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Technical contribution

A MICRODRIVE FOR USE WITH GLASS OR METAL MICROELECTRODES IN RECORDING FROM FREELY-MOVING RATS [1]

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Elucidation of the complex mechanisms of brain function and their relationship to behavior could probably be considered the ultimate goal of the neuroscientist. Success in this task will minimally require a synthesis of neuroanatomical, -electrophysiological, and -pharmacological information about brain subregions. Whatever the result of this process, its product must be measured against a rather inflexible if enigmatic standard: the behaving animal. However, gathering data from unanesthetized, freely-moving animals is itself a difficult undertaking, and one that has been approached with increasing sophistication in recent years. Investigators often desire to electrophysiologically monitor the activity of a specific neuron or neurons in a given brain region over an extended period of time and then, ideally, to perform pharmacological manipulations or morphologically identify the cell of interest.

The development of head-mounted moveable microelectrode assemblies (Ranck 1973; Winson 1973; Vertes 1975; Costa and Delacour 1976; Ainsworth and O'Keefe 1977; Sinnamon and Woodward 1977) has greatly aided achievement of the first objective. Unfortunately, to this point identification of the recorded cell or cells has been limited to localization of the electrode tip by passing a DC current through it, either producing a small lesion or in the case of electrodes containing ferrous alloys depositing iron which may be visualized by processing the tissue in potassium ferricyanide (Gomori 1936). Pharmacological manipulations at other than a systemic level have been impossible. The present report introduces the design for a subminiature microdrive capable of utilizing either glass or metal microelectrodes which offers precision and stability of electrode placements in the brain of freely-moving rats.

The microdrive is seen in an operational state in Fig. 1. A more formal illustration of the microdrive assembly is given in Fig. 2. The basic parts include (A) the microdrive, (B) the hub, which is permanently mounted on the animal's skull; and (C) the cap, which is screwed onto the hub during the periods between recording sessions. As can be seen from this figure, the basic design of the device utilizes three concentric cylinders. The two outer cylinders are apposingly threaded; rotation of the outermost cylinder around the stationary middle one provides

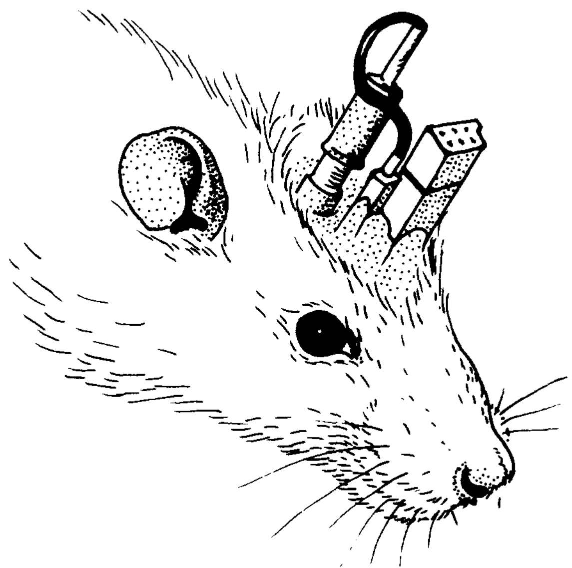

Fig. 1. Microdrive assembly in use. Note that a lead from the electrode is jumped to the permanently implanted socket which receives a plug-in cable from the preamplifier.

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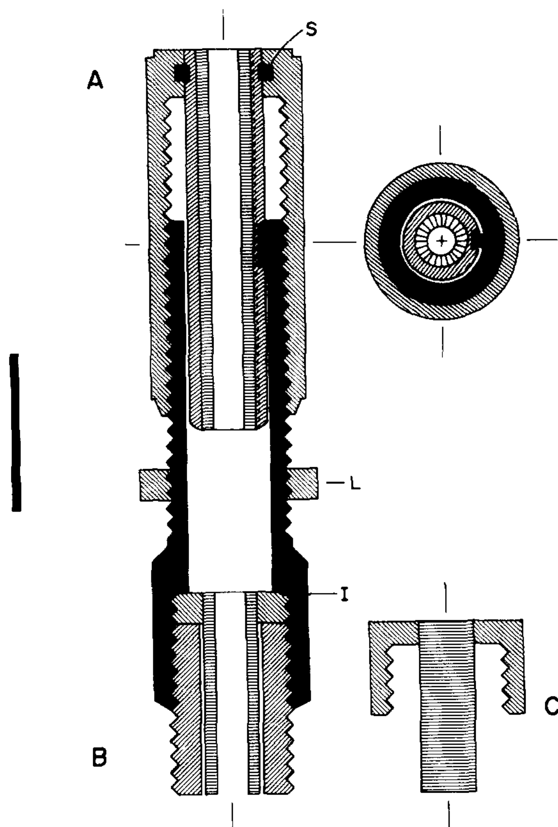

Fig. 2. Sectional views of the microdrive assembly. A: the microdrive; microdrive body (solid shading) remains stationary while inner and outer drive cylinders (diagonal shading) move; spring-slip (S) holds the two drive cylinders together. Teflon tubing (horizontal shading) lines the inner cylinder; tubing is also press-fit into an insert (I) fastened inside the base of the microdrive body to protect the electrode while it is being screwed onto the base. Base (B) is cemented to the animal's skull using dental acrylic. Cap (C), containing a solid teflon plug, is screwed onto the base when the microdrive is not in use. Top sectional view in upper right illustrates the key and keyway to keep the inner drive cylinder (which contains the electrode) from rotating. Locking collar (L) is tightened against the outer drive cylinder to prevent vertical motion once a recording site has been reached. Calibration bar = 5 mm.

vertical travel at the rate of 400 μm per full revolution. The innermost cylinder, which holds the recording electrode, has a keyway running its length which is engaged by a key projecting out from the adjacent inner face of the stationary cylinder (the microdrive body). The innermost (electrode containing) and outermost cylinders are joined at the top by a small spring-retainer ring.

