Stimulus control through the licking response[1]

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An apparatus allowing a rat's drinking response to terminate shock or deliver food is described. The system is constructed of commercial components and is sensitive to the intermittent, but regular, signal generated by a rat in the act of drinking.

Technical difficulties with "drinkometers" (Hill & Stellar, 1951) have been of two general types. First, some circuits cannot discriminate between the signal generated by drinking and that produced by other contacts, and second, some circuits operate erratically, or not at all, as a result of continuous contact with the drinking fount (e.g., Dawson et al, 1963). Keehn & Arnold (1960) have described the rat's licking rate as having an average frequency of about seven licks per sec. and variability on the order of only one lick per sec. The apparatus described here was designed to detect and respond to the intermittent, but regular, pulsations characteristic of the signal generated by the drinking rat.

Apparatus

Commercially available components were used quite satisfactorily. A diagram showing the inter-connections of these components and accessory equipment is shown in Fig. 1.

The contact sensor was a Richter type rodent drinking fount with a wire inserted through the glass to make electrical contact with the fluid in the bottle. The drinking fount was mounted proximal to the rodent cage (Scientific Prototype Model A-100) and the attached electrical conductor was connected to the grid circuit (terminal 8) of a Hunter Photo Contact Relay (Model 330S). This connection provides a route for a grid leak circuit which, when drawing current, alters the grid bias of a 2D21 thyratron sufficiently to permit the operation of a plate circuit relay. Any contact the animal makes with the wet drinking fount will close the plate circuit relay, but lapping will produce intermittent relay closure of approximately 6 to 8 cycles per sec.

The normally open contacts in the Photo Contact Relay were connected so that each closure provided a ground input to a reed relay timer (Scientific Prototype 4005-J). The duration of the interval generated by this timer is dependent on the timer setting and is *independent* of the duration of the input pulse. Solid state relays provide closures to ground at two terminals, viz., "Output" and "Inverse Output," on the reed timer. These two terminals act as a SPDT switch with Output normally open and Inverse Output normally closed. When the timing cycle is initiated Output is closed and Inverse Output is opened. A new time cycle begins with each new input pulse and terminates after the preset duration *unless* a new input pulse is received. With the selection of the proper time interval (.5 sec. is satisfactory) the device can be set to provide a Sidman paradigm in miniature with each successive tongue contact acting as the effective operant. In this fashion the Output of the timer can be maintained "on" and the Inverse Output in the "off" condition as long as the animal continues to lick at the rate of at least one lap per time interval. Cessation of licking *or* the maintenance of a *continuous contact* with the fluid for more than one time unit will result in termination of the interval.

Output or Inverse Output can be selected to power an externally operated relay. Depending on the selection, this relay can be held closed either by a sustained, but

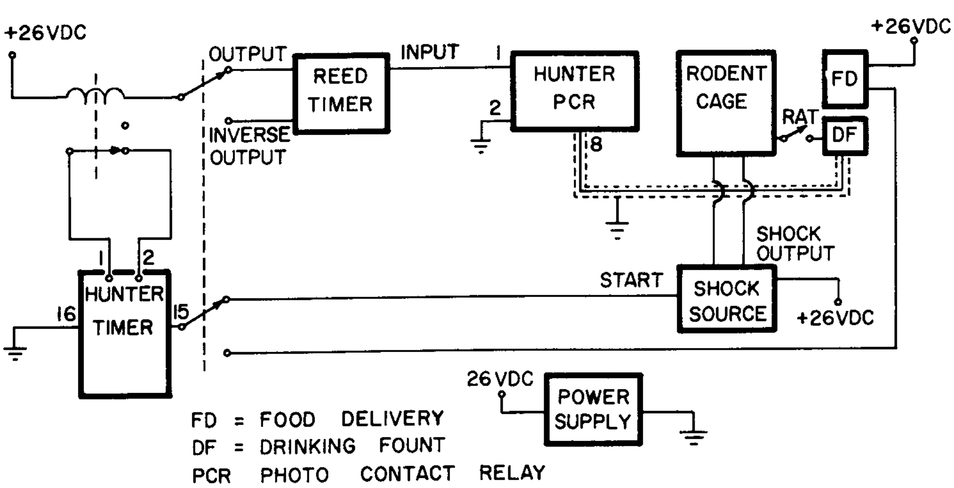

Fig. 1. The components are shown as they were connected together to form the conditioning apparatus. The numbers and labels at the junctions of components and conductors identify the terminals to which the conductors were connected.

intermittent, contact with the drinking fount *or* by the absence of that signal, viz., no contact or continuous contact.

