PS 12

Simultaneous Presentation of Visual Information with Auditory Input Simulating Cochlear Processors Reduces Memory in Normal-Hearing Listeners

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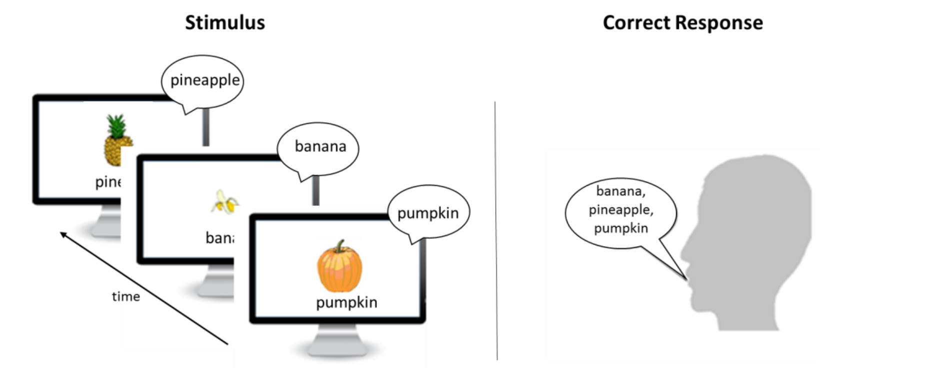
INTRODUCTION

- Auditory deprivation decreases the amount of input that reaches the brain. Reduced input could lead to deficits in neurocognitive processes, such as memory, that facilities speech comprehension.[1,2]
- AuBuchon *et al* showed that individuals who use cochlear implants **(CIs)** have a reduced short-term memory capacity relative to their normal-hearing **(NH)** peers in (1) visual and (2) audio domains.[3]
- Additionally, preliminary data in our lab show that children who use CIs have a reduced working memory capacity compared to their NH peers, despite receiving audio and visual information simultaneously.[4]

List Storing Task – Working Memory Test



Results[4]

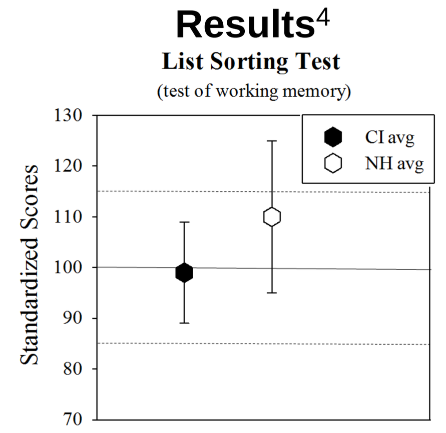


Fig 1. Procedure for list sorting task (top). Participants were presented with a series of items and instructed to verbally repeat the items in size order from smallest to largest. Average scores (*circles*) for CI and NH children on list sorting task. On average, CI children had a lower score (remembered less) than NH children on the list sorting task.

- While new research has begun to explore the impact of degraded auditory input on memory, few studies have investigated the effect of degraded auditory input on memory when combined with a visual cue.

The **purpose of this study** was to investigate if degraded auditory signals limit the amount of resources devoted to interpreting visual information.

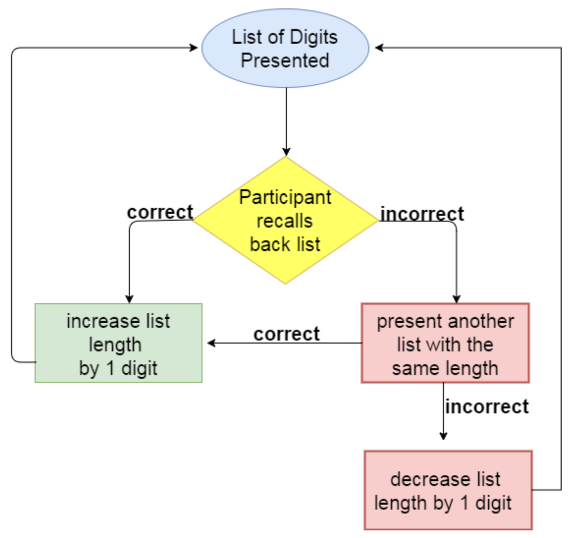
We hypothesize that if degraded auditory input is present, even in the presence of visual input, then memory capacity will decrease.

