SOME OBSERVATIONS CONCERNING PREPOTENCY AND PROBABILITY OF POSTPONING SHOCK WITH A TWO-LEVER AVOIDANCE PROCEDURE^{1, 2}

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Avoidance behavior can be generated and maintained when responding delays the occurrence of a brief electric shock (Sidman 1953a). In such a situation, two levers can be made available to a subject. If both levers are equally effective in delaying shock but produce a different shock-delay (RS) interval (Sidman, 1953b), a higher rate is emitted on that lever which regularly produces the longer RS interval for each response (Sidman, 1954).

The experiments reported were meant to explore another possible way of producing differential response rates on two levers. As in Sidman's multiple RS-interval experiment, avoidance responding was maintained on two levers. Responding on each lever, however, was associated with a different probability of postponing shock rather than with a different RS-interval duration.

As a part of the initial avoidance-training phase, all animals were given access to two levers before the probabilities of postponing shock were varied. Thus, all animals were run for a certain length of time with two levers simultaneously available. These levers were equally effective in resetting the RS interval each time either lever was pressed. Some observations made under these conditions are reported in the first part of the Results section. The second part of Results is concerned with the effects of manipulating the probabilities of resetting the RS interval.

METHOD

General Conditions

The subjects were eight male hooded rats, from 110 to 125 days old at the start of experimentation. A 6-hour experimental session was scheduled every other day, except on Sundays. Between sessions, the animals lived in individual cages, with food and water continuously available. Neither food nor water was present in the experimental cage.

Apparatus

The two experimental cages, each 10 inches wide, 10 inches long, and 7 inches high, had a stainless-steel grid floor. A grid-scrambler ensured that the animal would receive a pulsating shock regardless of which rod it was standing on. Shock was provided by a constant-current generator passing half-wave 60-cycle D.C.

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Two removable levers (Verhave, 1958) could be mounted in each experimental cage. If only one lever was to be available to an animal, the second lever was replaced with a metal plate mounted flush in the wall. When both levers were in use, they were mounted 6 inches apart from center to center at a height of 2.5 inches from the floor and were adjusted to require a force of 15 grams to effect opening of the normally closed contact points.

The probability with which a particular lever reset the single RS timer in the programming circuit could be varied by means of a special electronic device (Harley, 1961). One such "probability panel"³ was inserted in the circuit that connected a lever with the reset (clutch) mechanism of the RS timer. The probability panels ensured that only a certain percentage of the pulses from a lever would in effect reset the RS timer and thus postpone shock. The effective responses could be adjusted between 0 and 100%. The percentage selected is fixed for a large series of pulses. Whether or not any one response would reset the RS timer was determined on a completely random basis.

Specific Conditions

Throughout the entire experiment, four rats (Rats 142, 14, 15, and 16) were maintained on the free-operant avoidance schedule originated by Sidman (1953). The SS interval was 1.5 seconds and the RS interval was 30 seconds. The shock duration was fixed at 0.2 second at a current of 1.0 milliampere. Two levers were available to three of these animals from the first day of avoidance training until the termination of the experiment. Rat 16 had one lever available during the first four avoidance-training sessions.

Four other rats (Rats 71, 72, 73, and 74) had a lengthy history of avoidance training on only one lever. The avoidance procedure was the free-operant schedule with an added DRH contingency (Verhave, 1959). Under these conditions, more than one response has to be emitted within the RS interval to postpone shock. After initial training on the regular avoidance schedule, these animals were shaped to adjust to various number requirements. The following conditions remained the same throughout the experimentation: SS, 3 seconds; RS, 30 seconds; shock duration, 0.15 second; and current, 1.0 milliampere.

A second lever was made available sometime after the animals had a considerable period of training on the DRH avoidance schedule. Once both levers were made available, they were each equally effective in counting out the DRH number requirement. The probability of

³Manufactured by Lehigh Valley Electronics.

postponing shock (P) was 100% on whatever lever the rat completed the ratio within the 30-second RS interval.

RESULTS

Performance Characteristics When $P_A = P_B = 100\%$

The effect of manipulating the probability of postponing shock (*i.e.*, recycling the RS timer) on one of two levers can be assessed properly only when the performance characteristics on two levers with equal probabilities ($P_A = P_B$) are known. In the first observations to be reported, therefore, $P_A = P_B = 100\%$. All responses on either lever were equally effective in postponing shock.

