

The effect of degraded auditory input on memory

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Binaural Hearing and Speech Laboratory



INTRODUCTION

- Cochlear implants (CI) restore hearing capabilities to patients with profound hearing loss and allow them to develop successful spoken language skills.

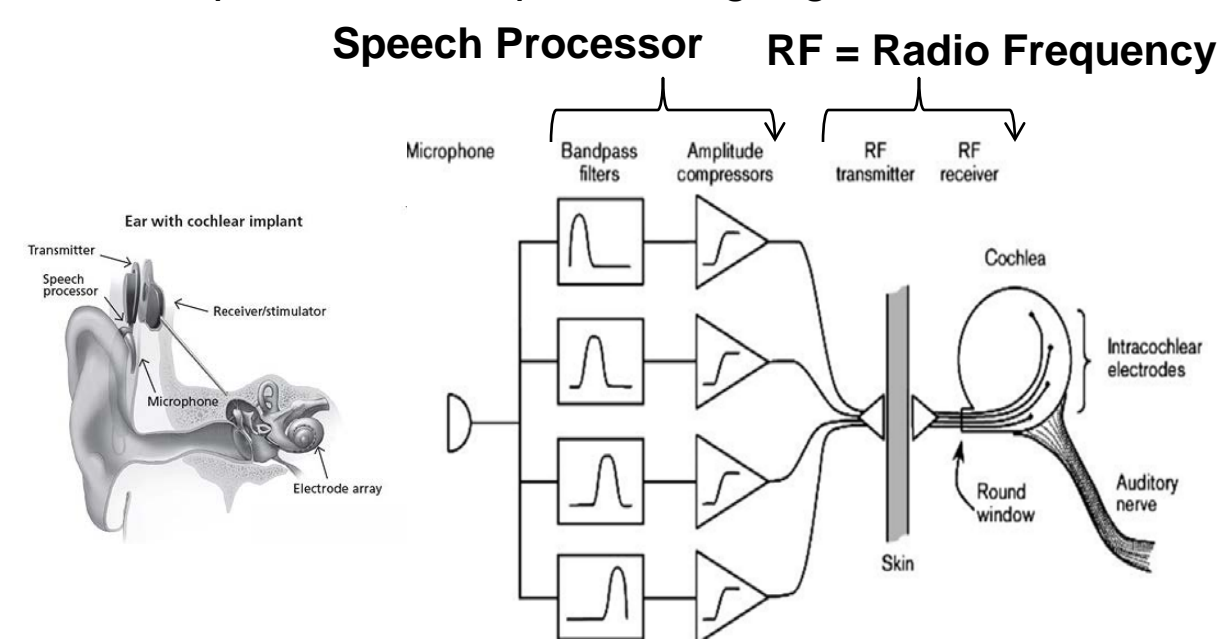


Fig 1. Basic components of cochlear implant (left) and illustration on how cochlear implants work (right)

- However, studies have shown that CI users have a reduced short-term memory capacity compared to their normal hearing (NH) peers.

Forward Digit Span Test

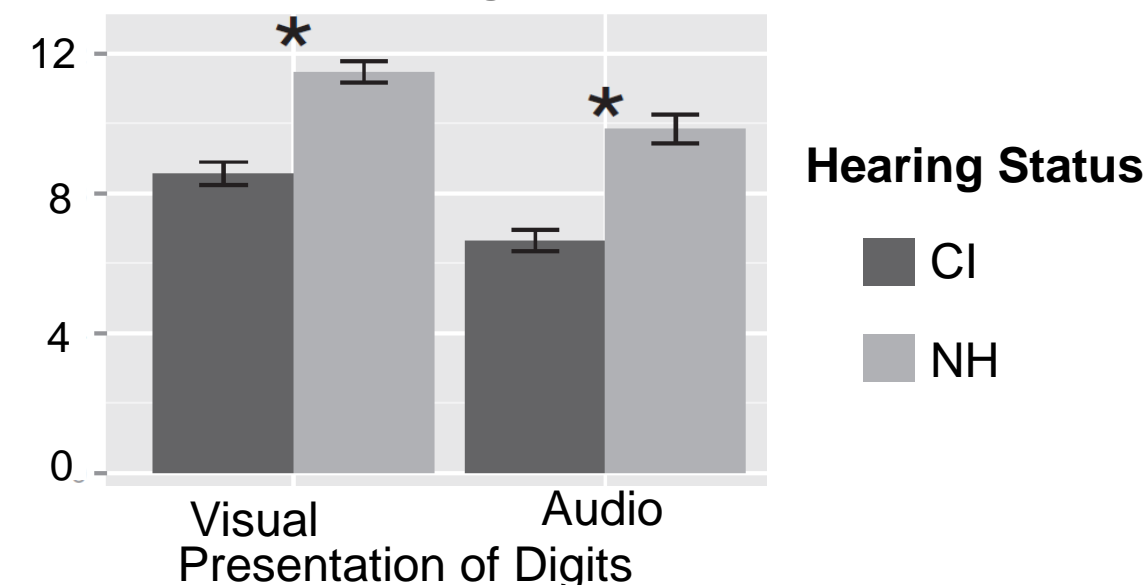


Fig 2. Performance on forward digit span test to measure short-term memory.