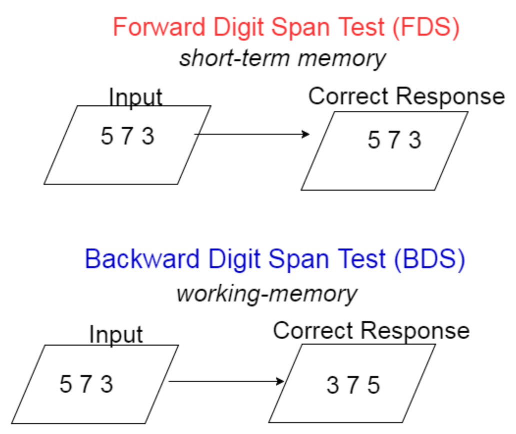
METHODS

PARTICIPANTS: 16 young listeners with normal hearing and normal vision (ages 18-24 years old)

PROCEDURE: Digit Span Test – measure of short-term and working memory

Digit Span Test | **x 2 Digit Span Test** | **x 5 conditions**





(1) Audio Only (AO)
(2) Degraded Audio Only (DAO)
(3) Visual Only (VO)
(4) Audiovisual (AV)
(5) Degraded Audiovisual (DA / V)

STIMULI: Digits (1-9) presented aurally, visually, or both

Condition	Quality of Stimuli	Presentation of Stimuli
Audio only (AO)	Normal	Headphones
Degraded Audio (dAO)	4 channel vocoder	
Visual only (VO)	Normal	Computer screen
Audiovisual (AV)	Normal	Headphones + computer screen
Degraded audio + Visual (DAV)	4 channel vocoder Normal visual	

Audio only: Digital recording of digits (1-9)
Degraded Audio: Stimuli were processed through AngelSim (http:// www.tigerspeech.com/angelsim)

Example of a Test Session

Test: FDS; Condition - Audiovisual				
Trial	*List Length*	*Presented*	*Response*	*Outcome*
1	3	8 2 4	8 2 4	1
2	4	9 8 6 1	9 8 6 1	1
3	5	8 9 7 4 6	8 9 7 4 6	1
4	6	2 7 1 3 8 9	2 7 1 3 8 9	1
5	7	1 4 8 2 5 6 3	1 **9** 8 2 **X** 6 3	0
6	7	7 6 2 5 9 4 3	7 6 **1** **8** 9 4 3	0
7	6	7 3 5 9 2 8	7 3 5 9 2 8	1

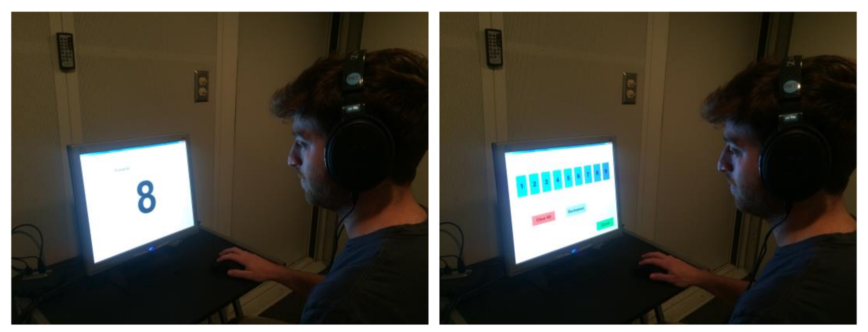


Fig 2. Sample of trials for the forward digit span (FDS) test in the audiovisual condition. Red number represents incorrect number recalled. X represents omitted number. Presentation of digits in the audiovisual condition (center). Digits were presented one at a time. After the list were presented, participants manually entered in their response (right)

Scoring Metric: Mean Span

Calculation of Mean Span

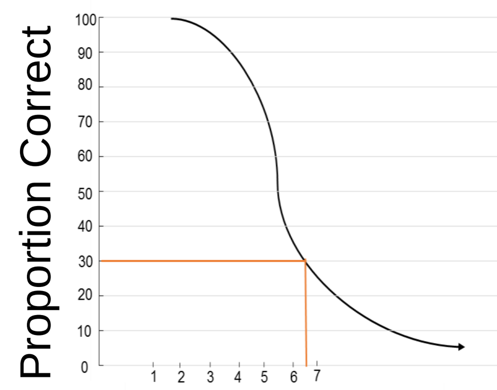
$$Baseline + \ Hit\ rate\ for\ each\ list\ length$$
$$= (Initial\ length - 0.3) + \ Hit\ rate\ for\ each\ list\ length$$

