Amplification of interaural level differences improves sound localization in acoustic simulations of bimodal hearing

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Introduction

- Bimodal listeners (users of a cochlear implant [CI] together with a hearing aid [HA]) in the contralateral ear have poor sound source localization performance.
- Bimodal listeners are sensitive to the two binaural cues, interaural time differences (ITDs) [1] and interaural level differences (ILDs) [2].
- ITDs are not available with clinical processing because
  - the CI-based processor measures the linear structure of the signal
  - the CI and HA stimulus are not synchronized in time due to different processing delays of the two devices and the additional traveling wave delay at the acoustic side [6]
- ILD cues are not available because in most subjects residual acoustic hearing is only available at the lower frequencies and ILD cues are mainly physically present at the high frequencies.

Methods - apparatus

If suffciently large ILD cues are available between the low frequencies of the residual acoustic hearing and the broader spectrum of the electric stimulation via the CI, they may improve on localization performance. The current study assesses simulations of bimodal hearing: when ILD cues are artificially introduced between conditions with and without application of an algorithm that determines ILD amplification: ILD is determined on the full band signal and is introduced into the low frequencies.

No systematic ITDs could be found in the resulting stimuli using cross correlations on either the full band stimulus or per critical band.

Stimuli

- 2 broadband input signals:
  - White noise (10kHz bandwidth), 400 ms long, cosine gated over 50 ms
  - Old-fashioned telephone dialing signal (“telephone”), 5000 ms long
- Virtual auditory space technique (head related transfer functions [HRTFs]) measured on an artificial head of type Cortex MK2 with omni-directional BTE microphones in an anechoic room, using the same loudspeaker configuration as in the testing room.
- Simulation of bimodal hearing:
  - Left ear: 6-channel noise band vocoder with differing analysis and synthesis filters to simulate research in plan of stimulus
  - Right ear: low pass filtered white noise, L = 80 dB
- ILD amplification: ILD is determined on the full band signal and is introduced into the ear that receives the low pass filtered signal (the “acoustic” ear)

Procedure

- 6 normal hearing subjects
- 2-3 sessions of about 1.5 h
- Measures localization performance (RMS localization error) with and without ILD introduction.
- Uniform level range of ±15 dB
- 3 presentations from each angle per run, total 30 presentations per run
- Training runs with feedback
- Normal runs without feedback
- First: 3 training runs for each stimulus/condition, until performance stable
- 3 more runs, alternated with training runs
- Calibration at 65 dB SPL of both stimuli at 0˚ for the left and right headphone channels

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Bibliography