Executive Functions in Children who are Deaf/Hard of Hearing

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What are Executive Functions?
“Air Traffic Control” analogy

1. A set of skills and abilities
   • Coordination
   • Prioritization
   • Management of incoming information
   • Holding and working with information in mind
   • Attention and distraction control
   • Being able to shift gears

2. Rooted in the Brain

3. Develops through practice and training = experience

4. Necessary for functioning

5. Develops early

Why might executive functions be affected by deafness?

- Deaf children born to hearing parents experience a lag in auditory and/or visual language access.
  - Delays in language affect development of cognitive processes
- Atypical early parent-child interactions may influence development of executive functions and social cognition/theory of mind
- Increasingly sophisticated language is required for EF development as a person matures
  - Persistent delays in language may influence EF development
- Other early social experiences that affect EF development may be atypical in deaf-hearing dyads
- Resource allocation: increased effort required to listen and comprehend language leads to reduced cognitive control (more impulsivity)
- Listening “primes” the brain for sequential processing => early period of auditory deprivation results in less efficiency in some neurocognitive processes (sequential memory, phonological awareness, for example).
Why are EFs important for children who are deaf/HOH?

Significance for development in other domains:

- **Math**: mental math, timed exercises, word problems, correcting errors.
- **Reading/Writing**: phonological awareness, sequencing sounds auditorily and visually to decode and encode words, verbal reasoning, perspective-taking, problem-solving, predicting, reflecting, etc.
- **Social competence**: regulating behavior in accordance with varying social demands; more proficient inhibitory control leads to more pro-social interactions (less competition); self-expression; empathy requires perspective-taking (inhibitory control).
- **Learning in general**: maintaining and controlling auditory and visual attention; listening/attending in different environments; following complicated directions in the classroom; planning and executing assignments in a timely manner; evaluating one’s work; problem-solving, learning and applying rules.
Heterogeneity in the population

- Deaf children of hearing parents
- Deaf children of Deaf parents
- Children who are deaf with additional disabilities
- Age of identification, age at intervention, etiology of the hearing loss, degree of hearing loss, communication mode.....
- Important to understand all of these potential confounds when evaluating research on EF in children who are deaf/HOH.
Measuring EF

Measures used in research:

- Parent report/Teacher report
  - Behavior Rating Inventory of Executive Function (BRIEF)

- Behavioral Assessment (performance on EF tasks)
  - Day-night task (inhibitory control)
  - Sorting cards based on dimensions (cognitive flexibility)
  - “Tower Test” (impulsivity)
  - Memory for designs (memory)
  - Design copy (organization)
Self-report measure of 9 domains of EF

Never a problem = 1
Sometimes a problem = 2
Often a problem = 3

“...in the last month”

Place totals in bottom left panel

Inhibitory Control

“When you see this card I want you to say day and when you see this card I want you to say night”

Gerstadt, Hong & Diamond (1994)
Cognitive flexibility

6 trials
“Let’s play the color game. If it is red it goes here, but if it is blue it goes here.”

6 trials
“Now we are going to play a different game called the shape game. If it is a bunny it goes here, but if it is a boat it goes here.”

Frye, Zelazo, & Palfai, 1995; Zelazo, 2006
Some relevant literature

- Marschark and Everhart (1999) found no differences in impulsivity between deaf children and hearing children in four age groups (age 7 through college).
- Young deaf adults of hearing parents demonstrated greater impulsivity during a continuous performance task (CPT) than a standardized sample (Parasnis, Samar, & Berent, 2003). Not found to be the case for Deaf children of Deaf parents.
- Rhine (2002) found that deaf children of hearing parents obtained higher negative ratings on the “inhibit”, “shift” and “working memory” subscales of the BRIEF.
- Rhine-Kalback (2004) found that language skills predicted performance-based measures of EF, and that EF scores on the BRIEF (parent rating) predicted social skills in children between 6 and 14 years of age.
Some relevant literature

- Remine, Care, and Brown (2008) found a significant relationship between expressive language and verbal measures of EF (20 Questions task), but no relationship between expressive language and non-verbal measures of EF (Tower Test) in a group of oral deaf teenagers. The deaf children in this study used similar problem-solving strategies to their peers with normal hearing.

- In an earlier study, Marschark and Everhart (1999) found that deaf children using sign language did not use similar problem solving strategies to their typically hearing peers on a 20 Questions Task. In their study, deaf students asked more questions rather than use a “constraint-seeking” strategy.

