Respondent Salivary Conditioning during Operant Lever Pressing in Dogs

Abstract. The lever-pressing response of four dogs was reinforced with food on a 2-minute fixed-interval schedule, with salivation also being recorded continuously. Respondent salivary conditioning was found to occur during operant lever-pressing conditioning, the occurrences of the two conditioned responses being positively correlated.

Most psychologists in the field of learning accept the convention of distinguishing between two types of conditioning. However, in this country the amount of research conducted in operant conditioning has always far outweighed the volume of research in respondent conditioning. There are several reasons for this relative lack of research in the latter area, not the least of which is the fact that respondent conditioning procedures are more laborious and time consuming when applied to animals. Furthermore, the unsystematic texture of results obtained with respondent procedures has done little to attract investigators. Therefore, one of the purposes of this experiment was to develop a new approach toward the study of respondent conditioning.

In all operant studies, in which an experimental space and manipulanda are employed, the contingency between an operant and the reinforcing stimulus is such that a relationship between time and reinforcement is also established, the probability distribution of the relationship being a function of the particular schedule and the animal's operant behavior. If the reinforcing stimulus is food, the stimuli associated with the performance of the operant and the passage of time should serve as conditioned stimuli for a salivary respondent. Thus, it was proposed that respondent salivary conditioning be studied in conjunction with operant lever-pressing conditioning, with regard to schedules of reinforcement. The investigation reported here is concerned with fixed-interval reinforcement.

Prior to the beginning of the experiment, each of four dogs was surgically prepared to allow the continuous recording of salivary secretion from the right parotid gland. Preparation consisted of a 1-hour operation during which a v-shaped polyethylene tube was inserted into the excised salivary duct, the duct was ligated, and the tube was then brought under the skin and out a small incision located on the dorsal surface of the neck.

The apparatus consisted of an experimental space with a square lever on one wall; the tray into which the magazine deposited the food pellet was located above the lever. A metal cable attached to the ceiling of the cubicle was connected to a harness fastened about the dog. A polyethylene tube passed through this cable and at the beginning of each experimental session the tube was filled with water, the end of the tube in the cubicle was slipped over the polyethylene tube emerging from the dog's neck, and the other end of the tube outside the cubicle was attached to a hypodermic needle. The secretion of saliva by the dog then resulted in 0.01-ml drops being formed at the end of the needle, making contact with the metal rod located directly below. This provided the means of measuring the salivary secretion of a freely moving animal.

Each dog was given magazine training with the lever retracted. After this the lever was introduced into the box, and thereafter all food presentations were contingent upon the lever-pressing activity of the subject. At first all presses were reinforced; then only the first press after a fixed interval of time had elapsed was reinforced, and the duration of the interval was gradually increased to 1½ minutes. This generally required about 2 hours after the first lever press. On the following day the animal was started on the 2-minute fixed-interval schedule, with reinforcement contingent upon lever pressing. Ten 2-hour sessions were administered. The animal received its daily supply of food while working in the box, and only water was available in its home cage.

Figure 1 shows the mean salivary response curve for one animal during the last experimental session. Each 2-minute interreinforcement interval was divided into ten equal subintervals; the line shows the mean cumulative curve, and the bar graph the mean absolute number of responses during each interval. Immediately after the presentation of the reinforcing stimulus (S^R) the rate of responding is very high; the rate tapers off into a period of low responding, followed by a steady gradual increase in rate as the time for the next reinforcement approaches. If conventional terminology is used, the very high rate of responding following the food presentation would be called the unconditioned response, and the steady gradual increase in rate as the time for the next food presentation approaches, the conditioned response. Thus the salivary responding curve resembles the accepted operant lever-pressing curve for fixed-interval reinforcement, the one difference being the presence of an unconditioned response following the food presentation (S^R).

Figure 2, showing the behavior of a second subject during the 15th experimental hour, demonstrates the high correspondence between the rates of prereinforcement lever pressing and salivation, that is, the correspondence between operantly conditioned lever pressing and respondently conditioned salivation. The upper portion of the figure depicts the cumulative salivary responding, with the occurrence of reinforcement indicated by a diagonal downstroke of the pen; noncumulated lever presses are shown in the lower portion. A comparison of the conditioned lever pressing and the conditioned salivation, just prior to each reinforcement, shows that the amount of conditioned salivation varies directly with the amount of lever pressing, or vice versa.

