

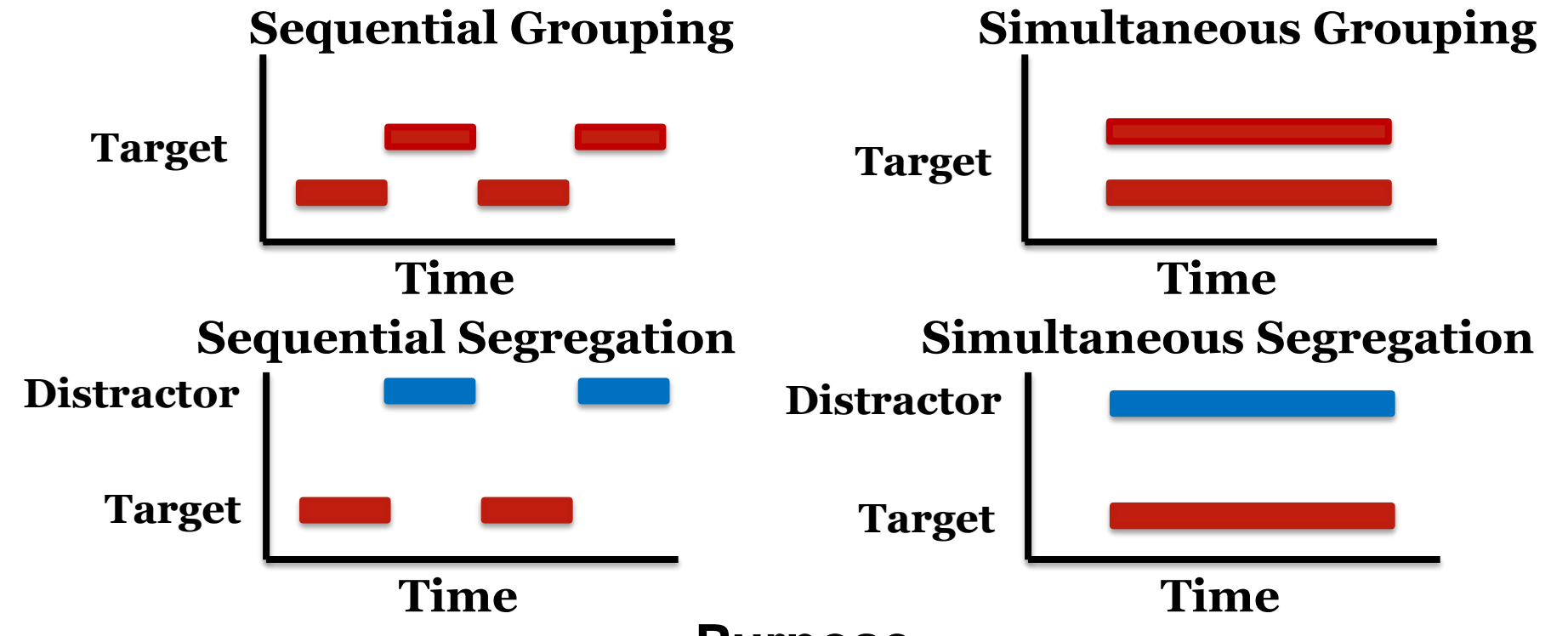
Effects of Elevated Amplitude Modulation Discrimination Threshold on Simultaneous Amplitude Modulation Rate Discrimination



