Stimulus onset and its effect on S+ and S- performance in differential conditioning

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Forty rats served as Ss in an investigation of differential conditioning involving various manners of presentation of the discriminative cues in a runway. For one group of Ss, the cues were presented only in the startbox, while for a second group, the cues were presented in the startbox and during the instrumental response chain. A third group received the cues during the entire instrumental response chain, but only after the start door was raised. A fourth group served as a nondiscriminative control group. The results indicated that the only effects of differential presentation of the discriminative cues were on performance to S- and that this effect on performance to S- occurred only when stimulus onset coincided with the initiation of the response.

Several investigators (e.g., Bower, 1961; Goldstein & Spence, 1963; Ludvigson & Gay, 1967) have been concerned with the interaction between different conditions or amounts of reinforcement (i.e., differential conditioning). Typically, in this situation, the S is given a large reward (S+) in the presence of a discriminative stimulus (e.g., a black alley) and a small reward (S-) in the presence of another discriminative stimulus (e.g., a white alley). Results of studies in this area have generally indicated that Ss are able to discriminate the stimuli associated with the different reward magnitudes and respond appropriately (i.e., fast to large reward, slow to small reward). Some exceptions to this general conclusion have been reported. For example, MacKinnon (1967) and MacKinnon & Russotti (1967) reported an inverse relationship with small S+/S- reward ratios. Seymann (1969) reported nondifferential responding on the part of Ss receiving an equal number of S+ and S- trials with an S+/S- reward ratio of 4:1.

Studies by Ludvigson & S. Gay (1966) and Ludvigson & R. Gay (1967) have indicated that differential performance is greatest at the point of onset of the discriminative stimulus and that this is mainly due to response to S-. The results of the Ludvigson & S. Gay (1966) study showed that the largest decrement in performance to S- occurred in the start measure, just after the presentation of the discriminative S- cue. In this study, all Ss were started from a nondiscriminative startbox. In the Ludvigson & R. Gay (1967) study, the discriminative cues were presented to some Ss in the startbox. These Ss showed a decrement in the speed of orientation to the start door on S- trials. In both studies, there was a progressive increase in S- performance as the S approached the goal. It would

appear that the longer the S was in the presence of the discriminative S- cue, the smaller the decrement in S- performance. The present study was designed to investigate the effects on differential conditioning of several different manners of presentation of the discriminative stimuli in relation to responding in a runway.

SUBJECTS

Forty naive albino female rats (DUB-SDD strain) purchased from Flow Labs, Inc., Dublin, Va., were used as Ss. All Ss were approximately 90 days old at the start of the experiment. Beginning 1 week before the start and continuing for the duration of the experiment, the Ss were placed on deprivation and maintained at 85% body weight. The Ss were housed in individual cages with water always available and were fed at the completion of the daily experimental session.

APPARATUS

The apparatus (more fully described in Davis, Crutchfield, Shaver, & Sullivan, 1970) was a single straight runway with a white startbox and black run and goal sections. The top of the apparatus was covered with 6.35-mm-square wire mesh. Raising the start door activated a Standard Electric Timer which was stopped by breaking a photoelectric beam located 15.24 cm from the start door (start time). A second timer was activated by the breaking of this beam. This timer was stopped (run time) and a third timer (goal time) was activated by depressing a treadle switch located 60.96 cm from the photobeam. The goal timer was stopped by depressing a treadle switch located in front of the goalcup. Four 24-W lights were located along one interior wall of the apparatus. One light was located equidistant from each end of the startbox. Two lights were located equidistant from each other and from each end of the run section. The

fourth light was located equidistant from each end of the goalbox. A 110-V buzzer was mounted on the apparatus adjacent to the startbox. The lights and buzzer served as discriminative cues.

PROCEDURE

A pretraining phase, consisting of handling and taming, habituation to the 45-mg Noyes reward pellets in the home cage, and habituation to the apparatus, was begun 5 days before the start of the experiment. At the end of pretraining, four equal groups were formed randomly: SO (discriminative cues presented in startbox only); WA (discriminative cues presented in the whole apparatus); RO (discriminative cues presented in the run and goal sections only); and ND (nondiscriminative cue presentation). Each S received four trials (2+, 12 pellets; 2-, 1 pellet) per day for the duration of the experiment (18 days). The order for administering the four daily trials to each S was determined by random assignment of one of the six possible sequences of + and - events, with the restriction that no sequence could occur more than twice in a row. The order for running the Ss was also randomized daily, with all Ss receiving Trial 1 before Trial 2 was begun, etc. All Ss were confined to the startbox for 5 sec before the start door was raised and the trial begun. The groups differed with respect to the presentation of the discriminative cues. Ss in Group SO received the cues in the startbox and during the entire instrumental response (i.e., until they were removed from the goalbox). For Ss in Group RO, the cues were present during the entire instrumental response but were not presented until after the start door was raised. The use of lights and buzzer as the S+ or S- cue was counterbalanced within these groups. Group ND served as a nondiscriminative control group, with one-half of the Ss receiving the lights in the startbox and during the entire instrumental response on all trials. The remaining Ss in Group ND received the buzzer in a similar manner on all trials.

