SALIVARY CONDITIONING IN DOGS DURING FIXED-INTERVAL REINFORCEMENT CONTINGENT UPON LEVER PRESSING[1, 2]

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In all operant studies, employing an experimental space and manipulanda, 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 animal's operant behavior and the particular schedule of reinforcement. Furthermore, if the reinforcing stimulus is food, the stimuli associated with the performance of the operant and the passage of time should serve as CS's for a salivary respondent. Thus, it was proposed that respondent salivary conditioning be studied in conjunction with operant lever-pressing conditioning in reference to schedules of reinforcement. To accomplish the recording of salivary conditioning in a free-moving animal, a surgical technique devised by Lauer, Shapiro, and Radell (1960)[3] was modified.

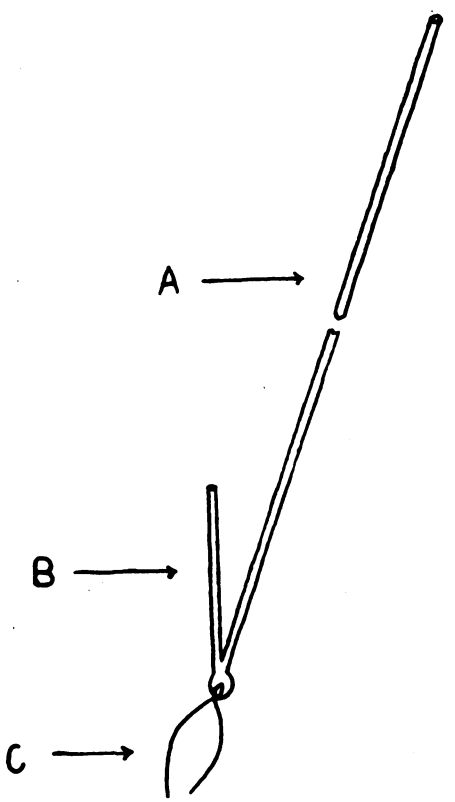

Fig. 1. A diagram of the polyethylene tube implanted in the dog. A length of tube is heated and bent to form a v-shape, with a flat tab of polyethylene formed at the crook of the v. Suturing material (C) is put through the tab and tied to it. End B is inserted into the salivary duct, the suturing material secured to the surrounding tissue, and End A brought under the skin and out to the external surface at the back of the dog's neck.

METHOD

Subjects

The subjects were four adult, mongrel dogs obtained from a local supplier. All dogs which were supplied were used, the only restriction given the supplier was that they be small enough to be accommodated in the experimental space.

Surgical Procedure

A 30-centimeter length of Clay-Adams PE 50 polyethylene tubing was prepared as indicated in Fig. 1. The course of the duct was identified within the mouth. In the external labial tissue, an incision was made parallel to the duct and 1 centimeter ventrad from it, beginning 2 centimeters posterior to its orifice and extending 18-20 millimeters caudad. The duct was exposed by blunt dissection, and a 2-millimeter longitudinal incision was made 2 centimeters from the orifice. The specially prepared PE 50 tubing was inserted into the duct; this tubing was cut such that the end of the tube was within 5 millimeters of the parotid gland and the v-curve was within 2 millimeters of the incision in the duct. Both duct and tubing were ligated to prevent leakage around the tube, and the v-curve of the tube was sutured to the surrounding musculature to prevent movement of the tube. The end of the duct proximal to the orifice was also ligated to prevent communication with the mouth. With a flexible metal probe, the tube was passed under the epidermis to the dorsal surface of the dog's neck and then out a 3-millimeter incision made on that surface. The external labial incision was then closed, approximating the various layers of tissue. The operation was performed with as much asepsis as possible, and antibiotics were administered postoperatively.

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[2]Fragments of this research were reported at the 1960 Convention of the Midwestern Psychological Association and in *Science*, Sept. 2, 1960, Vol. 132, No. 3427, pages 619-620.

