Temporal Sequence Processing in Deaf Children: Cross-Sectional Data

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Abstract/Background

- Cochlear implantation is increasingly becoming the standard-of-care for children born with significant hearing loss. Despite improved surgical techniques, enhanced technology, and earlier implantation ages, significant variability remains in spoken language outcomes
- One body of research has looked at how neurocognitive functions may mediate spoken language acquisition post-implant: working memory [1], executive function [2], sequence learning [3]
- Auditory scaffolding hypothesis [4] proposes that lack of audition has negative impact on domain general temporal processing abilities; supported by data from deaf children who receive CIs [e.g. 3, 5]
- *Alternative explanation: language deprivation has a greater impact than does auditory deprivation*
- Here we report data from the 1st wave of a longitudinal study of deaf children designed to compare auditory and language deprivation models
  - Four visual temporal tasks (RSVP, continuous performance, n-back, Simon)
  - Three groups (hearing, mild-moderate deafness, severe-profound deafness)

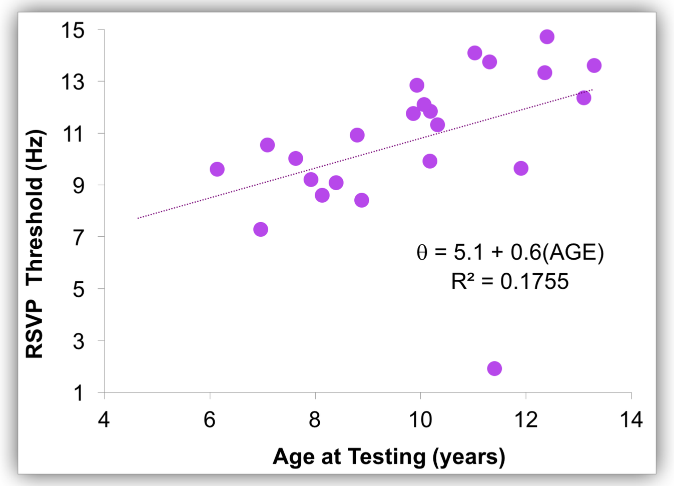
PILOT: DEVELOPMENTAL SENSITIVITY

Participants

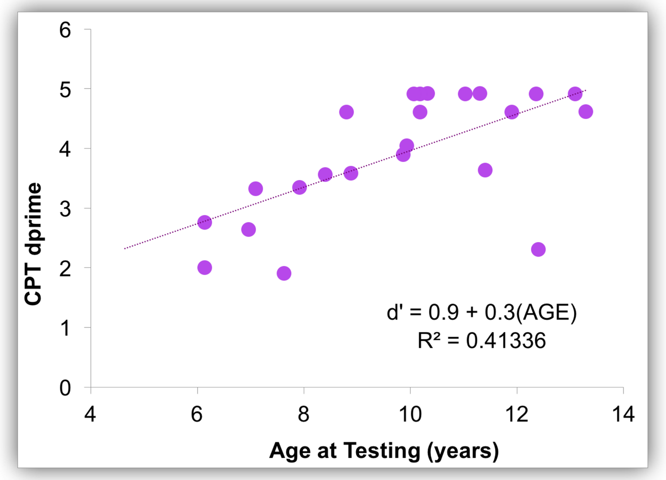
- Children with no diagnosed hearing loss (N = 24) were recruited from the Rochester NY community via Facebook announcements
- Mean age: 9;9 (6;2 – 13;4)
- 14 boys and 10 girls

Results

RSVP

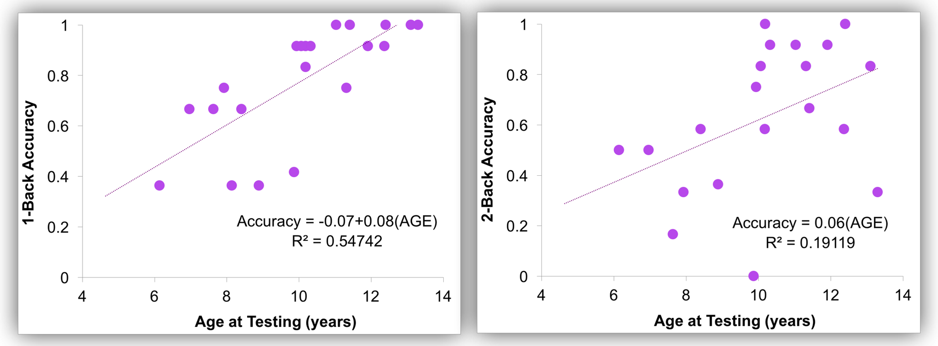


Continuous Performance



Results contd.