The relay powered by the reed timer was wired to activate the "Interval" circuit (terminals 1 and 2) of a Hunter timer (Model 111-B). Through various standard wiring arrangements associated with the Hunter timer, the reinforcing stimulus can be made to occur or cease contiguously with the licking response; to occur or cease after a predetermined time interval; or to maintain an on or off condition for a predetermined interval subsequent to the operant emission.

In the shock escape (or avoidance) paradigm, for which this apparatus was primarily used, a ground connection was wired through an NO Finish relay on the Hunter timer to the Start input on a scrambled shock source (Scientific Prototype 4008-J) and the Hunter timer was set for an 8 sec. interval. The external relay "normally" holds the Interval circuit closed and the Hunter timer cycles through its preset interval, at the end of which the Finish relays close delivering shock which continues until another contact with the drinking fount occurs.

To use the circuit for food delivery, the DPDT switch must be thrown to the poles shown open in Fig. 1. In this way the external relay coil remains energized, breaking the Hunter timer's Interval circuit, when the animal is *not* drinking. The animal can be required to drink for any predetermined time to activate the food delivery mechanism. If the animal stops drinking for an interval longer than that set on the reed timer, the Hunter timer will reset obviating closure of the Finish relays and, hence, food delivery.

Evaluation

The apparatus described here has many properties identical to the drinkometer design published by Davis (1961). The important difference is that the Hunter Photo Contact relay requires no fixed mechanical connection to act as an electrical return for the drinkometer circuit. The floor bars may, therefore, be charged with an independent shock circuit allowing the system to be used for escape, or avoidance, conditioning. In order for the Photo Contact relay to be activated by the animal's touch it is necessary for the animal to be in contact with a rather large metal surface such as the cage. Operating this relay without a fixed ground return connection requires that the bias control be adjusted very carefully to a point just short of tube conduction.

With the present equipment, preventing the animal from grasping the drinking fount is not of prime importance. Continuous contact will not postpone shock indefinitely. It is, however, important to prevent the animal from grasping the drinking fount *while* he is drinking. If this happens the animal may be punished (or fail to be rewarded) when he is actually emitting the desired operant, viz., drinking. Grasping the fount while drinking can be obviated by making the rat insert his head through a 1-1/8 in. hole to reach the drinking fount. The use of a Richter bottle prevents the animal from grasping the fount with his teeth while drinking. Continuous contact with the animal's chin can be reduced by placing the lip of the fount about 1-1/2 in. away from, and slightly below, the hole and by tilting the fount slightly toward the animal to allow easier access to the fluid.

With its present design the apparatus could offer one difficulty when operating in the shock mode. The animal could simply touch *and release* the drinking fount once during each shock-off period and secure an additional 8 sec. reprieve from shock. If the animal's behavior is shaped under a thirst motive, the drinking operant seems fairly firmly established and the single contact "solution" to the shock avoidance problem rarely occurs.

In the food delivery mode the apparatus allows for the reinforcement of virtually no "spurious" operants. The food delivery mechanism can *only* be operated by sustaining the relatively high frequency intermittent contact for the predetermined time period. In the application for which this apparatus was developed the animal was required to make at least one contact every .5 sec. for 8 sec. to activate the feeding mechanism. The animal would have difficulty producing this response rate with any portion of anatomy other than his tongue. The lapping response is virtually the only operant which can be effective in producing food delivery.

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Notes

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2. The second author is now at the University of Oklahoma.