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Long-term high-variability training for adult cochlear implant users

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Introduction

Although cochlear implants have been demonstrated to be effective surgical treatments for deafness, new implant users must undergo an intense period of perceptual learning and adaptation to learn to hear with their prosthesis. Few adult CI users receive any formal training following implantation, and as a result, the perceptual skills that they develop are highly variable. This study assessed the efficacy of a new training program for adult CI users.

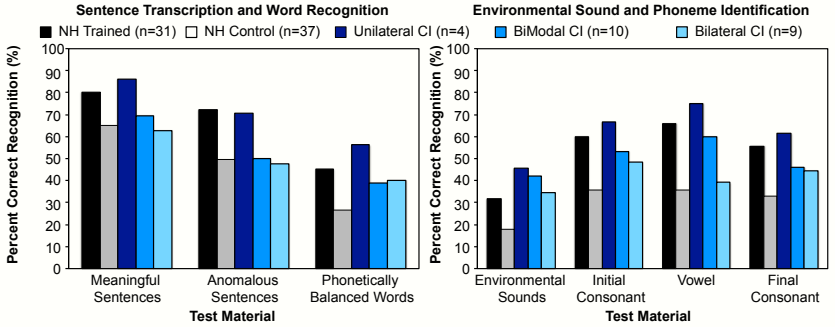
The goal of our interactive, adaptive, high-variability training program is to 1. provide empirically-based, adaptive and interactive perceptual training to new CI users to help them adjust to their prosthesis; 2. develop a common set of robust and adaptive cognitive auditory skills in CI users that will help them to hear in real world situations; 3. Establish baseline levels of performance for experienced CI users to evaluate successful implant use by new users.

Method

- **Participants**
  - Normal Hearing Listeners (n=68)
    - Average age 21.14 years (Range 18-23 years), no reported speech, hearing or language deficits
    - 8-channel sinewave vocoder (CIS, 200-7000Hz BPF, 400Hz LPF)
  - Experienced CI Users (n=23)
    - Unilateral (n=5), Bilateral (n=9), Bimodal (n=10)
    - Average Age 59.13 years (Range 25-78 years)
    - Average Implant use 4.86 years (Range 1-13 years)
  - New CI User (n=1)
    - Age 46 years, Prelingually Deafened, Bimodal
- **Materials**
  - Talker Identification (Clopper & Pisoni, 2006)
    - Focuses attention on the acoustic indexical features of the voice
    - Generalizes to speech perception (Loebach, Bent & Pisoni, 2008)
    - Ex. A spoiled child is a brat.
  - Harvard sentences (IEEE, 1969)
    - Focuses attention on words and understanding word relations in the sentence. Context can be used as a bootstrap. Ecologically valid, but challenging since **NOT** as easy as reflexive automatic speech
    - Ex. The steady drip is worse than the drenching rain
  - Anomalous Harvard sentences (Herman & Pisoni, 2000)
    - Focuses attention on the letter and word sounds themselves, and prevents overreliance on sentence context, but are more difficult
    - Generalizes to meaningful sentences transcription and word recognition (Loebach & Pisoni, 2008)
    - Ex. The dust was firm on the nasty smile
  - Phonetically Balanced words (Egan, 1948)
    - Promote lexical access in isolation, easier due to fewer phonological neighbors
    - Ex. charge, bought, cloud, mute
  - MRT words (House, Williams, Hecker & Kryter, 1963)
    - Promote phoneme identification and discrimination
    - Ex. late, lake, lay, lace, lame, lane
  - Environmental sounds (Marcell et al., 2002)
    - Focuses attention on complex acoustic nonlinguistic information
    - Generalizes to speech (Loebach & Pisoni, 2008)
    - Ex. dog barking, car horn, accordion, door slamming
  - Subjects made open-set typed responses or spoke their responses aloud
  - Received orthographic and auditory feedback irrespective of their answer

