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Histological and physiological effects of the central auditory prosthesis: Surface versus Penetrating electrodes

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To rehabilitate profoundly deaf patients who are not suitable for cochlear implants, central auditory prostheses have been implanted. Penetrating and surface electrical stimulation of the cochlear nucleus was tested on guinea pigs and cats. Electrophysiological, autoradiographic and histological measures were used to study effects of the central auditory prostheses on the auditory pathway. The animals were anaesthetised with ketamine hydrochloride (40 mg/kg i.p.) and xylazine (3.8 mg/kg i.p.) during the experiment. The results showed that a successful electrically evoked auditory brainstem response (EABR) could be recorded with both surface and penetrating electrodes in cats and guinea pigs. In guinea pigs the penetrating electrodes had advantages over surface arrays in the sense of lower thresholds and wider dynamic ranges. In cats penetrat- ing electrodes showed lower thresholds than surface ones. In cats and guinea pigs stimulated with either surface or penetrating electrodes, evoked 2-deoxyglucose (2-DG) label was found in the auditory pathway from the cochlear nucleus to the inferior colliculus. Non-auditory tissues were found with evoked 2-DG label. Histological results showed that in the guinea pig cochlear nucleus stimulated with penetrating electrodes the neuron density was decreased, and the mean soma area was increased compared with the control side. In the cat, penetrating electrodes were associated only with increased mean soma area in parts of the stimulated cochlear nucleus. These results suggest that the physiological advantages of penetrating electrodes over surface ones were achieved with some trade-off in safety, especially in the guinea pig.

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TEMPORAL RESPONSE PROPERTIES OF PRIMARY-LIKE UNITS IN THE ANTEROVENTRAL COCHLEAR NUCLEUS TO ACOUSTIC AND ELECTRICAL STIMULATION.

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Auditory information is encoded in the central auditory pathway in both the spatial and temporal domains. The magnitude of the contributing role of each domain remains unresolved. Scala tympani electrical stimulation of the auditory pathway may provide insights into the relative importance of these different coding domains. This study investigates the temporal response of acoustically-characterised primary-like units in the anteroventral cochlear nucleus (AVCN) to acoustic and electrical stimulation. Response synchrony to acoustic stimulation at and below the units characteristic frequency (CF) and to electrical stimulation at rates up to 1000 Hz has been analysed with respect to the phase of the stimulus and the intervals between successive spikes. Normal hearing adult cats were anaesthetised with pentobarbitone sodium (Nembutal; 45 mg/kg i.v.) and the AVCN exposed via a dorsal approach. Micropipette electrodes (4 - 30 MΩ) were advanced dorsoventrally through the AVCN and the response timing of isolated units recorded on computer for off-line analysis. To compare the variance in the timing of the response with respect to the phase of the stimulus and with respect to the intervals between successive responses, cross-correlation of spike timing and cross-correlation of spike intervals were performed. For acoustic stimulation these results show that the variance in the timing of the response with respect to the phase of the stimulus is lower (i.e. higher correlation) than that seen in the interval variance. A similar result was not however found following electrical stimulation. Cross-correlations on different order intervals, (i.e. 1st, 2nd, 3rd etc.), show that variance across the different order intervals does not systematically vary. These data suggest that the temporal response to acoustic stimuli at this level of the auditory pathway more precisely codes stimulus phase than stimulus interval.