Neurocognitive testing and cochlear implantation: insights into performance in older adults

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Disclosures

• none
introduction

• Emerging research has established an association between hearing loss and dementia
  – hearing loss independently associated with 40% rate of accelerated cognitive decline
  – This relationship may be linear: those with more severe hearing loss are at highest risk
    • individuals with mild, moderate and severe HL had a 2, 3, and 5 fold increased risk of all-cause dementia over >10 yrs of follow-up

• Recent data suggest that interventions for hearing loss may impact cognition in older adults
objective

To assess the impact of auditory rehabilitation with cochlear implantation (CI) on the cognitive function of elderly patients over time
• N=7, post-lingually deafened female
  • No known cognitive impairment
• age 67-81 yrs at CI
• Testing Pre-CI and follow-up 2-4 yrs (mean 3.7)
• Speech perception testing: CNCw in quiet
Neurocognitive Tests:
- 20 tests in 5 domains
- intellectual function, learning, short- and long-term memory, verbal fluency, attention, mental flexibility, and processing speed
- 4 hours
- All performed by trained neuropsychologist

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>Description of main test (and subtests, if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test of Premorbid Functioning (TOPF)</td>
<td>A sight word reading test wherein individuals are asked to read out loud single words that have irregular spelling rules (i.e., words that cannot be sounded out using phonics alone). The measure is used to estimate an individual's &quot;premorbid&quot; level of intellectual functioning as assessed by a standardized instrument such as one of the Wechsler scales.</td>
</tr>
</tbody>
</table>
| Wechsler Abbreviated Scale of Intelligence (WASI) | Consists of four subtests, two assessing verbally-based abilities (vocabulary and abstract reasoning) and two assessing visually-based abilities (visuospatial construction and visual analogic reasoning), that are used to estimate current general intellectual ability.  
  - Vocabulary: IQ, language  
  - Block design: IQ, Abstract reasoning  
  - Similarities: IQ, Language, Verbal abstract reasoning  
  - Matrix reasoning: IQ, Non-verbal, Abstract reasoning, Mental flexibility |
| The Trail Making Test (TMT)                      | A measure that assesses visual scanning, visual attention, processing speed, and simple cognitive flexibility. It is a paper and pencil task that asks individuals to connect a series of targets in a prescribed order as quickly as they can.  
  - A: Speeded linear processing, visual tracking  
  - B: Speeded multi-tasking, mental control, visual tracking |
| Controlled Oral Word Association Tests (COWAT)   | Assess behavioral initiation and rapid word retrieval by asking individuals to 1) name as many animals as possible within 60 seconds (Animals) or 2) as many words as they can that start with a specific letter in a 60 second interval; there are 3 trials using the letters "F", "A", and "S".  
  - Animals: Verbal fluency, processing speed  
  - F-A-S: Verbal fluency, mental flexibility |
| The Boston Naming Test (BNT)                     | Assesses visual confrontation naming by asking individuals to name a pictured item. The width of the items becomes increasing lower as the test progresses making it more challenging with each successive item.  
  - Coding: Divided attention  
  - Digits forward: ST verbal recall  
  - Complex Figure: Motor based processing  
  - Line Orientation: Motor based processing  
  - Semantic Fluency: Verbal fluency, processing speed |
| The Repeatable Battery for the Assessment of Neuropsychological Functioning (RBANS) |  
  - List Recall: ST verbal learning  
  - List Recognition: ST verbal recognition memory  
  - Story Recall: LT verbal recall memory  
  - Visual Memory: LT visual recall memory, motor-based processing  
  - List learning: Learning capacity |

LT, long term; IQ, intelligence quotient; ST, short term
analyses

- **Individual** and **aggregate** differences in cognition and speech perception over time
  - $\Delta$ individual = Post-CI score - Pre-CI score
  - $\Delta$ sample=Aggregate post-CI score - Aggregate pre-CI score
- **Domain-specific**
- **Magnitude** of change
- **Logistic Regression**: relationship between cognitive performance and post-CI speech perception at years 1, 2 and 3
results

• post-CI scores improved from pre-CI scores in 70% of tests
  – Minimal, moderate, pronounced
• all improved in speech perception

Table 3 Summary of differences in performance-based graduated improvement comparing qualitative scores before and after cochlear implantation

