

The effect of a longer fixed- and variable-duration CS on operant responding

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A light was associated with fixed-time (FT), variable-time (VT), fixed-interval (FI), or variable-interval (VI) schedules. With FT, the light was terminated after 50 sec and a response-independent food pellet was presented. With VT, the duration of the light varied about a mean value of 50 sec. With FI, the first response emitted after 50 sec produced a food pellet. With VI, the interval was varied about a mean value of 50 sec. These schedules were presented intermittently, and operant responding was maintained on a VI schedule in the absence of the light. The FT and VT schedules produced facilitation of operant responding. The FI and VI schedules also produced facilitation of operant responding, but there was no difference in the rate between FT and FI and between VT and VI.

Of continuing interest in the field of conditioning has been the interaction between operant and Pavlovian paradigms (e.g., Hearst, 1975; Henton & Iverson, 1978). A standard procedure for studying this interaction has been to first establish and maintain responding on an operant schedule of reinforcement. A conditioned stimulus (CS) is then presented independently of responding, and upon termination of this stimulus, a second stimulus (UCS) (e.g., food, water, electrical stimulation of the brain) is presented.

The typical finding has been that the rate of responding on the operant schedule during the CS, relative to that during the absence of the CS, is suppressed. This effect has been referred to as positive conditioned suppression (Azrin & Hake, 1969; Hake & Powell, 1970; Meltzer & Brahlek, 1970; Miczek & Grossman, 1971; Stubbs, Hughes, & Cohen, 1978; Van Dyne, 1971). Positive conditioned suppression is most often found when the CS is of short duration (e.g., 10 sec) and is superimposed upon a variable-interval (VI) schedule of operant reinforcement. The results are less clear when a long-duration (300- to 1,220-sec) CS is used, as both facilitation (Brady, 1961; Meltzer & Brahlek, 1970) and suppression (Miczek & Grossman, 1971) have been reported.

Recently, Miller and Judd (1977) reported an increase in rate of maintained VI responding during a 10-sec CS. Their procedure involved a much higher ratio of total CS duration to total non-CS duration than in previous

studies that reported suppression with a short-duration CS. This was believed to be important because the longer and more often the CS occurred in a session, the more likely it would be that operant VI reinforcers would be obtained by responding during the CS. These VI reinforcers would have the effect on operant responding of increasing the rate of responding during the CS, thereby promoting a contingency between responding and response-independent reinforcers. To the extent that a contingency between these two events may develop, the schedule would approximate a fixed-interval (FI) rather than a fixed-time (FT) schedule. Such an adventitious response-reinforcer relationship could serve to facilitate responding during a stimulus correlated with response-independent food.

In the present study, a 50-sec stimulus was presented eight times (total stimulus duration = 400 sec) during a 40-min session. This is similar to the Miller and Judd (1977) study, in which a 10-sec CS was presented 44 times during a 40-min session. The question was whether an increase in responding would also occur under these circumstances. In addition, stimulus duration was maintained at a constant 50 sec for one group but was varied around an average duration of 50 sec for a second group. In previous studies, stimulus duration has remained constant. Finally, an explicit contingency between responding and reinforcement was established by correlating an FI 50-sec schedule or a VI 50-sec schedule with the CS. The question was to what extent the explicit contingency affects responding during the CS as compared with the absence of an explicit contingency (FT or variable time, VT).

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METHOD

Subjects

Fourteen adult male albino rats, about 8 months old at the start of the experiment, were maintained at 85% of their free-feeding weights.

Apparatus

Standard Grason-Stadler rat chambers were used. The CS was a 15-W white light with an intensity of 61.6 cd/m² (18 fc) at the lever. The light was located directly above the lever on the outside of the clear Plexiglas roof.

