Intraoral self injection: I. Effects of delay of reinforcement on resistance to extinction and implications for self-stimulation¹

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Rats prepared with chronic mouth fistulas were allowed to self-inject themselves intraorally with a highly appetitive solution. Resistance to extinction did not differ between animals reinforced contingently with a bar press and animals reinforced after a bar press, at a liquid dipper as in the conventional free operant situation, but did differ from animals reinforced contingently for licking a dipper.

A characteristic of behavior controlled by rewarding electrical stimulation of the brain (ESB) in the free operant situation is rapid extinction. It has, however, been pointed out that performance measures from instrumental learning situations using conventional reinforcers cannot be adequately compared with situations using ESB as reward unless the temporo-spatial relation between response and reinforcement is equated (Gibson, Reid, Sakai, & Porter, 1965). Specifically, in free operant bar pressing situations using ESB, the reward is usually simultaneous with the response. With conventional rewards, however, the bar press activates a dispensing mechanism, and the animal has to make a chain of approach and consummatory responses before the reward is obtained. When the temporo-spatial relations are made similar by either prolonging the response-reinforcement delay in the ESB reward situation to the delays typical of conventional free operant situations (Gibson et al, 1965; Pliskoff, Wright, & Hawkins, 1965), or by using discrete trial situations such as the runway (Olds, 1956), extinction data has been reported to be comparable for the two rewards.

It has not yet, however, been adequately demonstrated that the behavior controlled by the two types of reinforcement are similar when the contingencies of the conventional reward situation are made identical to those of the normal ESB situation. One study (Gibson et al, 1965) has reported an attempt to shorten the latency of food reward presentation to match that of the ESB situation. In that study rats received sugar water or ESB immediately upon licking a liquid dipper. Both groups of animals extinguished equally rapidly. However, since the food reinforcement was delivered in the same dipper where the response occurred, it is possible that the animals working for sugar water were not required to make a true instrumental response. Licking, the unconditioned response in the presence of the liquid reinforcement, may have been sufficient to maintain the continued administration of reward. Hence the fast extinction exhibited by that group could merely

have been the decrease of the unconditioned response in the absence of the appropriate consummatory object.

This experiment was designed to test whether low resistance to extinction still occurs if the response-reinforcement contingency is maintained but the response is changed to one of a clearly instrumental nature—a bar press. Rats were prepared with chronic mouth fistulae so that a reinforcement solution could be delivered directly into the mouth with a minimum of delay. The nature of this preparation precluded the chain of sensory interaction with the reward object preceding ingestion, and is thus a close approximation of ESB administration. The effects of immediate intra-oral administration of reward were studied in terms of acquisition, extinction, and spontaneous recovery.

Method

Subjects. Twenty male albino rats weighing 250–350 g were randomly assigned to five experimental conditions, four to a group. Three groups were implanted with chronic mouth fistulae by the method described by De Bold, Miller, & Jensen (1965), and the other two groups were unoperated controls. Ss were maintained on a 23 h food deprivation schedule for at least one week before the operation and for one week between the operation and the initiation of training. During experimental testing, Ss were maintained on a 23–1/2 h food deprivation schedule.

Apparatus. A single lever operant conditioning box 9–1/4 x 8 x 7–1/2 in. with a Lehigh Valley liquid dipper mounted 2 in. to the left of the bar served as the experimental chamber. A circuit for sensing contacts was attached to the dipper. The apparatus for self-injection of fluids in a free operant situation has been described (Panksepp, Trowill, & Trehub, in press). The reinforcement used for all groups was commercially prepared chocolate milk. Each reinforcement, whether administered intraorally or by dipper, was .04 ml in volume.

Procedure. Experimental conditions differed in the method of administration of reward and in the delay of reward. For three groups reinforcement was available at the dipper. For one of these groups, designated as D-D (dipper-delay), a bar press activated the dipper mechanism. For the second group, D-I (dipper-immediate), touching the liquid cup of the dipper activated the dipper mechanism and made food available. Two sec later the touch sensor was reactivated to allow another lick to activate the dipper. The interval allowed ade-

Fig. 1. Responses during extinction. Extinction responding is represented by 1-min means on the left and by 5-min means on the right. Base response rate during stabilization days is on extreme left.

quate time for the ingestion of the .04 ml reward. For the third group, O-C (oral-chained), a bar press armed the dipper touch sensor and the S's contact with the dipper caused liquid reinforcement to be injected introrally. Because of a leak in one S's fistula, data were collected from only three Ss in this group.

For the other two groups the liquid reward was dispensed directly into the mouth at the bar. For one group, O-I (oral-immediate), the injection was contiguous with the bar press. For the other group, O-D (oral-delay), the injection was administered 3.3 sec after the bar press. This delay represented the average latency between the bar press and the ingestion of the reward by Group D-D. Since a retractable lever was not used, the Ss responded during the reinforcement delay, and thus, in effect, responded as a low variable-ratio group.

All Ss were given a day of training and three days for stabilization of the response. During each of these sessions, all Ss were allowed 100 reinforcements. On Day 5, 50 rewards were given followed by a 30 min extinction session. On the third day after extinction all Ss were given a 15 min session to test for spontaneous recovery. The number of shaping trials necessary to lead to acquisition (i.e., sustained responding in the situation) was measured for Ss in Groups O-I and D-D, and the number of responses per minute was recorded during training, extinction, and spontaneous recovery.

Results and Discussion

The Ss in the O-I group showed remarkably fast acquisition, such as is often found with animals taught to self-stimulate. All O-I Ss were trained in between 1 and 3.5 min with a maximum of 21 shaping reinforcements. D-D Ss required between 18 and 35 min of shaping, during which time 63-80 reinforcements were administered. Both these differences were significant ($p < .014$) by the U test.

Since a short delay of reinforcement has been asserted to lead to fast extinction (Gibson et al, 1965), it would be expected that Group O-I would show less resistance to extinction than Groups D-D, O-C, and O-D. The extinction data (Fig. 1) failed to confirm this prediction. Statistical tests² showed that there were no significant differences ($ps > .343$) between these groups. Group D-I, however, did have significantly ($p < .024$) less resistance to extinction than any of the other groups. Even if the licking response cannot be validly compared to a bar press, the D-I group replicated an effect which has been previously reported (Gibson et al, 1965). This effect has been the basis for maintaining that there are no differences in resistance to extinction between ESB and conventional rewards once the delay of reward has been equated. The present data, however, show that the same low resistance to extinction did not occur in Group O-I, a group where the reward was also delivered immediately. Thus with the use of a high incentive reward and within the limits of the delays used in this experiment, delay of reinforcement did not seem to be a crucial variable in resistance to extinction.

Responding during the spontaneous recovery session was significantly greater ($p < .028$) for Groups O-I, O-D, and D-D than for Group D-I. Groups O-I, O-C, O-D, and D-D again did not differ significantly ($p > .343$), however, from each other. The low spontaneous recovery and extinction score of Group D-I suggests that licking the liquid dipper was not a true instrumental response in this situation.

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Notes

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- All statistical tests were done with the Mann-Whitney U test.