Spatial Release of Cognitive Load in NH and HI Listeners

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Introduction

- Depending on which acoustic cues are available in two different scenarios, a listener may utilize different amounts of cognitive resources to achieve the same speech recognition performance.
- To test this hypothesis, we compared the cognitive load of recognizing speech in multi-talker environments that differ in the cues available for segregating talkers.
- A measure of cognitive load that is sensitive to segregation cues can be valuable for the assessment of hearing technology that affects cue fidelity.

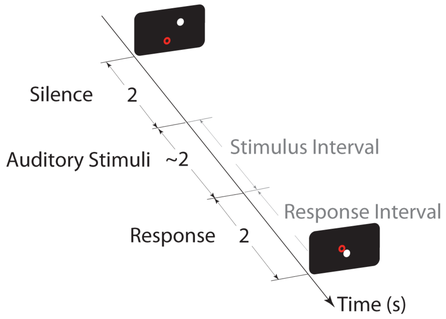
In this poster:

- Determine using a dual-task paradigm if spatial segregation cues reduce the cognitive load of recognizing speech in a multi-talker environment?

Methods

Task

Simultaneous speech recognition and visual tracking



Tracking accuracy measured as percent of time when curser (red circle) is on target (white dot).

Primary: Report keywords of target speech

Secondary: Track moving target on touch screen -- performance reflects the cognitive load of speech recognition

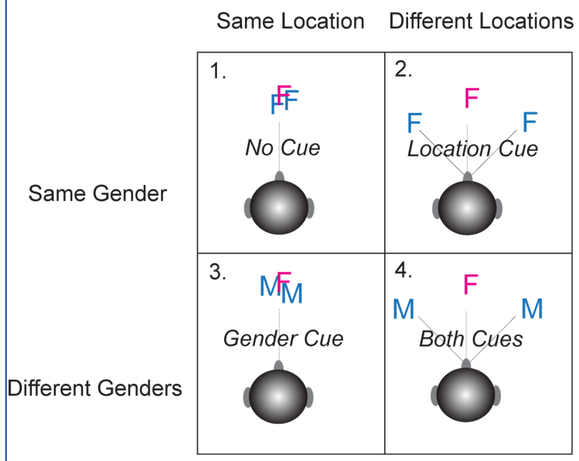
Single task baseline for controlling individual variability

- Speech recognition performance in single task
- Visual tracking as single task with speed of target adjusted for 60% accuracy.

Listening cost = tracking accuracy (in single task – in dual task)

Methods (cont.)

Four Multi-talker Speech Recognition Conditions

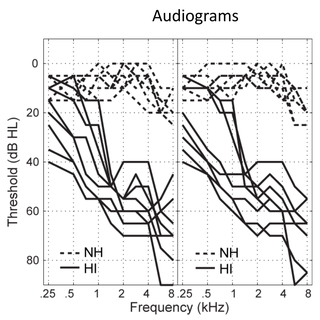


Target: F (female) talker
Interferers: F (female) or M (male) talkers

Interferers in different-location conditions: +/-15° in **Exp. I**, +/-60° in **Exp. II**.

Participants and Stimuli

- 8 NH (51~61 years) in both **Exp. I** and **Exp. II**
- 8 HI (59~66 years) in **Exp. II** only

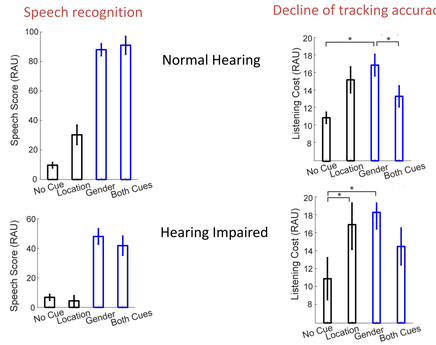


- 3 CRM[1] sentences each trial, all at 65-dB SPL at the source
- Sound-source locations simulated using HRTFs[2]
- NAL-R[3] amplification for HI

Results

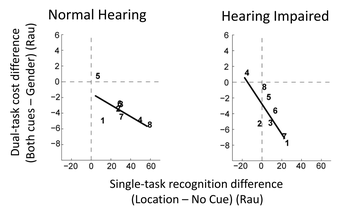
Exp. I (15° separation)

Addition of a location cue to an existing gender difference lowers the cognitive load of recognizing speech.



- Combining both gender and location cues incurred less listening cost than gender only, for comparable speech performances (for NH).
- Low cost of no-cue condition can be understood from excessive difficulty of speech task causing subjects to divert resources to tracking task.
- HI: location cue is cognitively more costly than no cue, despite no impact of the cue on speech performance. This suggests listeners have access to spatial cues, although they are unable to use them for recognizing target speech.

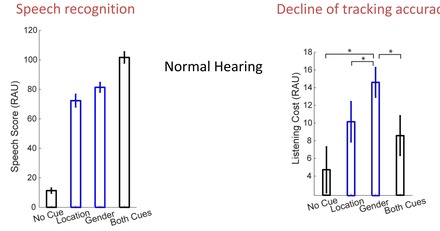
Spatial benefit for cognitive load vs. spatial benefit for speech recognition



- Benefit of location difference for lowering cognitive load is associated with ability to make use of location difference for recognizing speech in a multi-talker environment.

Exp. II (60° separation)

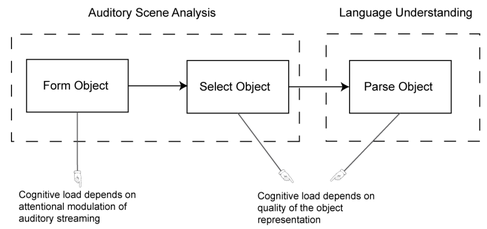
Location cue consumes fewer cognitive resources than gender cue.



- Lower listening cost for comparable speech performance with location compared to gender only.
- High speech performance and low listening cost with both cues.

Summary and Discussion

A conceptual model for the cognitive load of recognizing speech amidst multiple talkers



Cognitive load of recognizing speech amidst interferers includes
- resources deployed to auditory scene analysis
- resources deployed to language understanding[4]

Cognitive load of auditory scene analysis depends on
- attentional modulation of auditory object formation
- quality of auditory object representations

Cognitive load of listening can be reduced by
- enhancing segregation cues to reduce attention deployment
- increasing SNR to improve object representation

Conclusions

- **Addition of spatial separation cues can reduce cognitive load even when it does not improve speech recognition.**
- **Location-based auditory processing is less cognitively expensive than gender-based auditory processing, consistent with past evidence that the former does not require attention[5] for streaming while the latter does[6].**
- **Individual differences in the spatial release of cognitive load are related to the ability to make use of spatial information in forming and selecting objects.**

References

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