RESPONSE COST AND THE CONTROL OF VERBAL BEHAVIOR UNDER FREE-OPERANT AVOIDANCE SCHEDULES¹

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Human subjects were tested in a free-operant avoidance procedure. Shock could be avoided by the emission of a verbal response of adequate intensity and duration. These schedules were found to control the emission of verbal operants in the same way they control motor operants. Some subjects showed conventional control by this schedule with or without response-produced feedback. Other subjects verbalized at a high rate under both these conditions until the addition of response cost brought this behavior under conventional schedule control.

Previous studies of verbal behavior as maintained by non-verbal reinforcement have concentrated mainly on positive reinforcement (Holz and Azrin, 1966). There are few data on the maintenance of verbal behavior by avoidance schedules, although Lal (1967) has shown that vocalization in rats can be maintained in this way. In the present study, electric shock was used in a typical free-operant avoidance procedure to control the emission of a wide class verbal operant by human subjects. Under such a schedule a response of a given class leads to the avoidance of shock for a fixed period of time (the RS interval). If no response is made, shocks occur at fixed intervals (the SS interval).

The relationship between RS interval and rate of bar-pressing in the rat has been reported by Sidman (1953). The general finding is that response rate is inversely related to the RS interval, except for very short RS intervals. Weiner (1963) has examined the performance of human subjects under similar schedules. It was found that when a response of low cost (microswitch pressing) was used, subjects responded at a uniformly high rate which was not directly related to the RS interval. The effect of adding cost, in the form of points lost per response, was to reduce the response rate and produce records very similar to those produced by rats under free-operant schedules.

The present experiment was designed to determine whether or not similar factors control the rate of verbal responding under these schedules. The effect of varying the RS interval upon the rate and duration of responding was measured under three conditions: responding without feedback, with visual feedback, and with added response cost. The semantic aspects of verbal behavior were ignored, an adequate response being defined only in terms of amplitude and duration.

METHOD

Subjects

Seven college students, none of whom had taken courses in psychology, served. They were paid \$1 per session.

Apparatus

The subject lay supine on a couch in a normally lit sound-reduced room. A microphone and associated pre-amplifier were suspended 2 ft directly above the subject's head. The program was controlled by remotely placed Grason-Stadler equipment. Verbal responses triggered a Grason-Stadler voice-operated relay having a rise time of 30 msec and a delay of 60 msec. The voice-operated relay was set to trigger at 60 db sound pressure level at 1000 cps. The output from the voice operated relay was processed in two ways. The unformed output keyed an audio frequency signal on to magnetic tape, the length of each tone being equivalent to the "on" period of the relay. The relay output was also formed into standard 30-msec pulses to actuate the program-

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ming equipment and to switch a light or counter in the subject's room when feedback or response-cost procedures were used. The tape recording was later analyzed by a Grason-Stadler class time analyzer to give inter-response times and response durations. Monophasic dc shock was produced by a Grass stimulator and applied to metal electrodes taped to the distal phalanges of the first and third fingers of the subject's hand. Shock duration was 30 msec throughout the experiment.

Procedure

Three procedures were carried out. All used the same sequence of RS intervals: 20, 10, 5, 3, 1.5, and 10 sec (baseline recovery). Each RS interval was in effect for 15 min. The SS interval was kept constant at 5 sec.

Subjects were given the following instructions:

"Please lie down on the couch, and stay lying down for the duration of the experiment. We shall be taking various measurements during the experiment which will be upset by excessive movement around the room. Some time after I have left the room you will begin to feel mild shocks to your fingers. Please tell us, i.e., say out loud, when the intensity of shocks reaches a level which is mildly uncomfortable. We shall be able to hear all you say through a microphone in this room. You will find that when you do talk, shocks will not be given for a period of time, and that you can avoid shock altogether by talking sufficiently often. After the first few minutes of the experiment we shall set the shock at the level you consider mildly aversive and leave it there for the rest of the experiment. Your task will be to avoid as many of the shocks as you can."

A 20-sec interval elapsed after these instructions before the first shock was given at a standard level of 15 v. The shock was then increased in 5-v steps every 5 sec until the subject made a verbal response of sufficient intensity and duration to trigger the voice operated relay, thereby initiating the RS interval. At this point, the shock level was set at 45 v, pilot experiments having established this as the median level for reports of moderate discomfort.

