PS 554

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Perceptual Integration of Speech Information Across Ears With Bilateral Cochlear Implants and Simulations in Normal-Hearing

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Introduction

- **Bilateral cochlear implants (BiCIs)** generally improve speech-in-noise understanding compared to one CI alone. However, the amount of benefit attained varies across patients [1-3].
  - Many patients with hearing loss, including those with BiCIs, have **asymmetric hearing outcomes across ears [1,3-5]**.
- Some patients experience **interference**: poorer speech understanding with two ears compared to one ear alone [6-9].
  - **Interference occurs when target speech is presented to at least one ear with poor speech understanding.**
- Interference could result from **poorer ability to perceptually integrate or segregate speech** from different talkers [10].
  - Integration/segregation happens at multiple levels of language processing (e.g., phonetic, semantic) [11,12].

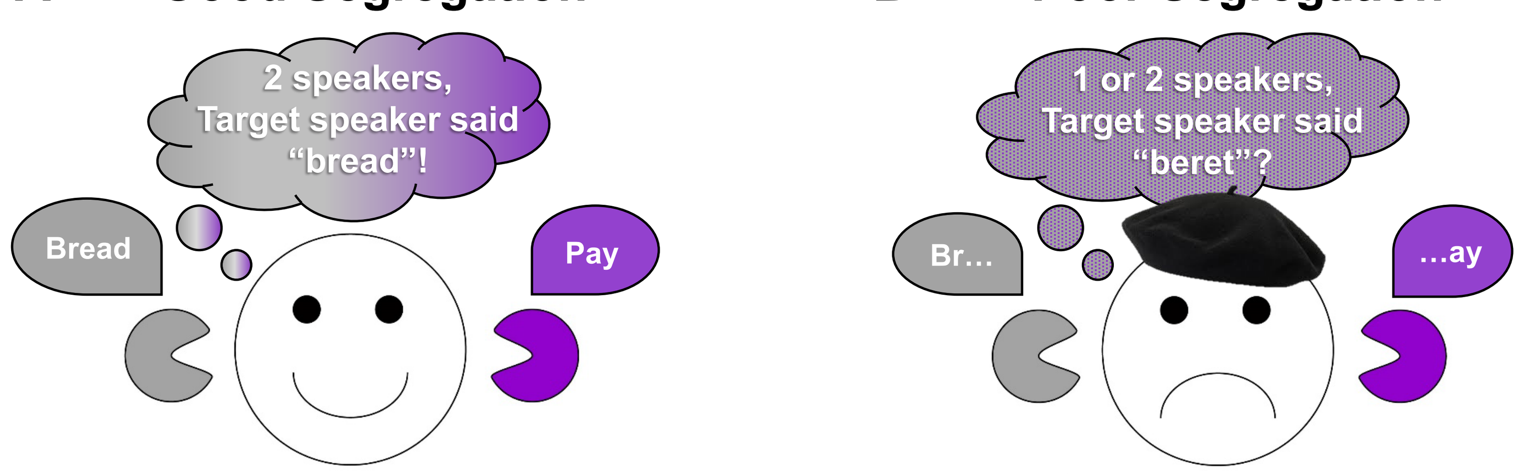

Fig. 1: A. When listeners appropriately segregate speech from both ears (e.g., by its location), they can correctly report the target word. **B.** When listeners are unable to appropriately segregate speech from both ears, it may be maladaptively integrated.

- **Question:** How does each ear contribute to speech perception when one or both ears exhibit poor speech understanding?

Goal: Determine whether having at least one ear with poor speech understanding leads to poorer segregation of speech information across ears.