N-back



- For these three tasks, better performance was positively correlated with age (all $p < .05$)
- Evidence of asymptotic performance around 10-12 years of age

Conclusions

- Selected tasks are sensitive to age-related changes in performance in the target age range (6-13 years)
- Tasks need to be made slightly more difficult to avoid ceiling effects

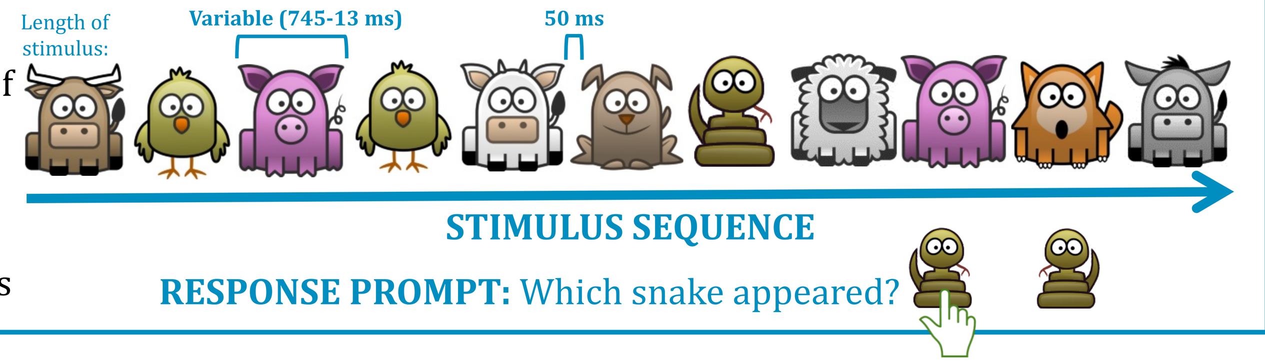
Measures of Temporal Processing

Our studies use four measures of attention, presented on a touchscreen tablet (GETAC F110) running the stimulus presentation programs *Paradigm* (for RSVP, CPT, and N-back) and *E-Prime* (for Simon).

Rapid Serial Visual Presentation

Goal: In a sequence of animals, identify if the **SNAKE** is pointing left or right. Speed of presentation is determined by a staircase procedure: 1.3 to 15.8 Hz.

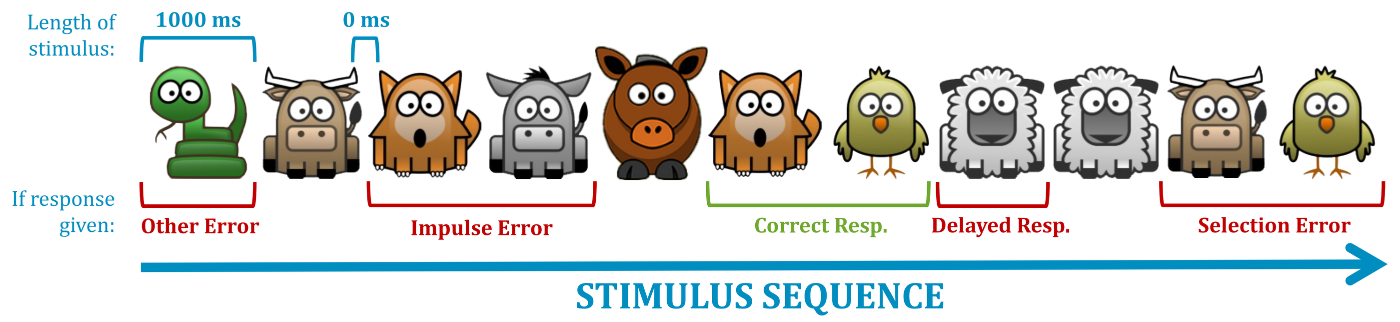
Measures: Ability to temporally segment a rapid stream of stimuli into discrete objects



Continuous Performance Task

Goal: In a sequence of 540 animals, respond whenever a **CHICK** appears after a **FOX**.