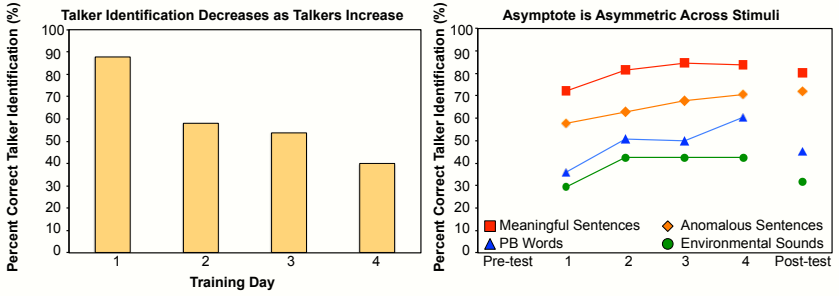
Results

Experience Influences Recognition Accuracy

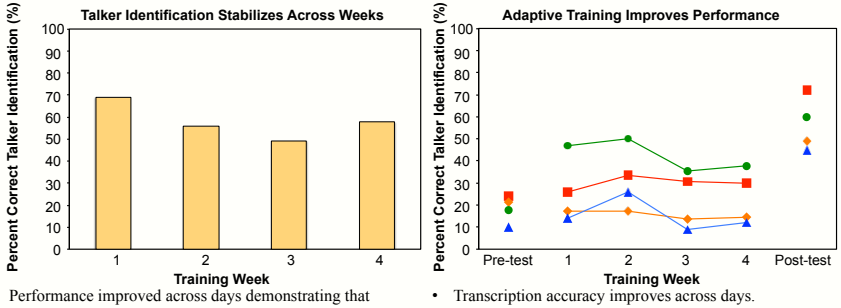


- Open-set transcription of sentences (with and without context), words and phoneme identification varied across groups
  - NH listeners trained over 4 days performed comparably to the best experienced CI users
  - Untrained NH listeners performed comparably to the poorest performing experienced CI users
  - Bilateral CI users performed lower than Bimodal CI users, while the Unilateral CI users performed best overall
- Some CI users outperformed the NH Control group, while the rest were at least equal to the Control NH listeners

Training Over 4 Days Improves Performance of NH Listeners



Training Over 4 Weeks for one Prelingually Deafened CI User



- Performance improved across days demonstrating that participants were able to learn to identify talkers by voice
- As the number of talkers increased (from 4 to 6 to 8), accuracy initially decreased, but stabilized over sessions
- Transcription accuracy improves across days.
- Adaptive training increases task difficulty across sessions by using less intelligible talkers, foreign accented English, and less commonly encountered environmental sounds

Discussion

- Perceptual learning is influenced by training materials
  - All types of training generalize to easy materials (meaningful sentences, PB words)
  - Training specificity is observed for difficult materials (anomalous sentences, environmental sounds), and only similar stimuli will generalize (Loebach & Pisoni, 2008; Loebach, Pisoni & Svirsky, 2010)
  - A desirable level of difficulty (Bjork, 1994) is needed to promote robust perceptual learning and should enhance generalization to hearing in real world environments
    - If the task is too easy, learning does not occur
    - If the task is too difficult, learning does not occur
- Generalization of perceptual learning depends on the depth of processing required during training
  - Tasks that require deeper analysis generalize to sentence transcription
  - Tasks that require shallow analysis do not (Loebach, Bent & Pisoni, 2008; Bent, Loebach, Phillips & Pisoni, 2011)
  - Manipulation of depth of processing (Craik & Lockhart, 1972) will foster robust generalization to difficult tasks
  - Highly variable stimulus sets require deeper levels of analysis and promote robust perceptual learning
- Targeted training in cochlear implant users may
  - Reduce variability in outcome by standardizing the perceptual learning process across individuals
  - Provide better assessment of gains and expectations
  - Enhance neurocognitive coping skills in a variety of real world listening situations
  - Challenge listeners to do better and give them a framework in which they can improve
- Future directions
  - Recruit additional experienced, postlingually deafened adult CI users to provide normalization data
  - Implement the training program in additional new CI users
  - Finish an online version of the training program so users can train from home more easily

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