Assessment and Intervention of Working Memory in Students who are Deaf or Hard of Hearing

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Learning Outcomes

1. Compare and contrast between working memory and short-term memory.
2. Discuss working memory, language and literacy skills and their relationship in students who are DHH.
3. Explain the efficacy of Cogmed Working Memory Training (CWMT) program in improving WM in students who are DHH.

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Working Memory

- Working memory (WM) involves an active system **where visual or auditory (verbal)** information is held in mind, internalized, assembled, manipulated or transformed and then recalled or used in its new format (Baddeley, 2000; Cowan, 2014).

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Working Memory versus Short-term Memory

Short-term memory is a passive process. Examples include remembering what was just heard or repeating a series of numbers (e.g., 4-6-9-8) that was just heard.

Working memory is an active process that involves manipulating information held in short-term memory. Examples include following directions, writing recipes or planning a multi-step solution to a problem.

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Working Memory

WM is related to attention, executive functions, language skills, and reading comprehension (e.g., Bigorra, et al., 2015; Peng, et al., 2018; Delage & Frauenfelder, 2020).

WM is also shown to be a good predictor of academic success (Gathercole, et al., 2003; Maehler & Schuchardt, 2016).

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Working Memory in Children who are Deaf or Hard of Hearing (DHH)

Children who are DHH demonstrate difficulties with WM (e.g., Dawson et al., 2002; Bharadwaj et al., 2015).

WM deficits in children who are DHH are positively correlated with growth in vocabulary, language comprehension and reading skills (e.g., Kronenberger et al, 2013).

While there is limited data, preliminary studies have shown that cognitive interventions can improve working memory in children who are DHH (e.g., Kronenberger et al., 2011).

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Objectives of the Assessment Study

The proposed study aims to

1. Examine WM, language and literacy skills in students who are DHH and use spoken language as one of the primary modes of communication
2. Assess the relationship between working memory and language and literacy variables in students who are DHH.

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Assessment Study

Participants

Sample size: Twenty-two children (14 girls and 8 boys) who are DHH and in general education with supports

Grades and Ages: K-8 | 6-14 years

Hearing profile: All but one child had bilateral moderate-profound hearing loss.

Hearing Technologies: BAHA, hearing aids, cochlear implants or bimodal technology.

Communication mode/s: All children used spoken language as a primary mode of communication, with some using sign support.

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Assessment Study

- 13 Subtests
- 4 Standardized, Norm-referenced Instruments
  - Woodcock Johnson IV Test of Cognitive Abilities
  - Woodcock Johnson IV Test of Achievement
  - Wechsler's Intelligence Scale for Children (WISC-V)
  - Clinical Evaluation of Language Fundamentals (CELF-5)
- 1.5 to 2 hours of testing time |over 2 sessions

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Assessment Study

- **Assent**
- **Ling 6 Six Sound Test**
- **Trained interpreters**
- **Well-lit room and quiet room**
- **Multiple testing sessions to prevent fatigue**

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Assessment Study

Testing-related Accommodations
Repeating trial items
Extra time to process instructions
Speech reading cues
Accepting signed responses for certain subtests
Use of Interpreters
Extra time to respond
Breaks between subtests
Use of FM systems

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Assessment Study

Cognitive measures

- Number Series
- Matrix Reasoning
- Verbal Attention
- Digit Span
- Spatial Span
- Auditory-Visual Learning

Reading measures

- Word Attack
- Passage Comprehension

Language measures

- Oral Vocabulary
- Formulated Sentences
- Understanding Spoken Paragraphs
- Following Directions
- Recalling Sentences

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Assessment Study - Results

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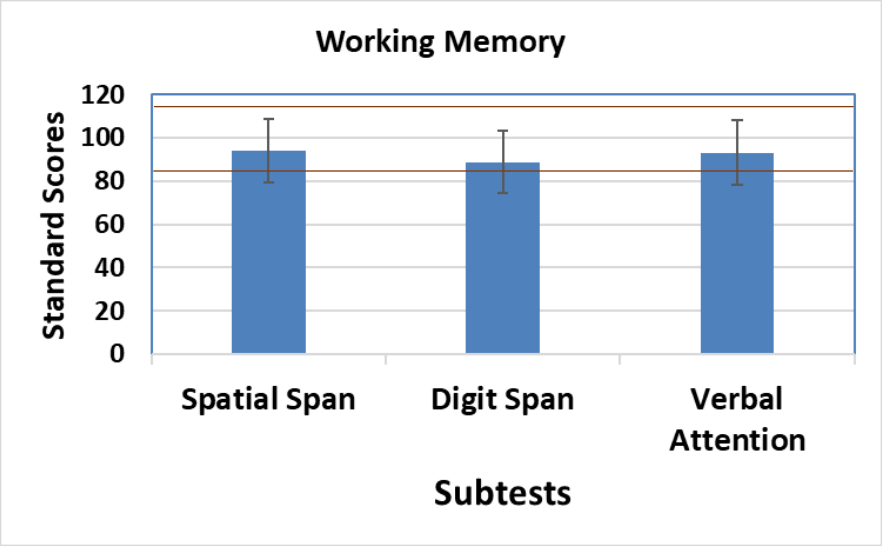