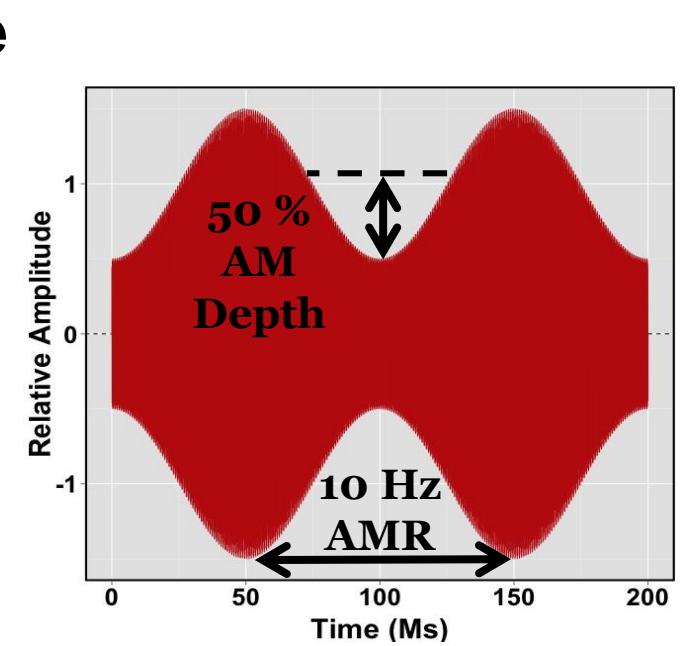
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Introduction

- In a complex auditory scene, listeners use many auditory grouping cues to attend to a target of interest [1].
 - Grouping cues can be broken down into *sequential* (i.e., auditory streaming) and *simultaneous* (i.e., fusion) [1,2].



- The frequency of amplitude modulation, or amplitude modulation rate (AMR) is a sequential [3] and simultaneous [4] auditory grouping cue in NH listeners.**
- Envelope encoding is preserved in CI processing, suggesting it may be an accessible auditory grouping cue, but sequential AMR discrimination thresholds differ depending electrode site for CI users [5].



Goal: Estimate the effects of diminished AM salience at specific electrode sites in CI users

Approach: Simulate CI performance by reducing AM depth from 50% to 20% in NH listeners, diminishing AMR salience

Simultaneous Comparison of AMR in Cochlear Implants

- Either one (reference) or two (reference and variable) AMRs were presented simultaneously at two or four different cochlear sites (in one or two pairs).
 - Across or within ears
 - Same or different carrier frequencies
- Subjects discriminate whether the pairs have the **same or different** AMRs.

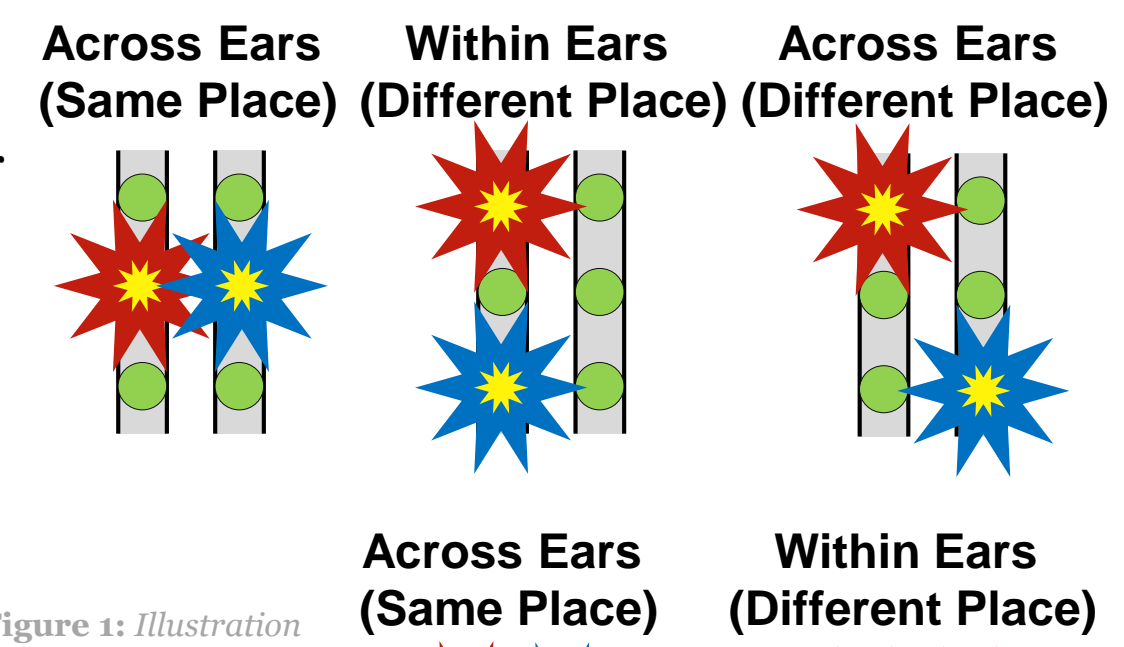


Figure 1: Illustration of simultaneous AMR comparisons. Red stars indicate a reference AMR (either 10 or 90 Hz) and blue stars indicate a variable AMR (which was always a faster rate than the reference), in one or two pairs of stimuli.