Stimuli & Listeners

- Monosyllabic, English words spoken by one male talker
- Listeners and presentation
  - 4 normal-hearing (NH): unprocessed and noise-vocoded speech via circumaural headphones at 65 dB SPL
  - 5 BiCI: unprocessed speech via direct connect (Cochlear) or circumaural headphones (Advanced Bionics T-mic) at a comfortable level

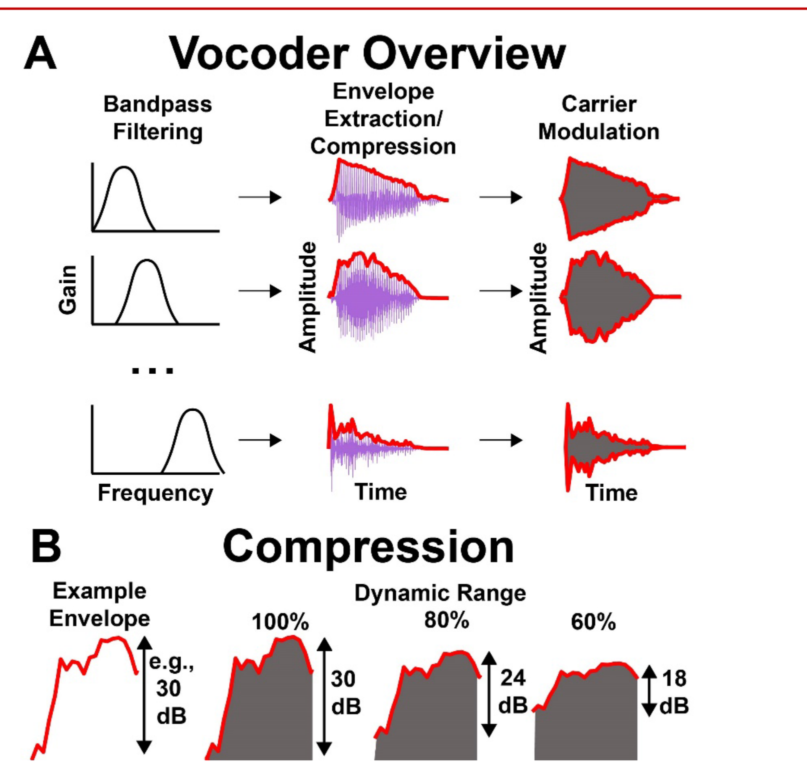

Fig. 2: A. Sixteen-channel vocoding [13] was completed with low-noise noise carriers. **B.** The dynamic range was manipulated to elicit changes in speech understanding (see Fig. 5A). RMS level remained 65 dB SPL across dynamic ranges.

Task

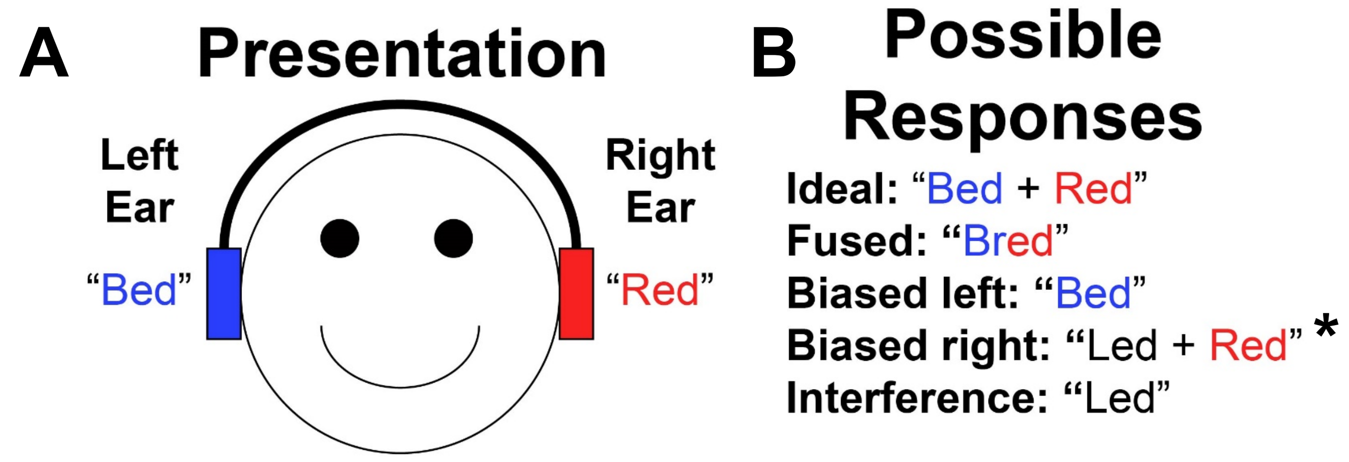

Fig. 3: A. One word was presented to each ear. Listeners responded with the word(s) that they heard. Listeners did *not* indicate the side from which words were presented. **B.** Responses were sorted into categories based upon listening strategy.