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Assessment Study - Results

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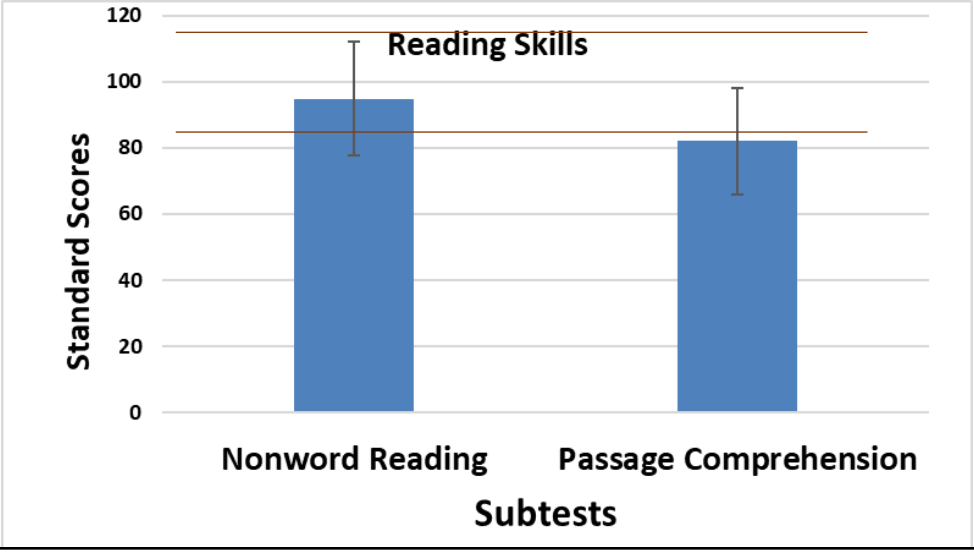

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Assessment Study Results

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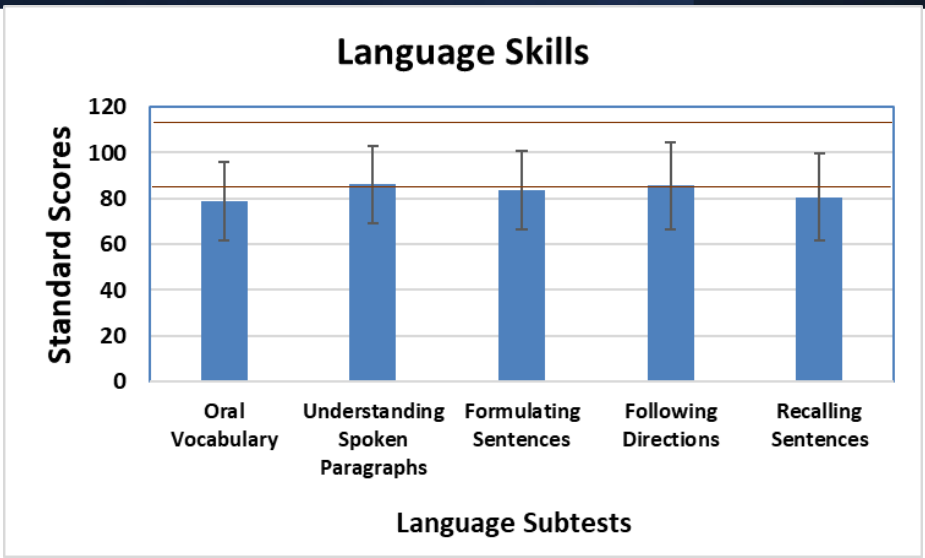

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Assessment Study Results

- Correlation analyses showed that the Digit span subtest (verbal working memory) scores were significantly ($p < 0.05$) correlated with the following language and reading measures:
- Recalling sentences (r= 0.53)
- Following directions (r= 0.45)
- Formulated sentences (r= 0. 51)
- Oral Vocabulary (r= 0.45)
- Word attack (r= 0.68)
- Passage comprehension (r= 0.43)

