Cognitive Measures Explain Variance in Speech-in-Noise Among Older Adults

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Background

Older adults often struggle to understand speech in noisy environments, a challenge that significantly impacts their daily communication and quality of life. While age-related hearing loss is a well-established contributor to these difficulties, the relationship is likely more complex than previously understood.

- **Adequate speech understanding relies on integrating multiple cues, like spatial and informational masking (Kidd et al., 2010).**
- **Older participants have a more difficult time with cognitive tasks which have been shown to affect speech-in-noise ability in relation to hearing loss (Burkhardt et al., 2022).**

We explored this by evaluating various cognitive tasks and speech-in-noise abilities across different ages, using the Coordinate Response Measure (CRM). The CRM helps us understand spatial masking, or the ability to recognize target sounds separated from background noise. Our focus is on cognitive processes such as working memory, which involves short-term information retention, and processing speed, which refers to how quickly one can respond to stimuli.

Research Questions

Is processing speed predictive of speech-in-noise abilities?

- *We hypothesize that individuals with higher processing speed will demonstrate better performance on the CRM with greater spatial separation of masking noise from speech.*

Methods

Participants	Average ages	Age range (years)	Sex
N = 23	**X̄ = 39**	**20-80**	**F (17) M (6)**

Coordinate Response Measure (speech-in-noise understanding task)

During the CRM listening task, participants listened to target sentences presented concurrently with two interfering sentences. The participants were instructed to follow the call sign *"Baron"* to identify a color and number sequence spoken by the target talker while ignoring the sequences spoken by the speech maskers.

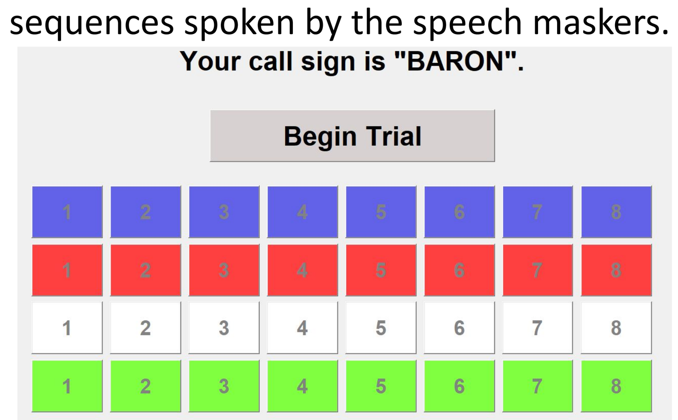


Figure 1: CRM colored number options, participants are directed to a color and number by the call sign *"Baron."*

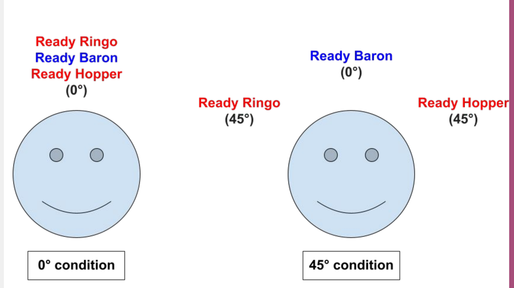


Figure 2: Perceived location of the interfering talkers in relation to the target.

Cognitive Tasks

The NIH Toolbox Cognition Battery has seven validated measures designed to assess cognitive functioning (Episodic Memory, Reading, Vocabulary, Processing Speed, Working Memory, Executive Function, and Attention). This study utilized the following cognitive measures:

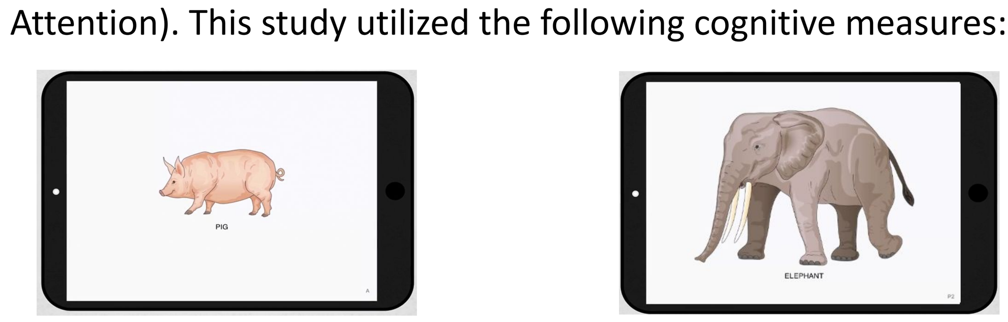


Figure 3: The List Sort Working Memory Assessment measures working memory by asking participants to recall and sequence different stimuli (e.g., animals and foods) in size order.