Procedure

All animals were first shaped to barpress on a continuous reinforcement schedule with 45-mg Noyes pellets and were then placed on a VI 33-sec schedule for 12 40-min sessions. During the next six habituation sessions, only the light (CS) was superimposed on the VI schedule, with eight presentations occurring in random order in the course of each session. For the constant-duration group (Subjects 1-6), the duration of each light presentation was 50 sec. For the variable-duration group (Subjects 7-14), the average duration of the light was 50 sec, with a range from 10 to 90 sec. For the next eight sessions, the termination of the light was correlated with delivery of a single 45-mg Noyes pellet. That is, Subjects 1-6 and Subjects 7-14 received response-independent food according to FT or VT 50-sec schedules, respectively. The VI 33-sec schedule remained in effect throughout the FT or VT component. For the final eight sessions, the schedule was changed from FT 50 sec to FI 50 sec for Subjects 1-4 and from VT 50 sec to VI 50 sec for Subjects 7-14. Here, a response was required in order to produce the pellet of food. If a response did not occur immediately after the FI or VI had elapsed, the light remained on until a response was emitted and the pellet was delivered. Baseline VI reinforcers were not available during the light.

RESULTS

The data for the FT and FI and VT and VI schedules are illustrated in Figures 1 and 2, respectively. The data are presented in terms of an inflection ratio (Kamin, 1961) that measures the change in responding during the stimulus relative to the level of responding in the absence of the stimulus. The ratio is expressed as [(rate during stimulus - rate in absence of stimulus)/rate during stimulus] × 100. A ratio of 50, greater than 50, or less than 50, respectively, indicates no change, an increase, or a decrease in the level of responding during the stimulus relative to that in the absence of the stimulus. Response rate was determined by dividing the total number of responses emitted during a particular condition by the total time spent in that condition.

For purposes of statistical analysis, the data from each of two successive sessions during habituation were combined and the data from each of two successive sessions during the eight test sessions were combined, yielding three blocks for habituation and four blocks for the test sessions. Considering the data for the FT condition, an analysis of variance was conducted with the four treatment blocks and the last habituation block. A significant difference was found [F(4,20) = 5.91, p < .01]. Post hoc analysis with the Newman-Keuls test revealed that the inflection ratio for each of the four test blocks was significantly greater than the inflection

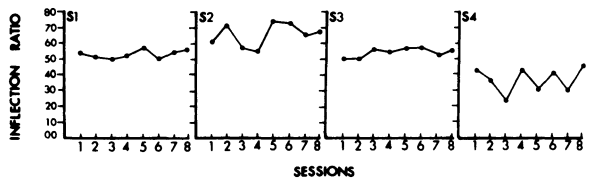
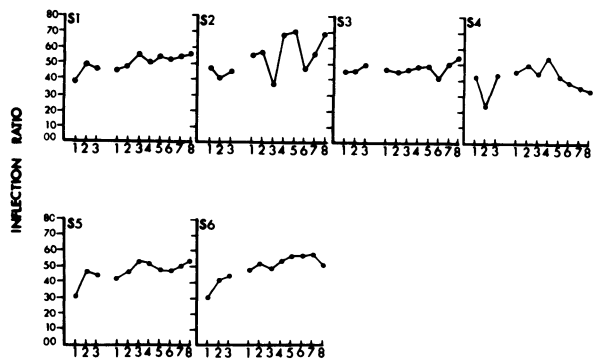


Figure 1. Inflection ratios for the FT and FI schedules are shown in the top and bottom parts of the figure, respectively. CS duration was a constant 50 sec. The habituation data for the FT schedule appear as the first three data points, with each data point representing the mean of two successive habituation sessions. During the next eight test sessions, a food pellet was presented upon termination of the CS.