- Furthermore, preliminary data from the Litovsky lab indicate that CI users have reduced working memory capabilities compared to their NH peers despite receiving audio and visual information concurrently.

List Sorting Task – Working Memory Test

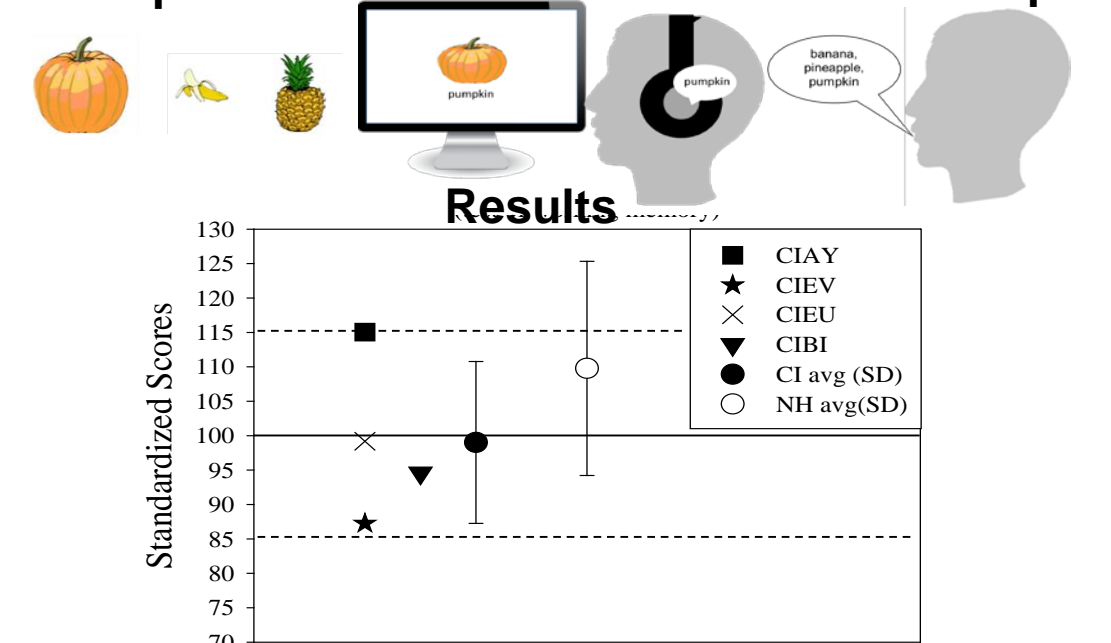


Fig 3. Procedure for list sorting task (top). Participants were presented with a series of items and instructed to verbally repeat the items in size order from smallest to largest. Individual scores (shapes) and average scores (circles) for CI and NH children on list sorting task

