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SOME TEMPORAL FACTORS EFFECTING SHUTTLE SIDMAN AVOIDANCE PERFORMANCE IN RATS

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The purpose of this research was to determine the effects of two independent variables on avoidance efficiency in a modified shuttle Sidman-avoidance task. The task modification consisted of allowing subjects to accumulate shock free time as a consequence of their response, thus resulting in a variable response-shock interval. The two independent variables employed were magnitude of shock delay and intensity of electric footshock.

One of the most useful tasks for the study of aversive learning and motivation has been free operant Sidman avoidance. In this task animal subjects in an operant conditioning chamber, press a lever in order to avoid or postpone a brief inescapable aversive stimulus (usually electric shock). If the subject does not bar press within some predetermined period of time, brief, inescapable footshocks are administered until the subject does respond appropriately. The time period between these repeated shocks is termed the "S-S" or shock-shock interval. When the subject presses the lever in this task the shock is postponed. The time period between the subject's response and the next scheduled shock is termed the "R-S" or response-shock interval. The actual time between shocks depends on the number and timing of the subject's responses. In general, it has been found, that optimal performance is achieved when S-S intervals are much shorter (e.g. 5 sec.) than R-S intervals (e.g. 30 sec.). Performance tends to deteriorate with shorter R-S intervals or as R-S and S-S intervals become more nearly equal.

The major difficulty encountered with Sidman avoidance is that many subjects are unable to learn the task when a lever-press is employed as the operant avoidance response. An alternative to lever-press Sidman avoidance is to use a shuttle box and employ a hurdle-jump response (e.g. Osborne, 1977, 1978; Riess, 1971). Subjects generally acquire efficient responding on this task within a very few sessions.

Sidman (1953b) has employed an interesting variant in his basic avoidance paradigm. In this variant each response postponed shock for an additional 5 seconds. Thus a single response postponed shock for 5 seconds, two responses for 10 seconds, and so on. Using this paradigm, Sidman found no regular correlation between the probability of a response and the time since the last response, as had been found with constant R-S intervals. He suggested that longer subject imposed R-S intervals made shock onset too unpredictable and hence broke up the regular patterns of response observed with constant R-S intervals. It is unclear whether the actual response pattern - or lack of it - as a consequence of variable R-S intervals would be the same for a shuttle Sidman task as for the lever-press task, because of numerous task differences. This relationship would have to be empirically determined. It might also be asked how other variables such as shock intensity influence performance on an adjusting schedule Sidman avoidance task. Shock intensity has been found to have predictable effects on both lever-press Sidman (Boren, Sidman, and Herrnstein, 1959) and shuttle Sidman (Osborne, 1978) avoidance behavior, i.e. performance is directly proportional to shock intensity. Presumably, greater shock intensity leads to greater conditioned fear reduction as a consequence of the avoidance response. If the optimal R-S avoidance increment is related to the aversiveness of the situation, presumably greater shock intensities could lead to more efficient responding especially when shorter duration avoidance increments are used.

Thus, the purpose of this research was to determine the effects of varying the length of avoidance increments and varying the intensity of electric footshock on the efficiency of performance in a shuttle-Sidman avoidance task.

Method

Subjects. Sixteen experimentally naive male Wistar albino rats approximately 75 days old were randomly assigned to one of three experimental groups.

Apparatus. A single Lehigh Valley rat shuttle box, (model 164 04), was used as the Sidman Avoidance task Chamber. A center hurdle divided the shuttle box into two equal (22.5cm. X 20.5cm.) compartments. The center hurdle consisted of two metal plates laminated to a plastic insulator and was electrified when shock was administered to prevent "perching". The electric shock (UCS) consisted of either a scrambled 0.6 mA shock, 1.3 mA shock, or a 2.0 mA shock, all of which were administered by the same shock source, (Grayson-Stadler model 700). Events such as the presentation of shock and the subjects' responses were recorded on electromechanical counters and an Esterline Angus (Model Operation Recorder) 20 pen event recorder.

Design and Procedure. Subjects were weighed and handled for 5 min. All subjects were run for 9 daily sessions on a shuttle Sidman Avoidance task. Each session consisted of 90 min. Subjects were run at approximately the same pre-determined time of day, everyday, for 9 consecutive days. Treatment of subjects differed only in the intensity of shock to be employed. This variable was randomly assigned to each subject and remained constant for the subject throughout the experiment. Thus there were three groups of subjects exposed to three different shock intensities on a Shuttle Sidman Avoidance task.