[3]Lauer, D. W., Shapiro, M. M., and Radell, A. A chronic salivary fistula in the dog. (In preparation)

Apparatus

The experimental apparatus was contained in a soundproof room, and the electronic control equipment in an adjoining room. The experimental space was a 30- by 30- by 30-inch sheet metal box which had been painted aluminum. A 6- by 6-inch one-way screen was located in the center of the door. The intelligence panel, located on the rear wall, contained a 6- by 6-inch retractable lever, 2.5 inches from the floor; the lever housing, which protruded from the external surface, rested on a microswitch. A 3- by 3-inch metal food tray was situated 4.5 inches above the lever. The food magazine was a locally constructed version of the conventional rotary disc dispenser with hopper, designed to accommodate Hartz Mountain Dog Yummies; this mechanism was mounted on the external surface of the panel. When a pellet was released, it fell through a 5-inch chute into the food tray on the internal surface of the panel. In the upper left-hand corner of the panel was a vent through which a fan mounted on the external surface supplied continuous ventilation and masking noise. A 15-inch, 15-watt fluorescent lamp, mounted at the top of the panel, was the houselight. In addition, three 5-watt bulbs (one white, one green, and one red) were located between the houselight and the food tray. A 36-inch-long, 0.25-inch-diameter, flexible metal cable was contained in the box. One end of this was attached to the ceiling of the box and protruded 2 inches from it; the other end, contained in the box, was attached to a leather harness which could be fastened about the front legs of a dog and around its chest. A PE 100 polyethylene tube was passed through the cable so that one end protruded over the harness; the other end of the tube was connected to a No. 25 hypodermic needle whose point had been removed. The needle was mounted on a vertical piece of Plexiglas located on the floor, 5 feet below the roof of the box; a metal rod was mounted directly below the needle. One shielded electrical line led to the needle, and one led to the rod.

In the control room, the two electrical lines from the needle and rod led to the terminals of an electronic relay which was activated whenever a drop of liquid closed the gap between the needle and rod. The activation of the electronic relay and the closing of the microswitch under the lever were denoted on a cumulative recorder. All experimental operations were automatically controlled.

Procedure

Before each experimental session, the PE 100 tubing was filled with water. The animal was then placed in the box and the harness fastened around its body; the end of the PE 100 tubing was slipped over the end of the PE 50 tubing emerging from the back of the dog's neck, and the other end of the PE 100 was connected to the hypodermic needle. The dog's secretion of saliva then caused 0.01-cubic centimeter drops to form at the end of the needle, making contact with the metal rod located directly below, and thus activating the electronic relay. The animal received its daily supply of food in the experimental space, and only water was available in its home cage.

Each of the four animals was given magazine training with the lever retracted; food was presented at unsystematic intervals until the salivary response showed short latencies, indicating that the animal was eating the food immediately after presentation. Following this, the lever was introduced into the cubicle, and, thereafter, all food presentations were contingent upon *S*'s lever-pressing activity. At first, all presses were reinforced; but, then, only the first press after a fixed interval of time had elapsed was reinforced. The timer reset and supplied a pulse to the latching relay whenever the fixed period of time had expired. With this procedure, the interval between availability of reinforcements, and not the minimum time between reinforcements, was kept constant. The duration of the interval was increased to 1.5 minutes, generally requiring approximately 2 hours of training following the first lever press. The occurrences of drops of saliva were recorded on the cumulative pen of the recorder, and lever presses were recorded noncumulatively by the event marking pen. On the day following the original training, *S* was started on the FI 2-minute schedule with reinforcement contingent upon lever pressing. Ten daily 2-hour sessions were administered.

Because of an apparatus failure (magazine jammed while turning) during the fifth session of one dog's training, this *S* was, in effect, put on extinction for 30 minutes.

RESULTS AND DISCUSSION

Figure 2 shows the behavior of the one female *S*, A-2, during the last experimental session, the 20th hour. The generally regular nature of the cumulative salivary responding is evident, although the shape of the curve may not be readily apparent because this small dog had a low rate of responding. The animal exhibited a rate of lever pressing which cannot be quantified because the line made by the pen was so thick. Figure 3 shows the mean salivary-response curve for this same animal during this same session, obtained by dividing each 2-minute inter-reinforcement interval into 10 12-second intervals, and counting the number of drops within each. The line shows the mean cumulative curve, and the bar graph shows the mean absolute number of responses within each interval. Immediately after the presentation of the reinforcing stimulus (S^R), the rate of responding was very high (UR); the rate tapered off into a period of low responding, followed by a slow gradual increase in rate as the time for the next reinforcement approached (CR).