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Assessment Study Results

- Correlation analyses showed that Verbal Attention (verbal working memory) scores were significantly ($p < 0.05$) correlated with the following language and reading measures:
- Recalling sentences (r= 0.47)
- Following directions (r= 0.46)
- Formulated sentences (r= 0. 49)
- Oral Vocabulary (r= 0.65)
- Word attack (r= 0.69)
- Passage comprehension (r= 0.47)

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Summary and Conclusions

- Nearly 40% of students showed below average working memory as compared to normative data
- Approximately 59% of students demonstrated below average performance in following directions and recalling sentences subtests as compared to normative data
- Most children showed below average performance on oral vocabulary, formulated sentences, understanding spoken paragraphs and reading comprehension as compared to normative data.
- More importantly, verbal working memory measures were found to have moderate, positive correlations with language and reading measures.
- Therefore, an intervention study was conducted to determine if improvements in working memory would transfer to language and reading.

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Objectives of the Intervention Study

- The study aimed to
  - Investigate the efficacy of Cogmed Working Memory Training (CWMT) program in improving WM in students who are DHH.
  - Assess whether training in working memory transfers to untrained language tasks

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Rationale for the Cogmed Intervention Study

- The premise of CWMT is that repetitive mental exercise results in improved cognitive functioning (Schiller et al., 2019).
- Currently, there is only one published pilot study on the efficacy of CWMT program in improving **WM in children who are DHH** (Kronenberger et al., 2011).
- While preliminary findings suggested that CWMT is beneficial in improving WM in children who are DHH; the study did not examine whether CWMT program improves untrained language tasks that are important for academic success.

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Cogmed Working Memory Training Program

The program is designed to be administered 3–5 days per week for short sessions.

Cogmed JM: For ages 4–6, with sessions that are 10–15 minutes long

Cogmed RM: For ages 7 and up, with sessions that are 30–45 minutes long

Cogmed QM: For ages 18 and up, with sessions that are 30–45 minutes long

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Cogmed Working Memory Training Program

- Videogame-like exercises that are designed to target visual working memory.
- Exercises are adaptive in nature.

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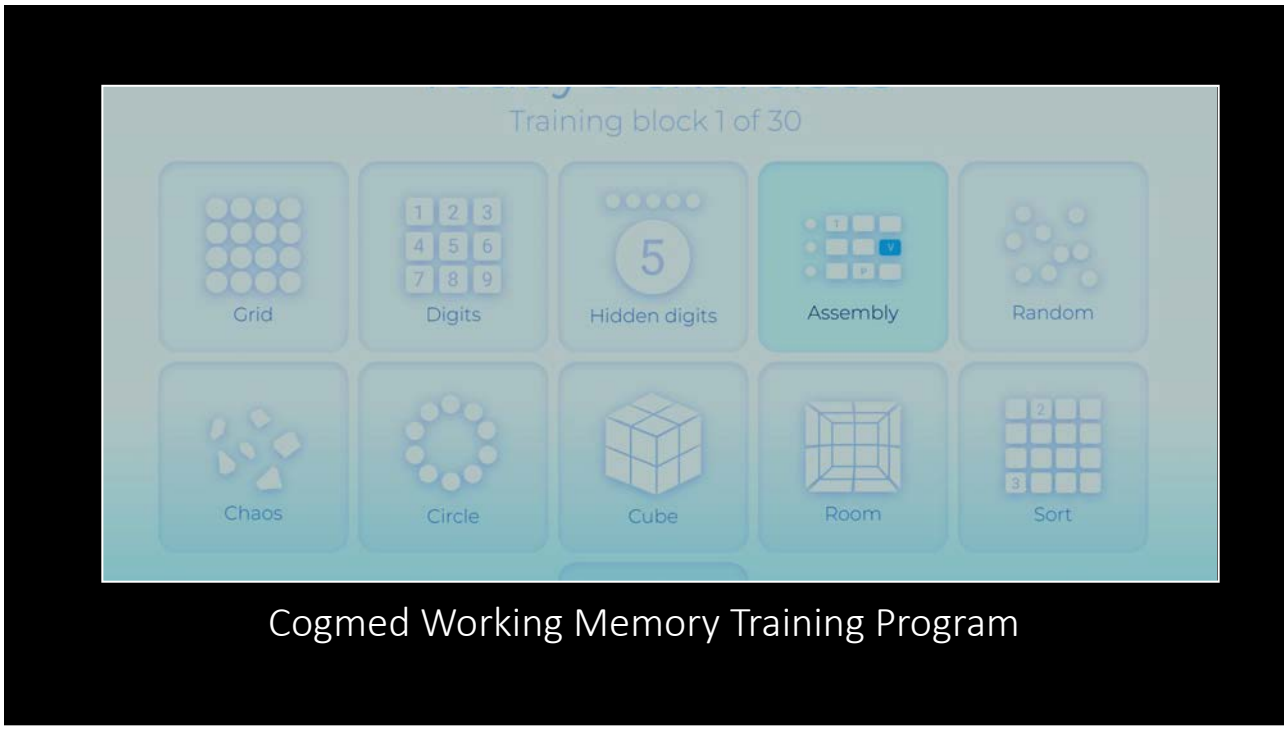

