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BRIEF COMMUNICATION

An Easily Constructed, Reusable, Bipolar, Concentric Stimulation Electrode for Use With Intracranial Guide Cannula Assemblies

H. GEORG SCHULZE AND BORIS B. GORZALKA[1]

Department of Psychology, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada

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SCHULZE, H. G. AND B. B. GORZALKA. *An easily constructed, reusable, bipolar, concentric stimulation electrode for use with intracranial guide cannula assemblies.* PHARMACOL BIOCHEM BEHAV 47(4) 993-995, 1994.—The construction of a stimulation electrode is described. This electrode is removable and is designed to be used with intracranial guide cannula assemblies. It is a concentric, bipolar electrode, and is easy and inexpensive to assemble from materials readily available in most laboratories. A detailed description is also given of procedures to connect the electrode to stimulation equipment in a manner that would minimize interference by the test animal with the operation of the electrode.

Removable electrode Bipolar stimulation Electrical stimulation Concentric electrode Guide cannula assembly Intracranial stimulation

NEURAL signalling generally has an electrical and a chemical component. As a consequence, the investigation of central aspects of behavior has frequently involved neurochemical stimulation or electrical stimulation and sometimes a combination of both. Numerous techniques exist for localized neurochemical stimulation [e.g., (2-5,9)] as well as electrical stimulation [e.g., (7,8)]. However, when both types of intervention are required, the common approach has been to apply a neuroactive substance peripherally to induce the desired chemical stimulation and use an intracranially implanted electrode for the electrical stimulation. Some techniques also allow the microinjection of substances into specific brain sites and electrical stimulation through the guide cannula [e.g., (1,6)]. However, there appears to be a general lack of published techniques that would permit the simultaneous localized intracranial electrical and/or chemical stimulation of a variety of central sites in the same freely moving animals. Such techniques can be very useful in studies requiring a site to be uniquely neurochemically activated or inhibited prior to electrical stimulation of the same site and in studies where the neurochemical treatment of a specific site is necessary before or during electrical stimulation of another site. Consequently, we designed a removable, concentric, bipolar electrode that could be used repeatedly with guide cannula assemblies [e.g., (9)] to effect localized and interchangeable neurochemical and electrical stimulation. Although our technique does not permit simultaneous infusion and electrical stimulation, the use of neuroactive substances with delayed or long-lasting action would permit concurrent electrical and neurochemical manipulations.

METHOD

The removable stimulation electrode is fashioned in a manner similar to that of an infusion needle and it is made from the following materials: a) a 30 gauge stainless steel hypodermic needle (BD23G1, catalog #5145, Becton Dickinson and Company, Rutherford, NJ); b) a 23 gauge stainless steel hypodermic needle (BD30G1/2, catalog #5106, Becton Dickinson and Company, Rutherford, NJ); c) approximately 50 cm of

[1] Requests for reprints should be addressed to Boris B. Gorzalka, 2136 West Mall, Department of Psychology, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada.