RESULTS

Figure 1 presents the mean speeds (meters per second) for the four groups for the start, run, and goal measures. Analyses of variance comparing S+ and S- speeds were performed over the last three blocks (asymptotic speeds) of trials for all three measures. No significant differences were obtained in any measure for S+ comparisons. However, S- comparisons indicated a significant difference in the start measure ($F = 5.16$, $df = 3/36$, $p < .01$). No significant S- differences were found in the run or goal measures. A subsequent Newman-Keuls test

Fig. 1. Mean speeds for blocks of trials (4+, 4- trials per block).

indicated that the significant S- start difference was attributed to Group RO being significantly ($p < .01$) slower than Groups SO, WA, and ND.

These results point to between-group S+ and S- differences as a function of the method of stimulus presentation but say nothing about the development of discriminations within the respective groups. To investigate any within-group effects, a t test (two-tailed) for correlated samples comparing S+ and S- speeds was performed at the last block of trials for each group for the three measures. Nonsignificant differences were shown for Groups SO, WA, and ND for all measures and for Group RO in the goal measure. However, significant differences between S+ and S- speeds were shown in the start ($t = 4.67$, $df = 9$, $p < .01$) and run ($t = 2.83$, $df = 9$, $p < .05$) measures for Group RO.

DISCUSSION

The results of this study suggest that the discriminative "S-" stimuli affect performance only when their onset coincides with the initiation of the response. Thus, a decrement in performance can be seen in Fig. 1 for Group RO, but not for Groups SO and WA. As in the Ludvigson & S. Gay (1966) study, the decrement occurs most strongly in the start measure, to a lesser extent in the run measure, and very slightly, if at all, in the goal measure. Performance to the S+ alternative does not appear to be affected by the different methods used to present the discriminative stimuli.

The nondifferential performance on

Group WA would seem to suggest that the 5-sec presentation of the S- cue during the startbox confinement was sufficient to allow inhibitory tendencies to dissipate. This finding is consistent with those reported by Ludvigson & R. Gay (1967). However, they reported that preresponse exposure to the S- stimuli only attenuated the start measure decrement. It did not eliminate it, as would appear to be the case in the present experiment. A methodological difference may account for these seemingly discrepant results. In the Ludvigson & R. Gay (1967) study, Ss were required to orient toward the start door for 1 sec before it was raised and the trial begun. In the present study, the start door was opened on all trials at the end of the 5-sec confinement time. Thus, all Ss received a full 5-sec exposure to the S- cue in the present study. However, in the Ludvigson & R. Gay (1967) study, it was possible for the Ss to initiate a trial in considerably less than 5 sec. In view of this, it would seem possible that the Ss in that study might, in some instances, be initiating a trial before the inhibitory tendencies aroused by the S- stimulus had a chance to fully dissipate. This would appear not to be the case in the present study.

Group SO would also appear to be reacting in a manner similar to Group WA. However, the same conclusions cannot be made as strongly about Group SO as were made about Group WA. It is possible that even though discriminative cues were presented to Ss in Group SO

during the startbox confinement period, they were unable to make a discrimination, and consequently their behavior is more like that of Group ND than Group WA. At present, there is no clear-cut answer to this problem, and further research is needed to resolve it.

As pointed out earlier, the results reported by Seymann (1969) are somewhat discrepant with the usual findings in the area of differential reward conditioning. It is interesting to note that Group RO in the present study is very similar to Group 50 in Experiment II reported by Seymann (1969). Both groups started from a neutral startbox, and the discriminative cues were presented at the start of the trial. Also, both groups received an equal number of S+ and S- trials. Seymann found nondifferential performance on S+ and S- trials under these conditions, while our study showed differential responding by Ss in Group RO. Despite these similarities, there are methodological differences which may account for the discrepant results. First, the S+/S- reward ratio was only 4:1 in Seymann's study, while it was 12:1 in the present study. As already pointed out, the results of studies by MacKinnon (1967) and MacKinnon & Russotti (1967) using small S+/S- reward ratios have shown an inverse performance pattern. It seems possible that the reward ratio used by Seymann (1969) was small enough that his Ss were behaving like those of the MacKinnon (1967) and MacKinnon & Russotti (1967) studies rather than like those receiving large S+/S- ratios. Secondly, Seymann's (1969) Ss were confined in the startbox for 10 sec. The behavior of Group WA in the present study suggests the possibility that Seymann's (1969) Ss may have been given the discriminative cues inadvertently during this 10-sec confinement period.

