Introduction

Everyday more people with residual hearing receive cochlear implants (CIs) to obtain electroacoustic stimulation (EAS). Modern surgery methods and new electrode designs allow for minimal traumatic insertion to preserve residual hearing. It has been shown that although EAS CI users in general benefit from combined devices (CI + hearing aid), some of them do not use the hearing aid and some others only rely on electric stimulation.

Motivation
To understand the interaction effects between electric and acoustic stimulation a EAS masking experiment is being evaluated. Acoustic masking on electric stimulation and electric masking on acoustic stimulation will be investigated.

Hypothesis

- The fitting of the CI and the sound coding strategy design may play an important role to improve the speech performance of EAS devices.
- The optimal fitting for EAS CI users may depend on an additional factor: The interaction/masking between acoustic and electric stimulation.

Material

Software
- EAS-Masking research interface for electric-acoustic and acoustic-electric masking experiments developed in MATLAB
- CI-Interface support (Cochlear, Med-El, AB)

Hardware
- Acoustic stimulation: sound card, headphones amplifier, headphones
- Electric stimulation: NIC, RIB, HRStream

Methods

Measurement
The masking thresholds will be measured in a 3 interval 2 alternative forced choice task and a 1up-2down procedure following the same approach as Lin, et al. (2011).

Electrical stimulation will be measured using unmodulated pulse trains presented via CI-Hardware-Interfaces. Acoustic stimulation will be measured with pure tones of a given frequency and amplitude. This test will be performed for different combinations of electrodes and acoustic frequencies depending on the individual data of insertion depths and residual hearing.

Subjects
Adult CI users (n=10-15) with residual hearing on the ipsilateral ear with some overlap between electrode insertion depth and residual hearing will participate in the study. Participants have a hearing loss of less than approximately 80 dB HL in a wide range of frequencies.

- Condition 1: electric-acoustic
  - Pulse Trains
  - Pulse rate: 1000 pps
  - Pulse width: 25 µs
  - Interphase gap: 8 µs

- Condition 2: acoustic-electric
  - Pure Tones
  - Frequencies: 125, 250, 500, 750, 1000 Hz
  - Depends on residual hearing

Amount of masking
Digital Volume Tomography (DVT) imaging data will be used to correlate the amount of masking with the overlap between electrode insertion depth and residual hearing.

- Based on the method introduced by Wuerfel, et al. (2014) the individual cochlear length and electrode position can be determined.

Results

Acoustic electric interaction was observed only in CI users having large residual hearing. Preliminary results showed a threshold elevation for acoustic probes with frequencies coinciding with the electrode positions. A mean threshold elevation of 40% of the acoustic dynamic range was observed with a maximum of 10.5 dB SPL equivalent to 57.5% of the acoustic dynamic range. One subject showed a threshold elevation for the acoustic masker condition. For the most apical electrode in the presence of a 1000 Hz and a 750 Hz acoustic masker a threshold elevation of 60% dynamic range and 7.5 dB SPL was observed.

Discussion

- Preliminary results show interaction between acoustic and electric stimulation for CI users having large residual hearing.
- It remains a question whether this interaction impacts speech intelligibility.
- The fitting of the CI and the sound coding strategy design may play an important role to improve the speech performance of EAS devices.

Literature

This work was supported by the DFG Cluster of Excellence EXC 1077/1 “Hearing4all”.
