Functional Properties of the Primary Cortical Auditory Area in Man*

Flavio Puletti, M.D., and Gastone G. Celesia, M.D.

Division of Neurosurgery, and Department of Neurology, University of Wisconsin, and Veterans Administration Hospital, Madison, Wisconsin

During the last decade, computer averaging techniques that extract small signals from background activity have been used successfully in the study of human sensory systems. We have already described the extent of the human parieto-temporal cortex activated by sound and the location and nature of the primary auditory cortical area of man. In this paper we are reporting some of the physiological characteristics of the auditory cortex by comparing the potentials evoked with ipsilateral, contralateral, and binaural stimulation and by observation of the recovery cycle of this area.

Material and Methods

Recordings were carried out in six adult patients undergoing surgery for the treatment of intracranial diseases. The ethical principles of the declaration of Helsinki (1964) were followed. Five of the patients had focal temporal lobe epilepsy (four right temporal, one left temporal), and one a right frontoparietal metastatic tumor. Four were operated on under local anesthesia using 1:1500 nupercaine solution, and two under general anesthesia using Halothane and nitrous oxide.

To explore the depth of the Sylvian fissure we used the Ray multicontact electrode held by a specially designed holder consisting of a Fleximount positioner and a guide. The electrode was inserted perpendicularly into the superior temporal gyrus through a footplate with a central hole to prevent pulsation. It was then advanced manually to a depth of 3 to 3.5 cm into or immediately under the cortex of Heschl's gyrus parallel to the superior temporal plane. Our recordings were monopolar, and the bone at the edge of the craniotomy was used as the reference point. The input from the electrodes was fed into four Grass P511 preamplifiers adjusted to a band width of 0.3 cps to 1 kps. From the preamplifiers the output was fed into a Tektronix 565 oscilloscope, a Sanborn tape recorder, a Fabri-tek 1052 Averager, and an Offner type T electroencephalographer. Write-outs from the computer were made with an X-Y plotter.

Auditory stimulation consisted of clicks generated by a square pulse of 0.5 msec duration fed through a Hewlett Packard type 350 D attenuator and a matching transformer to two Grason-Stadler Type D-308 earphones. The intensity of the stimulus was 60 db above threshold. For each cortical point explored, 50 to 64 responses were averaged.

Results and Discussion

The primary auditory evoked responses were obtained from the transverse temporal gyri and consisted of the complex polyphasic potential previously reported. The early components of the potential, occurring in the first 40 msec following the stimulus, consisted essentially of a double positive wave named P1 and P2. They were quite stable and could be recorded in every subject. On the other hand, the later waves varied considerably in amplitude and latency from time to time and from patient to patient. In some instances no specific deflection was seen 150 msec after the auditory stimulus. The two positive waves P1 and P2 persisted unchanged during a period of about 16 minutes while the later waves changed in amplitude and latency. The state of consciousness did not influence the morphology of the poten-
These results indicate that in man both ears are represented in the primary auditory area of each hemisphere, but suggest a predominance of a contralateral cochlear representation. This is in agreement with the data obtained in man by Chatrian, et al.,5 and by Penfield and Jasper9 in their electrical stimulation of Heschl's gyri which was often associated with perception of simple sounds referred mostly to the contralateral ear. Similar conclusions were reached in the squirrel monkey by Massopust, et al.,7 and in the cat by Bremer2 and by Rosenzweig.11

The recovery cycle of the primary auditory area was studied in two patients. In Subject 68-03, under light general Halothane-nitrous oxide anesthesia, four cortical points were examined. The recovery cycle was retested 8 minutes later for each point to ascertain the consistency of the results. The auditory recovery curve was similar for the two positive components P1 and P2 of the potential complex (Figs. 1 and 2). There

![Diagram](image-url)

**Fig. 1.** Auditory recovery cycle of P1 wave in man. Each of the three cortical points is identified by a different pattern. The number following P indicates the position of the recording electrode in mm from the tip of the temporal lobe. Numbers following D refer to the depth in mm from the surface of the superior temporal gyrus.