*A PRECISION LIQUID FEEDING SYSTEM CONTROLLED
BY LICKING BEHAVIOR¹*

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This paper describes a system for accurately controlling the delivery of different quantities of fluids to rats as they lick from a drinking tube. In outline, the system consists of a special drinking tube, an electronic relay² which operates each time the animal licks on the drinking tube, and an infusion pump operated by the electronic relay.

The drinking tube, shown in Fig. 1, is a tube of plexiglas, 0.5 inch in diameter, with a 2-millimeter fluid hole in its center. A piece of 0.0625-inch brass rod, which serves as a contact for the electronic relay, is pressed-fit through a second hole in the tube so that one end is flush with the bevelled surface of the tube's tip and located 0.0625 inch below the fluid hole. The drinking tube is mounted, as shown in Fig. 1, so that its fluid hole is in the center and about 0.0625 inch behind a 0.3125-by-0.25-inch vertical slot in a 0.125-inch-thick plexiglas shield attached to one wall of the experimental chamber. This shield serves to keep the animal's nose off the tube and relay contact.

Figure 1. The drinking tube and shield. A, plexiglas shield; B, slot through which animal licks; C, plexiglas drinking tube; D, fluid hole; E, brass rod for electronic relay contact; F, pressure tubing to liquid pump; G, adjustable holder and sleeve for drinking tube; H, set screw; J, wall of experimental chamber.

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²The electronic relay currently in use is based on a circuit developed in this laboratory by Otis and Boenning (in press). The circuit operates by passing minute A.C., rather than D.C., current through the animal. This results in a more reliable operation of the relay and avoids ionization at the tongue, as Otis and Boenning note, making the present system useful for taste research.

With each lick on the contact of the drinking tube, the electronic relay closes and operates an infusion pump which delivers a drop of fluid of predetermined amount to the end of the drinking tube. The infusion pump is shown at left in Fig. 2. It is very accurately adjusted for almost any drop size, operates almost instantaneously, and has proved extremely reliable. The pump is operated by a Ledex rotary solenoid³ which turns a set of gears. The gear system is connected to a lead screw which advances a metal bar. The latter pushes the plunger on a hypodermic syringe a given distance each time the rotary solenoid is pulsed. Drop size can be easily varied by using different gear ratios and different-sized syringes.

Figure 2. The liquid pump (left) and solenoid-driven lever (right).

Since the system makes fluid delivery directly contingent upon the occurrence of licking behavior, it provides a means for using the tongue lick as an operant response. With the addition of suitable programming equipment and a solenoid-driven lever shown at right in Fig. 2, the delivery of drops of water can be arranged according to any of the traditional schedules of reinforcement. The solenoid-driven lever assures that the animal will not make contact with the fluid column on nonreinforced licks. It operates simultaneously with the infusion pump and slightly squeezes, but does not close, the pressure tubing leading from the pump to the drinking tube as the pump delivers fluid. After the animal's tongue is off the drinking tube, the lever returns to its resting position. The resulting negative pressure draws the fluid column away from the tip of the drinking tube until the pump and solenoid are pulsed for the next reinforcement. A very tiny excursion of the lever is required, since the fluid column needs to be withdrawn only a millimeter or so.

Two or three features of this system deserve special mention since they have proved of some importance for its trouble-free operation. First of all, the size and location of the

³Manufactured by G. H. Leland, Inc., 123 Webster Street, Dayton 2, Ohio. The shaft of the solenoid currently in use moves 30 degrees per pulse. Other models are available.

relay contact on the face of the drinking tube are fairly critical if the system is to be used with schedules of reinforcement. The contact must be small so that a rather precise and deliberate tongue lick is required to operate the electronic relay. Larger contacts tend to produce imprecise "washing" movements over the face of the tube. If response-based schedules of reinforcement are used, these "washing" movements are reinforced since they can cause rapid series of "false" electrical contacts which operate the programming circuit at an artificially high rate. Additional insurance against such false tongue contacts is provided by locating the relay contact on the bevelled surface below the fluid hole, as shown in Fig. 1. Since the relay contact is both below and behind the fluid hole, false contacts cannot occur as the tongue returns downward across the face of the tube following a lick. Finally, the dimensions of the slot in the shield, together with the distance and position of the drinking tube behind the slot, may have to be adjusted slightly if large differences in size exist among the animals being used. This is by no means a critical factor; no adjustment at all has proved necessary for the normal differences in size which occur among rats of a particular strain run under a particular set of deprivation conditions.

This system provides very precise quantitative control over many aspects of consummatory behavior such as amount consumed per lick, total amount consumed, and schedule of reinforcement of the licking response. As described, it is suitable for the rat and, presumably, other small animals; in principle, it should be easily adaptable for any species which uses licking as a mode of ingestion.

REFERENCE

- Otis, L. S., and Boenning, R. A. A transistorized circuit for recording 'contact' responses, *J. exp. anal. Behav.*, in press.

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