The increment of time that a single response delayed shock (R-S increment) was varied over the course of the experiment. The R-S increments employed were: 30 sec on days 1 and 2; 20 sec on day 3; 10 sec on days 4 and 5; and 5 sec on days 6 thru 9. Subjects were exposed to long intervals first, because preliminary data indicated that subjects did not learn the avoidance response when both the R-S increment and the S-S interval were 5 sec. The actual time between shocks depended on the number and timing of the subject's responses. Subjects were able to additively accumulate no-shock time, by multiple responding. The actual time accumulated depended upon the R-S increment assigned to that day. The procedure was initiated for each subject as follows: The subject was placed in the shuttle Sidman Avoidance task chamber. Each session began with presenting repeated shocks at 5 sec intervals until the animal jumped the center hurdle to avoid shock. The time period between these repeated shocks (S-S interval) was held constant for all subjects throughout the experiment (i.e.,S-S interval = 5 sec, UCS duration = .5sec.) At the end of each 90 min. session, the animal was immediately removed from the shuttle box to prevent "extinction", and placed back into his home cage.

Thus the independent variables employed in this study were: 1. the length of the R-S increment by which subjects postponed shock (i.e. 30, 20, 10 or 5 sec) in a "within subjects" design; and 2. the intensity of shock motivating that response (i.e. 0.6, 1.3, or 2.0 mA) in a "between groups" design. The response measures made in all avoidance sessions were: 1. the total number of shocks received; 2. the number of S-S or repetitive shocks received; 3. the total number of shuttle responses emitted; and 4. the number of R-S or avoidance responses emitted.

Results.

Shock and response data. Figure 1 represents the mean number of shocks received by each shock intensity group as a function of the four R-S avoidance increments employed in the study. For clarity, the data in the figure is for the last session of each R-S increment. That is, days 2, 3, 5, and 9 for the 30, 20, 10, and 5 second increments, respectively. Inspection of the figure suggests that the shock groups received 20 to 40 shocks during the 20 and 30 second R-S increment terminal sessions. During the 10 second R-S increment, the 0.6 and 1.3 mA groups maintained their shock frequencies, however, the 2.0 mA group received nearly three times as many shocks as the weaker intensity groups. When the R-S increment and S-S interval were both 5 seconds, all groups received many more shocks, with the 2.0 and 0.6 mA groups increasing shock frequency most dramatically. Parametric analysis of the mean number of shocks over all nine sessions indicated that all four 5 second R-S increment sessions resulted in more shock than the terminal sessions of all other increments. (NOTE. The shock intensity variable was not statistically significant in any of the reported analyses, presumably because of the small sample sizes involved: 6, 5, and 5. Therefore, the data and the conclusions drawn are at best tentative.)

Thus, the shock frequency data suggest the optimal R-S increment on the Shuttle-Sidman avoidance task would appear to be 10 seconds or greater with medium and low shock intensities and 20 seconds or longer with higher shock intensities.

For the purpose of this study an avoidance response was defined as a shuttle response preceded by another shuttle response rather than an electric shock.

Figure 2 presents the mean number of avoidance responses for the shock intensity groups as a function of the four R-S increment terminal sessions. The figure suggests that all groups increased the frequency of avoidance responses as the R-S increments were made progressively smaller. Closer examination suggests that the 2.0 mA group demonstrated a smaller increase during the 5 and 10 second increment sessions and the 0.6 mA group increased less during the 5 second increment sessions. This data is consistent with the shock frequency data for these groups during the corresponding sessions. Parametric analysis indicated that the terminal session of each decreasing R-S increment did result in significantly more avoidance responses than the longer R-S increment sessions. However, this relationship is difficult to interpret in that R-S increment was confounded with stage of practice in the present design.

The number of repetitive shocks and the total number of responses were also examined. However, in that these measures showed trends similar to the present shock-response data, they will not be presented.

Avoidance Efficiency. Although the number of shocks received and responses made can give a reliable estimate of the subject's behavior in a Sidman avoidance task, these measures are complexly interrelated. One index which attempts to combine these separate response measures into a single estimate of avoidance efficiency is the efficiency index ($\text{Avoid Efficiency} = \frac{\text{Total \# Shocks}}{\text{Max. \# Shocks Possible}} \times \frac{\text{Total \# Responses + Min. \# Responses}}{\text{Min. \# Responses}}$) where: Scores approaching zero indicate better efficiency with this index. Large scores indicate less efficient responding, although scores rarely exceed 1.00.

