Brain maps of auditory processes in normal hearing, postlingual deafness and cochlear implantation

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ABSTRACT

This PhD project was carried out at the PET center and ENT Department, Aarhus University Hospital, in collaboration with the Center of Functionally Integrative Neuroscience, Aarhus University.

The multichannel cochlear implant (CI) is a hearing prosthesis that provides auditory stimulation for the profoundly hearing impaired by electrically stimulating the cochlea. The application of functional neuroimaging in the field of cochlear implantation serves to identify factors that promote a beneficial outcome of the implantation. We completed three studies intended to reveal incremental brain activity in normally hearing subjects, postlingually deaf subjects, and CI users, during appropriate stimulation.

First, we used positron emission tomography in normally hearing subjects, stimulated via the promontory in the middle ear in a procedure that mimics the auditory nerve stimulation with a CI. Discrimination of fine temporal differences by the subjects raised cerebral blood flow in right posterior middle temporal gyrus and prefrontal cortex. As these areas are known to be active in fine discrimination of words, based on temporal information, their recruitment is important to the comprehension of speech containing mostly temporal cues.

Second, to find out whether postlingually deaf subjects recruit the same areas as seen above when they make similar temporal discriminations, we stimulated in the ear chosen for implantation. Subjects performing well on the duration discrimination task demonstrated right-lateralised fronto-temporal and left-lateralised temporal activity in the respective duration dicrimination and gap detection tasks, in contrast to subjects who failed to detect duration differences of less than 200 ms.

Overall, the studies identified a right fronto-temporal network with relation to working memory as crucial to the perception of fine time structure in sound.

The third study tested the null hypothesis that activity in the left inferior prefrontal cortex (LIPC) characterizes good language comprehension in postlingually deaf CI users. The LIPC is involved in speech comprehension in normal hearing. Previous functional brain mapping has not revealed incremental activity in this region when users of CI comprehend speech. The study concluded that the LIPC and right temporal lobe are involved in speech comprehension after cochlear implantation.

The present findings have implications for future rehabilitation strategies after cochlear implantation that emphazise the improvement of temporal discrimination abilities. Future research will focus on brain plasticity as a function of time and the influence of sign language on the development of normal hearing in congenitally deaf children.