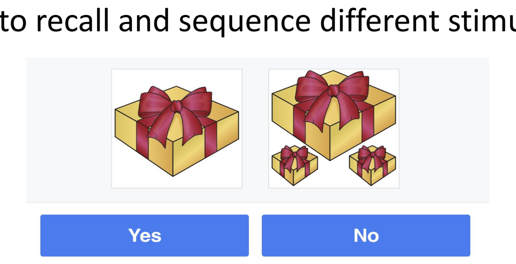


Figure 4: Pattern Comparison measures processing speed by determining how many trials of a task (e.g., picture comparison) participants can complete within a certain time frame.

Results

Better processing speed is predictive of spatial release from masking benefit

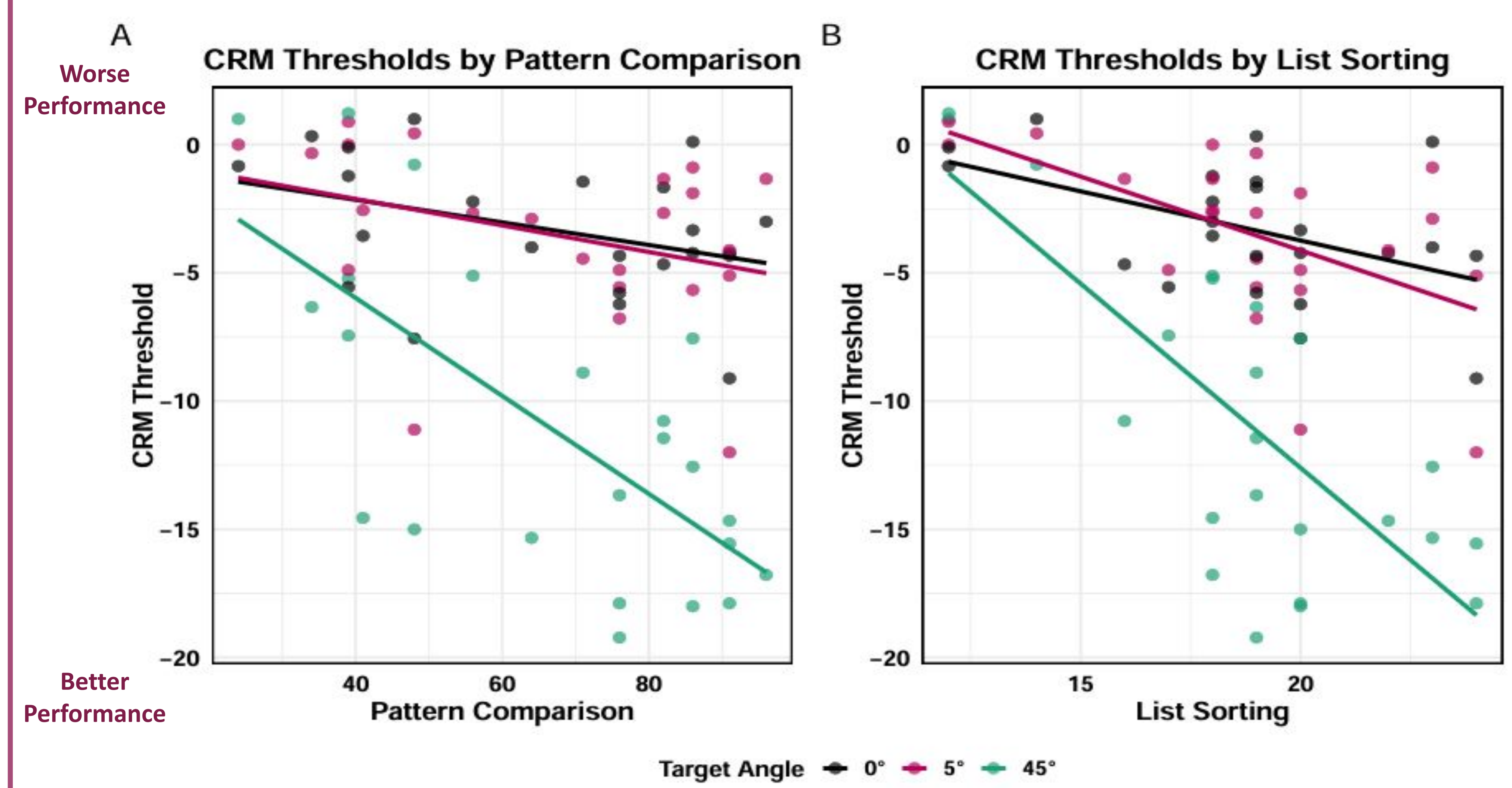
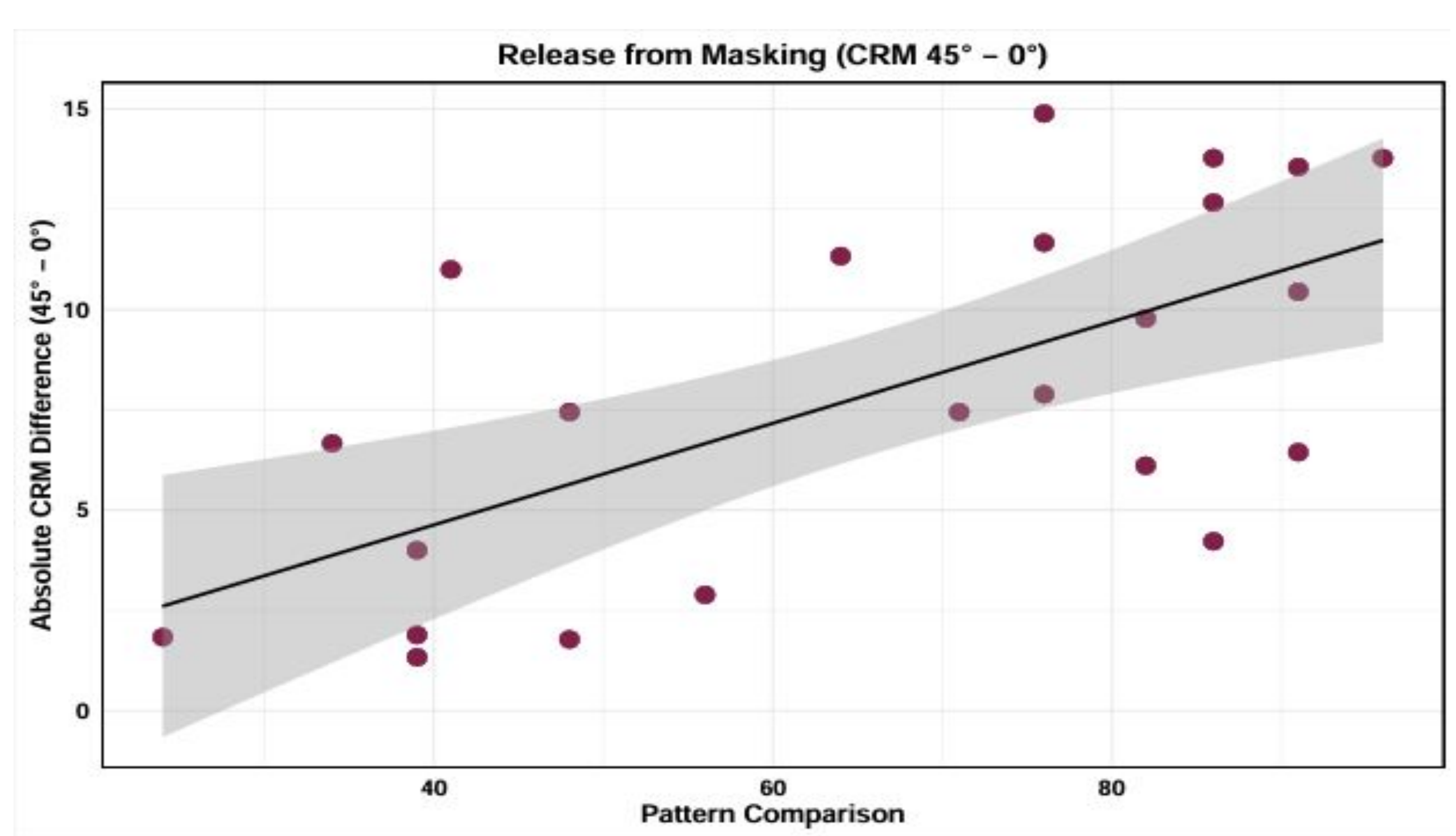


Figure 5: Pattern Comparison (A) and List Sorting (B) results in relation to CRM thresholds across the three spatial talker angles (0°, 5°. and 45°). Each color line reflects a separate linear regression fit for each spatial condition.

- Higher Pattern Comparison scores significantly predicted better speech-in-noise recognition at 45° (p = 0.00026, R^2 = 0.478), suggesting that processing speed plays a role in spatial listening ability.
- List Sorting scores significantly predicted better speech-in-noise recognition at 45° ($p = 0.0002$, R^2 = 0.641), suggesting that working memory plays a role in processing speech in complex environments.
- Pattern Comparison scores will be analyzed to examine processing speed's contribution to spatial release from masking, as spatial cue utilization may depend on rapid information processing. The high correlation between Pattern Comparison and List Sorting scores (r= .55) supports focusing on processing speed to avoid redundant predictors while testing its specific role in spatial hearing.

