Effect of residual hearing in bimodal users on top-down repair of interrupted speech

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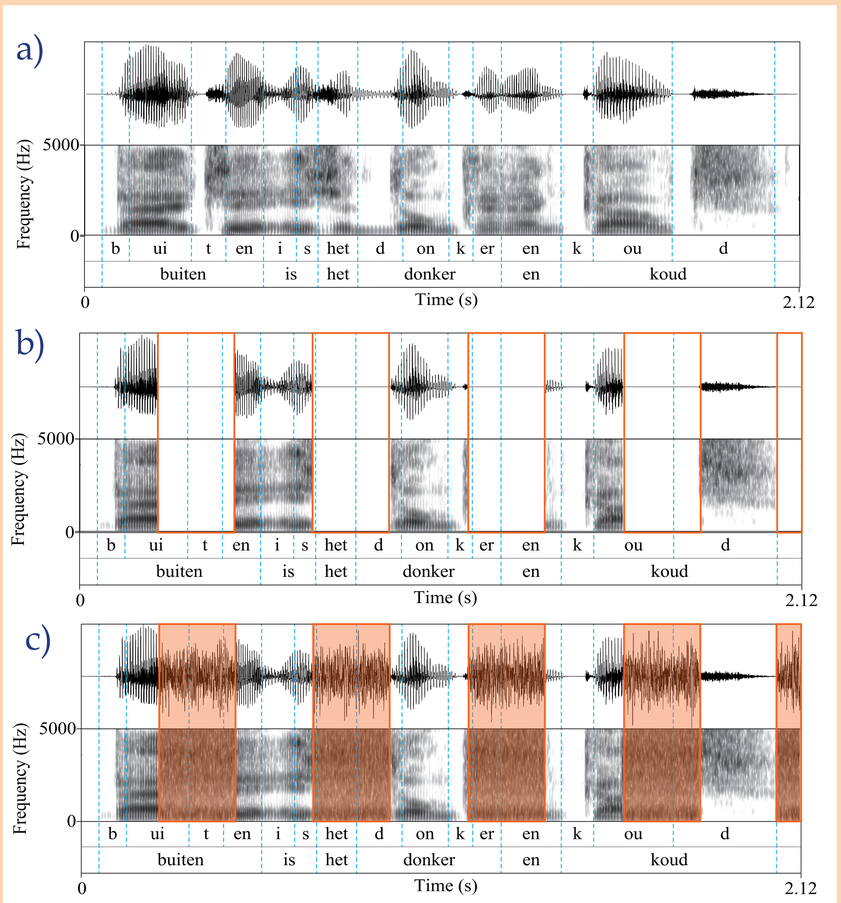
Introduction

Users of cochlear implants (CIs) show decreased speech intelligibility in noisy environment, as well as reduced top-down restoration of speech [1].

Top-down repair of speech is also known as phonemic restoration [1]. Phonemic restoration (PR) is your brain's ability to perceptually reconstruct speech with missing segments.



a) Waveform and spectrogram of the example sentence "Buiten is het donker en koud" uttered by a male Dutch speaker.

b) Same sentence interrupted with silence.

c) Same sentence interrupted with noise.

PR can be measured by the improvement of intelligibility of periodically interrupted speech after silent intervals are filled with noise bursts.

CI users show different patterns than normal-hearing listeners for top-down restoration of degraded speech, depending on the duty cycle of the interruptions [2]. One contributing factor can be the poor pitch representation in their device. Besides, pitch is usefull for perceptual organization [3] (i.e. how your brain decides that different components belong to a same object).

Moreover, an EAS (electric-acoustic simulation) study showed that the addition of low-frequency (< 500 Hz) speech information to CI simulation enhances the overall intelligibility of interrupted speech at high spectral resolution [4].

Furthermore, an CI simulation study showed that adding pitch information (F0) to spectrally degraded speech enhanced both the overall intelligibility and top-down repair of interrupted speech [5].

Similarly, pitch enhancement can occur in bimodal CI users (using a CI in one ear and a hearing aid – HA – in the other), where low frequency information can be transmitted in the contralateral ear (with the HA) if enough acoustic hearing is present.

Research question: Does acoustic residual hearing in bimodal (CI+HA) users benefit top-down repair of interrupted speech?

Method

- Stimuli: meaningful Dutch sentences from VU corpus [6].
- 12 conditions: 3 duty cycles, 2 types of interruption, 2 hearing modes.
- Interruption rate: IR = 1.5 Hz. Duty cycles = 50%, 62.5%, and 75%.
- Sound level: sentences presented at 65 dB SPL, presented with silent interruptions and interruption filled with noise (SNR = 0 dB).
- Participants: native Dutch bimodal users tested with both devices (CI+HA) and with CI only (HA ear plugged).
- Task: participants will listen to interrupted sentences and repeat what they can understand.
- Intelligibility scores are measured as the number of words correctly identified, transformed in RAU scores.

Expected results

- Hypothesis for a benefit:
  - Low frequency cues provided by the HA will contribute to a better pitch representation.
  - The complementary information from the two ears can be properly integrated into one object by the brain.
- Expected results:
  - Global intelligibility of interrupted speech will be better when both CI and HA are used compared to CI only.
  - Phonemic restoration will improve as the duty cycle increases, providing more speech cues that can be used to better activate the top-down repair mechanisms.
- In general : access to pitch cues will help bimodal users to perform better for speech perception in adverse listening situations.

Conclusion

Improved pitch perception could provide sufficient extra cues to yield restoration for CI users who do not usually show restoration [2, 4, 5] and thus improve their speech intelligibility in noisy environment.

We expect to see a benefit of acoustic residual hearing in bimodal (CI+HA) users for top-down repair of interrupted speech.

References

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