However, these results do suggest that the use of threats, under the appropriate conditions, can have beneficial effects on further interaction which occurs when the threat is no longer present.

In conclusion, the present study suggests that threats, as coercive but justifiable devices, can induce a high rate of compliance without necessarily creating conditions which so often seem to result in an eventual increase of conflict.

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(Received for publication November 29, 1974.)

Bulletin of the Psychonomic Society
1975, Vol. 5 (3), 225-227

Intermittent reinforcement and intertrial interval effects on shuttlebox avoidance in the gerbil

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Separate groups of gerbils received 100% or 50% reinforcement during discriminative avoidance conditioning at either a 30-sec or 90-sec intertrial interval (ITI), and then each group was extinguished at the same ITI in effect during acquisition. Both 100% and 50% reinforcement animals showed superior acquisition performance at the 90-sec ITI, while in extinction the 30-sec ITI gerbils were more persistent than the 90-sec animals under both reinforcement schedules. These results were interpreted in terms of theories of avoidance in which the role of ITI length in reinforcement of the avoidance response is stressed.

The extensiveness of the instrumental learning literature dealing with the effects of partial reinforcement (PR) on performance in the appetitive case is in sharp contrast to the paucity of research concerned with intermittent reinforcement in aversive situations. In the case of discriminative avoidance learning, the neglect of investigating PR effects undoubtedly stems, at least in part, from the failure to identify unequivocally the sources of reinforcement for the avoidance response (see Bolles, Moot, & Grossen, 1971; Katzev & Enkema, 1973). Due to the uncertainty as to the nature of reinforcement in the avoidance situation, of course there arises a related difficulty in operationalizing nonreinforcement. In this connection, Davenport and Olson (1968) have proposed that a nonreinforced avoidance trial should involve the elimination of the avoidance contingency as well as the CS termination contingency. Thus, on a nonreinforced avoidance trial the CS is followed by the aversive stimulus irrespective of the animal's behavior, i.e., the subject receives a CS-US pairing. Studies of PR in discriminative avoidance in which nonreinforcement has been so defined (Davenport, Olson, & Olson, 1971; Galvani, 1971, 1973a, 1973b; Olson, Davenport, & Kamichoff, 1971) have consistently shown that intermittent reinforcement results in substantially inferior acquisition relative to continuous reinforcement.

To further explore the suppressive effect of PR

The research for this paper was supported by Grant B04355-001 from the Division of Biological and Medical Sciences, National Science Foundation, awarded to the first author.

schedules on acquisition in discriminative avoidance, one might assess the effects of variables known to affect performance level under continuous reinforcement on PR subjects. One such variable is the intertrial interval (ITI). Increasing ITI duration (at least up to 5 min) has been shown to facilitate shuttlebox avoidance performance (Brush, 1962; Kurtz & Shafer, 1967; Levine & England, 1960; Pinckney, 1966). Accordingly, the present experiment investigated shuttlebox avoidance acquisition and extinction under PR and continuous reinforcement in animals trained at either a short (30-sec) or long (90-sec) ITI. A secondary purpose of the study was to determine whether or not the ITI variable has effects on avoidance behavior in gerbils similar to those observed in previously studied species, e.g., rats and fish.

METHOD

Subjects

The subjects were 40 adult male gerbils obtained from Tumblebrook Farms, West Brookfield, Massachusetts. All subjects were individually housed in a continuously illuminated room and maintained on ad-lib food and water.

Apparatus

The apparatus consisted of two Scientific Prototype Model A100S toggle-floor shuttleboxes (13.5 x 13 x 40 cm) described in Galvani (1971). Each shuttlebox was enclosed in a ventilated, sound-attenuated chamber illuminated by a 7.5-W incandescent lamp and provided with a one-way window. A continuous masking noise was delivered through an 8-cm speaker centered above the shuttlebox via a BRS-Foringer audio generator (AU-902). The tonal CS (2,500-Hz) was also delivered through an 8-cm speaker by the same audio generator. The tone raised the sound level (86 dB with masking noise and ventilating fan on) about 2 dB on the C scale of a General Radio Type 1561-A sound-level meter. The US was a .5-mA (nominal), .5-sec scrambled electric shock delivered to the grid floor of the shuttlebox by a Grason-Stadler Model GS 700 shock generator. Programming and data recording equipment were located next to the sound-attenuated chambers.

