Binaural unmasking and executive function in older adults

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Association for Research in Otolaryngology
Baltimore, MD
2017

Introduction

There are many factors that play a role in the ability to selectively attend to target speech in noisy environments.

Aging

Many older adults report difficulty hearing speech in noisy environments, but present with audiometric thresholds within normal limits. There is some research that suggests aging may negatively impact aspects of auditory processing, even for older adults with *NH*[2]. However, little is known about auditory attention & source segregation abilities in this population.

Ability to hear speech-in-noise

Auditory Input

It is known that listening to speech in noisy environments can be particularly challenging for adults who are deaf and use *bilateral cochlear implants (BiCIs)*, compared to individuals with *normal hearing (NH)*. This is particularly true in situations in which monaural cues are limited and listeners must rely on binaural cues[1].

Executive Function

Executive function (EF) is a term used to describe an array of cognitive abilities that facilitate the organization of information for purposeful and goal-directed behavior—specific to this study are working memory, inhibition, and attention shifting. These components are thought to be necessary in order to function in multi-source auditory environments. It is known that *EF declines with age*[3]. This may influence the ability to *attend* to target speech in noise, regardless of hearing status.

Goals of the current study

- *Investigate the effects of (1)* ***aging*** *and (2)* ***degraded auditory input*** *on auditory attention and binaural unmasking.*
- *Explore the relationship between auditory attention and* ***executive function*** *for older NH adults.*

Participants

- Study was designed to compare performance between three groups:

(1) older adults with NH, (2) older adults with BiCIs, and (3) younger adults with NH.

The NH groups listened to the stimuli in two different modes: unprocessed and vocoded

- Performance of older NH adults in the current study was compared to previously published data[4] from older adults with BiCIs (n=11, 47-71 yrs) and younger adults with NH (unprocessed stimuli, n=19; vocoded stimuli, n=10, all college-aged).
- Thus far, 6 older adults with *normal hearing (NH) (ages 45 - 65 years) have been tested
  -All 6 completed the testing listening to unprocessed stimuli. Thus far, 4 have completed testing listening to vocoded stimuli.

*NH defined as air conduction thresholds ≤25 dB HL from 250 Hz through 4,000 Hz, with ≤10 dB asymmetry between the right and left ears at each frequency.

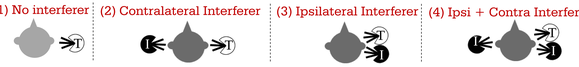
Auditory Attention & Binaural Unmasking

Stimuli:

- 5-word closed-set sentences (name, verb, number, adjective, & object)[5]
  - **Target (T)** : female talker; **Interferer (I):** male talker
  - Participants listened in all conditions with both the **unprocessed** and **vocoded** stimuli (all stimuli were presented via headphones)
  - Reference level= 70 dB SPL ; **Positive TMR:** *Interferer* level *decreased* ; **Negative TMR:** *Target* level *decreased*
    - *Lower TMR=better performance*

Conditions:

(1) No interferer | (2) Contralateral Interferer | (3) Ipsilateral Interferer | (4) Ipsi + Contra Interferer

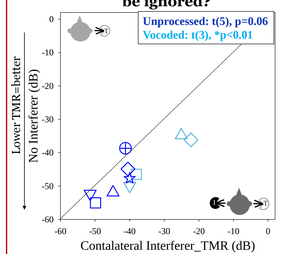


Procedure:

- Order of conditions and TMRs were randomized
  - Trials/condition: 5 words/sentence x 10 sentences/block x 2 blocks/TMR = 100 trials/condition
  - A psychometric function was created for each condition[6], TMR defined as 50% correct

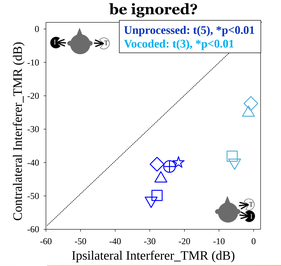
Results: Comparison between conditions for *older adults with NH*

(A) Can a contralateral interferer be ignored?



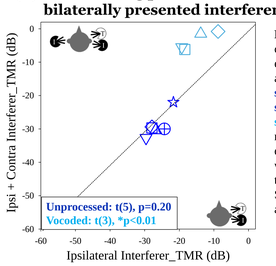
(A) When listening to vocoded stimuli, the target needs to be played significantly louder with a contralateral interferer (~10 dB), compared to when there is no interferer.

(B) Can an ipsilateral interferer be ignored?



(B) The target needs to be played significantly louder for both the unprocessed (18 dB) and vocoded stimuli (28 dB) when the stimuli are ipsilateral vs. contralateral.

(C) Is unmasking perceived with a bilaterally presented interferer?



(C) TMR improved by ~12 dB as a result of unmasking for the vocoded stimuli only.

Fig 1. Thresholds between conditions are compared for each listener (represented with a different symbol: **dark blue symbols= unprocessed stimuli**, **light blue= vocoded stimuli**). The diagonal line represents equal performance in each condition. Paired t-tests were conducted within stimuli-type between condition. Significance is indicated with an asterisks (*p<0.05).

Results: Comparison between *younger* (NH) and *older* (NH & BiCI) adults

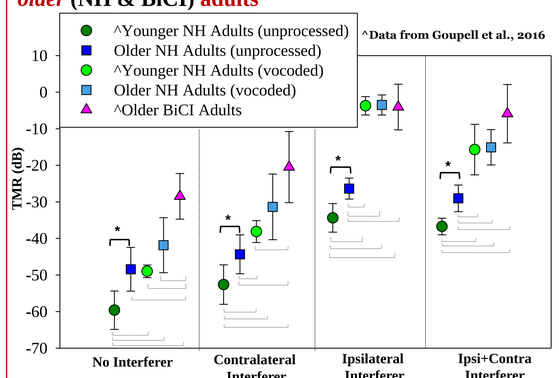


Fig 2. Mean (±SD) TMRs for each group/condition. TMRs between-group were analyzed using independent sample t-tests, with a bonferroni correction (*p<0.01). Significant differences are indicated with brackets (**bolded** brackets indicate significant comparisons of between the young and old group *within* each stimuli type (unprocessed vs. vocoded).

