SOME OBSERVATIONS ON AN OPERANT IN HUMAN SUBJECTS AND ITS MODIFICATION BY DEXTRO AMPHETAMINE[1]

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This paper describes an experiment in which the response of pressing a telegraph key by normal human subjects led to the delivery of nickels under contingencies which combined features of both fixed-ratio and DRL[2] schedules of reinforcement. In this schedule the reinforcing stimuli (delivery of nickels) are presented each *nth* time a response occurs which follows the immediately preceding response by at least x seconds. Responses which occur within less than x seconds since the preceding response merely start a new inter-response time, and do not count toward the completion of the n responses. The schedule stands in the same relation to a simple DRL as does FR to *crf*[3].

Studies with animals (Dews, 1958; Morse & Herrnstein, 1956; Sidman, 1955) have suggested that the effects of the amphetamines are likely to be seen best when responses occur relatively infrequently. The above schedule would be expected to, and in fact did, give a low rate of responding. It was therefore used in an exploratory experiment to determine whether this operant behavior of normal subjects would be consistently modified by small doses (5 milligrams) of dextro amphetamine sulfate.

METHOD

A telegraph key was mounted on a wooden base. Immediately behind the key was a box (12 by 12 by 24 inches) which enclosed a coin vending machine. The coin machine was a modified "change maker" such as used in soft-drink dispensers, and was set to deliver four nickels when pulsed. The apparatus was set on a bench so that a subject could sit with his arm resting comfortably on the bench and his hand on or near the key. The nickels were ejected towards the subject through an orifice in the front of the box. Also in the front of the box were two 6-watt pilot lamps, one lighted for the duration of the experimental session, and the other lighted only during the delivery of nickels.

The basic schedule has been described already. Two pairs of values for the schedule parameters n and x were used. In one pair, n was 100 and x seconds was 2.5 seconds; for the other pair, n was 10 and x seconds was 25 seconds. The distribution of inter-response times was recorded automatically, with class intervals of 0.5 second or 5 seconds depending upon whether the required delay was 2.5 seconds or 25 seconds, respectively.

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[2]Following contemporary usage, we modify Ferster and Skinner's (1957) terminology by using the term DRL in place of *crf drl*.

[3]This schedule may be alternatively described as fixed-ratio reinforcement of responses, each of which concludes an inter-response time exceeding a minimum value (i.e., a fixed ratio of responses meeting a "DRL contingency," or as a tandem DRL DRL DRL . . . DRL.

Subjects were seven male medical students. Each subject was alone in the experimental room during the session. The programming equipment was in a different room, separated from the experimental room by an intervening room, and its operation was inaudible to the subject. The subject was introduced into the experimental room, and then a tape recording of the following message was played:

> "The experiment begins when the light on the left comes on and finishes when it goes off, one hour later. During the experiment you are to push the telegraph key. Your object is to obtain as many nickels as possible. The light on the right will come on and nickels will be delivered to you when you have pressed the key a minimum of 100 times. However, presses made within two and one-half seconds of a previous press will *not* count. On the other hand, any time you wait beyond two and one-half seconds is wasted time. To obtain as many nickels as possible you should therefore press the key regularly at intervals as little as possible in excess of two and one-half seconds. The following sequence of clicks occur at intervals of two and one-half seconds. (Then followed 8 clicks at 2.5-second intervals.) Start pressing the key as soon as the light on the left comes on."

When the other pair of parameter values was in operation, a similar message was played, except that the references to 100 responses and 2.5 seconds were changed to 10 responses and 25 seconds, respectively.

Five subjects were studied at each of the two pairs of values for the parameters. (Although seven subjects were studied, only three were observed at both parameter values.) The results to be presented are for a "control" day and a "drug" day. Observations were made during a period of 1 hour and were at weekly intervals for individual subjects. On the "drug" days (which sometimes preceded and sometimes succeeded the "control" days), the subject was given a small orange tablet containing 5 milligrams of dextro amphetamine. He swallowed it under direct observation and then drank 150 milliliters of water. One-half hour later the experimental session was started. On control days, an identical routine was followed except that the tablet swallowed contained no pharmacologically active ingredients. All subjects had been exposed to the schedule for at least one session before either the control or drug day. Preliminary experimentation suggested that there was no consistent trend in the performance after the initial session on each procedure.

RESULTS

Figure 1 shows mean inter-response-time distributions for five subjects at both parameter values. The unbroken lines give the average distribution for "control" days and the dotted lines are for the "drug" days. Sample cumulative records of daily sessions for individual subjects are shown in Fig. 2 and 3. For each pair of parameter values, a control and a drug session are shown for two subjects.