The result of this arrangement is that while the electrode is being lowered into place by rotating the outer cylinder, the cylinder containing the electrode itself does not rotate but travels only in the vertical direction. The advantage of this feature, especially when using electrodes without tips which are perfectly symmetric with respect to their long axis or which have not been exactly centered in the microdrive, is readily apparent.

Either metal or glass microelectrodes may be utilized in the microdrive. In the case of metal electrodes a teflon sleeve is inserted into the inner cylinder, the inner diameter (I.D.) of which (0.050 in. ± 0.005 in., TFE AWG 17, Golden State Plastics, Santa Ana, Calif.) will just accommodate a solid male Amphenol pin (outer diameter, 0.049 in.) into which the electrode has been crimped. Usually a layer or two of the enamel used to insulate the electrode wire is also applied to the pin to ensure a snug fit.

Recording with glass microelectrodes involves removing the teflon tube from the inner cylinder of the microdrive and replacing it with a polypropylene insert which has an inner diameter which is the same as the outer diameter (O.D.) of the glass being used. We find 1 mm (O.D.) capillary tubing convenient for our purposes. The electrodes are pulled with tapers on both ends, one of which is broken quite short. This blunted end is inserted into the microdrive from the base, subsequently broken off and the electrode is filled with electrolyte (usually 2 N NaCl). Tapering the glass before insertion prevents the sharp edges of the capillary wall from scraping away at the insert, a process which will eventually result in the loss of the tight friction-fit of the electrode.

Once an electrode has been placed in the microdrive the cap is removed from the animal's head and the assembly is screwed into place. A lead from the electrode is jumped to the socket which receives the recording cable and plug from the preamplifier. The electrode is then lowered to the region of interest; once the proper location has been reached the locking collar is tightened against the outer drive cylinder.

Using 150 μm tungsten wire etched to a tip diameter of 1—3 μm we have routinely recorded from isolated granule cells (diameter 10—12 μm) in the dentate gyrus of the hippocampal formation of rats for several hours during electrophysiologically-monitored training sessions (Deadwyler et al. 1979). The electrode position remained unchanged despite the rather rigorous behavioral repertoire exhibited by the animals during these sessions, which occasionally included banging of assembly against the side of the testing chamber. Glass and metal electrodes seem to be equally effective in this respect; the only advantage of the metal microelectrodes is that they may be reused over several sessions.

During longer term experiments the microdrive (containing a metal microelectrode) has often been left on the animal's head continuously between recording periods. The evoked potentials which were initially used as an aid to locating the electrode's position generally show no significant changes in either the shape or amplitude of the wave form (indicators that the recording electrode has drifted from its original location) for intervals of a week or more. In all these experiments histologically observed tissue damage due to the recording electrode was seen to be minimal. Even with repeated penetrations (greater than 30 over a period of several weeks) made along essentially the same track, distortion of characteristic stimulus-evoked wave forms was not observed and single cell isolation was routinely performed.

The small size and light weight of the apparatus (just slightly less than 2 g for the entire assembly including a metal microelectrode and lead) allow its use without visibly restricting movements or otherwise altering normal behavior patterns. The stability of the microdrive has been discussed; the precision of the assembly is such that the experimenter can be assured of essentially identical electrode placements day after day over the course of an experiment. The non-rotating status of the electrode results in very little tissue damage, even after multiple penetrations. Lastly, the use of glass micropipettes offers the possibility of cell marking, through the use of HRP, for example (West et al. 1975), or discrete pharmacological manipulations in the behaving rat.

Summary

A new subminiature microdrive assembly is described for electrophysiological recording from behaving rats. This very small, lightweight system allows excellent precision in electrode placement and can maintain stable recordings over extended periods. Since the electrode is nonrotating, tissue damage is minimized. Either metal or glass microelectrodes may be used with the system, offering the possibility of iontophoresis for cell marking or neuropharmacological manipulations.

Résumé

Micromanipulateur pour microélectrodes (verre ou métal) utilisable pour l'enregistrement chez le rat libre de ses mouvements

Les auteurs décrivent un nouveau micromanipulateur miniature destiné à l'enregistrement électrophysiologique au cours de différents comportements chez le rat. Ce système, très petit et très léger, permet le placement de l'électrode avec une excellente précision et permet de maintenir des enregistrements stables pendant de longues périodes. En outre, l'électrode étant non rotative, la lésion tissulaire est minimale. Des microélectrodes métalliques ou en verre peuvent être utilisées, offrant ainsi la possibilité d'applications iontophorétiques pour le marquage cellulaire ou pour des manipulations neuropharmacologiques.

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