Figure 3 depicts the mean avoidance efficiency scores for the three shock groups as a function of the four R-S increments employed. This data closely parallels the shock frequency data observed in Figure 1. That is, shock efficiency is poorer (i.e. the efficiency scores are larger) for the 2.0 mA group for both the 5 and 10 second increments. All groups are less efficient by this index for the 5 second increment, although the 0.6 mA group is intermediate between the other groups. Parametric analysis of these data also indicated that performance during the four 5 second R-S increment sessions was significantly poorer than during terminal sessions of the longer R-S increments.

Thus, although the subjects were avoiding more frequently during the short increment (i.e. 5 second) sessions, the concommitant increase in shock frequency resulted in poorer efficiency.

One way in which increased avoidance responding might still result in decreased efficiency is for the pattern of responses to change. For example, if the subject displays bursts of responses many shocks might still result if the subject displayed long pauses between these response bursts - this increase in shock frequency would result in a poorer efficiency index. Another poor efficiency response pattern might be the result of spaced responding such that many responses are the direct result of a recent shock. This pattern would be associated with fewer multiple shocks together with fewer avoidance (i.e. R-S) responses. These response patterns might be quantified by examining the proportion of R-S avoidance intervals that time out to shock rather than another avoidance response. These data are depicted in Figure 4 for the three shock groups as a function of the 4 R-S increment terminal sessions. This index suggests some relationships not evident before. First, the 1.3 mA group which was generally superior when examining the other response measures, allowed over half of their R-S intervals to time out to shock during the last 30 second increment session. This would seem to suggest that these subjects were more apt to give single shuttle responses at that time. Second, the 0.6 mA subjects rather consistently allowed 10 to 20% of their R-S intervals to time out to shock, suggesting these subjects tended to burst and pause throughout the sessions. Presumably, constant duration pauses would result in more shocks and hence less efficient responding during the short R-S increment sessions. Finally, the 2.0 mA groups show a consistent pattern of approximately 30% of their R-S intervals resulting in shock. Apparently, the higher intensity shocks received by these animals were less likely to result in multiple avoidance responses as evidenced by the other groups throughout the experiment.

Discussion.

The most significant result of the present study was that short R-S avoidance increments tended to disrupt efficient avoidance responding, which is consistent with the effect of short R-S intervals when a constant shock delay condition is employed. Avoidance increments of 5 or 10 seconds led to significantly increased shock frequency and poorer efficiency at the end of 9 sessions on a task usually mastered in two or three sessions. Of further interest was the fact that shorter R-S increments did not significantly alter the likelihood of additional responses once the initial response was made. Presumably, the " burst-pause" nature of performance on this task assisted in maintaining responding once responding was initiated.

The second variable employed, shock intensity, did not lead to results consistent with previous constant R-S interval studies. Instead of facilitating performance, high shock intensities tended to be associated with poorer avoidance efficiency, especially with short R-S avoidance increments. Conceivably, short R-S avoidance increments made the task more difficult and increasing motivational levels interfered with efficient performance as has been observed with other complex tasks. However, it is equally likely that the small sample sizes employed in the present study have allowed individual subject differences to obscure the nature of the true relationship between shock intensity and performance on this task. A third possibility might be abstracted from Sidman's study (1962) with the adjusting avoidance schedule. Sidman suggested that the unpredictability and irregularity of shock presentation with the adjusting schedule interfered with the subject's timing on this task. Response delay is not differentially reinforced on the adjusting schedules as it is on a constant R-S interval schedule. Perhaps the disruption in timing behavior is magnified by higher shock intensities resulting in decreased avoidance efficiency. More work needs to be done with this task to establish these relationships and sort out their probable causes.

Summary

This study systematically investigated the joint effects of shock intensity and shock delay as determined by the subject in a shuttle Sidman avoidance task. Each response delayed shock by 5 to 30 sec depending on stage of training. The results indicated that increased shock intensity, contrary to the results of other variants of Sidman avoidance, led to poorer performance especially when briefer shock delay intervals were employed (i.e. 5 or 10 sec). Similarly, shorter delay intervals resulted in poorer avoidance efficiency especially when greater shock intensity was employed (i.e. 2.0 mA). The results suggest that as the task became more difficult (shorter shock delay conditions), increased motivation (greater shock intensity) interfered with rather than facilitated performance.