Adventures in Bionic Hearing

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Cochlear implants provide a surprising level of speech understanding in completely deaf patients. However, cochlear implants are not useful for patients with no remaining auditory nerve, so new prosthetic devices have been designed to stimulate the cochlear nucleus in the brainstem and the inferior colliculus in the midbrain, using both surface and penetrating electrodes. I will present psychophysical results and speech recognition results from surface and penetrating electrodes at the level of the cochlear nucleus. Surprisingly, psychophysical measures of temporal, spectral and intensity resolution are mostly similar across stimulation sites and electrode types. Speech recognition is excellent in cochlear implants and in some patients with stimulation of the cochlear nucleus. Recently, brainstem implants have produced high levels of auditory performance in adults who lost their VIII nerve from tumors or trauma, and in some young children born without a cochlea or auditory nerve. Quantitative comparison of results from electrical stimulation of the auditory system at different stages of neural processing, and across patients with different etiologies can provide insights into auditory processing mechanisms. An emerging hypothesis is that the normal auditory system contains a separate processing subsystem for speech patterns that is distinct as early in the system as the cochlear nucleus. I will suggest that there may be separate auditory processing streams for fine structure (both spectral and temporal) and global structure. Auditory prostheses provide sufficient information to allow the global system to extract speech from the highly impoverished prosthetic pattern of activation, but this putative global system may be damaged during tumor removal.

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