Figure 4, which shows the behavior of Subject A-1 during the 15th hour, demonstrates the high correspondence between the rate of prereinforcement (conditioned) salivation and lever pressing. This animal

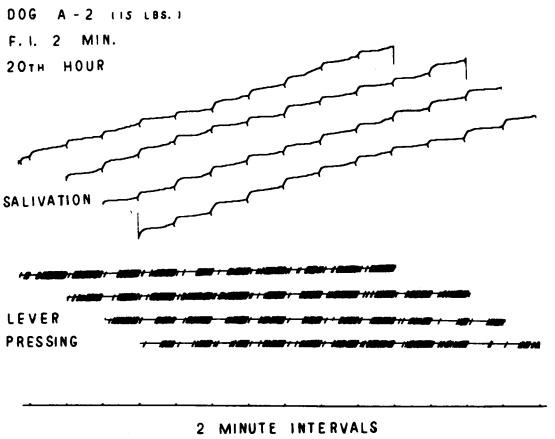

Fig. 2. The record for Dog A-2 during the 20th experimental hour of training in which reinforcement was contingent upon lever pressing on an FI 2-minute schedule, salivation being measured concurrently. Cumulative salivary responding is shown in the upper portion and discrete lever presses in the lower portion; reinforcements are designated by the diagonal downstrokes 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.

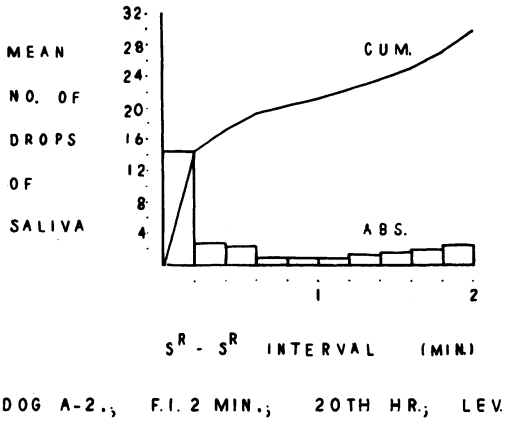

Fig. 3. The mean salivary responding for Dog A-2 during the 20th experimental hour of S^R contingent upon lever pressing on an FI 2-minute schedule. The points on this graph were computed by dividing each 2-minute S^R-S^R interval of Fig. 2 into 10 equal subintervals and calculating the mean number of drops falling in each. The line shows the mean cumulative curve, and the bar graph shows the mean absolute curve.

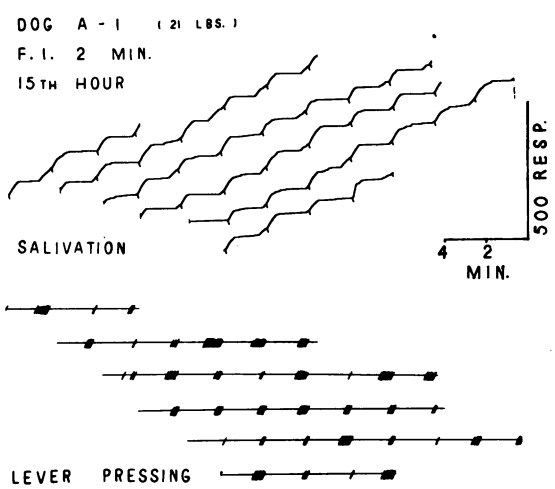

Fig. 4. The record for Dog A-1 during the fifteenth experimental hour of FI 2-minute reinforcement contingent upon lever pressing, with salivation measured concurrently. The figure was prepared in the same manner as Fig. 2.

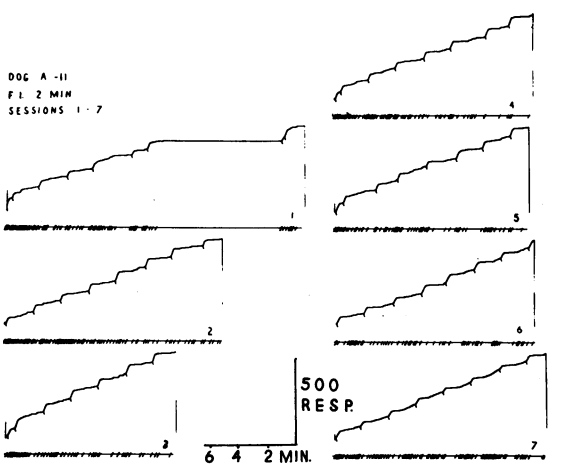

Fig. 5. A portion of the records for Dog A-11 from the first seven sessions. Each curve shows the first excursion of the cumulative (salivary) pen and the concurrent non-cumulative lever pressing from each session. Reinforcements, designated by diagonal downstrokes of the cumulative pen, were contingent upon lever presses on an FI 2-minute schedule.