Cogmed Working Memory Training Program

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INSERT VIDEO

Cogmed Working Memory Training Program

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Cogmed Intervention Study

Current Study:

- Intervention was conducted during school hours
- Around 2-3 times / week for 15-25 mins
- A total of 40 sessions
- Standard program – includes letters, numbers and advanced sequencing

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Intervention Study

Participants

Sample size: Eleven children (7 girls and 4 boys)

Grades and Ages: K-5 | 6-12 years;

Hearing profile: All but one child had bilateral moderate-profound hearing loss.

Hearing Technologies: BAHA, hearing aids, cochlear implants or bimodal technology.

Communication mode/s: All children used spoken language as a primary mode of communication, with some using sign support.

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Intervention Study

- Teacher training was completed prior to the onset of the study
- Student training was also completed using a demo program
- A separate profile and log in credentials were created for each child
- Teachers monitored the students during the log in process and ensured that the block was completed
- Students received encouragement and redirection during the training to complete the tasks (e.g., sticker chart)
- Students received a gift card at the end of the study

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Intervention Study

Treatment Compliance:

- 7 participants completed all 40 sessions
- 2 participants completed 39 sessions
- 1 participant completed 38 sessions
- 1 participant completed 36 sessions

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Intervention Study - Results

Average % of intervention session completed	Average Time spent per session	Average Blocks / week	Average Improvement index
98.18%	18.72 mins	2.27	15

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Intervention Study - Results

Cogmed provides indices of working memory

- **Start Index**
  - A number created based on the results of the first three blocks of training. This number is an indication of the underlying working memory capacity at the start of the program.
- **The Max Index**
  - A weighted average of the four highest performing trials that the Trainee has completed at any time so far during the program
- **Improvement index**
  - The difference between start index and max index and is calculated as percentage.

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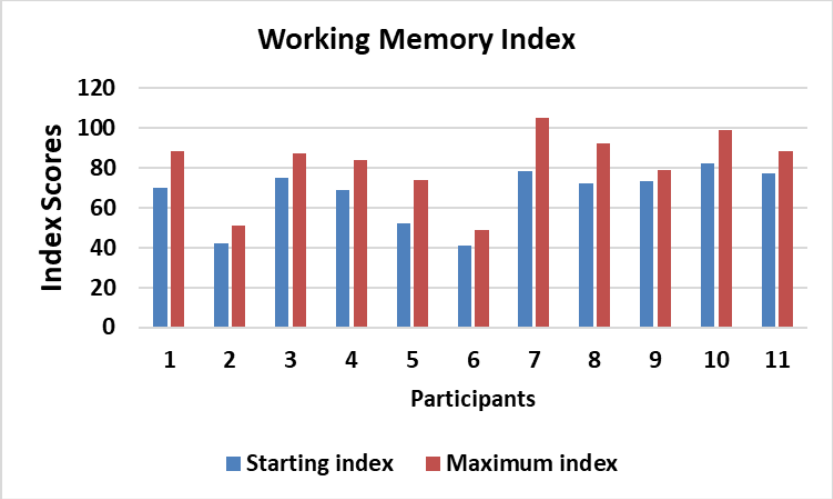
Intervention Study Results



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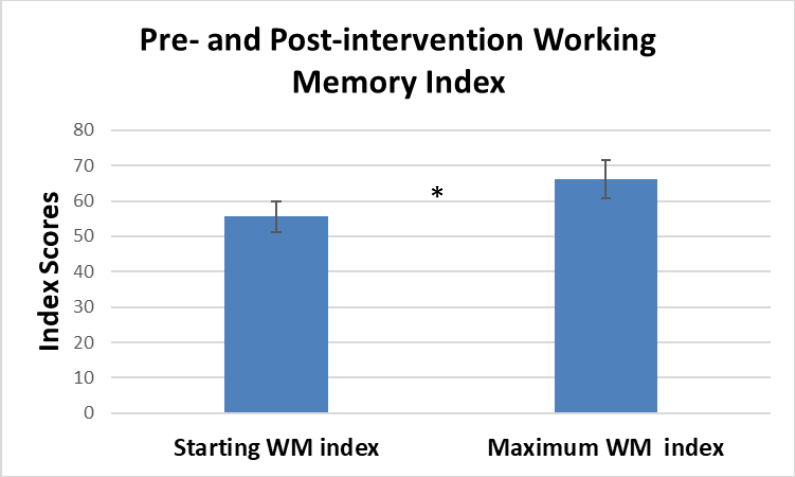
Intervention Study Results