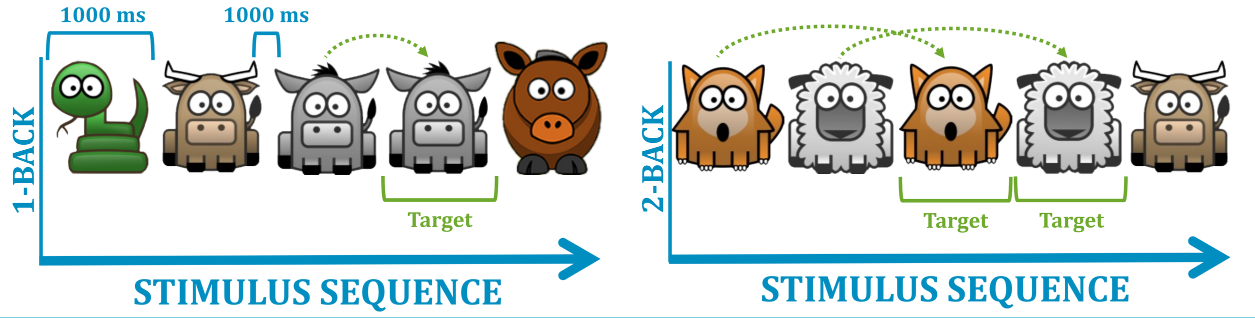
Measures: Ability to sustain attention over time and maintain a goal set



N-Back Working Memory

Goal: Respond whenever two animals appear **CONSECUTIVELY** (1-back) or with **ONE ANIMAL IN BETWEEN** (2-back).

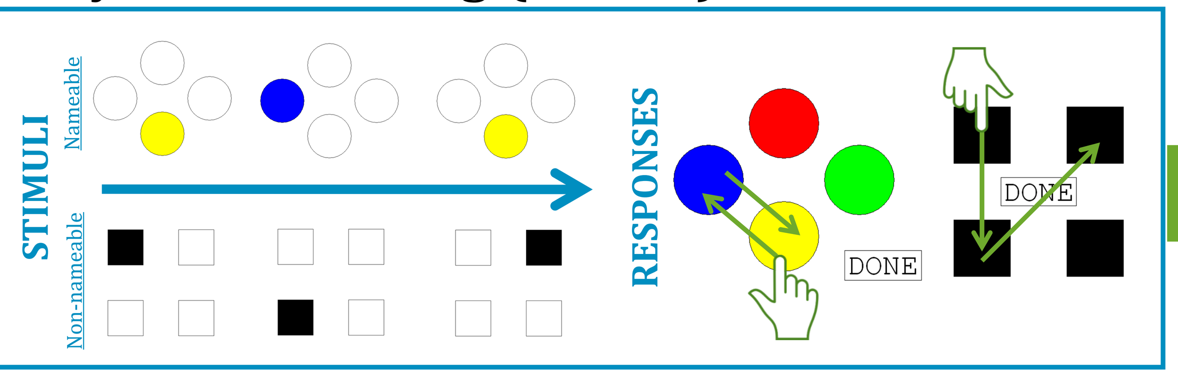
Measures: Ability to retain and continually update temporal order of items in working memory



Sequence Memory and Learning (Simon)

Goal: Follow the sequence shown. There are two variations: nameable (color) or non-nameable. Sequences vary in length: either a fixed sequence, or a randomized sequence dictated by an internal grammar.

Measures: Sequential processing ability: memory (fixed) and pattern learning (random).



Language Measures

Our longitudinal study on deaf children also measures multimodal language skills, to assess their impact on development of temporal sequence processing ability:

OWLS-II Listening Comprehension Subscale

ASL Receptive Skills Test

1st WAVE: DEAF CHILDREN

Participants

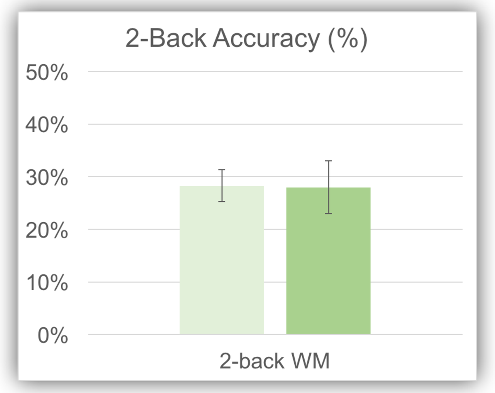
- Deaf children (N = 30) recruited from four deaf schools
- Part of an ongoing longitudinal study in which 150 deaf children's language and attention development will be measured over three years
- Tested at their schools or homes in two separate sessions: first, attention tests, then language tests
- Instructions were given in American Sign Language
- Approved by IRB at RIT/NTID (informed written consent from parents, and assent from children)