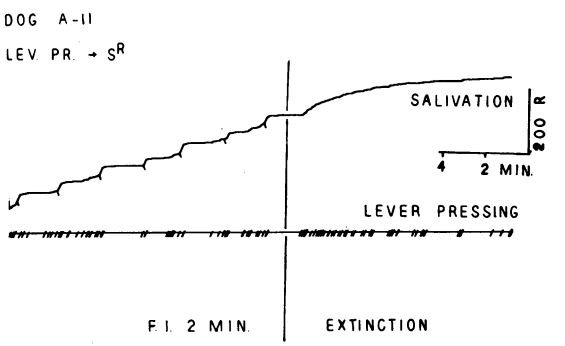

Fig. 6. A portion of the record for Dog A-11 during the 11th experimental hour. The animal was trained on FI 2-minute reinforcement contingent upon lever pressing; however, at the point where the vertical line is drawn, the animal was inadvertently put on extinction because of an apparatus failure. Salivation is cumulated on the upper curve, with reinforcement designated by diagonal downstrokes. Lever presses shown in the lower portion are not cumulated.

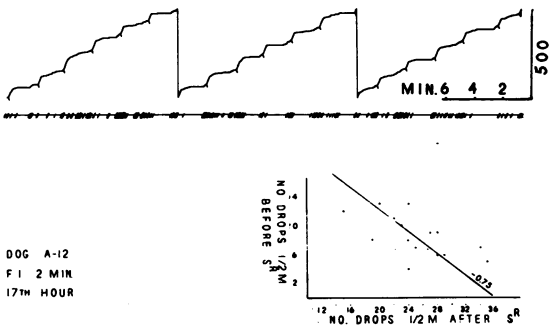

Fig. 7. The upper part of the figure shows a portion of the record of Dog A-12 during the 17th hour of training on FI 2 minutes contingent upon lever pressing. Salivation is cumulated, lever presses noncumulated; and reinforcements are designated by diagonal downstrokes of the cumulative pen. In the lower portion of the figure, each point of the scatter diagram (computed from the above) represents the number of drops of saliva during the 0.5-minute period before an S^R (ordinate) and the number of drops of saliva during the 0.5-minute period after the S^R (abscissa).

had developed a good FI temporal discrimination, but its behavior was still variable enough at this point in training to give an adequate sampling of differing numbers of prereinforcement responses. An inspection of the records of the two responses shows that the amount of prereinforcement (conditioned) salivation varies directly with the amount of lever pressing, or vice versa. This somewhat larger animal evidenced a higher salivary-response rate than the smaller, previous dog, A-2.

Figure 5 shows the first excursion of the cumulative salivation pen and the concurrent lever pressing during the first seven sessions for another animal, A-11. A comparison of the curves over the sessions shows the development of the conditioned salivary response. During the 5th session, the food magazine jammed and *S* A-11 was on extinction for approximately 30 minutes. The results during this extinction period are presented in Fig. 6, which shows that the lever pressing and the salivation exhibit comparable extinction rates.

Figure 7 shows the behavior of the 4th subject during the 17th experimental hour. The results have been further analyzed in an attempt to investigate the relationship between the magnitude of the pre- and post-S^R salivation, *i.e.*, the relationship between the CR and UR magnitudes. In the lower portion of the figure, the number of drops in the 30 seconds before S^R is on the ordinate, and the number of drops in the 30 seconds after S^R is on the abscissa. The regression line determined from the scatter diagram has a slope of −0.75. In other words, the greater the magnitude of the CR, the lower the UR; in fact, the UR decreases more rapidly than the CR increases. This is perhaps somewhat surprising since it means that the greater the CR the lower the CR plus UR magnitude. The results certainly are not conclusive on this one question since there is only fair agreement from all the data.

SUMMARY

The lever-pressing response of four dogs was recorded and reinforced with food on an FI 2-minute schedule, with salivation being recorded continuously. Respondent salivary conditioning was found to occur during operant lever-pressing conditioning, the occurrences of the two CR's being positively correlated.

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