Bed	Led	Red	Bled	Bread
Pay	Lay	Ray	Play	Pray
Go	Low	Row	Glow	Grow

Fig. 4: Responses were recorded using this graphical user interface. Stimuli were a subset of words from Cutting, 1975 [11].

- This task indexes accuracy and integration (Fig. 3).
- 33% of trials had same word, stop + liquid pair (Fig. 3A), or words with differing vowels.
- Responses were sorted into categories (Fig. 3B).
  - * Responses considered biased if they were only correct for one side.

NH Results

Hypothesis: Poor speech understanding ***in both ears*** will lead to greater interference in speech perception.

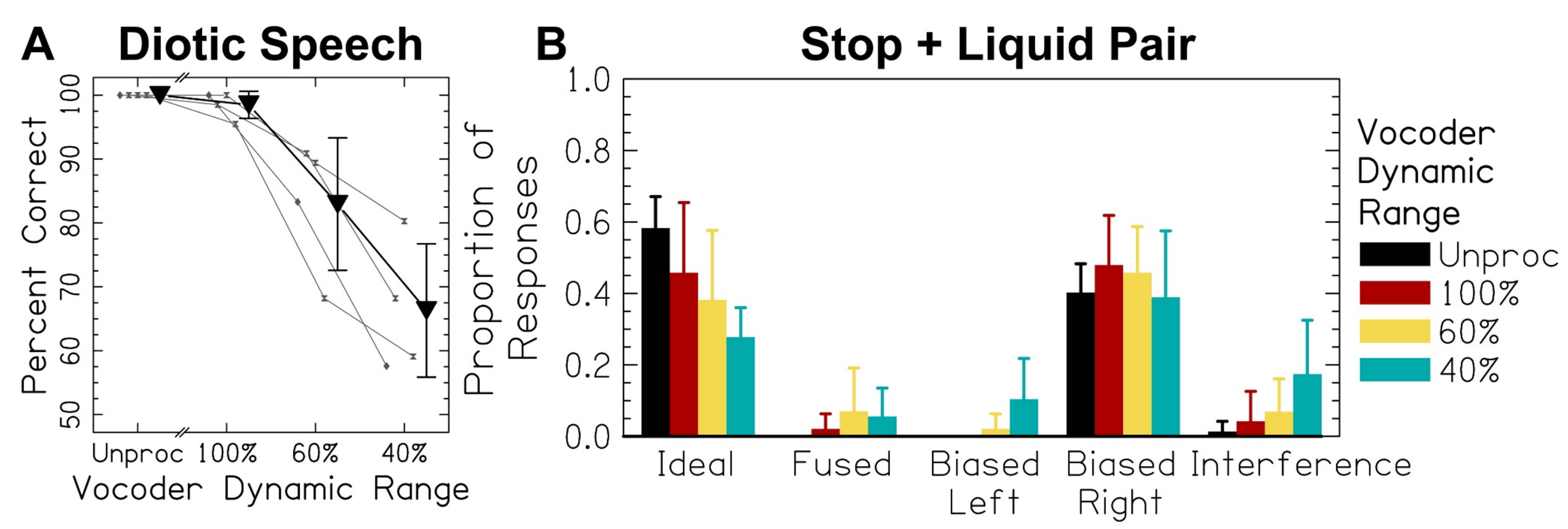

Fig. 5: Mean results across 4 NH listeners. Error bars represent ±1 standard deviation. **A.** Mean is shown in black and individuals are shown in gray. **B.** Response categories (see Fig. 3) are shown by vocoder condition.

- Smaller dynamic range resulted in poorer speech understanding when the same word was presented to both ears (**Fig. 5A**).
- The amount of interference increased as dynamic range decreased (i.e., temporal resolution decreased; **Fig. 5B**).
  - Ideal responses decreased (accurate identification of speech in both ears) as dynamic range decreased, resulting in a trade-off between ideal and interference responses.
  - This is consistent with NH results showing interference in speech-in-noise with few vs. many vocoder channels [10].

