Spatial Release from Masking: Effects of Simulated Unilateral Hearing Loss

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

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Background and Rationale

The overall objective of this program of research is to understand how unilateral hearing loss (UHL) impacts children's functional auditory skills. The aim of the present study was to develop a feasible method to assess the effects of UHL on children's masked speech perception and their use of spatial cues in the context of substantial informational and energetic masking.

There is no consensus regarding the best approach for managing UHL in children (e.g., Fitzpatrick et al. 2010). This is partly due to the lack of evidence regarding which children with UHL have the greatest need for intervention, which intervention is most beneficial, and when intervention is necessary. Most studies examining the extent to which UHL affects children's auditory skills have used relatively steady-state maskers which may not fully capture children's everyday listening difficulties (e.g., Lieu et al. 2013). Studies using psychoacoustic methods and more complex auditory tasks that assess contributions of both energetic and information masking may more accurately capture functional auditory skills of children with UHL, which would inform future clinical procedures to identify at-risk children and guide intervention.

Experimental Hypotheses

1. Listeners perform better in normal-hearing (NH) relative to simulated-unilateral-hearing-loss (SimUHL) conditions for both co-located and spatially separated maskers. The rationale is that listeners with symmetrical normal hearing use summation, squelch, and head-shadow cues to their benefit.

2. Effects related to spatial separation of stimuli are larger for two-talker than speech-shaped noise maskers. This is due to the presence of substantial informational masking produced by the two-talker speech masker.

Method

Listeners: Eleven adults (19 - 30 years) with normal hearing, bilaterally.

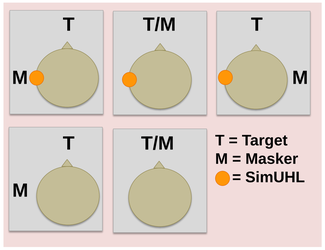
Stimuli: Target stimuli were recordings of the Revised Bamford-Kowal-Bench Sentence Test spoken by a female talker. There were two masker conditions: (1) two-female-talker speech and (2) speech-shaped noise.

Procedure: Sentence recognition was assessed using an open-set adaptive tracking procedure. Target and masker levels were adapted to converge on the signal-to-noise ratio (SNR) corresponding to 50% correct sentence recognition. The overall level of the target + masker was fixed at 60 dB SPL.

Listening conditions: Target sentences were presented at 0 degrees azimuth. The masker was presented at 0, +90, or -90 degrees azimuth.

Method

Figure 1: Listening Conditions



Hearing loss simulation procedure: Unilateral hearing loss was simulated using a foam earplug and a supra-aural earmuff. The average attenuation provided by the earplug and earmuff combination at 500 Hz, 1000 Hz, and 2000 Hz was measured behaviorally in the sound field while 50 dB HL narrowband masking noise was presented to the contralateral, or "normal-hearing" ear.

Average Attenuation of Earplug + Earmuff (dB SPL)

500 Hz	1000 Hz	2000 Hz
58.5	54.5	43

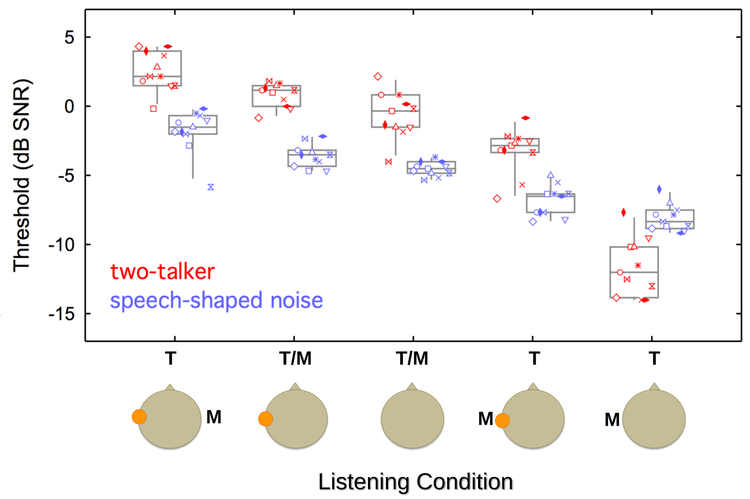
Results: Individual and Group Performance

Figure 2 *shows individual and group data for adults in the five different listening conditions* in two-*talker speech or speech-shaped noise.*

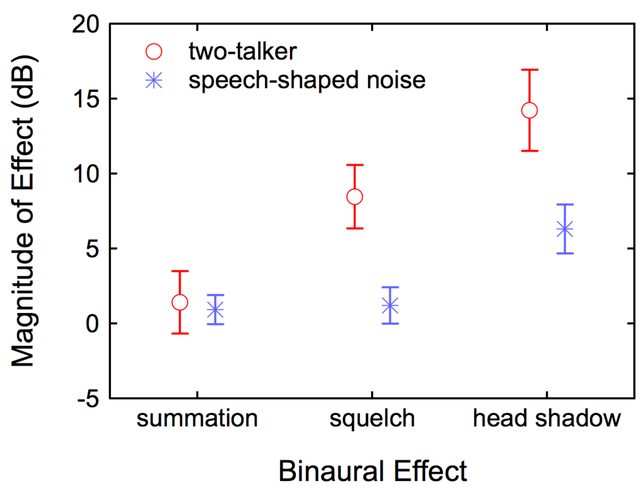
Thresholds in two-talker speech were consistently higher than those in speech-shaped noise, except in the NH condition with spatial separation. In this condition, listeners benefitted from spatial separation; thresholds were better in the two-talker speech than in the speech-shaped noise masker.

A binaural benefit was observed under the following conditions *(p < .05, with Bonferroni adjustments for multiple comparisons):*

- *In two-talker speech when stimuli are spatially separated*
- *In speech-shaped noise when stimuli are spatially separated such that the masker is at the ear with NH in the SimUHL condition*



Results: Binaural Effects



Effect	Definition
Summation T/M MINUS T/M	The advantage of listening with two relative to one normal-hearing ear in the co-located condition.
Squelch T M MINUS T M	Effect of plugging the ear ipsilateral to the masker.
Head shadow T M MINUS T M	Effect of plugging the ear contralateral to the masker.

Figure 3 *shows the average binaural effects in two-talker speech and speech-shaped noise.*

Conclusions

Hypothesis 1: Listeners perform better in the NH relative to SimUHL listening conditions.

- Listeners did not perform significantly better in the NH relative to the SimUHL condition when the target and masker were co-located in either masker.
- In the two-talker speech, but not in the speech-shaped noise, listeners performed better with NH than SimUHL in all spatially separated conditions.

Hypothesis 2: Effects related to spatial separation of target and masker stimuli are larger for two-talker speech compared with speech-shaped noise maskers.

- The squelch and head shadow effects were significantly larger in the two-talker speech compared with the speech-shaped noise.
- There was no masker effect for summation.

Future Directions

- Data collection in children with normal hearing, ages 8 to 10 years, is ongoing.
- The ultimate goal of this study is to apply and extend this method of testing to children with UHL.
- Differences observed for the squelch and head shadow effects in the two-talker speech and speech-shaped noise maskers indicate that assessment of spatial hearing in a two-talker masker may reveal performance differences not captured by relatively steady-state noise maskers.
- Assessment of children with UHL in the two-talker masker may reveal underlying functional auditory skills and capture performance differences not apparent in the speech-shaped noise masker (Hillock-Dunn et al. 2015).
- Potential associations between performance on cognitive and functional listening assessments and the current method of behavioral assessment will be investigated in future studies.

References

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