The results of this study would seem to support previous findings by showing that (1) the initial presentation of the discriminative cue is an important factor in differential conditioning; (2) the primary effect is on S- performance; and (3) the decrement in S- performance appears to diminish the longer the S is in the presence of the S- cues.

REFERENCES

- BOWER, G. H. A contrast effect in differential conditioning. *Journal of Experimental Psychology*, 1961, 62, 196-199.
- DAVIS, S. F., CRUTCHFIELD, W. P., SHAVER, J., & SULLIVAN, T. Interspecific odors as cues for runway behavior. *Psychonomic Science*, 1970, 20, 166-167.
- GOLDSTEIN, H., & SPENCE, K. W. Performance in differential conditioning

- as a function of variation in magnitude of reward. *Journal of Experimental Psychology*, 1963, 65, 86-93.
- LUDVIGSON, H. W., & GAY, S. E. Differential reward magnitude conditioning: S- contrast as a function of the magnitude of S+. *Psychonomic Science*, 1966, 5, 289-290.
- LUDVIGSON, H. W., & GAY, R. A. An investigation of conditions determining contrast effects in differential reward conditioning. *Journal of Experimental Psychology*, 1967, 75, 37-42.
- MacKINNON, J. R. Interactive effects of the two rewards in a differential magnitude of reward discrimination. *Journal of Experimental Psychology*, 1967, 75, 329-338.
- MacKINNON, J. R., & RUSSOTTI, J. S. An inverse performance pattern in a discrimination based on differential magnitudes of reward. *Psychonomic Science*, 1967, 7, 395-396.
- SEYMANN, R. G. Effect of differences in reward magnitude with correlated cues on running speed. *Journal of Experimental Psychology*, 1969, 81, 504-509.

CURRENT LITERATURE ON ANIMAL CONDITIONING

- ASATO, H. (Veterans Administration Hospital, Phoenix, Ariz. 85012), & FLEMING, D. E. The relationship between EEG amplitude and the rate of classical conditioning. *Psychonomic Science*, 1971, 22, 37-38.
- ASDOURIAN, D. (Wayne State University, Detroit, Mich. 48202), & ANDREZIK, J. Cerebellar stimulation is effective as a CS at low stimulation intensities in rats. *Journal of Comparative and Physiological Psychology*, 1971, 75, 165-170.
- BARRETT, R. J. (Psychology Research Laboratories, Veterans Administration Hospital, Nashville, Tenn. 37203), HUGHES, R. A., & RAY, O. S. ECS disruption of time-dependent processes in discriminated-avoidance conditioning in rats: Incubation or consolidation? *Journal of Comparative and Physiological Psychology*, 1971, 74, 319-324.
- BRACKBILL, R. M. (Franklin and Marshall College, Lancaster, Pa. 17604), & BROOKSHIRE, K. H. Conditioned taste aversions as a function of the number of CS-US pairs. *Psychonomic Science*, 1971, 22, 25-26.
- COX, B. (University of Chicago, Chicago, Ill. 60637). Simulation of neural sets. *Behavior Research Methods & Instrumentation*, 1971, 3, 81-84.
- GILBERT, R. M. (Alcoholism and Drug Addiction Research Foundation, Toronto 179, Ontario, Canada). Signal functions in discriminated avoidance behavior. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 97-108.
- GLASGOW, B. (University of Minnesota, Minneapolis, Minn. 55455). Voltage sensing with a unijunction transistor. *Behavior Research Methods & Instrumentation*, 1971, 3, 129-130.
- HAWORTH, J. T. (University of Manchester, Manchester 13, England). Conditioned emotional response phenomena and brain stimulation. *British Journal of Psychology*, 1971, 62, 97-103.
- HOUTEN, R. V. (Dalhousie University, Halifax, Nova Scotia, Canada), & RUDOLPH, R. Summation of punishment suppression. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 117-121.
- LoLORDO, V. M. (University of North Carolina, Chapel Hill, N.C. 27514). Facilitation of food-reinforced responding by a signal for response-independent food. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 49-55.
- MATTHEWS, T. J. (Brown University, Providence, R.I. 02912), MORIN, L. P., & CHURCH, R. M. Avoidance of thermal stimuli in the rat. *Psychonomic Science*, 1971, 22, 59-60.
- SMITH, S. G. (University of Mississippi, University, Miss. 38677), BORGES, L. A., DAVIS, W. M., & PACE, H. B. Automatic magazine and bar-press training in the rat. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 197-198.
- STEIN, N. (Syracuse University, Syracuse, N.Y. 13210), HOFFMAN, H. S., & STITT, C. Collateral behavior of the pigeon during conditioned suppression of key pecking. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 83-93.