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Understanding the Complex Modulation Spectrum for Consonants and Consonant Features

Kenneth Grant, Sandeep Phatak and Elena Grassi
Walter Reed Army Medical Center, Army Audiology and Speech Center, 6900 Georgia Ave. NW, Washington, DC 20307-5001, USA

Speech intelligibility is highly dependent on the magnitude and phase characteristics of the low-frequency modulation spectrum. However, unlike more traditional representations of speech, such as the spectrogram, associating details of the modulation spectrum to specific phonemes and sub-phonemic units of speech has not been readily forthcoming. In the present study we used local time reversals of the speech waveform between 20-160 ms to selectively distort portions of the complex modulation spectrum. Normal-hearing subjects were tested on a consonant recognition task and a detailed analysis of the perceptual confusions was performed. Consistent with earlier results using sentence-length materials, average consonant intelligibility declined as the length of the time reversal segment increased. Further analyses were conducted to determine the effect of time-reversal segment duration on the amount of information transmitted for individual consonants (including specific consonant productions) and acoustic features for voicing, manner of articulation, and place of articulation. An acoustic analysis using a biologically motivated auditory processing model was also performed to determine the effect of time reversals on cochlear and cortical representations of speech. The relations between changes to the complex modulation spectrum and the percent information transmission of selected speech segments and features are discussed.