by the inescapable shock program, can be seen in both figures. The inhibitory effect on PAR was immediate and abrupt (fig. 2), whereas the prolongation of ART appeared to be more gradual (fig. 3). Both figures show an overall return to pre-stress levels of behavior for the group B rats, 2 sessions after termination of the inescapable shock program.

In addition to measuring the rats behavior as a whole, maintenance of the relative performance levels of individual rats from session to session, or their "rank order", was calculated by means of the Spearman Rank Correlation Coefficient test. Relative performance levels for group A rats, under both measurement parameters, remained significantly constant among animals. On the other hand, the same analysis revealed a distinct disruption of the relative performance levels of group B rats during sessions 5–7, indicating that some animals were more susceptible to the stress of the inescapable shock program than others, with these behavioral changes varying substantially from week to week. Order appeared to be established in group B between sessions 7 and 8 ($p < .05$), a tendency which was maintained over sessions 9 and 10, especially in regard to the measurement of PAR.

As further evidence of the considerable differences seen among individual rats during the inescapable shock sessions, and as an adjunct to fig. 2 and 3 in regard to recovery after those sessions, tab. 1 shows the % of total response failures exhibited by each rat during the 70 normal trials of the inescapable response sessions, i.e. when it was possible for the rat to either avoid or escape the shock, but with its having made neither response.

	Session No.					
	5	6	7	8	9	10
Rat No.	%	%	%	%	%	%
1	4	6	43	53	17	0
2	13	16	14	13	11	0
3	3	1	37	47	27	13
4	4	46	26	43	0	0
5	0	37	66	71	44	0
6	0	16	40	71	0	0
7	7	21	71	50	10	0
8	6	11	20	34	0	0
9	1	7	19	3	0	0
10	7	13	27	44	7	1
11	4	19	44	59	0	0
12	1	11	21	4	0	0
13	1	0	6	7	0	0
14	6	24	60	37	36	3
15	4	4	3	7	0	0

Tab. 1 % of total response failures for each group B rat during the experimental phase (sessions 5—8), and recovery phase (sessions 9—10), including only those trials (runs) where escape or avoidance were possible.

Discussion

This study differed from that of *Weiss, Krieckhaus* and *Conte* (1968) in regard to degree of training, methods of measurement, type of inescapable shock exposures, and the duration and spacing of all sessions.

However, both studies indicated that it is very difficult, if not impossible, to permanently disrupt the avoidance behavior of highly trained rats by the presentation of inescapable shocks, even when they are administered on such a scale as in this present experiment. Operant behavior experiments have demonstrated that trained rats will continue to respond even when as few as 15% of the shocks could be avoided (*Jones,* 1969), and will continue to lever-press during exposure to inescapable shocks (*Domjan* and *Rowell,* 1969). The latter authors, citing *Migler* (1963), have suggested that responding during inescapable shock could be considered a superstitious escape behavior.

Without intending to make any direct comparisons between operant behavior and shuttlebox behavior, it should be mentioned here that considering the conditions of the experimental phase of this study (sessions 5–8), where it was actually possible for the group B rats to escape or even avoid in 70% of the trials, remaining immobile in the original side of the box for the whole shock duration was frequently observed during these, as well as during the inescapable shock, trials (tab. 1). This behavior was most predominant during sessions 7 and 8 and could be interpreted as probably being associated with the phenomena of "learned helplessness" and/or "freezing", which have been previously discussed by *Weiss* and coworkers (1968, 1970) in relation to avoidance behavior. All group B animals exhibited this "non-response" to some degree or another, the considerable variation of which among rats can be seen in tab. 1 and the large standard deviation of fig. 3, sessions 6–8.

The overall return to pre-stress levels of performance within the 2 "follow-up" sessions, however, indicated that in even the most severe cases, the original learned response (perhaps regenerated in the form of superstitious behavior) regained control over the shuttlebox behavior of these rats. This finding would seem to be in agreement with that of *Storms, Boroczi* and *Broen* (1963), who concluded that the effects of prior training and habitual behavior are not permanently inhibited by shock punishment in rats, this having been postulated several years previously, by *Kamin* (1959). Nor have these effects been found to be permanently disrupted in various "pair situation" studies which have put 2 trained rats together in running- or lever pressing-escape situations (*Azrin, Hutchinson* and *Hake*, 1967; *Ulrich*, 1967; *Wolfe, Ulrich* and *Dulaney,* 1971).