BiCI Results

Hypothesis: Poor speech understanding ***in at least one ear*** will lead to greater interference in speech perception.

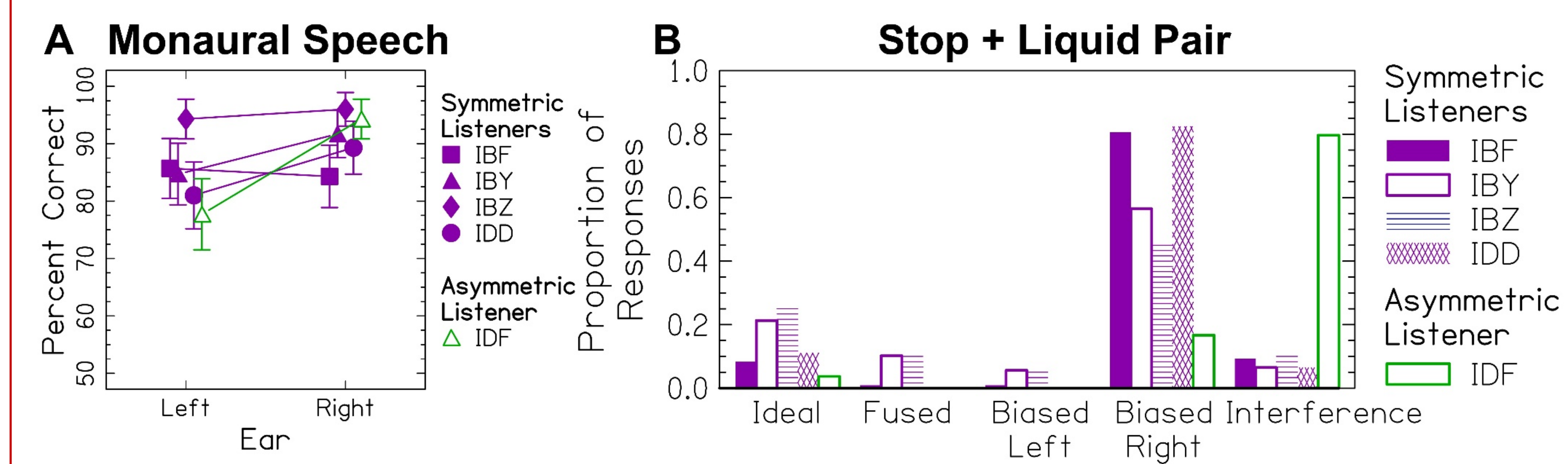

Fig. 6: Individual BiCI listeners that have symmetric or asymmetric speech understanding are shown in purple and green, respectively, based on data in A. **A.** Error bars represent 99% confidence intervals. Listener IDF's confidence intervals did not overlap for the left and right ear. **B.** Response categories (see Fig. 3) shown by listener.

- One listener showed asymmetric speech understanding (**Fig. 6A**).
- Listeners with symmetric speech understanding exhibited a bias toward correctly reporting the word from their right ear (**Fig. 6B**).
  - All listeners except IBY were first implanted in their right ear.
- The amount of interference was greater for the listener with asymmetric speech understanding (**Fig. 6B**).
  - Could the poorer ear limit speech perception, or does asymmetry alone lead to interference?

Summary

- Interference occurs for some BiCI listeners and could be due to limitations in speech perception that have not been investigated.
- **Smaller dynamic range of vocoders in NH** listeners, which resulted in poorer speech understanding (Fig. 5A), **resulted in more frequent interference in speech perception (Fig. 5B).**
- **BiCI listeners** show large amounts of **right-sided bias and interference in speech perception (Fig. 6B)** than NH.
- **Thus, poorer speech understanding resulted in poorer ability to accurately segregate speech** when presented to both ears.
- Future studies will investigate asymmetric dynamic range in NH, and BiCI listeners with good or poor speech understanding in both ears.

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