*Older NH adults need the level of the target to be played significantly louder (*p<0.01) than the younger NH adults in all conditions (see Fig. 2 bolded brackets) with the unprocessed stimuli. No statistically significant differences were found between the younger and older NH groups with the vocoded stimuli; however, TMRs were ~7 dB worse for the older vs. younger NH adults in the no interferer and contralateral interferer conditions.*

Results: Difference in TMR between the Ipsilateral Interferer & Ipsi + Contra Interferer conditions

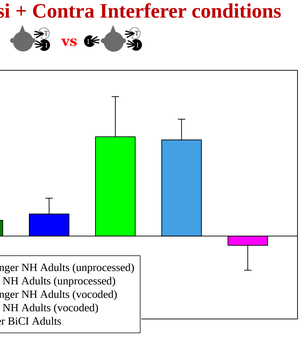


Fig 3. Difference in the mean TMRs for each group in the Monaural vs Dichotic Separation conditions. Paired samples t-tests were conducted to investigate within-group difference between the monaural and dichotic separation conditions. *Significant differences were found for the older and younger NH groups when listening to vocoded stimuli (*p<0.05)*

No unmasking was demonstrated in either group when listening to the unprocessed stimuli.

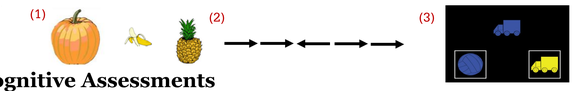
The older and younger NH adults demonstrated ~12 dB unmasking with the vocoded stimuli, unlike the age-matched adults with BiCIs.

The BiCI group did not demonstrate any unmasking with a bilaterally presented interferer (i.e. ipsi + contra interferer condition).

Measures of Executive Function

NIH Toolbox Cognition Battery (www.nihtoolbox.org)

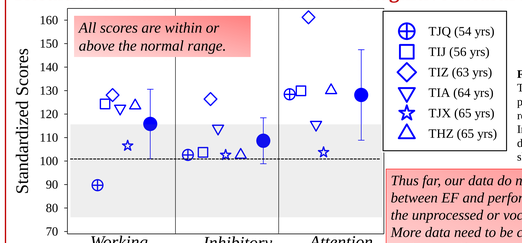
1. **Working Memory,** *List Sort Task:* Participants presented with a series of items (food, or food & animals) and instructed to verbally repeat the items in size order from smallest to largest.
2. **Inhibitory Control,** *Flanker:* Participants indicate the direction of the middle arrow while simultaneously inhibiting the other arrows.
3. **Attention Shifting,** *Dimensional Change Card Sort:* Target pictures that vary along two dimensions (color, shape) are presented. Participants match the target picture to test pictures for either color or shape, depending on the prompt.



Other Cognitive Assessments

- **Intelligence Quotient** *Kaufman Brief Intelligence Test (KBit)*

Results: Standardized scores for EF and cognitive measures for *older adults with NH.*



Mean (±SD) *brief IQ*
122.67 (8.62)

Fig 4. Standardized scores for EF measures. The dashed line represents average performance, and the shaded region represents performance within normal range. Individual participants are represented by different symbols. Group mean (±SD) are shown to the right of the individual symbols.

Thus far, our data do not show any significant correlations between EF and performance on the auditory task with either the unprocessed or vocoded stimuli, in any of the conditions. More data need to be collected before conclusions can be made regarding any relationship between EF and auditory attention in older NH adults.

Discussion

- **Aging & Degraded Auditory Input**
  - When listening to unprocessed stimuli, older NH adults performed worse than younger NH adults in all conditions (Fig. 2).
    - *This suggests that either (1) the task was more demanding for older NH adults, or (2) there may have been differences in hearing thresholds between the two groups that were not identified with the hearing test in the protocol used here.*
  - *No unmasking* was demonstrated when listening to the unprocessed stimuli for the younger[4] or older NH adults.
    - *It may be that with the unprocessed stimuli, adults with NH are able to use voice-pitch cues between the male target and female interferer (i.e. fundamental frequency of voices), providing cues that aid in separation of the two sources even when they are played ipsilaterally.*
  - Both the older and younger[4] NH adults demonstrated *unmasking* for the vocoded stimuli; however, the older BiCI adults did not demonstrate any unmasking[4].
    - *Thus far, our results suggest that it is likely other factors besides age, such as limitations of the CI devices, have a greater impact on the lack of unmasking demonstrated by older adults with BiCIs.*
- **Executive Function**
  - More data needs to be collected to make conclusions regarding the relationship between EF and auditory attention. Thus far, our participants have all performed at or above average on the EF measures which likely limited any significant correlations.

References

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This research is supported by NIH-NIDCD Grant No. R01 DC003083 (R. Litovsky), and in part by a core grant from the NIH-NIDCD (U54 HD090256 to Waisman Center).

We would like to thank all of the listeners for their participation in our experiments. We would also like to Tanvi Thakkar for her help with programming. Lastly, we would like to thank Emily Burg, Chantal van Ginkel, and Shelly Godar for their help with scheduling and data collection.

Printing courtesy of the Friends of the Waisman Center