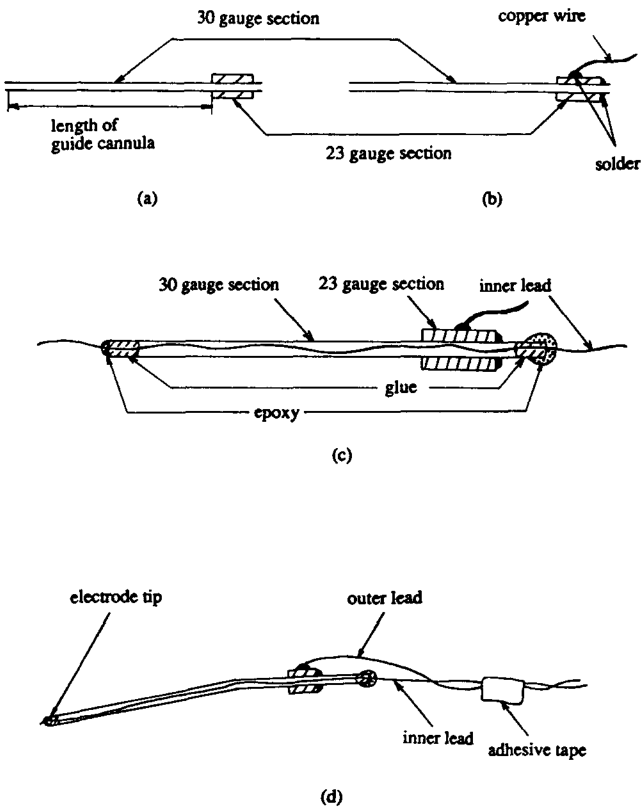

FIG. 1. Several stages in the construction of the stimulation electrode are shown: (a) determination of the length of the electrode; (b) connection of the outer lead; (c) connection of the inner lead; and (d) preparation of the electrode tip. Details are discussed in the text.

Teflon-coated stainless steel wire (diameters: bare 0.003"; coated 0.0045", A-M Systems Inc., Everett, WA) and a 50 cm section of stranded copper wire (catalog #278-1385, Radio Shack). In addition, a soldering iron and solder as well as two types of glue are needed (LePage #8 Instabond; LePage #12 5-min epoxy glue).

The bevelled tip of the 30 gauge (g) stainless steel needle is filed away on a rotary grinder. The opening at the machined part of the needle is then cleared of metal debris and rough edges. Following that, the needle is denuded by separating the plastic hub from the stainless steel tubing.

A 10 mm section is now cut from a denuded 23 g needle and ground to about 5 mm. The inside of this 5 mm section is also cleared of metal debris and rough edges. This section is then fitted over the 30 g needle in such a manner that the distance from the machined end of the 30 g needle to the leading edge of the 23 g needle is of the required length. This is shown in Fig. 1a. The 5 mm section of 23 g needle is then soldered onto the 30 g needle on the side of the 30 g needle that would not be inserted into the guide cannula. The 50 cm section of stranded copper wire is then soldered onto the 5 mm section of 23 g needle in such a fashion that the wire would lead away from the cranium when the electrode is inserted into the guide cannula. These manipulations are illustrated in Fig. 1b.

The 50 cm section of Teflon-coated stainless steel wire is now threaded through the 30 g part of the electrode, starting from the side of the electrode that would not be inserted into the guide cannula, until about 2 cm is protruding beyond the machined end of the 30 g section of the electrode. Instabond glue is applied to both ends of the 30 g section of the electrode to secure the Teflon-coated wire to the inside of the 30 g section. Once the glue has dried, epoxy glue is applied again to both ends of the electrode. This is shown in Fig. 1c. The electrode is left overnight for the glue to set.

The Teflon-coated wire is subsequently cut such that only about 0.5 mm protrudes beyond the machined end of the 30 g section of the electrode. This may result in the end of the fine wire being flush with the hardened glue or some of the glue may have to be cut along with the wire. The Teflon-coated inner wire and the stranded copper outer wire are now twisted together and secured with adhesive tape. The 30 g part of the electrode is given a slight bend to allow the electrode to remain in position during the central stimulation of freely moving animals. These manipulations are shown in Fig. 1d.

Surgery and Stimulation

Animals are fitted with guide cannula assemblies as described elsewhere [e.g., (5,9)]. During guide cannula implantation, a section of paper clip (approximately 1 cm is cut off from one of the ends) is inserted anterior to the guide cannula into the dental acrylic cement. This manipulation allows the head of the animal to be tethered to this section of paper clip to prevent undue strain being put on the electrode leads. For this same purpose a 40 cm piece of stranded copper wire is stripped of the insulation material to prevent animals from gnawing at the leads. This tether wire is then cut in half. The two halves are joined together with a moderately strong piece of elastic band about 10 cm in length. In parallel with the elastic band, a 15 cm section of stranded wire is also used to