HYPOTHESIS

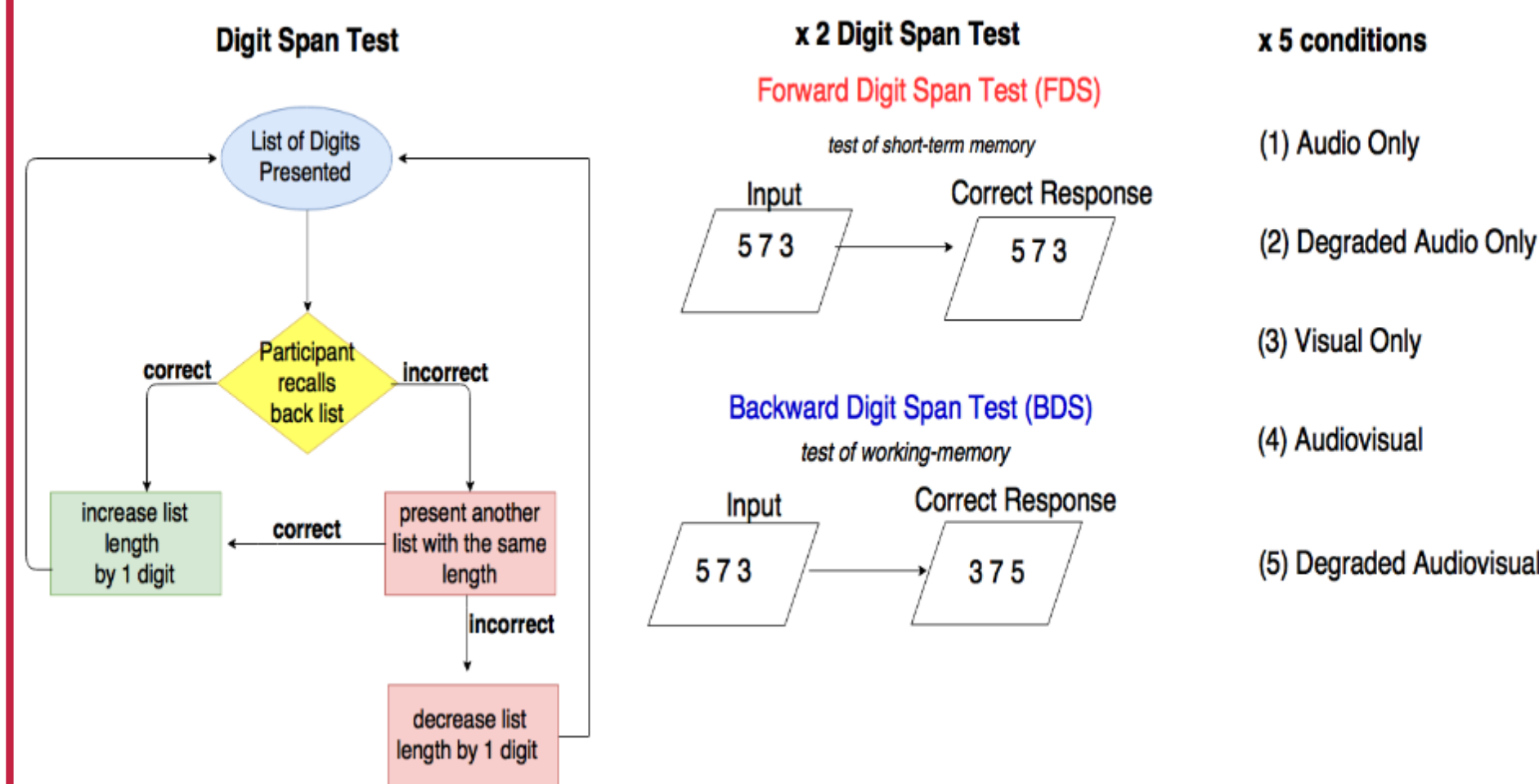
- The degraded auditory signal conveyed through the CIs will limit the amount of cognitive resources available for interpreting the accompanying visual information.

METHODS

- PARTICIPANTS:** The participants were aged 18-24 years old and were native English speakers with normal hearing and sight capabilities.
- STIMULI:** The digits 1-9 were verbally recited then were recorded and degraded digitally through a CI simulation 4-channel vocoder. The digits were presented aurally, visually, or both

Condition	Quality of Stimuli	Presentation of Stimuli
Audio only (AO)	Clear	Headphones
Degraded Audio only (DAO)	Distorted - simulating CI processor	
Visual only (VO)	Clear	Computer screen
Audiovisual (AV)	Clear	Headphones + computer screen
Degraded audio Visual (DAV)	Distorted– simulating CI processor Clear visual	