Control Performance

The form of the distribution of inter-response times (i.e., the population of intervals between consecutive responses) was similar for all subjects and at both parameter values. The distributions were skewed to the right, with a peak in the class interval just in excess of the minimum "effective" delay value. For individual subjects, the mode was in the class interval 2.5 to 3.0 seconds on all but one occasion, when the "required" delay was 2.5 seconds; and in the class interval 25 to 30 seconds, on all but one occasion, when the "required" delay was 25 seconds.

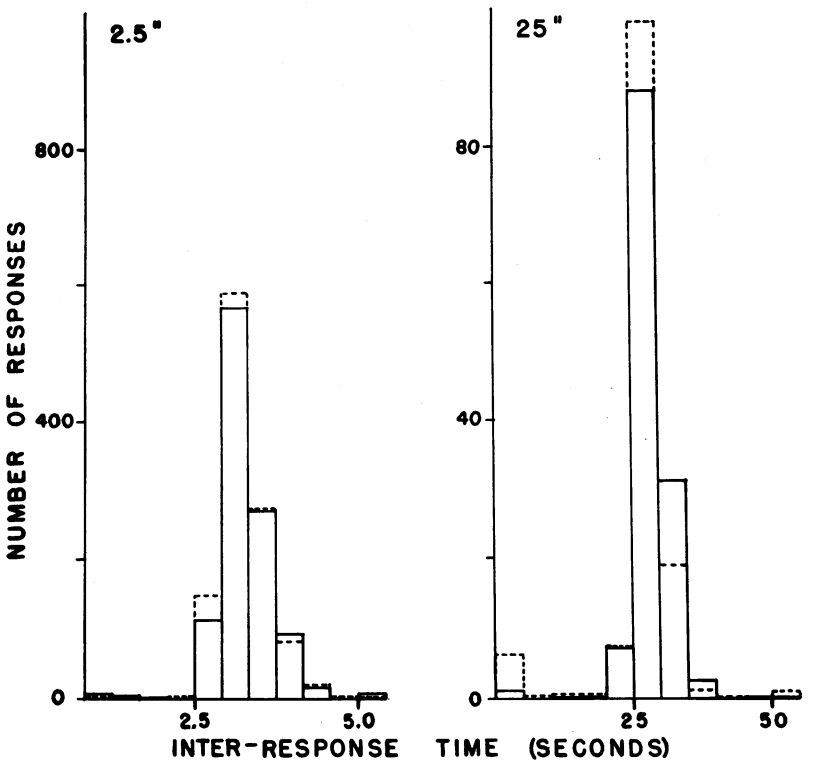

Figure 1. Average inter-response-time distributions for five subjects. In the portion of the figure labeled 2.5", the 100th response which followed the immediately preceding response by at least 2.5 seconds was reinforced. In the portion labeled 25", the 10th response which followed the immediately preceding response by at least 25 seconds was reinforced. The solid lines show the average distributions following a placebo; the dotted lines show the average distributions following 5 milligrams of dextro amphetamine.

The subjects performed "more efficiently" when the delay was 25 seconds than when it was 2.5 seconds in that they a) obtained more nickel deliveries on the average (11.8 vs. 9.0); b) the proportion of responses in the class interval just in excess of the minimum delay was greater (0.67 vs. 0.54); and c) the coefficient of variation[4] of the inter-response times was less (0.10 vs. 0.20), i.e., they were "steadier." The latter effect is best seen in the sample cumulative records. In contrast to the steady rate maintained when the parameter values were 10 responses and 25 seconds, the prevailing rate fluctuated gradually up and down during the session when the values were 100 responses and 2.5 seconds.

Effect of dextro amphetamine

On days when 5 milligrams of dextro amphetamine had been given, the inter-response times tended to be shorter than when placebo had been given. Although

[4]Means and standard deviations of the distributions in Fig. 1 were obtained by multiplying the number of responses in each class interval by the mid-point of the class interval. However, since inter-response times are not independent observations, these statistics should be used only for descriptive purposes.