Hypothesis: If the AM depth of one SAM tone in a pair of AMRs is reduced from 50% to 20%, simultaneous AMR discrimination threshold will increase.

Methods

- Stimuli
 - Sinusoidally amplitude-modulated (SAM) tones
 - Carrier: 4000 Hz or 7260 Hz
 - 600 ms
 - Presented at 65 dB SPL(A) via circumaural headphones
 - ± 2 dB rove was applied to each tone to reduce use of loudness cues in AMR discrimination.
- Subjects (age 22-25)
 - Six normal-hearing subjects in sequential AMR discrimination
 - Five normal-hearing subjects in simultaneous AMR discrimination
- Thresholds converted to **Weber constants**.

$$\text{Weber Constant} = \frac{\text{Just noticeable Difference in AMR}}{\text{Reference AMR}}$$

Sequential AMR Discrimination

- 3 interval, 2 alternative forced-choice task
 - First interval was reference AMR
- 3 reference AMRs (10, 30, and 90 Hz)
- Subjects chose the fastest AMR
- Adaptive tracking
 - 3 tracks interleaved for each reference AMR
 - 12 turnarounds

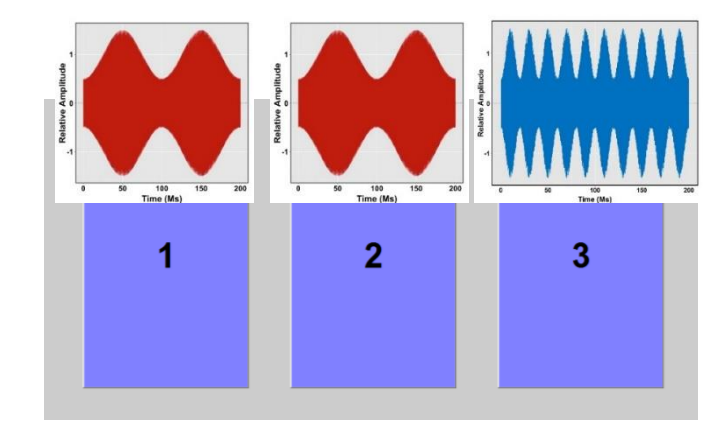
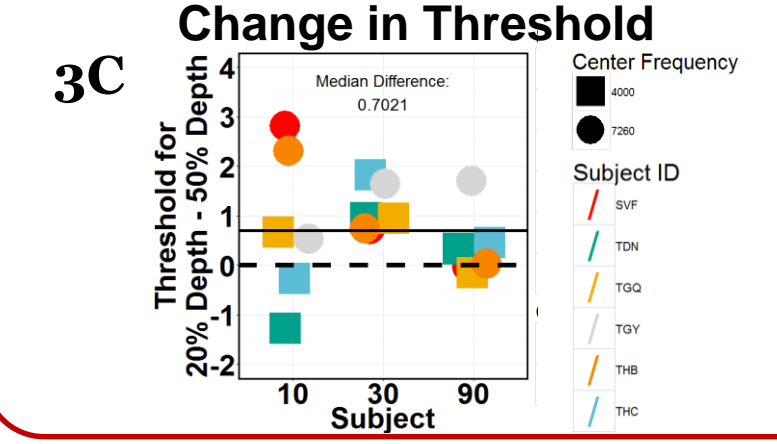
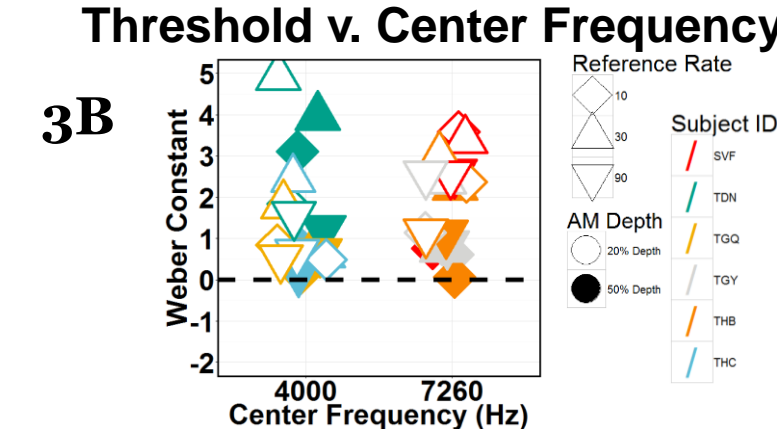
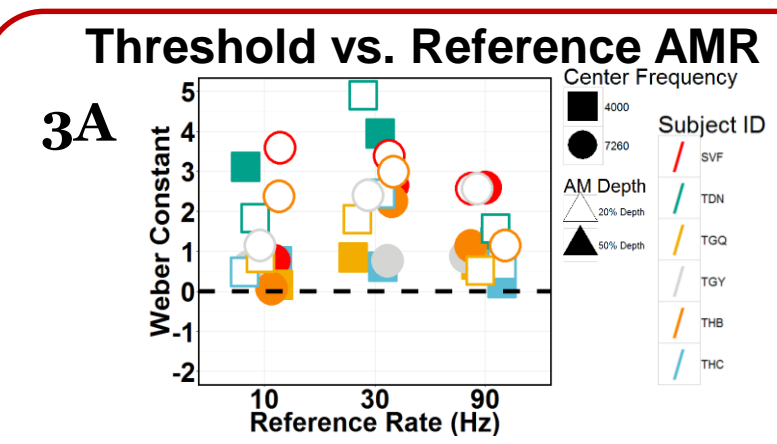


