A TEMPORAL PARAMETER INFLUENCING CHOICE BETWEEN SIGNALLED AND UNSIGNALLED SHOCK SCHEDULES¹

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The present study investigated whether choice of a signalled variable-time shock schedule over an unsignalled one was influenced by the average intershock interval. Eight rats were given a choice between signalled and unsignalled shock schedules in a series of conditions with average intershock intervals of 510, 270, 150, 90, 60, and 45 sec. Each test condition was preceded by a training-baseline condition, and schedule values were arranged in an ascending (four subjects) or descending (four subjects) order. Choice of the signalled conditions was directly related to the average intershock interval of the variable-time schedule for six of the eight subjects. The per cent of time in the signalled condition was highest when the average intershock interval was 150 sec or longer and lowest when the average intershock interval was 45 sec. The findings were interpreted as being due to changes in the safety features of the signalled schedule, rather than to changes in the average intershock interval *per se*.

Key words: choice, changeover, safety, signalled shock, rats

Recent research has provided information about the features of signalled and unsignalled schedules which importantly influence choice behavior. In one study, it was found that choice for signalled shock tended to vary as shock intensity varied between 0.15 mA and 3.0 mA (Harsh and Badia, 1975). Additional studies found that subjects continued to prefer signalled over unsignalled schedules even when the signalled shocks were longer, stronger, and denser than the unsignalled ones (Badia, Coker, and Harsh, 1973; Badia, Culbertson, and Harsh, 1973).

The purpose of the present study was to provide further information about the conditions under which subjects prefer signalled over unsignalled variable-time (VT) shock schedules. In the majority of earlier experiments, VT schedule values have been held constant while other variables were manipulated. In the present study, the schedule value varied between 45 sec and 510 sec.

METHOD

Subjects

Eight experimentally naive female albino rats of the Sprague-Dawley strain (Holtzman Co.) between 90 and 120 days old served. Each subject was individually housed with food and water always available.

Apparatus

Subjects were tested in two identical two-lever Foringer chambers enclosed within sound-attenuating boxes and modified so that the grid bars were perpendicular to the width of the levers. The chambers were 36.8 cm long, 25.4 cm wide, and 12.7 cm high. The response levers required about 0.2 N (20 g) to depress and were mounted 5 cm from the side along the 25.4-cm wall, 7.7 cm above the grid floor. A 30-sec, 1400-Hz tone (84 dB) served as the signal, and illumination of a 24-V bulb located 15.2 cm above the right lever (2.5 cm above a Plexiglas ceiling) and covered by a 2.5-cm white lens cap served as the correlated stimulus identifying the signalled schedule. The termination of a 28-V bulb capped by a 0.6-cm white jewelled lens cap and situated 5.1 cm above the left bar signalled the beginning of the experimental session and its onset signalled the end.

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A BRS constant-wattage shock source delivered a 0.5-sec 75-mW shock across the 0.6-cm stainless-steel grid bars which were spaced 1.9 cm apart center-to-center. The walls and response levers served as one contact in the grid scrambling circuit.

Procedure

All subjects were initially tested in 6-hr sessions every other day. The session length was later reduced to 3 hr. Close observation indicated that reduction in session length had no discernible effect on performance. Subjects spent a minimum of three sessions under each experimental condition.

The factor that varied between experimental conditions was the average intershock interval of the VT shock schedule. The values used were VT 510-sec (range 30 sec to 990 sec), VT 270-sec (range 30 sec to 510 sec), and VT 150-sec (range 30 sec to 270 sec), VT 90-sec (range 30 sec to 150 sec), VT 60-sec (range 30 sec to 90 sec), and VT 45-sec (range 30 sec to 60 sec). Each schedule was arranged in 30-sec blocks; thus, the signal duration was 30 sec and the minimum intershock interval was also 30 sec. Either an ascending or descending series of the above values was presented to each subject. The series was then repeated.

Training-baseline. Each subject was exposed to a minimum of three training-baseline sessions with each of the schedule values specified above. During training-baseline, the correlated stimulus was always on and all shocks were preceded by the signal. Responses on the changeover levers produced no stimulus changes; however, responses and the time that would have been spent in the changeover condition had these responses been effective were recorded. Each series of training sessions with a particular average intershock interval value was followed by a changeover condition with the same average intershock interval.

Changeover (CO). After responding on the changeover levers had stabilized (see below) during the training-baseline condition, subjects began the next session in the unsignalled condition, during which the correlated stimulus was always off and signals were never presented. A changeover response at this time produced a 1-min changeover period, during which the correlated stimulus was on and signals preceded shocks. The average intershock interval during the signalled condition

was identical to that during the preceding training-baseline condition. Additional responses during the changeover periods had no effect but were recorded. At the end of the changeover period, the correlated stimulus terminated and shocks were again unsignalled. Subjects at this time could remain in the unsignalled condition or re-instate the signalled one.

