TECHNICAL NOTE

A TAIL ELECTRODE FOR UNRESTRAINED RATS¹

A new tail electrode has been developed for delivering electric shock to freely-moving rats. It appears to overcome certain major difficulties encountered with grid shock since the rat cannot interrupt shock by jumping nor reduce its effectiveness by adopting certain postures. No surgery is involved; the electrode is removable and contacts rest on the surface of the skin. Complications reported with body electrodes (Appel, 1964), *i.e.*, sloughing off of electrodes during healing, discomfort to animals in home cages, muscle tetanization from sub-dermal stimulation, are thus not encountered.

The electrode (Fig. 1) fits snugly around the base of the rat's tail. It consists of a $\frac{1}{2}$ -in. length of rubber tubing ($\frac{1}{8}$ -in. thick with $\frac{3}{8}$ -in. inside diameter) with two #3-48 screws, which serve as the stimulating contacts, inserted through the tubing with heads opposite each other. Leads of thin, flexible wire (vinyl-covered, stranded, 0.040-in. in diameter) are connected on the outside of the tubing to each screw. Flexibility of leads can be increased by using 3-0 stainless steel stranded wire covered by Intramedic polyethylene #50 tubing for the first few inches of lead extending from these contacts. The rubber tubing is covered by flexible insulation (vinyl tubing, $\frac{5}{8}$ -in. outer diameter, $\frac{1}{8}$ -in. inner diameter) with holes made so that it will fit over the screw ends. The insulation is held in place by the nuts tightened over the screws, and the ends of the insulation are cemented in place with Duco Household cement. The wire leads are inserted through a small hole in the center of the insulation covering and the juncture is covered by a thin layer of adhesive tape extending $\frac{1}{4}$ in. up the wire. The leads are attached to an overhead boom mounted 3 to 4 ft above the rat and are subsequently connected to the poles of a shock source.

To permit greater ease in applying and removing the electrode, a 4-mm section of tubing is removed and a strip of rubber (cut from a surgical glove) placed across the opening. Holes in the strip of rubber fit over the screws, and the strip is fastened to the tubing with Duco Household cement. Thus, the electrode can be easily moved on and off the tail by pulling the screw ends outward, stretching the electrode slightly. Before attaching the electrode, a solution of normal saline (75%) and glycerine (25%) applied so it will not short the contacts, is rubbed lightly on either side of the base of the tail. This softens the skin and reduces

its electrical resistance, which otherwise was found to vary from 15 K to over 500 K.

The electrode has a gap of 5 to 6 mm between the screw heads and fits firmly on 350 to 500-g albino rats without cutting off circulation to the tail. The electrode usually cannot be displaced and does not seem to restrict the rat's movement (Fig. 2). While most rats initially ignore the electrode, after several minutes they may begin to chew at it. If a few shocks are given when they first begin to chew, they normally abandon this behavior. Extensive chewing does not generally

Fig. 1. Diagram of tail electrode: front view.

Fig. 2. Rat with electrode in position.

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recur when animals are trained to perform adaptive responses, such as wheel turning or running, to avoid or escape shock. Biting is most successfully minimized when the electrode is lightweight and leads are flexible; biting appears to be highly dependent upon the electrode irritating the rat rather than on its delivering shock. The weight of the present electrode and wires as borne by the rat is 4 to 5 g. Use of bulky electrodes with heavily shielded wires resulted in considerable biting. Similarly, low intensity shock, particularly of long duration, which mainly annoys the animal, causes more biting than does stronger, brief shock.

When shock is given through the electrode, current intensity, monitored on a milliammeter in series with the rat, remains unchanged regardless of the rat's responses. In addition, current intensity produced by a given voltage is quite stable from one rat to another; for example, 115 v (with 220 K resistance in series with the rat), which produced a mean shock level of 0.50 ma in 12 pilot subjects, produced a mean current of 0.51 ma in six rats given one-way avoidance training (described below) with a standard deviation of 0.03 ma.

Approximately 50 rats have been trained to perform one-way and two-way (shuttle) avoidance responses with shock delivered through the tail electrode. Sessions varied from 10 min to 2 hr in length and subjects have been run in repeated sessions up to eight times. During training, only one subject was discarded when it failed to perform the response because of biting. To demonstrate use of the electrode, six additional naive albino rats were placed in a standard one-way avoidance situation (conditioned stimulus—unconditioned stimulus interval 10 sec, intertrial interval = 2 min) in which subjects learned to run into a safe compartment to avoid shock. Before training, these subjects were given

a maximum of three pulses of shock for biting the electrode, after which the mean total time spent licking or chewing the electrode was 11.8 sec during an average of 37.5 min in training. Five rats learned the avoidance response to the criterion of 10 consecutive avoidance responses with performances comparable to that obtained with grid shock (mean escape trials = 7.0), while one rat was discarded for pulling off its electrode.

Pulses of shock (60 cycle) are superior to steady shock for training the responses mentioned above, because pulses more readily produce an unconditioned response of running and forward movement. In training the one-way avoidance response, shock was delivered in brief pulses (duration was the output pulse from a recycling timer) at the rate of 4 per sec. For pulses of shock, shock levels required to motivate rats with the tail electrode appear to be comparable to grid shock, while with steady shock, levels are slightly lower: many rats squeak when a steady current of 0.2 ma is applied and almost all rats are distressed when a current of 0.4 ma is applied. Above 1 ma, the unconditioned response to steady shock consists of disorganized activity and is generally unsuitable for training most responses.

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REFERENCE

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