Figure 2: Graphical user interface and example trial. Subject initiated trial and stimuli were presented. The first presentation was always a reference AMR. The variable AMR had a 0.5 probability of occurring on the second or third interval.

Simultaneous AMR Discrimination

- 1 interval, 2 alternative forced-choice task
 - “Same” or “Different” AMRs
 - 0.33 probability of being same AMR
- Method of constant stimuli
 - 2 reference AMRs interleaved
- Either 1 or 2 pairs of reference (10 or 90 Hz) and variable AMRs presented.
- The AM depth was reduced to 20% for one SAM tone in pairs in half of conditions.**

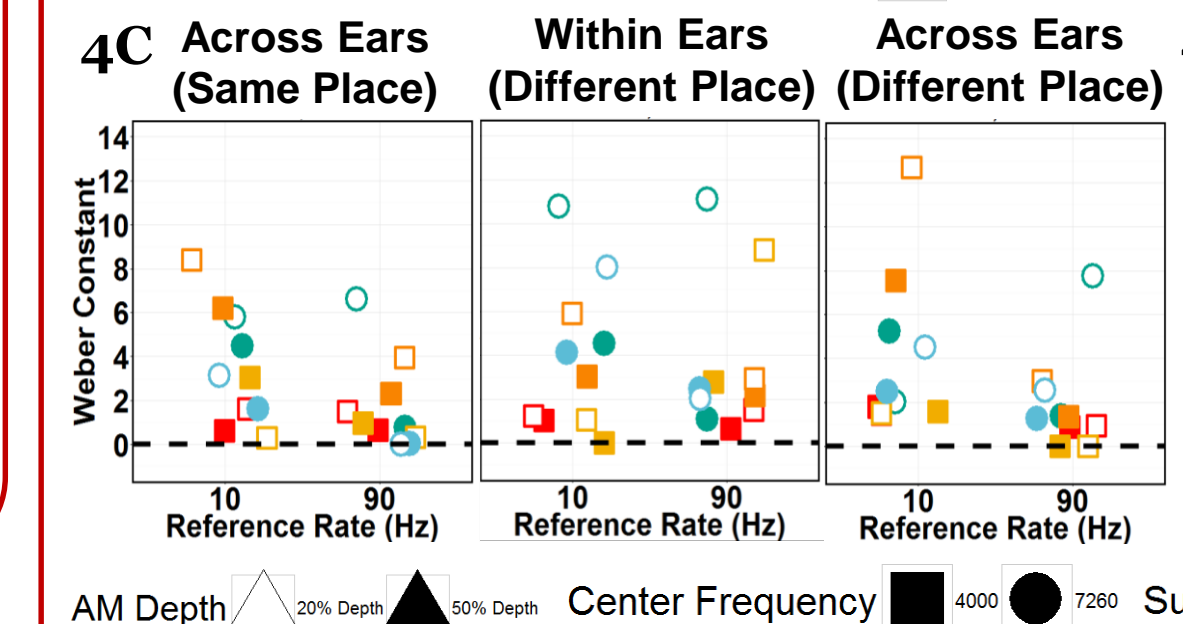
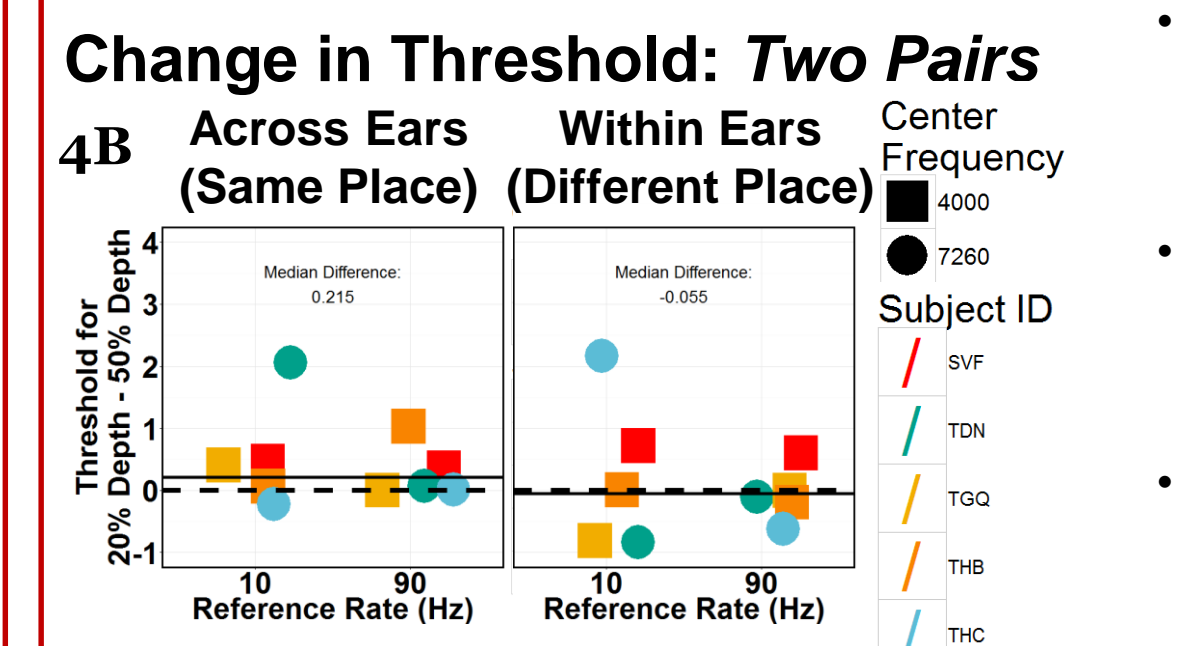
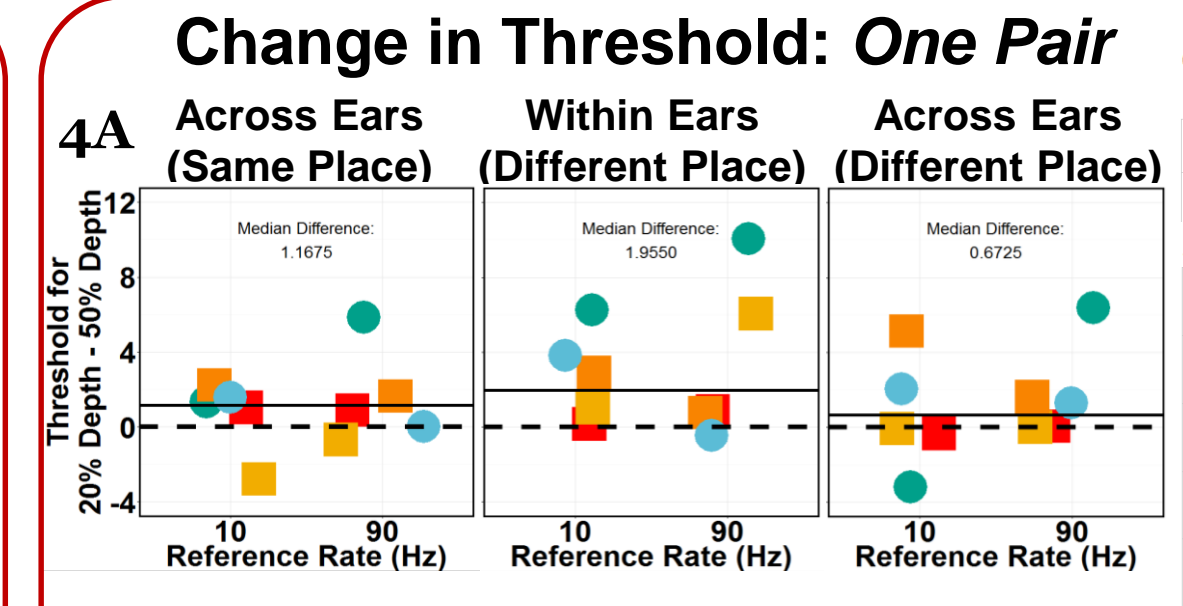
Results: Sequential AMR Discrimination



