Executive Function Profiles of Children Who Use Cochlear Implants

Uma G. Soman, M.E.D. and Anne Marie Tarpe, Ph.D.
Department of Hearing and Speech Sciences, Vanderbilt University School of Medicine, Nashville, TN

Project Rationales

1. Children with hearing loss can develop age-appropriate language and learning skills, but there can be variability in language, academic, and social outcomes that is not fully explained by demographic and audiological factors. Emerging evidence indicates that executive function skills might influence language and learning skills in children with hearing loss (e.g. Beer, Kronenberger, & Pisoni, 2011). Executive function skills may contribute to the ability to delay in place, maintain focus, follow rules, and solve problems. They have been associated with social outcomes that is not fully explained by demographic and audiological factors. Emerging evidence indicates that executive function profiles of children who use cochlear implants different from those of age-matched peers in the general population?

2. Is there a relationship between duration of auditory deprivation and performance on measures of executive function and memory?

Methods

Participants (N=18)

- 7 - 14 year old; M = 10 yrs, 3 mos; range = 7 yrs, 10 mos - 14 yrs, 1 mos
- Pre-lingual, severe-to-profound hearing loss
- Cochlear implant users
- Duration of cochlear implant usage (M = 8 yrs, 1 mos; range = 5 yrs, 1 mos - 10 yrs, 9 mos)
- English as primary mode of communication
- Average-to-above average non-verbal intelligence (M = 104, SD = 18)
- No additional disabilities
- No neurological or psychiatric disorders
- No developmental or speech disorders
- No sensorimotor deficits
- No language impairments

Diagnostic Tools

- Developmental Neuropsychological Assessment - II (NEPSY-II)
- Comprehensive Assessment of Spoken Language (CASL)
- Lezak's Semantic (vocabulary) and Global (spatial) tests
- Response Time Index: Children (RTI-CH); M = 89, SD = 23
- Digit Span subtest
- Behavioral Rating Inventory of Executive Function (BRIEF)
- Test of Non-Verbal Intelligence (TONI-IV)

Procedure

- Completion of eligibility measure and history and physical exam
- NEPSY-II assessment
- CASL assessment
- BRIEF parent report measure
- TONI-IV assessment
- Sensorimotor Index: Children (SNI-CH)
- Digit Span subtest
- Behavioral Rating Inventory of Executive Function (BRIEF)

Results

Participants in our study had average non-verbal intelligence, and had average to low-average language proficiency. They have been associated with deficits in processing time of visual and/or verbal tasks. Thus, it is reasonable to consider whether underlying differences in speed of processing verbal and visual information contribute to differences in performance on executive function tasks.

Auditory Attention and Response Set

- Scrambled Stimuli
- Example of stimuli: red, square, rose, yellow, blue, black
- "When you hear red, touch the red circle" (non-verbal response)
- "When you hear yellow, touch the yellow circle; when you hear blue, touch the blue circle; when you hear any other word, do nothing." (non-verbal response)
- Omission errors, commission errors, inhibition errors, total errors

- When you hear red, touch the red circle; when you hear yellow, touch the yellow circle; when you hear blue, touch the blue circle; when you hear any other word, do nothing.

Inhibition

- Naming (name of shape)
- Inhibition (switch shape name)
- Inhibition (switch shape name by color)

NEPSY - II Domain

Attention Function

- Auditory Attention & Response Set (2)
- Inhibition (2)
- Word List Interference (2)

Memory & Learning

- Memory for Faces (2)
- Narrative Memory (3)

Language

- Comprehension of Instructions (1)
- Spaced Naming (2)
- Finger Tapping (2)

Sensorimotor

- Speeded Naming (2)
- Visuomotor Precision (1)
- Auditory Attention & Executive Function Tasks

Table 1: Domains and subtests on NEPSY-II that were administered.

Conclusions and Future Directions

Compared to age-matched peers in the general population, children with hearing loss in our study had unique executive function profiles. In this study, most if not all participants had difficulty with certain tasks, such as, cue recall of verbal information, immediate recall of visual information, fine motor coordination within task constraints, and verbal response within task constraints. Our study demonstrated that participants completed the tasks, but were slower and/or less accurate in their responses. Findings from previous studies suggest that auditory deprivation may be related to motor planning deficits. Thus, it is important to understand whether underlying differences in speed of processing verbal and visual information contribute to differences in performance on executive function tasks.

Auditory Attention and Executive Function Tasks

Auditory Attention and Executive Function Tasks

Figure 2: Stimulus and expected response for three Inhibition tasks. All tasks required a verbal response.

Figure 3: Performance of participants on subtests from Attention and Executive Function domain, including median score, lowest score, and highest score are displayed. Shaded area = 1SD

On the WISC-IV Digit Span task involving repeating digits backwards and forward, mean performance of participants in this study was within one standard deviation; Digit Span M = 10.3, SD = 4.5; Digit Span Forward M = 10.4, SD = 3.4; and Digit Span Backwards M = 9.1, SD = 2.5. There was wide variability in performance on this task with scores ranging from the lowest possible score to the highest possible score. These average scores of participants in this study were better than those reported in previous studies by Beer, Kronenberger, Roman and Greens (2011) and Kronenberger, Pisoni, Henning and Colson (2012). On the BRIEF, parent report measure, on average participants scored within one standard deviation in all eight domains of executive function. One-third of the participants had elevated scores (i.e., above one standard deviation) on the inhibition and monitoring scale. These findings are similar to previous findings by Beer, Kronenberger and Pisoni (2011).

Recent studies have proposed that neurotic changes caused by early auditory deprivation might influence development of domain general skills, such as, verbal, visual and motor sequence learning. Future studies could explore the impact of early auditory deprivation by comparing domain general skills of children with hearing loss of varying ages, and age- and language-matched peers. Additionally, given that normally hearing bilingual children demonstrating a “bilingual advantage” for executive function, future studies could explore development of executive function in children with hearing loss who are bilingual.

Key References


Acknowledgements

We thank Dr. Daniel Ahmed and Bruce McCarrell for their collaboration on this project. We also thank Vanderbilt Bill Wilkerson Center. Clarke Schools for Hearing and Speech, and the parents and children who participated in this study. Funding for the PI is provided by the National Consortium for Leadership in Sensory Disabilities (NLSD), H325V090001, U.S. Department of Education, OSEP.