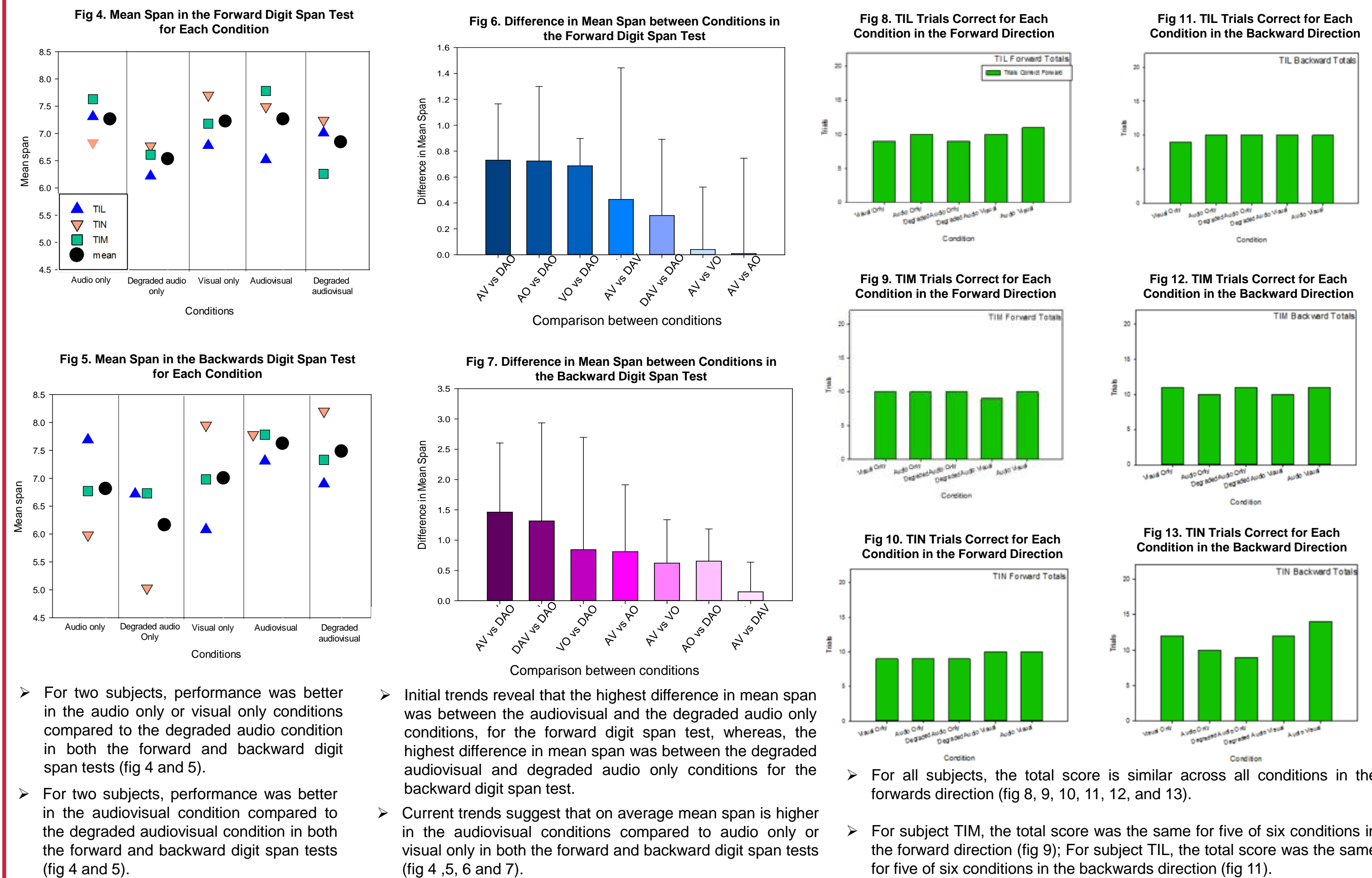
- PROCEDURE:** Participants were presented with the digit span test, a measure of short-term and working memory.



- SCORING METRIC:** The mean span and total score of each trial were calculated.
 - Total score = total number of lists correctly recalled
 - Mean span = baseline + hit rate for each list length
 - Baseline = Initial length (list length at trial 1 for each DS test; 3 for FDS; 2 for BDS) – 0.3
 - Hit rate = proportion of correct trials for each list length

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., 7=0)
Mean Span: 2.7 + 1 + 1 + 1 + 1 + 0 = 6.7

RESULTS



- For two subjects, performance was better in the audio only or visual only conditions compared to the degraded audio condition in both the forward and backward digit span tests (fig 4 and 5).
- For two subjects, performance was better in the audiovisual condition compared to the degraded audiovisual condition in both the forward and backward digit span tests (fig 4 and 5).
- Initial trends reveal that the highest difference in mean span was between the audiovisual and the degraded audio only conditions, for the forward digit span test, whereas, the highest difference in mean span was between the degraded audiovisual and degraded audio only conditions for the backward digit span test.
- Current trends suggest that on average mean span is higher in the audiovisual conditions compared to audio only or visual only in both the forward and backward digit span tests (fig 4, 5, 6 and 7).
- For all subjects, the total score is similar across all conditions in the forwards direction (fig 8, 9, 10, 11, 12, and 13).
- For subject TIM, the total score was the same for five of six conditions in the forward direction (fig 9); For subject TIL, the total score was the same for five of six conditions in the backwards direction (fig 11).

DISCUSSION

- The mean digit span in the backwards direction was highest under the audio-visual condition, indicating that information presented both visually and audibly is processed and stored more easily.
- Mean span was lower under the degraded audio/visual condition than under the clear audio-visual condition, which suggests that the degraded audio signal distracts from the clear visual cues. This may explain why cochlear implant users do not perform as well as their normal hearing counterparts on memory assessments that feature both auditory and visual signals.
- Current trends suggest that mean span is a better measurement of memory span than total score. This may be due to the fact that the hit rate term within the mean span calculation amounts for the number of times a particular list length was given.

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