PS - 260

Source segregation and the effects of executive function

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Association for Research in Otolaryngology
Baltimore, MD
February 21-25, 2015

INTRODUCTION

Segregating Auditory Sources

This study investigates spatial release from masking (SRM) (i.e., the improvement, or benefit, in speech understanding when the target speech is spatially separated from the interfering speech and noise) for a large and continuous age-range of normal hearing (NH) listeners.

Hypotheses:

- Complex auditory skills, such as ability to take advantage of spatial cues (i.e. SRM), should get better with age, especially at the most challenging signal-to-noise ratios (SNRs), because both central and peripheral components of the auditory system continue to develop and become more refined throughout adolescence.
- Sentences with semantic coherence should be easier to identify than sentences without coherent content, especially in conditions with less favorable SNRs, because semantic cues help to predict inaudible portions of speech based on neighboring information.

Relationship between Executive Function & Auditory Source Segregation

The relationship between executive function (EF) and the ability to segregate auditory sources was also investigated. We know variability exists when listening to speech in noise, especially for children, but little is known about *why* this variability occurs.

Hypothesis:

- Participants who are better able to focus attention, inhibit interfering stimuli, shift attention, and process and retain complex information should benefit more from spatial separation of sources because all of these skills are important when extracting and isolating target speech in complex auditory environments.

PARTICIPANTS

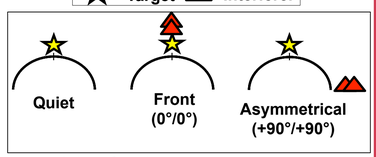
- All normal hearing (NH) listeners
- Age groups:
  7-10 yrs (n=24), 11-14 yrs (n=24),
  15-17 yrs (n=24), 18-23 yrs (n=23)

*Half of the participants in each age group listened with a noise interferer and half listened with a speech interferer

AUDITORY MEASURES

Method

Speech-in-noise task



Stimuli

- *Target*: 200 sentences (100 coherent, 100 anomalous)
  - Male speaker of standard American English (see Davis, *et al*., 2011)
- *Interferers*: Held constant at 55dB SPL (each participant tested with *either* the noise *or* the speech interferer)
  - Noise: Amplitude modulated speech-shaped noise (MSSN)
  - Speech: Sentences (2-talker interferer created by overlaying two recordings from the same female talker)
  - *Signal-to-noise ratio (SNR, dB)*: -16, -8, 0, +8

Environment/Design and Procedure

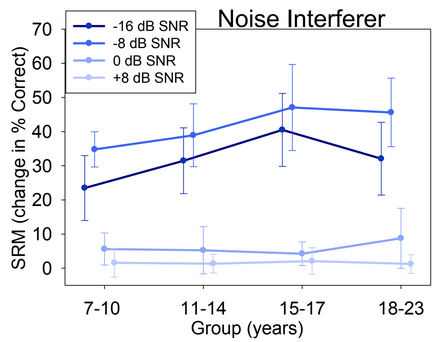
- Participants sat in the center of a loudspeaker array facing a computer monitor at 0°azimuth with all stimuli presented in free-field
- Instructions were "Listen for the man' s voice and repeat exactly what you hear." (no feedback was given)
- *Conditions:* Quiet, Front, Asymmetrical (pictured above)

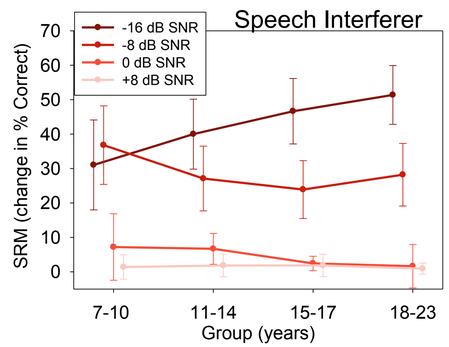
Example Stimuli

Coherent
Answer: There were bracelets and necklaces in her jewelry box
Response: There were bracelets and necklaces in her jewelry box 9/9

Anomalous
Answer: There were tweezers and novices in her listener heat
Response: There were ~~twins~~ and novices in her ~~blistering~~ heat 7/9

RESULTS: BENEFIT OF SPATIALLY SEPARATING SOURCES





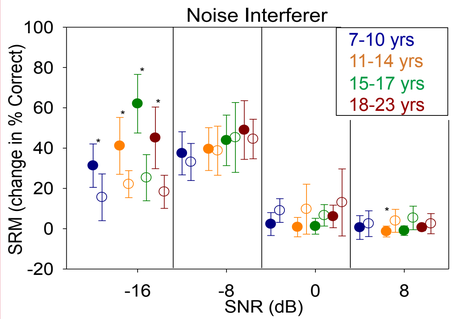
Effects of age
Significant main effect of group at **-16 dB SNR** (noise:p=0.001, speech:p<0.001); **-8 dB SNR** (noise: p=0.01, speech:p=0.019)

At unfavorable SNRs, SRM increases with age from 7-17yrs and then stabilizes.

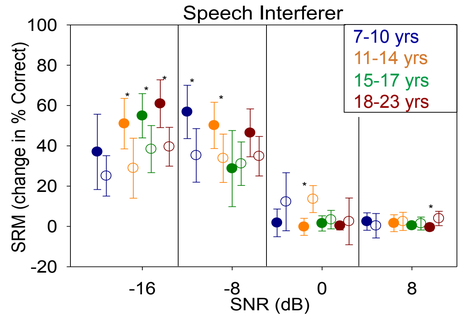
At the least favorable SNR, SRM systematically increases with age from 7-23 yrs.