Figure 1 shows the responding of Rat 75 on two levers during the first 24 consecutive avoidance sessions as well as the shock rate and the total output. The three points plotted for each session indicate the average rates obtained during the three successive 2-hour periods that make up a continuous 6-hour session. These data show that:

1. The animal eventually responded predominantly on one of the two available levers.
2. Sudden switches, or changes in prepotency, occurred for no obvious reasons. For example, Rat 75 suddenly switched to the Lever A at the start of Session 4. Other examples of such switches that may occur both between and within sessions will be given below. (See Fig. 2.)

The fact that the output on one of the two levers became predominant may induce one to speak of the animal's preference for a particular lever. In traditional research concerning "food preferences" in animals (Young, 1948), the occurrence of one response to the exclusion of another (in a choice situation) has been accepted as demonstrating a preference. However, if a preference is defined only by the fact that one operant is emitted to the partial exclusion of another, the alternative term "prepotency" may serve better for descriptive purposes. Skinner has noted that the important objection to everyday language in the description of behavior is that "many of its terms imply conceptual schemes" (Skinner, 1938, p. 7). The term preference is no exception to this objection. In common parlance, the term preference connotes considerably more than its dictionary definition as the "setting of one thing before or above another" (Webster). It usually implies the persistence of the phenomenon in time. Preferences are thought of as stable and as difficult to change. In addition, the reason for a preference is usually thought to be a difference in value, whatever that may be. If persistence of a preference is one of the defining criteria, no preference could be inferred from the present experimental data. Not all animals respond predominantly on one lever during the first few training sessions and then simply stick to that lever. In four out of the eight rats, under conditions where $P_A = P_B = 100\%$, prepotency was observed to shift abruptly back and forth between the two levers within a single session. More

Fig. 1. Response and shock rates during each of three successive 2-hour intervals in a two-lever, free-operant avoidance situation.

Fig. 2. Performance of Rat 15 on each of two levers.

gradual shifts during a few sessions also occur. Illustrations of these phenomena appear in the left panel of Fig. 2. Rat 15 was maintained on $P_A = P_B = 100\%$ from Session 1 up to Session 25. The three different points plotted for each session again indicate the rate values obtained during three successive 2-hour data-recording periods. When $P_A = P_B = 100\%$, the animal switched from one lever to the other within a single 6-hour session. (See, especially, Sessions 15, 16, 19, 20, and 21.) Switching also occurred between sessions. During Sessions 1 through 19, the rate was higher on Lever B than on Lever A. (For exceptions, see Sessions 15 and 16.) From Session 20 through Session 24, the opposite was true. An increase in rate on one lever was consistently correlated with a decrease in rate on the other lever. The total output (bottom left panel of Fig. 2) was relatively constant.

A clear example of abrupt switching appears in the data of Rat 74, one of the animals pretrained on one lever with the avoidance procedure plus a DRH contingency. From Session 1 to Session 45, this animal had run on regular avoidance, and thereafter on avoidance

with DRH 5. The second lever was made available at Session 57.

Figure 3 is a detailed picture of the performance of Rat 74 on both levers during Session 77. These cumulative records brought out three points: 1) Switching occurs abruptly. 2) Irrespective of which lever is momentarily prepotent, no changes in avoidance rate occur: The rat continues at the same rate after each switch. Here, the total output as a measure would be misleading. The animal responds exclusively on one lever for a period of time and then exclusively on the other. It does spend most of its time behind and on Lever B, however. The proportions of the total rate do not represent concurrent responding but successive segments of time spent exclusively on one or the other bar. 3) Although changing of levers occasionally seems to be prompted by the occurrence of a shock, this is not always the case. Figure 4 illustrates the performance of the same rat during Session 100. By this time, the animal again spent the larger part of its responding on Lever A. Abrupt shifts are again dramatically demonstrated; many occur without being preceded by a shock.

Fig. 3. Cumulative records obtained simultaneously on each of two levers in a two-lever avoidance situation.

The data on this animal demonstrate that training on two levers during the first sessions is not necessary to obtain switching, and that it can also be obtained when a DRH contingency is added to an avoidance schedule. Switching as dramatic as that of Rat 74 has been observed in at least six other animals that were run with the ordinary avoidance schedule.