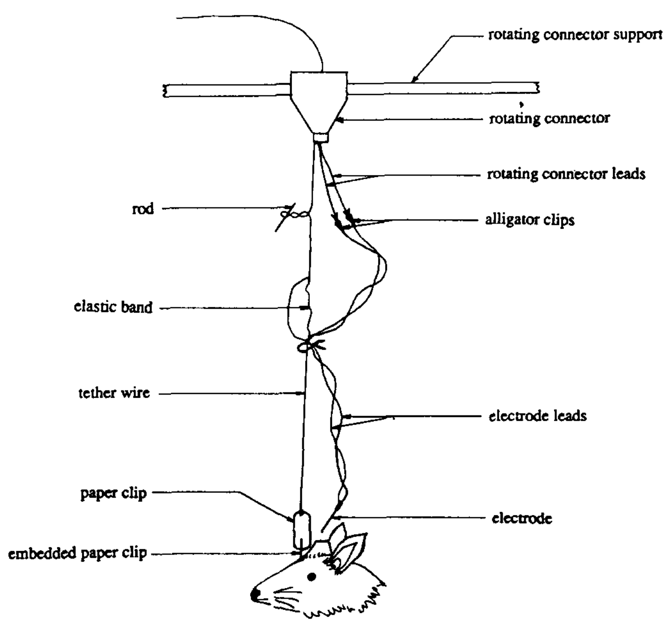

FIG. 2. The complete assembly with stimulation electrode and tether wire is shown. The electrode is inserted through a guide cannula fixed to the animal's skull and is connected to a rotating connector. The use of a tether wire prevents damage to the electrode or its leads by freely moving animals.

join the two halves of the tether wire together. The elastic band allows freely moving animals some leeway in head movement, and the parallel section of stranded wire prevents violent head movements from damaging or dislodging the electrode or leads. The one end of the tether wire is firmly secured to another paper clip while the other end is fixed to the metal socket that connects the leads to a rotating connector (rotating connector catalog #590, cap catalog #595, double lead receptacle catalog #592; Mercotac Inc., San Diego, CA). The upper section of the tether wire is adjusted in length until the bottom of the paper clip is approximately level with the dorsum of the animal being stimulated (e.g., by using a light rod to wind the tether wire). This procedure allows the animal to sniff at the ground by straining against the elastic. For this reason, the elastic should be neither too flimsy nor too strong. An alligator clip (catalog #270-373, Radio Shack) is next affixed to each of the leads running from the rotating connector for rapid connection to the stimulation equipment. The complete assembly is shown in Fig. 2.

Prior to using the electrode, it should be tested to ensure that it functions as required. This is done by connecting the inner and outer leads of the electrode to the alligator clips connected to the leads running from the rotating connector. The rotating connector is then secured to the roof of the testing chamber and hooked up to the stimulation equipment and an oscilloscope. The oscilloscope signal is inspected to verify that no leakage of current occurs. The electrode is subsequently immersed in an isotonic saline solution and the oscilloscope monitored to verify that the required current is passed. If the tip of the electrode is dried upon withdrawal and the current flow ceases, the electrode is ready for use. It is suggested that the electrode's integrity be verified before the stimulation of each animal.

The durability of this removable electrode is similar to that of an infusion needle. It is also inserted in the same manner as an infusion needle before the animal is released into the testing chamber. We suggest that several (3-5) electrodes be prepared and tested before an experimental session commences. Employing the electrode with well-handled animals makes the task easier and is more likely to prolong the electrode's life. We have tested this electrode on several animals and have found that as many as 30 (and perhaps more) animals can be tested with a single electrode. Should long-term stimulation be required, platinum components should be used instead of stainless steel to prevent iron deposits at the stimulation site [for excellent advice about stimulation electrodes, see (10)]. Some initial work seems to indicate that the electrodes could also be used for intracranial recording.

DISCUSSION

This inexpensive and easily constructed removable electrode, for use with intracranial guide cannula assemblies, provides a useful and versatile tool for the investigation of brain-behavior relationships. It should be particularly useful where electrical stimulation of the center of a chemically perfused area is required. In the electrode-cannula method (6), electrical stimulation occurs to the side of the infusion site. The use of a concentric electrode would allow a reduction in the amount of perfusate needed because a smaller area would be perfused. Furthermore, these electrodes can be used with an intracranially implanted multiple cannula assembly (9) that provides simultaneous access to a variety of brain sites. This approach would allow researchers to administer any combination of neurochemical and/or electrical stimulation sequentially to these sites, or concurrently when long-acting neuroactive compounds or compounds with delayed action are used.

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