List length at trial 1 for each DS test For FDS: 3; BDS: 2

Estimation of memory remaining at the longest list accurately recalled based on psychometric function (**fig. 3**)

Proportion of correct trials for each list length

Fig 3.Estimation of Memory Span[5]



Example: Mean Span for Example Test Session
Baseline: 3 – 0.3 = 2.7
Hit rate for each list length (3=1.0, 4=1.0, 5=1.0, 6=1.0, 7=0)
Mean Span: 2.7 + 1 + 1+ 1+ 1+ 0 = 6.7

RESULTS

Fig 4. Mean Span Comparisons between Conditions

A. Forward Digit Span Test | **D. Backward Digit Span Test**

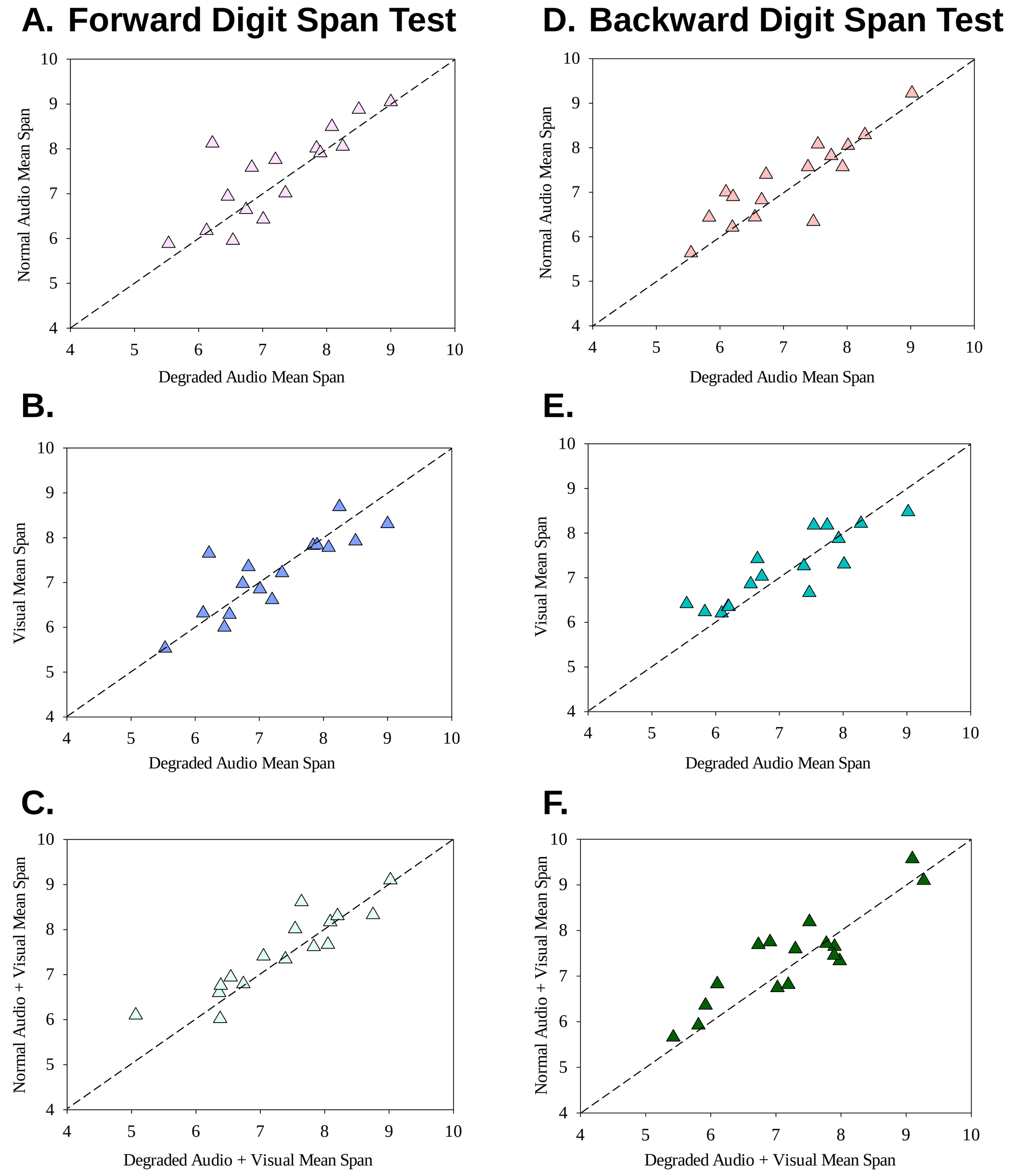
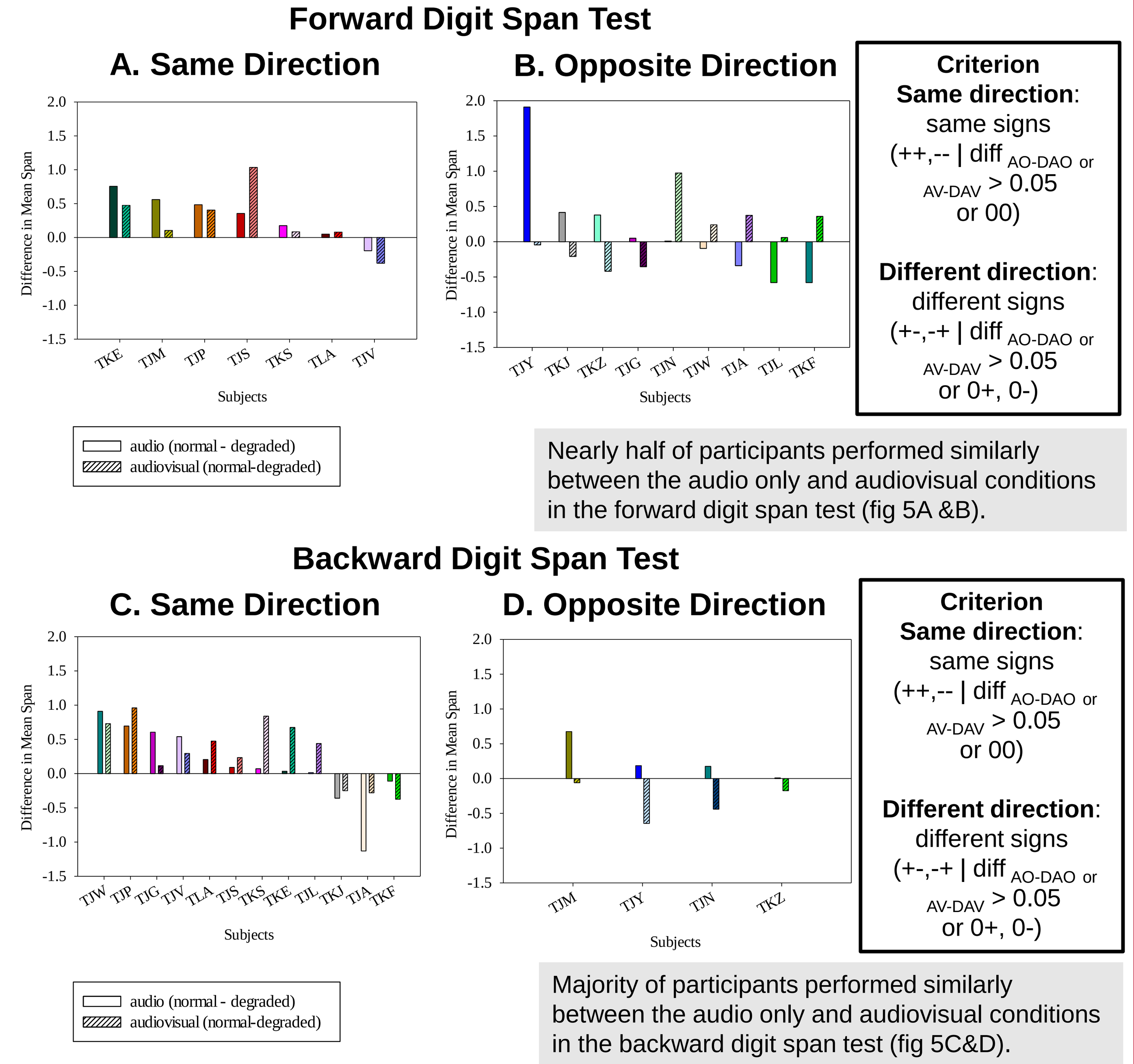


