Exploring the Relationship Between Hearing Loss & Working Memory

Sara M. Misurelli[1,2], Erica Bennett[3] & Ruth Y. Litovsky[1,2]
University of Wisconsin-Madison[1]
UW School of Medicine and Public Health, Department of Surgery-Division of Otolaryngology[2]
Henry Ford Health Systems[3]
Email: misurelli@surgery.wisc.edu

American Auditory Society 2018
Scottsdale, AZ

Abstract

Executive function (EF) constitutes multiple cognitive components thought to be involved in the regulation and control of purposeful and goal-directed behaviors. EF deficits can lead to the inability to perform everyday tasks. These deficits are exacerbated in complex auditory environments. Previous work suggests individuals with cochlear implants (CIs) perform worse on measures of EF, specifically tasks assessing working memory (WM), than individuals with normal-hearing (NH). The present study aims to understand factors likely to contribute to the gap in performance between CI and NH listeners. Participants completed the NIH-Toolbox List Sort WM Test. All individuals with CIs and half of the NH group was presented the auditory+visual stimuli; the other half of the NH group was presented visual-only stimuli. Results show that the NH auditory+visual group had the highest mean scores, indicating that auditory input provided important augmentative information for WM. These findings may impact habilitation after cochlear implantation. For example, there may be a benefit form including training of EF in therapy to enhance both auditory and neurocognitive mechanisms.

Working Memory (WM), Cochlear Implant (CI) & Speech in noise understanding

- Working memory (WM): a component of executive function that involves the conscious *storage*, *manipulation* and *integration* of information[1].
  - Deficits in WM can indicate problems processing incoming information, of which is vital for speech understanding.
- Listening to speech in multi-source auditory environments can be challenging, especially for individuals who use CIs and listen to speech through a degraded electrical signal[2-3].
  - In complex environments, individuals with CIs must work extra hard to decode and interpret a speech signal due to the degraded information that they receive through their processer. This in turn may leave *fewer available resources* for things like remembering, paying attention to, and processing of speech (i.e. aspects of WM).



Previous work suggests individuals with CIs perform worse on measures of EF than individuals with NH[4], specifically tasks assessing WM; however, there is little evidence as to why this occurs and what specific populations of CI users may be most at risk for deficits in WM.

Aims of the present study

- *To better understand factors that contribute to the gap in performance on measures of WM between individuals with CIs and with NH.*
  - *(1) Mode of presentation of stimuli*
    It is hypothesized that the mode of presentation of stimuli will impact WM, such that: (1) Individuals with NH will have the highest performance when stimuli is delivered in both an auditory + visual modality, compared to one modality alone, due to the redundancy of information, and (2) Individuals with CIs will perform lower (i.e. worse performance) on the WM task than NH participants, in the auditory + visual group, due to degraded auditory input delivered through the CI.
  - *(2) Onset of deafness*
    It is hypothesized CI users with early acoustic experience will have better WM than those with congenital hearing loss because early development of the WM system may be more like that of the NH group.

Methods

Participants:

Group	Auditory + Visual stimuli	Visual-only stimuli
Normal Hearing (NH)*	N=9	N=7
Cochlear Implant (CI)**	N=9	--------

*All individuals in the NH group passed a hearing screening indicating thresholds ≤20 dB HL at octave frequencies between 250-8000 Hz, in both ears.

**All but two individuals with CIs had congenital hearing loss.

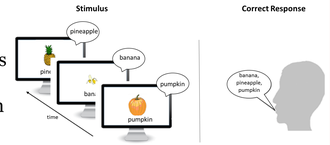
Testing Measures:

(1) Kaufman Brief Intelligence Test, Second Edition (KBIT-2)[5]

- **Non-verbal intelligence quotient (IQ)**
  - *Matrices subtest*: Assesses ability to perceive relationships & complete visual analogies.

(2) NIH Toolbox[6]

- **List Sort Working Memory Test** (Age 7+ v2.1)
  - Participants are instructed to view a series of items and verbally report the names of the items in size order from smallest to largest. The lists increase in length depending on individual performance (i.e. correct response initiates another list of longer length).
    - The first set of items consists of food *or* animals.
    - The second set of items consists of food *and* animals, and participants must to repeat the items in size order, within each category.



*All individuals with CIs, and half of the NH group, were presented stimuli via both **auditory** and **visual** cues. The other half of the NH group was presented stimuli using **only visual** cues.*

Results & Discussion

Results: List Sort Working Memory Test

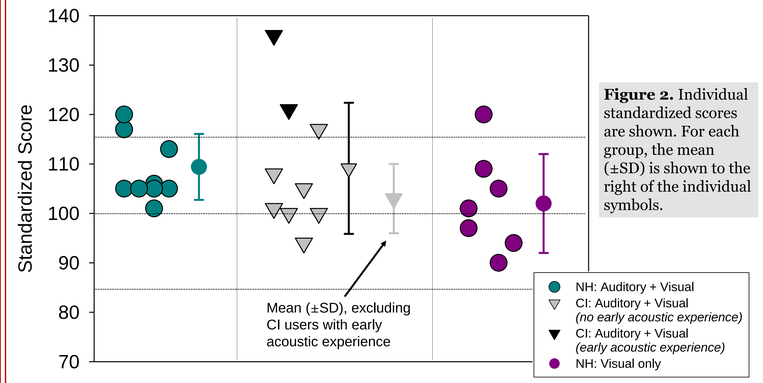


Figure 2. Individual standardized scores are shown. For each group, the mean (±SD) is shown to the right of the individual symbols.