In the first procedure no further instructions were given and no response feedback was provided. The second procedure was identical to the first, except that a signal light was placed in plain view of the subject and flashed for 30 msec each time an adequate response was made. The sequential order of exposure to procedures one and two was counterbalanced over subjects. The third procedure involved the additional instruction: *"In front of you is a dial which will count each time you talk. You start the experiment with \$2 and lose 0.1 cent each time you talk."*

Each procedure involved an experimental session of approximately 100 min. All subjects served one session under procedures one and two, and two subjects were given a further session under procedure three.

RESULTS

Two distinct response patterns emerged under the first procedure. One was characterized by a relatively low response rate closely related to the RS interval (Fig. 1), the other showing a uniformly high response rate little affected by changing the RS interval (Fig. 2). The IRT distributions in these figures and also in Fig. 3 show data from the entire period under each RS interval. The rate patterns shown in Fig. 1 and 2 were subject-specific and the introduc-

Fig. 1. Percentage frequency distributions of inter-response times at differing RS intervals for Subject A under free-operant avoidance schedules without response cost.

Fig. 2. Percentage frequency distributions of inter-response times at differing RS intervals for Subject B under free-operant avoidance schedules without response cost.

tion of response feedback in the form of a flash of light did not result in any significant change in the response pattern of any subject. Three subjects showed the low rate, and four the high rate pattern. It should be noted that both patterns of responding were equally effective in avoiding shock. For all subjects, the initial baseline rate under RS 10 sec was recovered after exposure to shorter RS intervals.

Monitoring verbal behavior during these procedures showed that each subject with the RS matching pattern came to use a stereotyped response, e.g., Subject A: "not now"; Subject C: "unpleasant". The other subjects tended to free associate using connected discourse. Their high rate of responding is reflected by the unimodal distribution of responses at short IRTs (Fig. 2).

Response feedback was introduced to try to eliminate this systematic difference in response rate between subjects. Since this was unsuccessful, two of the high-rate subjects were given procedure three in which a small amount of money (0.1 cent) was deducted from the subject's pay each time a verbal response was made. The effect of this was to reduce dramatically the overall response rate of these subjects. Figure 3 shows that the distribution of responses in time was now closely tied to the RS interval. A comparison of Fig. 1

Fig. 3. Percentage frequency distributions of inter-response times at differing RS intervals for Subject B under free-operant avoidance schedules with response cost.

and 3 shows the marked similarity of performance between Subject A with no response cost and Subject B with added response cost. As with those subjects who initially adopted a low response rate, subjects under response cost conditions used a restricted range of responses, "now" for one subject, and "hey" for the other.

Figure 4 shows a plot of response rate against RS interval for two subjects. For Subject A under no cost conditions, and for subject B under cost conditions, the decrease in rate with increasing RS interval is similar to that shown by Sidman (1953) using rats with a conventional bar-pressing operant under avoidance schedules.

When behavior was under precise schedule control, individual differences in IRT distribution were negligible. Once schedule control was established a change in RS interval was followed by a rapid change in response rate, as can be inferred from the narrow range of IRTs shown in Fig. 1 and 3.

The distribution of response durations showed no significant change between procedures for any subject.

DISCUSSION

These data show that free-operant avoidance schedules control the emission of a verbal

Fig. 4. Graph of response rate against RS interval for two subjects. Subject A is shown under no response cost conditions, and Subject B under both cost and no cost conditions. Response rates were derived from cumulative records.

operant, defined in terms of intensity and duration, in the same way that these procedures control motor operants in man and a number of other species (Ader and Tatum, 1961; Sidman, 1953). The present results parallel those of Weiner (1963) using human subjects who were required to press a light microswitch to avoid a period in which a large number of points were lost. Under no cost conditions, subjects showed a uniformly high response rate, but when a small points cost was added for each response, the rate dropped. The resultant record then resembled those produced by rats bar-pressing on similar schedules.

A number of subjects emitted verbal responses at a high and constant rate independent of the RS interval. The addition of response cost resulted in an overall reduction

in rate which then changed as a function of the RS interval. Weiner (1962) has also found that when response cost is low, human subjects respond continuously under a variety of schedules of reinforcement. Weiner's subjects were making manual rather than verbal responses, but if verbal operants also have low cost then it will be difficult to show conventional control of such operants by schedules of reinforcement. Some schedules of reinforcement do provide cost, at least for unreinforced responses. An example is the differential reinforcement of low rate (DRL) schedule in which a response is reinforced only if it follows another response of the same class by more than a fixed period of time. Using schedules of this type, Kapostins (1963) demonstrated precise control over verbal behavior. By the same token, some verbal responses could be considered to have inherently high cost, *e.g.*, those of extreme amplitude, duration or pitch, and similar considerations could apply to semantic aspects of verbal behavior.

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