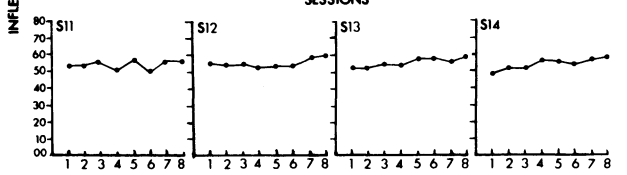
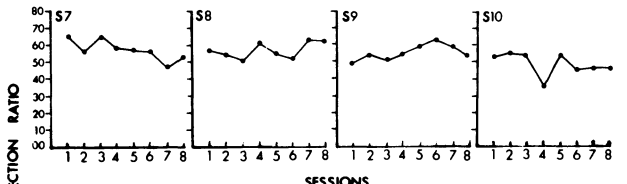
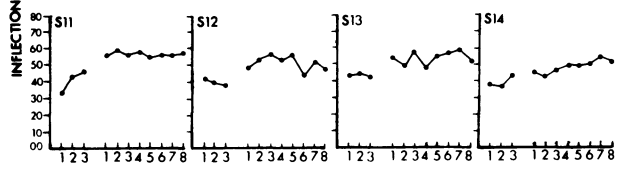
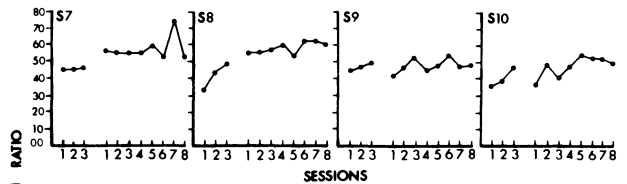


Figure 2. Inflection ratios for the VT and VI schedules are shown in the top and bottom parts of the figure, respectively. The average duration of the CS was 50 sec. The habituation data for the VT schedule appears as the first three data points, with each data point representing the mean of two successive habituation sessions.

ratio for habituation ($p < .05$ for Blocks 1, 2, and 3 vs. habituation, and $p < .01$ for Block 4 vs. habituation). There were no significant differences between the inflection ratios for any of the four test blocks ($p < .05$).

Considering the data for the FI condition, an analysis of variance was conducted with the four treatment blocks and the last block from the FT condition. The analysis revealed no significant difference [$F(4,12) = 1.61$, $p > .25$].

Considering the data for the VT schedule, analysis revealed a significant difference [$F(4,28) = 9.19$, $p < .01$]. Post hoc analysis revealed that the inflection ratio of each of the four blocks was significantly greater than that for the last two habituation sessions combined ($p < .05$ for Block 1 vs. habituation, and $p < .01$ for Blocks 2, 3, and 4 vs. habituation).

Considering the data for the VI schedule, an analysis was conducted with the four treatment blocks and the last block from the VT condition. The analysis revealed no significant difference [$F(4,28) < 1.0$, $p > .25$].

DISCUSSION

The data indicate that a fairly long-duration (50-sec) stimulus correlated with response-independent food produced facilitation of operant leverpressing maintained on a VI schedule of food reinforcement. This same result was obtained when the duration of the stimulus was varied about a mean of 50 sec. In both instances, operant VI reinforcers continued to be available during stimulus presentations.

These data are similar to the data obtained by Miller and Judd (1977) with a short-duration (10 sec) prefood stimulus. In their study, the rate of responding during the stimulus was higher than that in the absence of the stimulus with the FT schedule, but only when operant VI reinforcers could be obtained during the stimulus. In that and the present study, the total stimulus durations per session were very similar, and about the same numbers of VI reinforcers were obtained per session with both 10- and 50-sec durations. Miller and Judd explained their results in terms of a contingency that developed between the response-independent reinforcer and responding. This contingency was attributed to the tendency to maintain operant responding throughout the stimulus, since VI reinforcers continued to be available.

Both FT and FI 50-sec schedules maintained a higher rate of responding than occurred during habituation, but there was no difference in response rate between FT and FI. Likewise, when the VT 50-sec schedule was changed to VI 50 sec, an increase in rate was not obtained. This differs from the results of Miller and Judd (1977), who found that an FI 10-sec schedule produced a higher rate of responding than did FT 10 sec. This difference is likely to be related to changes in rate of responding as the duration of the interval is changed (Catania & Reynolds, 1968; Clark, 1958; Wilson, 1954) and to the number of operant VI reinforcers that can occur during any particular CS presentation.

In conclusion, it would appear that under certain conditions, facilitation of operant responding during a stimulus correlated with response-independent reinforcers can occur when the duration of the stimulus is either brief or of longer duration. This

effect does not seem to be the outcome of the interaction between operant and Pavlovian processes per se. Rather, facilitation is likely to be due to the occurrence of response-dependent reinforcers during the stimulus, which serve to increase the probability that responding will occur. This, in turn, allows a greater possibility of having a response during the stimulus adventitiously reinforced.

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