- *The NH auditory+visual group had the highest mean scores, indicating that auditory input provided important augmentative information for in NH listeners, above what the visual signal provided.*
- *The CI group with **no early acoustic experience** had similar mean scores to the NH visual-only group, suggesting that the CI group, when presented stimuli in two modes (i.e. auditory and visual), performed similarly to the NH group, when presented stimuli in only one mode (i.e. visual).*
- *Data collection is ongoing; lack of statistically significant differences between groups is likely due to the small sample size.*

Results & Discussion

Results: Non-verbal IQ

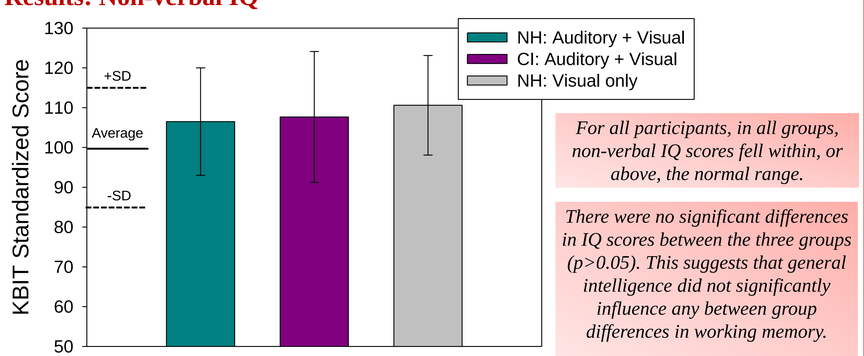


Figure 1. Each bar represents the group mean (±SD). The lines to the left of the graph indicate the range of scores that is considered to be within normal limits.

For all participants, in all groups, non-verbal IQ scores fell within, or above, the normal range.

There were no significant differences in IQ scores between the three groups ($p>0.05$). This suggests that general intelligence did not significantly influence any between group differences in working memory.

Future Directions & Clinical Implications

- Our goal is to further examine groups of CI users with both congenital and acquired hearing loss, in both modalities, in order to better understand the role of early acoustic experience in the development of the WM system.
- These findings may have clinical implications regarding aural (re)habilitation after cochlear implantation.
  - For example, there may be a benefit of including training of specific components of executive function (i.e. working memory) in everyday modalities (with both visual and auditory cues) in therapy, in order to enhance both auditory and neurocognitive mechanisms. This may be particularly helpful for certain groups of CI users.

References

(1) Baddeley, A. D., & Hitch, G. (1974). Working memory. In *Psychology of learning and motivation* (Vol. 8, pp. 47-89). Academic press.
(2) Litovsky, R. Y., Goupell, M. J., Godar, S., Grieco-Calub, T., Jones, G. L., Garadat, S. N., ... & Misurelli, S. (2012). Studies on bilateral cochlear implants at the University of Wisconsin's Binaural Hearing and Speech Laboratory. *Journal of the American Academy of Audiology*, *23*(6), 476-494.
(3) Litovsky, R. Y., Goupell, M. J., Misurelli, S. M., & Kan, A. (2017). Hearing with Cochlear Implants and Hearing Aids in Complex Auditory Scenes. In *The Auditory System at the Cocktail Party* (pp. 261-291). Springer, Cham.
(4) AuBuchon, A. M., Pisoni, D. B., & Kronenberger, W. G. (2015). Short-term and working memory impairments in early-implanted, long-term cochlear implant users are independent of audibility and speech production. *Ear and hearing*, *36*(6), 733.
(5) Kaufman, A. S., & Kaufman, N. L. (). 2004). *Kaufman brief intelligence test*. John Wiley & Sons, Inc..
(6) NIH Toolbox (Version 1.7) [Mobile application software]. Retrieved from http://itunes.apple.com

We would like to thank all of the participants for their participation in our experiments. We would also like to thank Emily Fisher (AuD student) and McKenzie Klein (SLP student) for their help with testing, and Shelly Godar for her help with administrative duties.

Printing courtesy of the Friends of the Waisman Center

This research is supported by NIH-NIDCD Grant Nos. R01DC003083 & R01DC008365 (R. Litovsky), and in part by a core grant from the NIH-NIDCD (U54 HD090256 to Waisman Center).