- Hauser, Lukomski, and Isquith (2007) found no differences on the BRIEF between deaf college students and hearing college students. Deaf-of-deaf college students had better ratings than deaf-of-hearing students, although none of the scores for the deaf students were in the clinical range.
Executive functions in children who are deaf with cochlear implants

- Working memory and inhibitory control have been shown by some to be poorer in preschool and school age children who are deaf and use cochlear implants (Beer, Pisoni, and Kronenberger, 2011; Burkholder & Pisoni, 2006; Pisoni, Conway, Kronenberger, Henning, & Anaya, 2010; Pisoni, Kronenberger, Henning, Colson, 2012).

- Pisoni, Kronenberger, Roman and Geers (2011) found that working memory and verbal rehearsal speed in elementary school were correlated with spoken language outcomes in high school for children with cochlear implants.
Executive functions in children who are deaf with cochlear implants

- Figueras, B., Edwards, L., & Langdon, D. (2008) found a correlation between language ability and EF (inhibition, impulse control and working memory) in deaf children with and without cochlear implants. The conclusion of the author was that “deaf children’s deficits in EF are not a consequence of deafness, but are linked to delayed language acquisition.”

- Inhibition: Children who are deaf need more time to inhibit the dominant cognitive response (say “day” when you see the moon, say “night” when you see the sun).

- Impulsivity: related to a child’s ability to use “self talk” to control and also monitor motor behavior

- Working memory: goal-setting/executing certain tasks requires storing a verbal plan in working memory.
Kids with CIs

Recent research from Indiana University School of Medicine (used with permission)
Organization in preschoolers with CIS

The CI sample did not differ from norms on ability or parent-report measures of visual organization.

Note: All norm-based scores were converted to scaled scores for purposes of consistency on graph. SD is 3.7 for VMI and 2.1 for BRIEF-PO. Results were not significantly different from the norm mean of 10 (p>0.40).
Attention-Concentration-Inhibition in Preschoolers with CIs

The CI sample had poorer attention-concentration scores than norms on both ability and parent-report measures.

Note: BRIEF T-score converted to scaled score for purposes of consistency on graph. SD is 2.2 for Leiter-AS and 3.0 for BRIEF-I. $t(11)=3.00, p=0.013$ and $2.59, p<0.025$ for Leiter-AS and BRIEF-I, respectively, compared to norm mean of 10.
The CI sample had poorer parent-report working memory scores than norms but did not differ from norms on a measure of memory for visual designs.

Note: BRIEF T-score converted to scaled score for purposes of consistency on graph. SD is 3.2 for NEPSY-MD and 3.1 for BRIEF-WM. t(11)=3.01, p=0.012 for BRIEF-WM compared to norm mean of 10.
Children with more problems related to WM had poorer speech perception but only in difficult listening situations

Beer et al, (2011)
Children with more problems related to WM had poorer language but not vocabulary

*Beer et al, (2011)*
What does the research tell us?

- Some but not all children who are deaf/HOH have difficulties with EF.
- Children who are deaf/HOH have difficulties in some but not all areas of EF.
- We see a pattern of weaknesses in inhibitory control and working memory for children who are deaf and who have hearing parents with or without cochlear implants. Weaknesses are found both in parent report and behavioral measures.
- Difficulties start as early as preschool but have been shown in high school students and adults who are deaf.
- Problems with working memory were found to be related to speech perception in noise and general language ability in deaf children with CIs.
What does the research tell us?

- Early deficits in working memory are associated with later language skills and literacy outcomes in children who are deaf/HOH.
- Deaf children with deaf parents demonstrated age appropriate EF on behavioral assessments and parent report (BRIEF). (Hauser, et al., 2007).
- Deaf teenagers who use sign language demonstrated poorer higher-level problem-solving skills than oral teenagers.
- Language ability appears to be correlated with EF in children who are deaf/HOH.
Educational Implications

- As EF develops, skills need to be “exercised.”
  - Tasks/activities that are novel and require rapid performance rather than overly familiar, simple routines (Gioia, Isquith & Guy, 2001)
  - Low-demand school tasks may not facilitate EF development
    - Not enough to practice easy tasks, the executive system needs to be challenged to improve

- Regulating visual attention is important for kids who are deaf regardless of communication mode (attention control and regulation = EF; important for incidental learning and understanding mental states of others).
  - Get kids’ attention before signing/talking
  - Use appropriate visual orientation strategies
    - Hearing/untrained teachers have been found to use confusing visual orientation strategies (Mather, 1989)
Educational Implications

- Hearing teachers have been found to dominate discourse and initiate more than deaf teachers when interacting with deaf students.