- Hypothesis: If AM depth is reduced from 50% to 20%, AMR threshold will increase.**
- Discrimination thresholds were highest at 30 Hz reference AMR (Fig. 3A).
- There was no trend in AMR threshold across carrier frequency (Fig. 3B).
- The median difference between AMR threshold for 20% - 50% was 0.7021 (Fig. 3C).
 - Positive values indicate that the AMR threshold was higher for the 20% depth SAM tones.

Figure 3: Sequential AMR discrimination thresholds. A-B. The y-axis represents threshold for the 20% and 50% AM depth conditions. Open shapes represent a greater modulation depth. C. The y-axis represents threshold for the 20% and 50% AM depth conditions. The black bar represents the median difference between depth conditions. A value above zero indicates that AMR threshold was higher for the 20% AM depth condition.

Results: Simultaneous AMR Discrimination



- For one pair of SAM tones, the median difference between 20% and 50% AM depth conditions was higher than zero in pair configurations (Fig. 4A).
- One pair, within ear had the highest median discrimination thresholds (Fig. 4A).
- Median differences between 20% and 50% AM depth were much smaller with two pairs of tones (Fig. 4B).
- Thresholds for two pairs were much lower than one pair on average (Fig. 4C and 4D).

Figure 4: Simultaneous AMR discrimination with one or two pairs of SAM tones. A-B. The y-axis represents change in threshold between the 20% and 50% AM depth conditions. The black bar represents the median difference between depth conditions. A value above zero indicates that AMR threshold was higher for the 20% AM depth condition. See Fig. 1 for stimulus configurations. C-D. The y-axis represents raw AMR discrimination thresholds.

Summary

- Individuals with CIs may be able to use sequential and simultaneous AMR as grouping cues, but performance could be limited by electrode specific factors.
- Sequential and simultaneous AMR discrimination were tested using a psychophysical task, where reduced AM depth was used to elicit increased thresholds.
- Sequential discrimination thresholds** for AMR tended to increase when AM depth was reduced, with no relationship to carrier frequency.
- Simultaneous discrimination thresholds** for AMR tended to increase when AM depth in one tone was reduced for one pair of tones, but not two. For one pair of simultaneous AMRs, thresholds were lowest in across ear conditions.
- This paradigm allows us to simulate CI users' performance on AMR discrimination tasks by reducing AM salience in NH listeners.

References

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Acknowledgements
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