These results are completely representative of the behavior of all four ani-

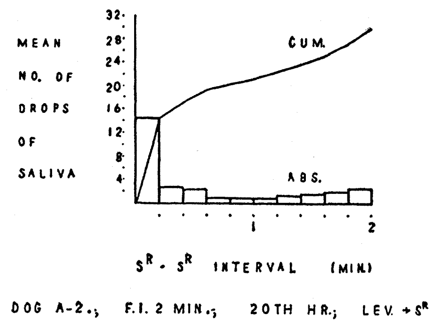

Fig. 1. The mean salivary responding for one dog during the 20th experimental hour was computed by dividing each 2-minute interreinforcement interval into ten equal subintervals and calculating the mean number of drops falling in each subinterval. The line shows the mean cumulative curve, and the bar graph shows the mean absolute curve.

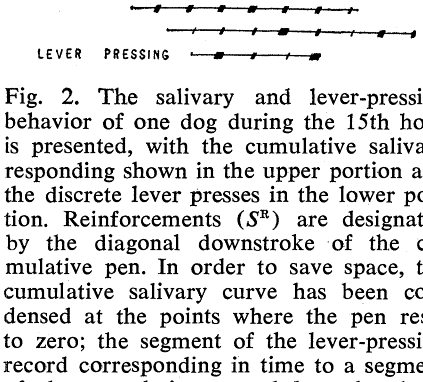

Fig. 2. The salivary and lever-pressing behavior of one dog during the 15th hour is presented, with the cumulative salivary responding shown in the upper portion and the discrete lever presses in the lower portion. Reinforcements (S^R) are designated by the diagonal downstroke of the cumulative pen. In order to save space, the cumulative salivary curve has been condensed at the points where the pen reset to zero; the segment of the lever-pressing record corresponding in time to a segment of the cumulative record has also been moved an equal distance down and to the left.

mals, and the respondent salivary conditioning obtained in this experiment was far more regular than that obtained with traditional procedures.

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Notes

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Avoidance Learning and Relearning as a Function of Shuttlebox Dimensions

Abstract. Rats in a low-ceiling shuttlebox initially show a lower level of learning than rats in a high-ceiling box. After an hour's interruption of conditioning the performance of animals in low-ceiling boxes improves and avoidance is slightly more efficient than in the unimproved performance of animals in high-ceiling boxes. Box height also interacts significantly with length of box.

Recently, Kamin (*1*) attempted to measure the amount of retention of an incompletely learned avoidance response. Rats were given 25 trials in a typical shuttlebox and 25 retention trials after delays of 0, ½, 1, 6, and 24 hours, and 19 days. The results were unexpected; instead of a monotonic decreasing function with time, a V-shaped curve obtained which declined from 0 to 1 hour and then rose from 1 hour to 24 hours. Differences in retention at 0, 24 hours, and 19 days were not statistically significant.

Kamin interpreted the data in terms of an initial forgetting function followed by a jelling of the avoidance habit.

Denny (*2*) reinterpreted Kamin's V-shaped function (the "Kamin effect") in terms of an immediate incubation of anxiety followed by a dissipation of this anxiety after an hour or so. According to this interpretation, the anxiety, which is typically manifested in "freezing" behavior, incubates in the interval immediately after original learning and thereby interferes with the act of shuttling. Sometime after the hour delay the anxiety begins to dissipate, and retention of the avoidance response is clearly apparent after 24 hours. Although the results of Denny's study supported this hypothesis, in the first session of 25 trials and in the second session after a 1-hour delay the rats made more avoidances than found by Kamin (10.7 vs. 5.7 in session 1 and 10.1 vs. 6.6 in session 2). Since Denny's shuttlebox had a higher ceiling (14 vs. 4¾ inches) and a shorter gridway (26 vs. 36 inches) the present study was designed to investigate the importance of length and height of shuttlebox, both in original learning and in relearning 1 hour later.