Figure 6: Pattern Comparison scores plotted against the absolute change in CRM from 0° to 45°. The data shows a statistically significant relationship between Pattern Comparison performance and release from masking (R^2 = 0.48, p < 0.001). Higher Pattern Comparison scores correspond with greater absolute CRM improvement when spatial separation increases from 0° to 45°.



- Pattern Comparison Scores demonstrated better benefit from spatial separation, suggesting that faster cognitive processing enables more effective use of spatial cues. For each additional point on the Pattern Comparison test, the CRM threshold improves by ~0.61 dB.
- This supports the interpretation that processing speed plays a direct role in spatial unmasking. Participants with higher Pattern Comparison Scores demonstrated a better benefit from spatial separation.

Results

Aging worsens spatial hearing and is not compensated by processing speed

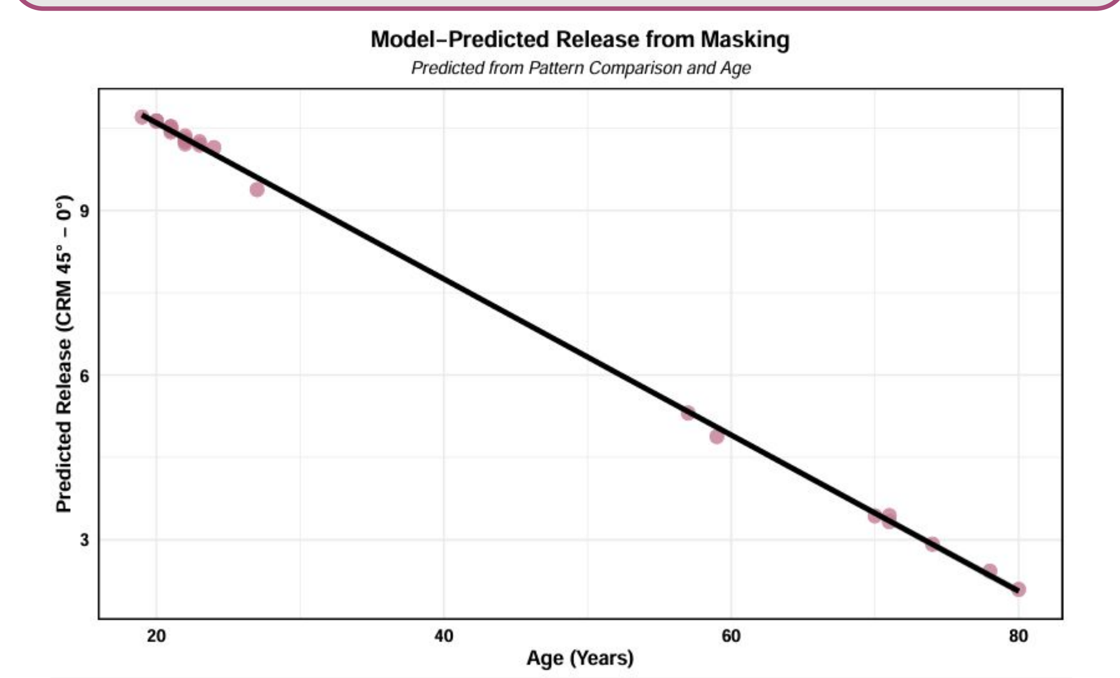


Figure 7: Predictive release mechanisms as a function of age, with measurements from pattern comparison and masking. Age is a significant predictor of SRM (p = 0.008), while Pattern Comparison shows no predictive value for SRM when accounting for age (p = 0.899). The interaction between age and Pattern Comparison was not significant (p = 0.68).

Discussion

- Previous studies have shown that older adults with hearing loss tend to have reduced spatial processing abilities. Cognitive factors play a role in spatial/speech processing, particularly in more complex environments.
- Age may act as a confounding factor in cognitive influences on speech-in-noise recognition.
- Individuals performed better on speech understanding when the target voice and background noise came from different directions, particularly at 45°.

Future Directions

- Future research should explore how cognitive training can enhance speech-in-noise understanding, particularly in older individuals.
- Further studies needed on targeted interventions for improving spatial listening abilities
- **Future research should explore exactly how hearing loss cognitive impairments lead to spatial hearing difficulties and how spatial hearing can be improved for this population. (Glyde et al., 2011).**

References

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