Responses during a 2.5-sec period following shock onset did not produce changeover periods. This delay was imposed to avoid the production of changeover periods by shock-elicited responses.

Stability criterion. Subjects remained under each condition (both training-baseline and changeover) until responding stabilized. The requirement for stability was a minimum of three consecutive sessions during which the per cent time in the changeover condition varied no more than 10% between sessions. Exceptions to this criterion were allowed if performance variability persisted over 10 sessions.

RESULTS

The per cent of total session time spent in changeover during both the training-baseline and changeover conditions is shown in Figures 1 and 2 for all subjects. Note that only five of the eight subjects completed all conditions. The remaining three died of a respiratory disease.

Training-Baseline Performance

The amount of changeover time produced during the training-baseline conditions was low and not clearly related to performance during changeover conditions for seven of the eight subjects (Figures 1 and 2). This was not the case, however, for Subject S8 (Figure 2). The level of training-baseline responding by Subject S8 often increased when the mean of the VT schedule was reduced. A close examination of C8's behavior revealed that most responses were shock-elicited.

Changeover Performance

The data obtained from subjects tested with the ascending series are shown in Figure 1. Subject S22 responded at a rate sufficient to spend about 35% of the time in the signalled condition when the changeover contingency

Fig. 1. Mean per cent of session time spent in changeover for the last three sessions of both training-baseline and changeover conditions for Subjects S4, S7, S9, and S22. Schedule values were presented in an ascending order.

was first introduced (closed circles). While this represents a relatively low level of changeover responding, this level is clearly higher than baseline performance. The per cent of time spent in the signalled condition for Subject S22 systematically increased to between 75% and 80% as the mean of the VT schedule was increased to 270 sec. Subjects S4, S7, and S9 performed somewhat differently than did S22, in that these subjects did not begin responding at rates higher than baseline levels until the VT 90-sec, VT 150-sec, and VT 60-sec conditions, respectively. Once these subjects began to changeover, however, the relationship between the schedule value and time spent in the signalled condition was similar to that observed for Subject S22.

Figure 1 also presents the data obtained from Subjects S4 and S22 when each of the conditions was repeated (open circles). The relationship observed was similar to that ob-

served during the initial series for Subject S22. Subject S4 differed in that the level of changeover at schedule values of VT 90-sec and VT 60-sec during the second series was much higher relative to the first series.

As seen in Figure 2, the performance of Subjects S14 and S23 tested with the descending series was similar to that of subjects tested with the ascending series (Figure 1). That is, the level of changeover tended to be higher when the value of the VT schedule was larger. This was particularly clear for the lower schedule values, *i.e.*, VT 90-sec, VT 60-sec, and VT 45-sec (Figure 2). The data for Subjects S8 and S16 when the series was first given, and again when it was repeated, differed from that of the other subjects. These subjects changed to the signalled schedule at a high rate when given the opportunity to do so (Figure 2). The unusual performance of S8 may have been due to the very high level of shock-

Fig. 2. Mean per cent of session time spent in changeover for the last three sessions of both training-baseline and changeover conditions for Subjects S8, S14, S16, and S23. Schedule values were presented in a descending order.

related responding that occurred during both training-baseline and changeover conditions. Changing to the signalled condition at a high rate continued for S16 until the VT 45-sec schedule was introduced. At this point, response rate decreased and the per cent of time spent in the changeover condition fell between 10% and 15% (Figure 2).

Figure 3 shows a portion of a typical event record obtained during the VT 150-sec condition (Subject 14). It can be seen that most responses were functional and under discriminative control, occurring only when they produced changeover periods. There were, however, occasions during which responses occurred when the changeover period was already in effect.

It is evident from Figure 3 that the time between the termination of one changeover period and the onset of the next one was not

always the same. At times, the signalled condition was re-instated immediately. At other times, there was a relatively long delay until the next response. An examination of Figure 3 reveals that the delay interval was influenced by the signal. That is, if the signal was not present when the changeover period terminated, subjects re-instated the signalled condition immediately. However, if the signal was present when the period terminated, subjects tended to delay re-instatement. This pattern of responding occurred with all subjects.

DISCUSSION

Although all subjects changed to the signalled condition, the data from only six of the eight subjects revealed a relationship between choice and the value of the VT schedule. For these six subjects, the per cent of time

Fig. 3. A representative event record (Subject S14) showing the temporal relations that developed under the changeover condition.

spent under the signalled schedule was highest when the VT schedule value was either 150 sec, 270 sec, or 510 sec and lowest when the VT schedule value was 45 sec. This relationship was not clearly observed for the two remaining subjects (Subjects S8 and S16). This relationship may have existed for Subject S8, but the high frequency of shock-elicited responding may have obscured it. Subject S16's failure to show the effect cannot be accounted for.