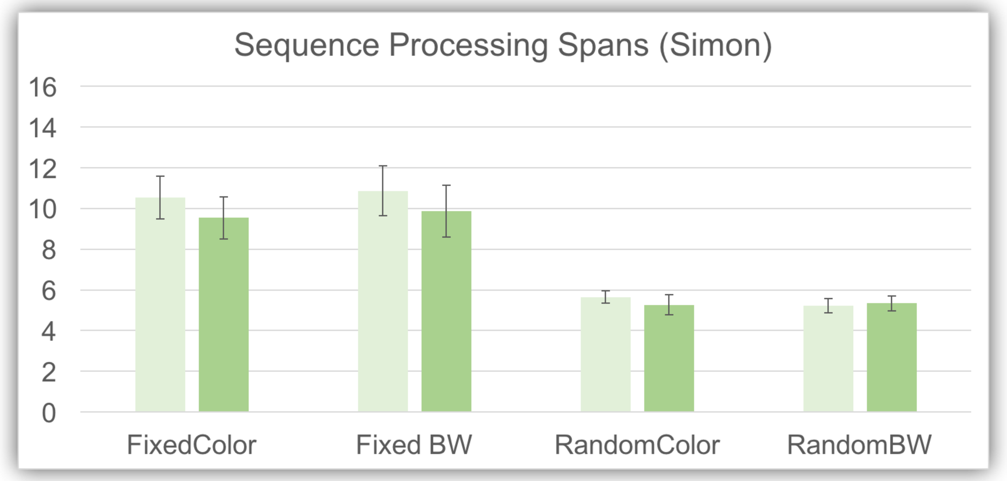
	Mild-to-Moderate HL	Severe-to-Profound HL
N	15	15
PTA HL (range)*	47dB (12-72dB)	95dB (73-110dB)
Age (range)	10;4 (7;7 – 11;9)	9;7 (7;4 – 10;10)
Boys:Girls	6:9	9:6
OWLS-LC (raw)*	37 (1-102)	8 (0-26)
OWLS-LC (std)*	57 (40-105)	40 (40-40)
ASL-RST (raw)	33 (27-37)	33 (26-37))
ASL-RST (std)	106 (101-110)	108 (101-111)

* $P < .05$

Results

- Longitudinal study will use multilevel models for change to determine relative impact of audiological and language-related measures on growth trajectories across tasks
- Here, we split deaf children into two groups on the basis of median reported PTA HL in better ear
  - Auditory-based hypotheses would predict worse performance in HIGH hearing loss group (also group with lowest listening comprehension scores on OWLS-II)
  - Language-based hypotheses would predict no group differences (both groups have age-appropriate ASL skills as measured by ASL-RST)





PTA HL 12-72 dB
OWLS-II LC mean std score = 57
ASL-RST mean std score = 106

PTA HL 73-110 dB
OWLS-II LC mean std score = 40 (minimum)
ASL-RST mean std score = 108

Conclusions

- Hearing level appears to have little-or-no impact on temporal task performance
- All children demonstrated typical (visual) language acquisition
  - Preliminary support for a language scaffolding hypothesis
- Recruitment and follow-up continues – goal to increase variability in ASL ability

References

[1] Casserly, E.D. & Pisoni, D.B. (2013). Nonword repetition as a predictor of long-term speech and language skills in children with cochlear implants. *Otol Neurol*, **34**(3), 460-470. [2] Kronenberger, W.G. et al. (2014). Executive functioning and speech-language skills following long-term use of cochlear implants. *J Deaf Stud Deaf Educ*, **19**(4), 456-470. [3] Conway, C.M. et al. (2011). Implicit sequence learning in deaf children with cochlear implants. *Dev Sci*, **14**(1), 69-82. [4] Conway, C.M. et al. (2009). The importance of sound for cognitive sequencing abilities: The auditory scaffolding hypothesis. *Curr Dir Psychol Sci*, **18**(5), 275-279. [5] Smith, L.B. et al. (1998). Audition and visual attention: The developmental trajectory in deaf and hearing populations. *Dev Psychol*, **34**(5), 840-850.

Acknowledgments

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