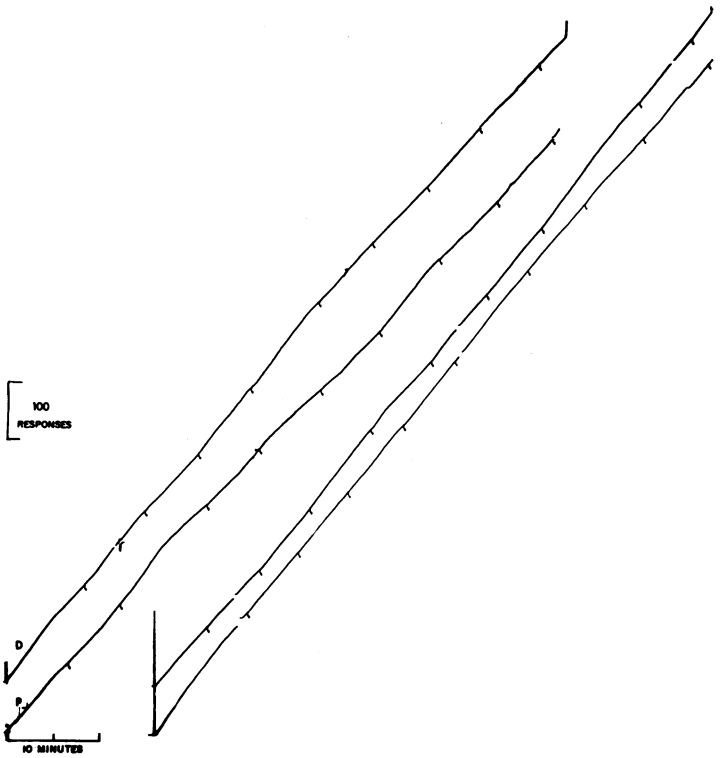

Figure 2. Cumulative-response records for two human subjects. The 100th response which follows the immediately preceding response by at least 2.5 seconds is reinforced. A drug (D) and a placebo (P) record is shown for each subject.

the mean number of responses emitted during the session increased slightly following the drug (an increase from 1067 to 1120 responses during the hour session on the 2.5-second delay, and an increase from 130 to 135 responses during the hour

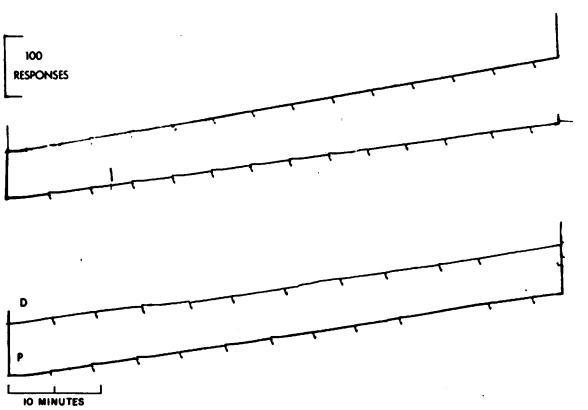

Figure 3. Cumulative-response records for two human subjects. The 10th response which follows the immediately preceding response by at least 25 seconds is reinforced. A drug (D) and a placebo (P) record is shown for each subject.

session on the 25-second delay), the effect is better seen in the distributions of inter-response times. That is, the form of the distribution was changed more consistently than the total number of responses. In Fig. 1, the average distributions based on the drug sessions are shifted to the left for both sets of parameter values. The changes in both distributions are statistically significant by x^2, and all but one subject showed the effect. The average number of reinforcements was not changed at all by the drug (an average of 10.4 reinforcements under both conditions on control days and 10.5 reinforcements on drug days), nor was the variability in the inter-response-time distributions, as measured by the coefficient of variation.

DISCUSSION AND SUMMARY

The subjects in this experiment obtained between 80 and 90% of the number of nickels that were theoretically possible in the time available, which is a higher percentage of "effective" responses than is ordinarily obtained using a DRL schedule in animals. Compared with other published distributions of inter-response times from DRL schedules, the peaks in these distributions at the class interval just exceeding the DRL requirement are more pronounced. In animals working on a DRL schedule, a considerable proportion of responses occur following very short inter-response times (Sidman, 1955). Holland (1958) has seen this phenomenon, commonly called "bursts," in human subjects. In our subjects, however, bursts were uncommon, although by no means absent. (See Fig. 1.)

There are several possible reasons for the differences between these inter-response-time distributions and those ordinarily obtained with animals.

1.) The subjects were verbally informed as to the nature of the schedule, and, further, were given samples of the interval they were to "aim for" before each session. They were not discouraged from "counting to themselves," and, in fact, all subjects developed a counting sequence which led up to the next response.

2.) Although our subjects could earn about $2.00 in the hour session, it is by no means clear to what extent the delivery of four nickels to a medical student is comparable with the delivery of food or water to a severely deprived animal.

3.) The change from DRL to a schedule requiring a number of minimum inter-response times per reinforcement may have increased the control of the contingencies of the schedule, but this is unlikely as an explanation since pigeons working on comparable schedules show bursts just as they do on a simple DRL schedule (unpublished).

The effects of dextro amphetamine were consistent with the results obtained with experiments on animals (Dews, 1958; Sidman, 1955). The inter-response-time distributions were shifted in the direction of shorter inter-response times. It should be noted, however, that the number of reinforcements obtained was not different for the control days and the drug days.

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