TECHNICAL NOTE

ELECTRICAL SELF-STIMULATION WITHOUT LEAD WIRES¹

The methodology used in self-stimulation studies requires subjects to press a bar in order to close a circuit. Current then passes to brain sites by means of lead wires connected from an electrical source to implanted electrodes. Among the disadvantages of this method are the difficulty and trauma sometimes encountered in connecting lead wires to electrodes in unanesthetized subjects. Also, the mobility and freedom of response of subjects are dependent upon the length and flexibility of the lead wires. The method described below offers an alternative that avoids those problems.

The method consists of having subjects themselves make the connection between their implanted electrodes and an electrical source. Only a few simple modifications in existing apparatus are necessary. A tiny piece of U-shaped wire is firmly attached to an implanted electrode so that the rounded part of the wire becomes a contact point for conducting electrical current into the electrode. The electrical source contact to be touched by the wire on the electrode is a copper plate attached to an ordinary response bar, which has been inverted and positioned at a height equal to or less than the height of the top of the subject's head when standing on all four feet.

The subject connects the implanted electrode to the electrical source contact by lifting its head until the wire on the electrode touches the smooth copper plate on the inverted bar. Once contact is made, the bar is raised to a point where a microswitch is closed, thus turning on the electrical stimulation source. Current is then conducted through a closed circuit consisting of the copper plate, the electrode contact point, the subject itself, and the floor grid. As long as the electrode contact continues to touch the copper plate, a current of controlled intensity passes to the stimulation site in the subject's brain. Duration of the stimulation train may also be controlled, so that each sustained contact with the copper plate can produce at most a preset duration of stimulation. The subject, by raising and lowering its head, is in effect repeatedly "plugging itself in".

How do head-lifting rates compare with rates obtained by ordinary bar-pressing for electrical stimulation? To answer this question, electrodes were

implanted (under suitable anesthesia) in or near the medial forebrain bundle of four 250-g male albino rats. Two of these rats were first shaped to bar-press for monopolar stimulation (60 Hz sine waves). Pressing rates were obtained in a counterbalanced manner at constant current levels (I rms) of 25, 50, and 75 μ a during a 1-hr session each day for six consecutive days. Then the subjects were shaped to head-lift, and lifting rates were obtained at the three intensity levels for six sessions. The other two rats were first shaped to head-lift and later to bar-press. A maximum stimulus duration of 0.2 sec per contact was used throughout. Figure 1 shows an electrode track obtained by histology on the brain of one of the subjects (Rat S3). The electrode tracks of the other three subjects terminated more ventrally, in the median forebrain bundle.

Results presented in Fig. 2 indicate that bar-pressing rates were generally somewhat higher than head-lifting rates, regardless of whether subjects were first shaped to head-lift or to bar-press. Only 5 g of downward pressure was required in order to complete the bar-press response, while the completion of the head-lift response required more effort, since the bar

Fig. 1. Photomicrograph of an electrode track from Rat S3. The brain section was taken at an angle to the electrode track to minimize tearing of the section. The arrow indicates the termination point of the track just dorsal to the median forebrain bundle. Electrode tracks in the other three subjects ended more ventrally, in the median forebrain bundle area.

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itself had to be lifted. On the other hand, the head-lifting response permitted train durations less than 0.2 sec through premature loss of contact with the copper plate (see below). The difference between rates from the two types of self-stimulation responses, in any case, may not be critical, since absolute rates usually are not as important as the relative relationships among rates obtained at various stimulus intensities or from various brain sites. As Fig. 2 illustrates, the relationships among rates obtained by bar-pressing at the three intensity levels were retained with head-lifting. The only exception to this was Rat S3, which experienced a right foreleg seizure when stimulated. The seizure apparently became severe enough at 75 μ a to interfere with the subject's bar-pressing responses but not with the head-lifting responses.

The data presented above suggest that the head-lift method can serve as a useful alternative to the usual bar-press method. There are, however, some important problems with head-lifting that should be considered. For example, one possibility is that the effects of resistance variation on stimulation current could be considerable as a subject's contact with the floor grid

varies and causes rapid changes in the path followed by the electrical current through the subject's body. This problem has been averted entirely by using a constant-current stimulating device designed to compensate for rapid resistance changes.

Also, as noted above, subjects may not always receive stimulation for the entire duration of the pulse delivered to the copper plate on the bar, since they can prematurely break the circuit by pulling their heads away from the bar. The frequency of occurrence of such premature circuit breaking appears to be dependent upon several factors. Two of the factors are the size of the bar and its height from the floor, with premature breaking increasing as the size of the bar diminishes and as the height of the bar increases above a level approximately equal to the subject's snout when it is standing on all four feet. Another factor is the pre-travel distance or "play" of the bar, with premature breaking increasing as the play decreases. A fourth is the duration of the pulse delivered to the copper bar; obviously, the longer the pulse, the greater the opportunity for the subject to break contact prematurely. A final possibility is that the fre-

Fig. 2. Representative data obtained by the head-lifting method compared to bar-pressing data from the same subjects. The subjects on the left were first shaped to head-lift, then to bar-press. Subjects on the right learned to bar-press first, then to head-lift.

quency of premature breaking may depend also upon the location of stimulation electrodes in the brain, since motoric side effects may differ for different loci stimulated. It is suggested that persons using the "wireless" self-stimulation method described here measure the frequency of such breaking in the particular experimental situation employed and report the results along with other methodological information. With our experimental apparatus, the lowest frequency of breaking yet observed was 1% for a rat that continuously held its electrode contact point up against the copper plate on the inverted bar, while moving its head back and forth just enough to close the microswitch controlling the current onset. With the same bar at exactly the same height, etc., other

subjects exhibited premature breaking at least 5% of the time and at most 20% of the time.

L. D. GRANT²
R. W. OLSHAVSKY
Carnegie-Mellon University
Pittsburgh

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²At the time of this investigation, the senior author was a National Aeronautics and Space Administration Pre-doctoral Trainee at Carnegie Institute of Technology. Reprints may be obtained from L. D. Grant, Psychology Dept., Carnegie-Mellon University, Schenley Park, Pittsburgh, Pennsylvania 15213.