A formant-based approach for channel selection in *'n-of-m'* sound coding strategies for cochlear implants

Juliana N. Saba, Hussnain Ali, John H. L. Hansen
Cochlear Implant Processing Lab, Center for Robust Speech Systems
University of Texas at Dallas, Richardson, Texas

Introduction. Advanced Combined Encoder (ACE) sound coding strategy is a popular signal processing scheme used in clinical cochlear implant (CI) processors. The premise of this '*n*-of-*m*' strategy is to select '*n*' information-rich frequency bands out of '*m*' available stimulation sites in each stimulation cycle related to the highest spectral content. Although such schemes are able to encode speech signal fairly well in quiet environments, they are inherently susceptible to the negative effects of noise and reverberation in adverse listening conditions (at which normal hearing individuals can understand speech at ceiling levels). Formant frequencies, or resonances in voiced speech, are considered to be fundamental in speech perception and have traditionally served as the backbone of early generations of sound coding strategies. The second formant frequency in particular can provide useful acoustic cues for speech understanding in noise and is normally masked (and hence not selected) in the conventional '*n-of-m'* approach.

Methods. A channel selection algorithm was developed to accurately detect the location of the second formant (F2) and enforce selection within each stimulation cycle within the '*n-maxima'* criteria of ACE processing. Prior work by the authors demonstrated improved performance of CI users in reverberation and noise using a computationally-expensive, formant-prioritization for the first three formants, called FACE[1,2]. Speech intelligibility was measured from CI users with IEEE and AzBio sentences presented in quiet, 10 dB, and 5 dB SNR speech shaped noise as well as babble noise. Subjective and two-forced-choice tasks were performed to quantify preference of either strategy, both in quiet and in noise. Sentence tokens were processed offline using MATLAB (MathWorks Inc.) and stimulated to the implanted electrode array using the CCi-MOBILE Research Platform[3] (developed at the University of Texas at Dallas).

Results. CI performance with the F2-priority-selection algorithm showed comparable performance to ACE and FACE (F1, F2, F3-priority selection), indicating an improvement in overall speech recognition in noisy environments.

Conclusion. Computational cost of the sound coding strategy was significantly reduced without significant loss in performance providing rationale to transition the algorithm into a real-time strategy. These results may serve as: (1) potential improvement on the existing framework of clinical sound processing strategies and (2) easy integration in commercial sound processors using ACE.

[1] Ali, H., Hong, F., Hansen, H.L., Tobey, E., "Improving channel selection of sound coding algorithms in cochlear implants," *IEEE ICASSP*, Florence, Italy, pp. 905-909, 2014.
[2]Saba, J.N., Ali, H., Hansen, H.L. "Formants priority channel selection for Advanced Combination Encoder processing strategy for cochlear implants," *submitted to:* Journal of the Acoustical Society of America.
[3] Ali, H., Hong, F., Wang, Hansen, J.H.L., "Mobile research interface for cochlear implants," 14th International Conference on Cochlear Implants and Other Implantable Technologies, Toronto, Canada, May 11 - May 14, 2016.

This work was supported by the grant R01 DC010494-01A from the National Institute on Deafness and Other Communication Disorders, National Institutes of Health.