Procedure

After a 10-min adaptation period in the shuttlebox, all gerbils received a single 100-trial acquisition session, followed immediately by a 100-trial extinction session. The CS-US interval was 5 sec on all trials. On acquisition trials shock onset occurred at the moment of CS offset.

The design was a 2 by 2 factorial in which one variable was ITI (30 vs. 90 sec) and the other was schedule reinforcement, i.e., regular avoidance training (AV) vs. partial reinforcement (PR). For AV-trained gerbils, a shuttle response made during the CS terminated the tone immediately and precluded shock on that trial. If no response occurred, the 5-sec CS was followed by shock. For PR subjects, a random 50% of their trials were of the AV type. On the remaining trials, the PR gerbils received classical conditioning trials, i.e., nonreinforced trials. On nonreinforced trials, the CS was inevitably followed by shock, whether or not the subject performed a shuttle response.

All gerbils received the same extinction treatment. No shocks were presented in extinction. A shuttle response terminated the CS immediately, and if no response occurred, the CS automatically terminated 5 sec after its onset.

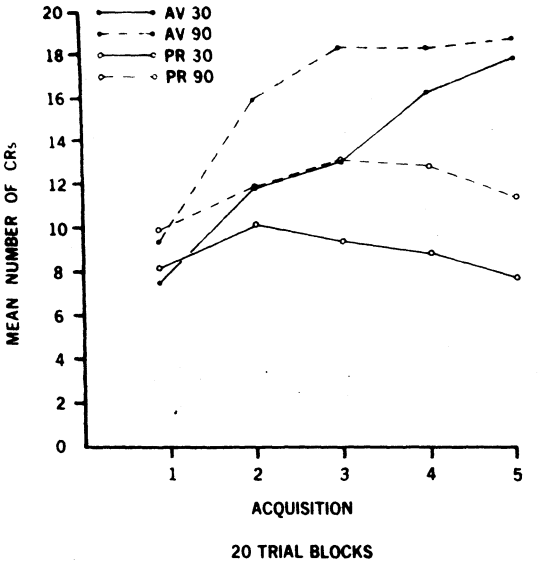

Figure 1. Mean number of CRs in 20-trial blocks in acquisition for continuous (AV) and partial (PR) reinforcement groups as a function of ITI length (30 or 90 sec).

RESULTS

The mean number of conditioned responses (CRs) for the 100-trial acquisition session for each group is shown in 20-trial blocks in Figure 1. For purposes of the present study, a CR was defined as any shuttle response occurring during the CS-US interval, whether or not it avoided shock. Inspection of Figure 1 reveals that superior avoidance performance was obtained in AV groups relative to PR groups, and that 90-sec ITI groups were superior to 30-sec groups. Analysis of variance of these data indicated that all main effects were reliable: ITI, $F(1,36) = 9.66$, $p < .005$; AV vs. PR, $F(1,36) = 22.14$, $p < .001$; and trial blocks, $F(4,144) = 18.75$, $p < .001$. The only significant interaction was the AV vs. PR by Trial Blocks interaction, $F(4,144) = 12.05$, $p < .001$. Follow-up tests revealed that while Groups AV-30 and AV-90 did not differ on Trial Block 5, the difference between Groups PR-30 and PR-90 approached significance, $t(18) = 1.88$, $p < .10$. The AV vs. PR by Trial Blocks interaction was further analyzed by use of a Scheffé test which compared the AV subjects' increase from Block 1 to 5 with the PR subjects' increase from Block 1 to 5, $S^2(4,144) = 20.56$, $p < .001$. Clearly AV animals showed a greater increment in CR frequency over trials than did PR gerbils, the latter showing essentially no improvement. (The PR groups, however, were substantially superior to classical-conditioning controls trained with comparable parameters in previous studies, e.g., Galvani, 1973a, 1974.)