The retention of learned avoidance behavior, therefore, and the accompanying strong resistance of that behavior to extinction, both provoked (*Baum*, 1970), and non-provoked (*Bättig,* 1957, *Driscoll* and *Bättig*, 1970), seem to be a prominent characteristic of highly trained rats. Later experiments with rats of both groups A and B have proven them to be equally adequate subjects for further, long-term shuttlebox studies not involving punishment of the learned response (*Driscoll* and *Bättig*, 1970). When the absence of any lasting effects resulting from the prolonged shock exposures to which the group B rats were subjected in this study is borne in mind, the realization of a continuous, 43-day long discriminated avoidance session, in which all resting or sleeping was interrupted at least once every 5 min. by either a response or a shock, and from which both rats emerged with apparently no ill effects (*Ulrich, Brierton, Mabry* and *Stachnik,* 1965), comes as less of a surprise.

The shuttlebox has been used in animal experiments for many years on such diverse grounds (to name but 2) as the investigation of a type of inborn survival behavior in animals comparable to avoidance of and escape from predators (*Bovet, Bovet-Nitti* and *Oliverio,* 1969), and the investigation of a

fear-motivated behavior in animals said to be similar in some respects to human anxiety-motivated behavior and neurotic disorders such as phobias (*Baum,* 1970). It can be concluded from this present study that the intense motivation and habitual behavior demonstrated by highly trained rats in this test, and the unpredictable differences among individuals, limit the advantages of using this type of animal-model for studies involving the after-effects of forced disruption of this behavior over an extended period of time. A more useful method, especially in regard to the two theoretical problems mentioned above, might be to conduct such studies with two highly contrasting strains and split-litter techniques, in order to observe a wide spectrum of behavioral responses which are, however, uniform and reproducible. Experiments are now in progress utilizing 24th generation (Wistar) Roman High Avoidance and Roman Low Avoidance rats (*Bignami,* 1965), in the pair situation. Preliminary results indicate that substantial contributions toward the understanding of this test and its theoretical implications may be gained by this method.

Zusammenfassung

Das angstbedingte Vermeidungsverhalten von Tieren wird oft mit dem menschlichen Furcht-motivierten Verhalten und neurotischem Furchtverhalten, wie es in Fällen von Phobie auftritt, verglichen. Durch das vorliegende Experiment wurde versucht, die Frage abzuklären, in welcher Weise erhöhter Streß in Form von unvermeidbaren elektrischen Schlägen die gelernte Vermeidung von Schlägen mit Fluchtmöglichkeiten beeinflußt. Dazu wurde einer Gruppe von 15 gut trainierten Ratten innerhalb vier Sitzungen mit je 70 normalen Schocks nach einem bestimmten Plan je 30 Schocks ohne Fluchtmöglichkeit gegeben. Gegenüber einer Kontrollgruppe von 15 Ratten ohne Streß sank die Vermeidungsleistung der experimentellen Gruppe während den vier Sitzungen mit erhöhtem Streß, stieg aber in zwei nachfolgenden Sitzungen wieder auf das Niveau vor dem Streß. Auch hatte der erhöhte Streß keinen Einfluß auf spätere «Shuttlebox»-Experimente.

Résumé

Le comportement d'évitement conditionné par la peur des animaux est souvent comparé avec le comportement humain motivé par la peur et avec le comportement de crainte neurotique, comme il apparaît en cas de phobie. Par la présente expérience nous avons essayé de répondre à la question suivante: par quelle manière le stress augmenté sous forme d'électrochocs inévitables influence-t-il l'évitement appris de chocs avec possibilités de fuite? Dans ce but, nous avons administré à un groupe de 15 rats bien entraînés 70 chocs normaux et, selon un plan défini, 30 chocs sans possibilité de fuite au cours de quatre sessions. En comparaison avec un groupe de contrôle de 15 rats sans stress, la performance d'évitement du groupe expérimental diminua au cours des quatre séances avec stress augmenté, s'éleva pourtant au cours des deux séances suivantes jusqu'au niveau initial. En plus, le stress augmenté n'influença pas les expériences ultérieures de «Shuttlebox».

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