Correlation of Neurocognitive Processing Subtypes with Language Performance in Young Children with Cochlear Implants

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The River School,
Washington DC
The River School, Washington DC
Founded, 1999

- Provides inclusive educational experiences for children with cochlear implants ages 18 months through 3rd grade.
- Fully-integrated setting with a classroom majority of typically developing hearing peers.
- Promotes clinical research and training in children’s social development, early language and literacy.
15 Years of longitudinal data collection:

Children enrolled in the RS program:

- Overcome significant language delays based upon objective neurocognitive and language assessment.
- Typically make more than 6 months language progress in 6 months time.
- 82% close the language gap within a 3 year intervention interval.
Core Language Results:

- **Children who closed the gap within the 34 month interval**
- **Children lost to follow-up**
- **Children who remained in the program, but followed a slower trajectory to close the gap**
Rationale for the study

- Investigation of the variability of outcomes observed in the population of early implanted children.

- Investigate sequential and simultaneous processing from a neuropsychological perspective and the application to children with cochlear implants.

- Investigate correlation of neurocognitive processing subtypes with language performance.
2009-2011 Academic years:

- Age-normed neurocognitive and language measures:
  - Kaufman Assessment Battery for Children-Second Ed (KABC-2)
    - Sequential vs. Simultaneous Processing
  - CELF, CELF-P, CELF-4 or CASL
    - Core language scores

- Measure yield mean standard score =100, standard deviation=15.
Sequential Processing Task:
Simultaneous Processing Task
Sequential Processing Pathway:
Simultaneous Processing Regions:

RLPFC
- Increased specificity for relational integration in adults
- Shorter latency response in adults enables accurate and efficient FR

Inferior Parietal Cortex
- Stronger engagement in adults supports relational processing

Lateral PFC
- Supports working memory and cognitive control demands of FR tasks
Simultaneous Processing Pathways:
Subjects:
22 children with CIs (ages 4-8)

Below Expectations (BE)
• N=13
• CI recipients with language scores SS=<100

Meeting/Exceeding Expectations (ME)
• N=8
• CI recipients with language scores SS=>100
## Demographic Data

<table>
<thead>
<tr>
<th></th>
<th>CI users with reduced rate of language growth trajectories (BE Group; n=13)</th>
<th>CI users with expected rate of language growth trajectories (ME Group; n=9)</th>
<th>p value&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Age, median (IQR)</strong></td>
<td>73 (64-90) [50-107]</td>
<td>76 (65-85) [56-106]</td>
<td>0.79</td>
</tr>
<tr>
<td><strong>Hearing Age, median (SD)</strong></td>
<td>50 (44-59) [15-92]</td>
<td>52 (36-63) [14-88]</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>Age at Implant Activation, median (IQR)</strong></td>
<td>16 (13-30) [10-53]</td>
<td>21 (13-26) [12-74]</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>Early CI Recipients (&lt;18m), n (%)</strong></td>
<td>7 (54)</td>
<td>4 (44)</td>
<td>0.99</td>
</tr>
<tr>
<td><strong>Etiology of Hearing Loss, n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetic</td>
<td>3 (23)</td>
<td>3 (33)</td>
<td>0.31</td>
</tr>
<tr>
<td>Connexin 26</td>
<td>0 (0)</td>
<td>2 (22)</td>
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</tr>
<tr>
<td>LVAS</td>
<td>1 (8)</td>
<td>1 (11)</td>
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<tr>
<td>Meningitis</td>
<td>2 (15)</td>
<td>0 (0)</td>
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<tr>
<td>CMV</td>
<td>1 (8)</td>
<td>0 (0)</td>
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<tr>
<td>Hirschspungs</td>
<td>0 (0)</td>
<td>1 (11)</td>
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<tr>
<td>Unknown</td>
<td>6 (46)</td>
<td>2 (22)</td>
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<tr>
<td><strong>Race</strong></td>
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<tr>
<td>Caucasian</td>
<td>9 (69)</td>
<td>9 (100)</td>
<td>0.24</td>
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<tr>
<td>African-American</td>
<td>1 (8)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>3 (23)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>9 (69)</td>
<td>4 (44)</td>
<td>0.38</td>
</tr>
<tr>
<td>Female</td>
<td>4 (31)</td>
<td>5 (56)</td>
<td></td>
</tr>
<tr>
<td><strong>Nonverbal IQ, mean (SD)</strong></td>
<td>116.5 (15.5-127.5) [92-145]</td>
<td>113 (103-122) [90-145]</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>Language Scores, median (IQ) [range]</strong></td>
<td>81 (74-92) [72-106]</td>
<td>115 (111-129) [106-135]</td>
<td>0.0001</td>
</tr>
</tbody>
</table>
Methods:

- **Cross-sectional study**
  - Neurocognitive processing scores of CI recipients with language score below expectations (BE) were compared with those of children meeting or exceeding expected language gains (ME).
  
  - Process vs. Outcome
Distribution of Neurocognitive Processing Subtypes Scores by Language Group

- Below Expectations (BE) - Simultaneous Processing: Mean = 116.0, p = 0.31
- Below Expectations (BE) - Sequential Processing: Mean = 91.2
- Meeting Expectations (ME) - Simultaneous Processing: Mean = 121.8, p = 0.002
- Meeting Expectations (ME) - Sequential Processing: Mean = 110.8

P-values based on Wilcoxon rank-sum test comparing BE group to ME group.
Language and Neurocognitive Processing Scores
Results:

- **Simultaneous processing standard scores** between ME and BE groups were similar:
  - (SS=116 and 122 respectively) (p=.31).

- **Sequential processing scores** median in the BE group, (SS=88)
  - were significantly lower (p=0.002) than sequential processing median of children meeting expectations (ME), (SS=115).

- **Adjustment for age of implantation** resulted in a 10 point higher Sequential Processing score correlated with a 7.4 point higher language score (p=0.027).
Findings:

- Pediatric CI users (n=22), enrolled in a fully inclusive educational program.
- At one specific point in time, 13 were not meeting expected language progress.
- Language testing results were correlated with neurocognitive processing subtypes.
- Analysis by multilinear regression revealed a statistically significant association between lower standard scores on sequential processing ability and language performance below expectations.
Discussion

- Deficient sequential cognitive processing,
- Reduced discrimination of auditory temporal patterns, and
- Lack of effective cognitive sequencing may impact speech-related tracking,
- With consequences for effecting language learning after implantation in a subset of children.
Further Investigation:

- Of the developmental trajectory of the rate at which children acquire language skills necessary to “close the gap”.

- Of intervention including remediation of working memory and other cognitive skills that facilitate development of sequential cognitive processing.
References:

- [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2858618/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2858618/)