Due to the reliable group differences obtained in

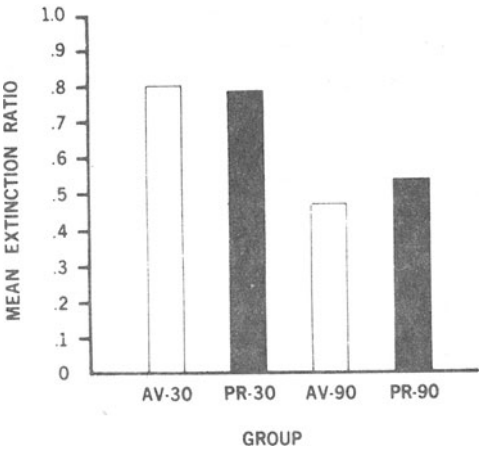

Figure 2. Mean extinction ratio as a function of acquisition treatment in all four groups.

acquisition, an "extinction ratio" (total number of CRs in extinction/total number of CRs in acquisition) was computed for each subject in order to evaluate relative degree of extinction between groups. These extinction ratios, depicted in terms of group means in Figure 2, became the basic data of extinction. Analysis of these data revealed that only the ITI effect was significant, $F(1,36) = 5.19$, $p < .05$. Specifically, subjects trained and extinguished under the 90-sec ITI showed reliably less CR persistence than animals exposed to the 30-sec ITI.

DISCUSSION

In general, the results suggest that the effect of the ITI on gerbil shuttlebox avoidance learning is comparable to the effect observed in both rats (Brush, 1962) and fish (Pinckney, 1966), i.e., increasing ITI length facilitates acquisition performance. Moreover, the facilitative effect of increasing ITI length was obtained for both continuously reinforced subjects and PR animals. Note, however, that the effect of the ITI variable on AV-trained gerbils appears to be on rate of acquisition, while ITI seems to influence acquisition asymptote under a 50% PR schedule. The major extinction finding was that the 90-sec ITI was shown to facilitate extinction. More rapid extinction in 90-sec animals relative to 30-sec animals was obtained for both the AV and PR groups.

Theories of avoidance behavior which have stressed the role of the ITI in the reinforcement of the avoidance response (e.g., Denny, 1971; Weisman & Litner, 1971) seem particularly relevant in interpreting both the acquisition and extinction results of the present study. In more detail, the length of the nonshock interval (ITI) following a successful avoidance response might be viewed as a magnitude of reward variable. Based on Denny's elicitation theory, longer ITIs permit greater opportunity for the elicitation of the long latency relaxation-approach response which facilitates the acquisition of the instrumental avoidance response. Alternatively, inhibition of fear produced by the avoidance response. Alternatively, inhibition of fear produced by the avoidance response might be the reinforcement mechanism as Weisman and Litner have have suggested. The longer the interval of safety signaled by a successful avoidance response, the greater the resultant inhibition of fear, hence the greater the magnitude of reinforcement for that response. On either view, superior acquisition with longer ITIs readily follows. Moreover, in PR-trained animals the 90-sec ITI apparently provided greater reinforcement for a successful avoidance response on reinforced trials than obtained in the 30-sec ITI and thereby counteracted the suppressive effect of nonreinforced trials to a greater degree than was true with the shorter ITI.

Another interpretation of the effect of ITI on acquisition might emphasize recent data (McAllister, McAllister, & Weldin, 1974) showing that increasing the ITI increases the strength of classically conditioned fear. On this view, 90-sec gerbils receive greater reinforcement of the avoidance response than 30-sec animals because CS termination is followed by greater fear reduction. On the other hand, this analysis does not seem to explain the inverse relation between resistance to extinction and ITI. Indeed, if the CS elicited greater conditioned fear in the 90-sec subjects, then one might expect greater persistence in these animals during extinction relative to 30-sec gerbils. More rapid extinction with the longer ITI, however, is consistent with Denny's relaxation theory in that the longer ITI should facilitate the elicitation of the relaxation response in extinction. Relaxation would thus emerge and compete with fear of the CS earlier in extinction under the long relative to the short ITI.

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(Received for publication December 12, 1974.)