T54: IMAGE-GUIDED FREQUENCY-PLACE MAPPING IN COCHLEAR IMPLANTS

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Contemporary cochlear implant (CI) sound processors filter acoustic signals into different frequency bands and provide electrical stimulation to tonotopically distributed spiral ganglion nerve fibers via an electrode array which is blindly threaded into the cochlea during surgery. The final positions of the electrodes in relation to the nerve fibers are generally unknown, resulting in a unique electrode positioning for each patient. This is in part due to the variable length of the cochlea with respect to the physical insertion depth of the electrode array. Despite this, default frequency assignments are a common practice in clinical fitting procedures. Suboptimal electrode array placement, variations in insertion depth, and exact positioning and proximity of electrodes to nerve fibers can all result in a mismatch between the intended and actual pitch perception. This frequency mismatch holds potential for reducing the efficacy of the coded information to the auditory cortex and, consequently, limit speech recognition. The present study leverages image-guided procedures to determine the true location of individual electrodes with respect to the nerve fibers and proposes a patient-specific frequency assignment strategy which helps to minimize sub-optimal frequency-place mapping distortions in CIs. Prior research in this domain suggests that peak performance is achieved when the full acoustic range is mapped to the tonotopic map where analysis bands exactly match the tonotopic map of the cochlea. While patients adapt to minor mismatch over time, severe mismatch, as seen with shallow insertion, can result in significant spectral distortion (Başkent & Shannon, 2005) and hence limit the level of asymptotic performance as well as increase adaptation time (Fu et al., 2002).

The proposed strategy utilizes pre and post implantation CT scans of recipients' cochleae to determine precise spatial location of electrode contacts and the corresponding neural stimulation sites and thus generate an optimal user-customized frequency-place function which is used to derive frequency characteristics of the filterbanks. This is achieved by maximizing the frequency match at lower frequencies (frequency range of first three formants), and introducing mild compression as needed to avoid truncation (e.g., due to shallow insertion). Mid and high frequency bands are assigned conventional logarithmic filter spacing. The performance of the proposed strategy was evaluated with 42 normal hearing (NH) listeners using vocoder-simulations. The simulation data indicate significantly better speech recognitions scores than the default clinical mapping scheme on all measures. Preliminary investigation with one CI user indicates statistically significant improvement in speech recognition and perception scores relative to the clinical map in acute experiments.

Lack of knowledge on the spatial relationship between electrodes and the stimulation sites has resulted in a generic one-size-fits-all frequency mapping paradigm with the hope that CI users will learn to adapt to the incorrect frequency locations of stimulation. The proposed solution optimizes the frequency-to-place mapping based on individual's cochlear physiology and true location of electrodes. The data from the present study suggest that user customized frequency maps can potentially aid in achieving higher asymptotic performance and possibly faster adaptation to electric hearing.

Başkent, D., and Shannon, R. V. (2005). "Interactions between cochlear implant electrode insertion depth and frequency-place mapping," The Journal of the Acoustical Society of America, 117 (3), 1405-1416.
Fu, Q. J., Shannon, R. V., and Galvin III, J. J. (2002), "Perceptual learning following changes in the frequency-to-electrode assignment with the Nucleus-22 cochlear implant," The Journal of the Acoustical Society of America, 112 (4), 1664-1674.