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(t(10) = 7.65; p< 0.0001; d= 2.31)

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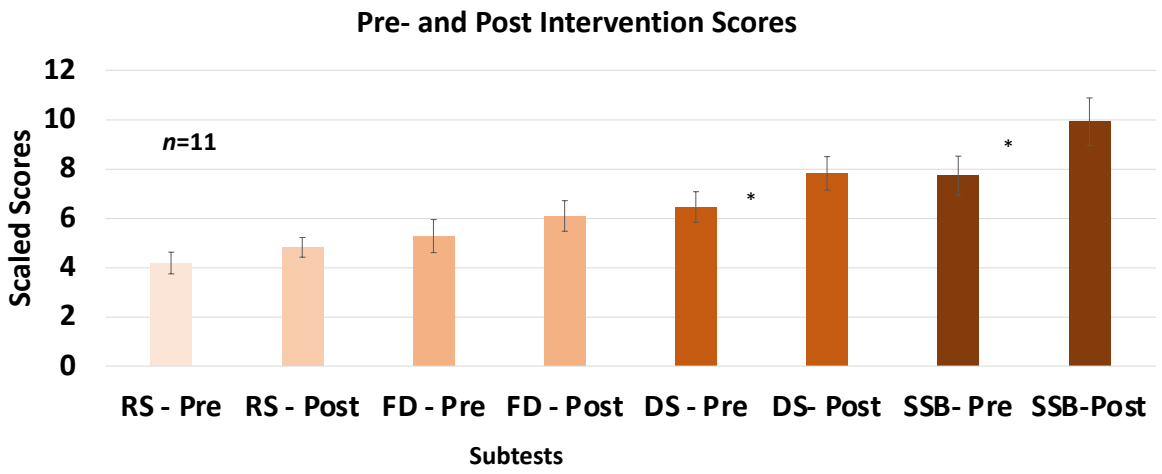
Pre- and Post-intervention Measures



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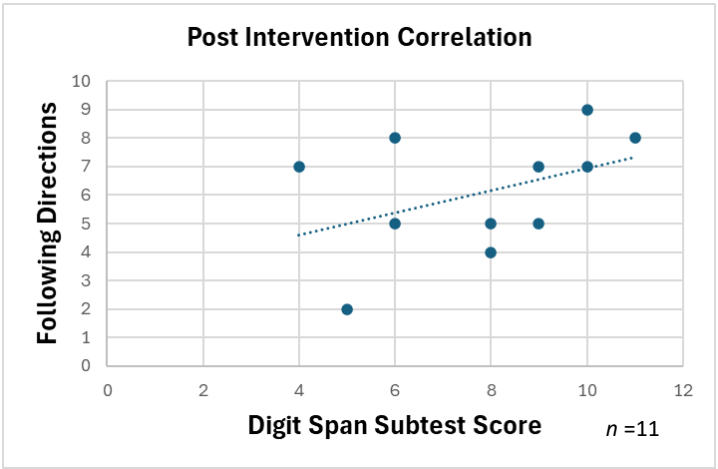
Intervention Study Results



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Summary and Conclusions

- All 11 children who participated in the Cogmed intervention demonstrated improvements in working memory index.
- As a group, students demonstrated significant improvements in working memory index (within Cogmed) and in post intervention Digit Span measures.
- The post intervention improvement in Digit span (working memory measure) was positively correlated to students' performance in following directions subtests.
- Preliminary data suggest that CWMT program leads to improvements in trained tasks (i.e. working memory).

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Limitations of the Study & Future Directions

The limitation of the study include:

- Small sample size
- Post-intervention assessment data collected for a small subset of measures
- Post-intervention assessment data collected within 2-3 weeks

Future studies should:

- Examine the relationship between visual and auditory working memory on a variety of language and literacy variables
- Investigate the long-term efficacy of CMWT on untrained language and literacy measures in a large group of students who are DHH.

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Thank you for your attention

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