- Wood and Kingsmill (1991) found that hearing teachers ask closed-ended questions more frequently than deaf teachers => control discourse too much:
  - Lower grammatical input to deaf students by hearing teachers
  - Less assertive behavior by deaf students (comprehension monitoring, asking for repetition/clarification).

- Fewer turns between hearing teachers and deaf students compared to deaf teachers and deaf students (Erting, 1980).
Strategies for children who are deaf/HOH
Toddlers

- Reinforce mental state and cognitive vocabulary
- Be explicit about your, the child’s and others’ feelings and thoughts
- Draw attention to the conversations of others (indirect modeling; “did you notice/hear what Nora said?” “what does she think?”)
- Guessing games
  - “I hear an animal…what do you think it is?”
  - “I see wheels; what could it be?”
  - “I feel something round; can you think of something round?”
- Model prediction
  - “Uh-oh! What’s going to happen?”
- Use experience books to talk about the past
  - “do you remember what happened when we went to the zoo?”
- Early development of extended turns (monitoring and coordinating conversation)
Preschoolers

- Talk about emotions and mental states (your own and others)
- Externalize self-talk
- Role play emotional events (so child can see how an event made you feel)
- Listen to and give hints that include less concrete information
  - “I’m thinking of a vehicle that lots of kids can ride in”
- Make predictions while reading
- Hypothesize
  - “why do you think that happened?”
- Target syntax: “she thought that it was X, but really it was Y.”
- Ask opened-ended questions, not just closed-ended questions: ask, “what do you think?” rather then give the answer
Elementary School

- Externalize self-talk
- Help with empathy “Imagine what that might feel like…”
- Avoid information overload and reduce distraction (attention)
- Think back and reminisce (“remember how that felt” “remember how we solved that problem.”)
- Plan and prepare for upcoming events/social interactions

Specific Activities:
- Persuade (Convince the teacher to have a homework-free night)
- Write your own captions or titles (What would he say? What do you think happened? What would be a good title for this story? Why?)
- Write alternative endings to stories
- Brainstorm
- Come up with alternative solutions to problems
- Target advanced syntax
Language activities with a working memory payoff

Instead of asking: “what’s this?”
Say this: “It’s black and white and starts with an ‘s’”

Instead of saying this: “say this…”
Say this: “combine these two sentences into one, but don’t say the word ‘and’: ‘the cat is big’ ‘the cat is on the chair’”

Instead of saying this: “point to ‘she brushed her teeth before she got dressed.’”
Say this: “put these two sentences together using the word ‘before.’”
Language activities with an inhibitory control payoff

Instead of asking: “find X?”
Say this: “find something that’s not X.”

Instead of saying this: “what can you use to cut?”
Ask this: “Why can’t you use this to cut?”

Instead of saying this: “touch your eyes and then touch your ears”
Say this: “touch a body part other than/instead of your eyes or ears.”
Building Response Inhibition

1. Always assume that the youngest children have very little impulse control
2. Help child learn to delay gratification by using formal waiting periods for things s/he wants to do or have (make it visual: “Time Timer”)
3. Prepare child for situations that require impulse control by reviewing them in advance (“what is the rule when we go to the store?”)
4. Practice response inhibition by role-playing
6. Cue child before s/he enters a situation that calls for a specific behavior being targeted and then reward when s/he exhibits self-control
Building Working Memory

1. Make sure you have the child’s attention before telling the child something you want him/her to remember
2. Keep external distractions to a minimum
3. Have child repeat back to you what you just said so you know s/he has heard you
4. Rehearse with the child what you expect him/her to remember
5. Help child think about ways to remember something important
6. Consider using a reward system for remembering key information.
Cultivating Meta-cognitive Skills

1. Provide explicit feedback for key elements of task performance (“I like the way you put every single block back in the box.”)
2. Teach child to evaluate his/her own performance on a task (“How do you know that is quality work?” “You wrote a really good sentence, but your words run together a little bit. You might try…”).
3. Have child identify what finished looks like (“how will you know when your room is clean?” “Visualize what you need to look like before you leave the house for school”)
4. Teach a set of questions children can ask themselves when confronted with problem situations (“What is the problem I need to solve?” “What is my plan?” “Am I following my plan?” “How did I do?”)
5. Play guessing games to teach the child how to read facial and other non-verbal cues.
6. Help children to recognize tone of voice and how it changes the meaning of what is being said.
7. Talk about the clues to someone feelings that can be spotted even when the person is trying to hide his/her feelings.
8. Ask child to identify how his/her actions might make someone feel.
References


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References