<table>
<thead>
<tr>
<th>Any improvement ($\Delta &gt; 0$)</th>
<th>20 sample-level differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal improvement ($0 \text{ units} &lt; \Delta &lt; 1 \text{ unit}$)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td>Moderate improvement ($1 \text{ unit} \leq \Delta &lt; 2 \text{ units}$)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td>Pronounced improvement (2-unit improvement or better)</td>
<td>4 (20%)</td>
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<tr>
<td>Any decline ($\Delta &lt; 0$)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td>Minimal decline ($0 \text{ units} &lt; \Delta \leq -1 \text{ unit}$)</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Moderate decline ($-1 \text{ unit} \leq \Delta &lt; -2 \text{ units}$)</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Pronounced decline (2-unit decline or worse)</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>No change in performance ($\Delta = 0$)</td>
<td>1 (5%)</td>
</tr>
</tbody>
</table>
Results: domain-specific and magnitude

<table>
<thead>
<tr>
<th>Test</th>
<th>Subtest</th>
<th>Verbal</th>
<th>Visual</th>
<th>Processing speed</th>
<th>Motor</th>
<th>Memory</th>
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<tbody>
<tr>
<td>WASI</td>
<td>Vocabulary</td>
<td>↑</td>
<td></td>
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<td>Block Design</td>
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<td>↑↑</td>
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<td>Similarities</td>
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<td>↑</td>
<td></td>
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<td></td>
<td>Matrix Reasoning</td>
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<tr>
<td>Other</td>
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<td>↓↓</td>
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<td>Line Orientation</td>
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<td>Story Memory</td>
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<td>Story Recall</td>
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<td></td>
<td>Visual Memory</td>
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</table>

Notes: Performance change (qualitative change) detected at the sample level: ↑ = 0 units < $\Delta_{\text{mean}}$ < 1 unit; ↑↑ = 1 unit ≤ $\Delta_{\text{mean}}$ < 2 units; ↑↑↑ = $\Delta_{\text{mean}}$ ≥ 2 units.

Abbreviations: BNT, Boston Naming Test; RBANS, Repeatable Battery for the Assessment of Neuropsychological Functioning; TMT A, Trail Making Test A; TMT B, Trail Making Test B; WASI, Wechsler Abbreviated Scale of Intelligence.
Regression analysis

- 5 cognitive tests were predictive of post-CI speech perception: WASI (IQ), vocabulary, matrix reasoning, Boston Naming Test, list learning ($p<0.0075$) at 2 and 3 yrs post-CI (CI only and bi-modal)
discussion

• Longitudinal improvement in cognitive testing in elderly patients is rarely documented
  – RBANS shown stability in community dwelling older adults (>500) over time (4+ yrs)
• Robust testing - same construct tested in different ways
• No auditory or cognitive training
• Unlikely influence of practice effects given time frame of testing (ie minimal after 1 yr)

Improvements in cognitive testing may reflect impact of CI
discussion

• **Domain-specific**
  – Improvements centered in verbal, memory, processing speed/mental flexibility domains
  – All declines involved motor, vision
    • Impact of prior axillary node dissection

• **Support Mosnier et al**
  – Difficulty comparing exact tests as only 1 overlap
  – Larger N, cognitive training, shorter follow up, minimal domain or magnitude analysis

• **Limitations of current study**
  – Sample size
  – Lack of normative scores in hearing-impaired population
  – No assessment of mood
discussion

• **Clinical vs. statistical** significance of improved cognitive testing is unknown (vs. speech understanding)
  – prior data demonstrate long-term stability of neurocognitive test results → interpreted any improvement as clinically significant
  – improvement in cognitive function is predictive of improved speech perception, thereby importing a framework of clinical significance to these gains

• **Future research:**
  – Larger sample sizes
  – validate the meaning/clinical relevance of these incremental changes in neurocognitive testing
  – **Neural plasticity in elderly**
    • Improved speech performance over time
    • cortical re-organization of the central auditory system have been shown in both animals and adults
    • Anatomic data from imaging studies shows evidence of cortical reorganization following CI in adults and kids, no studies in elderly CI
conclusion

• comprehensive neurocognitive testing of elderly women demonstrated areas of **improvement in cognitive function and auditory perception following cochlear implantation**

• Multiple neurocognitive tests were strongly associated with current speech perception measures

• **CI may slow expected age-related cognitive decline**, further research is needed to examine the impact of hearing restoration on cognitive decline
References

Thank you