There are features of the data that should be considered. For Subjects S4 and S22, the rate of changing to the signalled condition during the second exposure to VT 60-sec and VT 90-sec tended to be higher than that observed during the initial conditions. In addition, the level of responding for these subjects during these conditions was higher than that observed for Subjects S14 and S23 (see Figures 1 and 2). These differences may have been due, in part, to the influences of previous conditions. That is, the time spent in the changeover condition during the second exposure to VT 60-sec and VT 90-sec conditions for Subjects S4 and S22 may have been influenced by the previous condition (VT 510-sec), during which a high level of responding was maintained.

The present results are consistent with earlier findings (*e.g.*, Badia and Culbertson, 1972) in that, under certain of the conditions, each subject strongly preferred the signalled VT shock schedule over the unsignalled one. The data from six of the eight subjects extend previous findings by showing that strength of

preference is related to the average intershock interval.

The relationship observed allows for several interpretations. One possibility is that shock density directly determined changeover levels. That is, at the higher shock densities (VT 45-sec and VT 60-sec), changeover levels may have been relatively low because of response competition from shock-elicited responses, such as freezing, or perhaps because of a superstitious contingency between changeover responses and shock onset. This possibility, however, is not considered likely because high levels of changeover have been found in a previous study with a shock density comparable to that of the VT 60-sec condition in the present experiment (Badia, Harsh, and Coker, 1975).

An alternative interpretation relates to the notion that choice for predictable over unpredictable shock schedules is governed by the reinforcing value of shock-free (safe) periods, which are discriminable under predictable shock schedules but not under unpredictable ones (Badia, Culbertson, and Lewis, 1971; Badia, Harsh, and Coker, 1975; Seligman, Maier, and Solomon, 1971). In the present experiment, safe periods were always identified during the signalled schedule by the stimulus present in the absence of the signal. Thus, an interpretation based on the discriminability of safety alone is insufficient to account for the variations in changeover behavior observed. It is the case, however, that the average duration of the safety periods varied across condi-

tions from about 15 sec during the VT 45-sec schedule to 480 sec during the VT 510-sec schedule. Thus, strength of preference may have been determined by the duration of the shock-free periods. This notion is supported by data indicating that the reinforcing value of stimuli identifying periods free of shock is related to their duration (e.g., Denny, 1971; Verhave, 1962).

An additional possibility, also based on the importance of safety, is that preference for the signalled schedule is governed by the amount of time spent in a positively valued stimulus relative to a negatively valued one. Previous research has indicated that shock signals acquire aversive characteristics (e.g., Harsh and Badia, 1974) and, in the present experiment, preference was weak when the time spent in the safe stimulus (positively valued) was one-half (VT 45-sec) or equal to (VT 60-sec) the time spent in the signal (negatively valued). Preference was strong, however, when the time spent in the safe stimulus was four to 16 times longer than the time spent in the signal (VT 150-sec, VT 270-sec, VT 510-sec). Thus, strength of preference may be directly related to the proportion of time spent in safety during the signalled schedule. This notion is consistent with data indicating that escape and avoidance performance is more closely related to the relative duration of safe-box/shock-box confinement than to the absolute duration of safe-box confinement (Franchina and Schindele, 1975; Weisman, Denny, and Zerbolio, 1967).

Further research is needed to determine whether the present data are best accounted for by emphasizing the absolute duration of safety or the proportion of time spent in safety. Either account, however, is supported by the observation that subjects failed to reinstate quickly changeover periods that terminated while the signal was present (Figure 3).

Interpretations of preference based on preparation (e.g., Perkins, 1968) or information (e.g., Berlyne, 1960; Hendry, 1969) cannot account for the data collected in the present experiment without benefit of additional assumptions. According to the preparation view, signalled shock situations are preferred because signals permit the precise timing of responses that reduce the shocks' aversiveness. The information view holds that signalled situations are desirable because of the informa-

tion provided about the occurrence of shock. In the present experiment, however, the signalled schedule provided both information and an opportunity for preparation during each of the experimental conditions; yet, preference for six of the eight subjects varied systematically. These data make it apparent that factors in addition to information and preparation must be considered. Data from other studies in both appetitive and aversive situations indicate the inadequacy of preparation and information views (e.g., Arabian and Desiderato, 1975; Mulvaney, Dinsmoor, Jwaideh, and Hughes, 1974).

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