Fig. 1. Mean (±SD) SRM (change in %correct between the Front and Asymmetrical conditions) are plotted, for each age group, with both the noise and the speech interferers.

RESULTS: BENEFIT OF COHERENT TARGET SPEECH



Coherent= *filled circles*
Anomalous= *open circles*

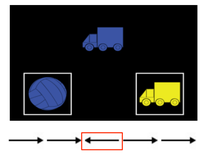


Coherent sentences aid in release from masking at unfavorable SNRs.

Fig. 2. Mean (±SD) SRM are plotted, at each SNR, for all groups for both the coherent (filled circles) and anomalous sentences (open circles). Significant differences for each group, within each SNR, between the coherent SRM and anomalous SRM *(p<0.0125)* are highlighted (*).

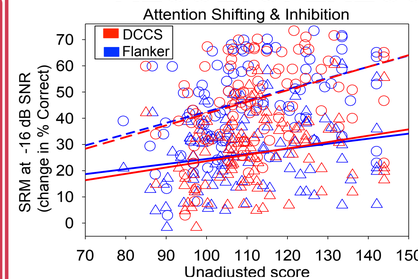
EXECUTIVE FUNCTION MEASURES

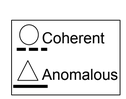
Methods

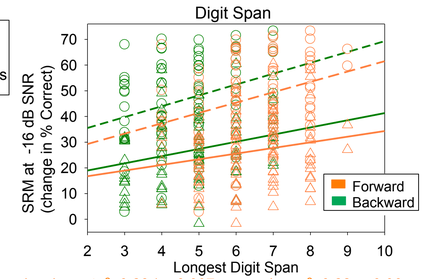


- **NIH Toolbox: Cognition** (all computer-based, www.nihtoolbox.org)
  - *Dimensional Change Card Sort (DCCS) (cognitive flexibility):* Target pictures vary along two dimensions (color, shape). Match target pictures to test pictures for either color or shape, depending on the prompt.
  - *Flanker (inhibitory control):* Indicate the direction of the middle arrow, while simultaneously inhibiting the other arrows.
    - *Unadjusted score*: Score compared to the normative sample, regardless of age or any other variable.
- **Non-computer based tests**
  - *Weschler Intelligence Scale* (Weschler, 1991) *(working and short-term memory):* Forward and Backward digit span subtests were administered to all participants in live-voice.
  - *Kaufman Brief Intelligence test, Second Edition (KBIT-2) (non-verbal intelligence quotient, IQ):* Matrices test asses ability to perceive relationships and complete visual analogies.
  - *Expressive vocabulary Test, Second Edition (EVT-2):* Participants are shown a picture and must respond with one word that is an acceptable label for the picture or, if instructed, a synonym of the picture.

RESULTS: EXECUTIVE FUNCTION AND SRM







DCCS: coherent r^2=0.34 *p=0.001, anomalous r^2=0.24 *p=0.024
Flanker: coherent r^2=0.39 *p<0.001, anomalous r^2=0.22 *p=0.035

Forward: coherent r^2=0.28 *p=0.007, anomalous r^2=0.22 p=0.06
Backward: coherent r^2=0.27 *p=0.009, anomalous r^2=0.26 *p=0.013

There were no significant findings of EF as a predictor for SRM at the -16 dB SNR level when age, expressive vocabulary and IQ were accounted for.
No relationships were found between EF and SRM for the -8, 0, +8 dB SNRs.

Fig. 3. Regression of relationship between SRM at -16 dB SNR and scores on EF measures for all groups combined. Circles (dashed line) represent the coherent sentences, and the triangles (solid line) represent the anomalous sentences.

GENERAL CONCLUSIONS

- Younger children benefited less than older children and adults from spatial separation of sources on the complex speech-in-noise task (i.e. less SRM), especially at the less favorable SNRs.
  - ***Possible reasons:*** Lack of development of optimal listening strategies & top-down processing, as well as incomplete physiological development.
- Sentences with coherence provided an additional release from masking in the most challenging listening conditions – beyond what was provided by spatially separating auditory sources.
  - ***Possible reasoning***: Listeners are better able to stream speech, and form a unified auditory object, when the target contains coherent content.
- Age, expressive vocabulary and general intelligence accounted for more variability in SRM than EF.
- **Future Directions:** Compare the results of SRM and EF in individuals with NH to clinical populations (i.e. cochlear implant users). It is particularly interesting to investigate online processing of the use of contextual cues in people who receive degraded spectral information (*see poster PS-270 MW, SM & RL*).

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ACKNOWLEDGEMENTS

We would like to thank all the families who participated, as well as the members of the Binaural Hearing and Speech Lab especially Sara Bernstein, Rachael Jocewicz, & Shelly Godar. We would also like to thank Ann Todd and Shaun Hernandez for being the voices of our stimuli. This research is supported by NIH-NIDCD Grant No. 5R01DC008365 (R. Litovsky), and in part by a core grant to the Waisman Center from the NICHD (P30 HD03352).