Seventy experimentally naive hooded, black and albino rats, 35 female and 35 male, ranging in age from 90 to 150 days were used. The rats were randomly assigned to seven groups, except for a sex equation of five males and five females per group.

The shuttlebox was 4 inches wide, painted flat black, and had a glass front. The box was designed so that, with removable partitions, it could be adjusted to any of three lengths: 36, 26, or 16 inches. The fixed ceiling was 14 inches high; to lower ceiling height a sheet of clear glass was inserted 5 inches from the floor. Thus there were six different apparatus conditions which describe the six experimental groups: three groups with a 14-inch ceiling for each length and three groups with a 5-inch ceiling for each length.

In session 1 (25 trials) the rat was placed in the shuttlebox for 1 minute before the trials began. The buzzer was sounded 5 seconds prior to the shock (1.7 ma) and continued until the rat had crossed the midline (shuttled). The intertrial interval was 1 minute.

After session 1 the rat was returned to an outer room where it was placed in its living cage with its cage mates. One hour later the rat was again taken from its living cage and given 25 identical additional trials (session 2).

A control group run in a shuttlebox with a 26-inch gridway and a 14-inch ceiling underwent session 1 followed immediately by session 2 (no delay). The control was included solely to determine whether the present sample would perform like the rats in the earlier study (*2*).

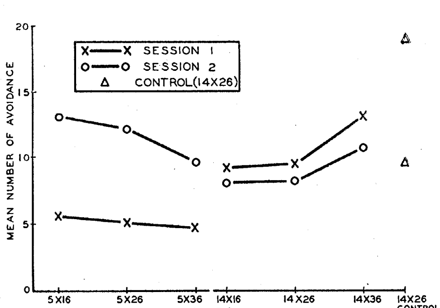

Fig. 1. Mean number of avoidance responses in each group for both sessions. The upper triangle represents session 2 for the control.

The experimental design, excluding the control group, lent itself to a 2 × 2 × 3 × 2 analysis of variance with repeated measures. It was found that two main variables, ceiling height and sessions, and three two-way interactions were significant (see Table 1).

Table 1. Analysis of variance. The nonsignificant third- and fourth-order interactions (degrees of freedom = 9) are not included.

Source of variation	Degrees of freedom	Mean square	*F*
Between	59		
Sex	1	0.8	
Height	1	56.0	4.66*
Length	2	6.7	
Sex × height	1	90.2	7.52†
Height × length	2	80.5	6.71*
Sex × length	2	31.0	
Error	48	12.1	
Within	60		
Sessions	1	187.5	187.5†
Sessions × sex	1	0.0	
Sessions × height	1	480.0	480.0†
Sessions × length	2	9.3	
Total	119		

* $p = .05$ † $p = .01$

The mean number of avoidances for both sessions for the six experimental groups are plotted in Fig. 1. The means of the experimental groups were compared by a "studentized" distribution and yielded the following significant differences: (i) rats in high-ceiling boxes made more avoidances in original learning than did rats in low ceiling boxes; (ii) rats in low-ceiling boxes showed improvement after a delay of 1 hour, whereas those in high-ceiling boxes did not; (iii) performance in session 2 in a low ceiling, short (16-inch) box was better than performance in session 2 in a high ceiling, short (16-inch) box.

The significant interaction between height and length indicates that with a high-ceiling box learning tends to be better the longer the alley and that with a low-ceiling box just the reverse is true. The significant interaction between sessions and height indicates, at a minimum, that the "Kamin Effect" occurs to a greater extent with a high-ceiling than with a low-ceiling box. Finally, the significant interaction between sex and box height refers to the fact that females, which are especially prone to "freezing" in a low-ceiling box, make considerably more avoidances with a high ceiling than with a low, whereas males make a few more avoidances in the low-ceiling box than in the high. The control group performed in both sessions at levels comparable to Denny's controls, and performance during relearning was excellent (see Fig. 1).

The superiority in original learning of the rats in the high-ceiling box sug-