Fig 5. Trend between Audio and Audiovisual Conditions

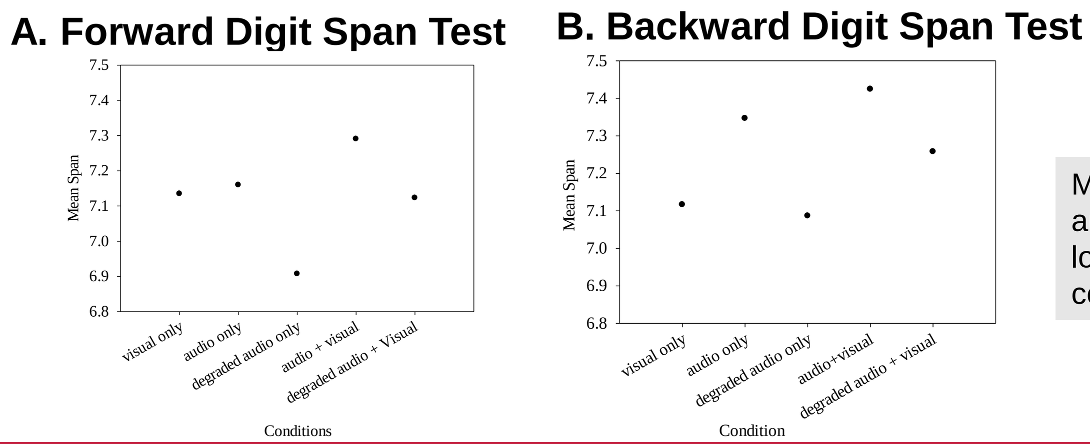


Nearly half of participants performed similarly between the audio only and audiovisual conditions in the forward digit span test (fig 5A &B).

Majority of participants performed similarly between the audio only and audiovisual conditions in the backward digit span test (fig 5C&D).

Fig 6. Group Averages

Mean span is higher when audio is normal than degraded, especially when provided with a visual cue (fig 4).



Mean span is highest for audiovisual condition and lowest for degraded audio condition (fig 6A&B).

DISCUSSION

- Mean span was lower in the degraded audiovisual condition vs. the unprocessed audiovisual condition, suggesting that a degraded auditory signal interferes with the ability to utilize the visual information. This might explain why CI users have a reduced memory capacity compared to their normal-hearing (NH) peers, despite receiving audio and visual information simultaneously.
- Performance in audiovisual conditions followed the same trend, but not magnitude, as performance on audio conditions. This may suggest that individuals weigh visual and audio cues differently when combined together.
- Current trends suggest that the presence of degraded auditory input might have an impact on some neurocognitive processes, such as memory.

REFERENCES

1. Kronenberger, WG, Beer J, Castellanos I, Pisoni, DB, Miyamoto, RT. Neurocognitive risk in children with cochlear implants. JAMA Otolaryngol Head Neck Surg 2014; 7: 608-15
2. Beer, Jessica; Kronenberger, William G.; Castellanos, Irina; Colson, Bethany G.; Henning, Shirley C.; Pisoni, David B. Journal of Speech, Language, and Hearing Research, v57 n4 p1521-1534 Aug 2014
3. AuBuchon, Rose, Pisoni, David B, Kronenberger, William G. Short-term and Working Memory Impairments in Early-Implanted Long-term Cochlear Implant Users are Independent of Audibility and Speech Production *Ear and Hear* 2015 36(6):733-737
4. Misurelli, Sara, Kan, Alan, Groupell, Matthew, Litovksy, Ruth. Auditory Attention and Sound Source Segregation in children with cochlear implants or normal hearing. *ARO Conference,* San Diego 2016
5. Levitt, H. Transformed Up-Down Methods in Psychoacoustics. *JASA 1970:* 467-477

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