The switching behavior under our experimental conditions is not easily explained. It may be pointed out, however, that the experimental situation fulfills the conditions for generating what Morse and Skinner have called a "sensory superstition" (Morse & Skinner, 1957). When shocks occur, any behavior in progress at the moment might become sufficiently suppressed to shift prepotency to another, strongly competing, operant. A stimulus situation (sitting in front of and working on Lever A) present when one class of responses is shocked may acquire discriminative control over the operant even though the presence of the specific conditions when shock occurs is adventitious.

The switching phenomenon, however, might also be looked upon as a specific example of the antithesis of the Law of Effect: Any dimension of an operant, such as duration, force, or topography, for which the reinforcement contingencies are nonspecific cannot be accurately specified. If no consequences are contingent upon changes in the duration or topography of an operant (always, of course, within certain limits), variability within the permitted range is to be expected.

Fig. 4. Cumulative records obtained simultaneously on each of two levers in a two-lever avoidance situation.

The Effect of Manipulating the Probability of Postponing Shock

Figure 1 shows the effect when one of two levers, both of which previously were equally effective in postponing shock, suddenly becomes nonfunctional. During the second 2-hour period of Sessions 17 and 21, the first lever was deactivated. In both cases the rat switched to the other lever; the total output, however, did not change. (See Arrows A and C.) During the second 2-hour period of Session 19, the second lever was taken out of commission. (See Arrow B.) Although the rate of responding on the second lever was higher than usual during the first 2 hours of that day, it dropped during the second 2-hour period.

Figure 5 shows the data of Rat 16 during 10 successive sessions. For this animal, each session lasted 9 hours. The three data points plotted for each session represent the rates emitted during the three succes-

Fig. 5. Response rates of Rat 16 before and after switching to a two-lever situation and under two probability conditions.

sive 3-hour periods making up the 9-hour sessions. This animal was initially trained with only one lever. From Session 5 on, two levers were available. The conditions during Sessions 5, 6, and 7 were identical to those described previously for Rat 15, when $P_A = P_B = 100\%$. During these three sessions, the rate on Lever B remained prepotent.

During Sessions 8 and 9, when P_B had been reduced from 100% to 50%, several rapid shifts in prepotency occurred. By Session 10, Lever B had won out over Lever A. Responding on Lever A stayed prepotent throughout the 12 following sessions when the conditions of the experiment remained unchanged.

Figure 2 shows similar data for Rat 15. This animal had spent considerably more time on $P_A = P_B = 100\%$ than on $P_A = 50\%$, $P_B = 100\%$. During the period that $P_A = P_B = 100\%$, many rapid shifts in prepotency had occurred. It may therefore not be accidental that the time required for Lever B to become predominant after P_A had been reduced from 100% to 50% is considerably shorter for Rat 15 than for Rat 16.

The change from $P_A = 100\%$ to $P_A = 50\%$ in Rat 15 also produced a temporary acceleration in rate on Lever A during the first session on $P_A = 50\%$. The phenomenon was correlated with an increase in shock rate during that session. Once responding on Lever B had become predominant, the response output on Lever B during Sessions 26 and 27 was within the range of the previous output on Lever A during Sessions 22, 23, and 24. The rates on Levers A and B during Sessions 26 and 27 are representative of those during Sessions 28 through 38 under identical conditions ($P_A = 50\%$, $P_B = 100\%$). No further switching was observed.

The data of a more elaborate experiment with Rat 14 are compiled in Fig. 6. This animal was moved through several phases during which Levers A and B were associated with different probabilities, as indicated at the top of the figure. In general, this rat responded pre-

Fig. 6. Performance of Rat 14 on each of two levers under various probability conditions.

dominantly on the lever associated with the greater likelihood of resetting the RS timer. When either the change in the probability values or the difference between the probability values is small, the transition to a stable prepotency may take several sessions.

From the data of the animals in these experiments and observations made on other rats, it is concluded that:

1. When $P_A = P_B = 100\%$, an animal is just as likely to respond on one lever as on the other. Responding on one lever exclusively, even during several sessions, does not indicate a permanent preference.

2. When P_A is higher than P_B , the rate on Lever A will eventually become higher. The transition may be gradual or abrupt.

3. The ratio of the rates, after stabilization under a given set of P conditions, does not correspond to the ratio of the P values. In general, the animals tend to play it safe, responding eventually almost exclusively on the lever associated with the highest P.

SUMMARY

Avoidance responding was maintained on each of two levers. Responding on each lever was associated with a different probability of postponing shock. The effects of various probabilities were explored.

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