ABSTRACT

Results

• CI users scored significantly higher than NH peers on 18 LEAF items (Table 2), of which were significant in cross-validation analyses (p<0.05 in both subsamples) and 4 of which were significant in one cross-validation sample and p<0.10 in the other.

• The 18 items fell into three broad categories: (1) Comprehension and Novel Learning; (2) Memory and Complex Processing; and (3) Controlled Attention (Figure 1)

• Internal consistency in the CI sample was excellent for subscales comprised of all 18 items (Cochlear Implant-Executive Functioning [CIEF] Index score, alpha=0.96), the 8 Comprehension and Novel Learning Items (alpha=0.93), the 5 Memory and Complex Processing Items (alpha=0.90), and the 5 Controlled Attention items (alpha=0.86) and was greater than internal consistency for those same subscales in the NH sample (alphas=0.89, 0.75, 0.75, and 0.75, respectively).

• The CIEF Index score correlated significantly with HINT-C, PPT-4, and CIEF-4 Core Language Scores (Figure 2). (LEAF; Kronenberger & Pisoni, 2009)

Conclusions

• Elevated risks for EF delays (based on parent-reports of everyday behaviors) in long-term CI users are greatest in the areas of comprehension and novel learning, memory and complex processing, and controlled attention.

• The LEAF CIEF Index based on items specifically evaluating these EF risks was significantly related to speech and language outcomes in early-implanted long-term CI users.

METHOD

Participants: N=50 long-term CI users and 50 normal-hearing (NH) peers. Samples did not differ on age, sex, family income, or nonverbal IQ (Table 1; all p>0.10)

• CI Sample: Severe-to-profound bilateral hearing loss by age 3; cochlear implantation by age 7; at least 7 years of CI use and NH sample in rehabilitative or educational program emphasizing spoken language development

• CI Sample: Hearing within normal limits (PTA < 20 dB)

• Both Samples: No developmental, cognitive, neurologic diagnoses; monolingual English home; 7-17 years old

Measures

• Learning, Executive, and Attentional Functioning Scale (LEAF; Kronenberger & Pisoni, 2009)

• 55 Item behavior checklist completed by parents – rate child’s behavior during the past week on a 0 (Never) to 3 (Very Often) scale

• Yields 8 EF subscales in first 40 items: (1) Comprehension and Conceptual Learning; (2) Factual Memory; (3) Attention; (4) Processing Speed; (5) Visual-Spatial Organization; (6) Sustained Sequential Processing; (7) Working Memory; and (8) Novel Problem-Solving

• Language

• Receptive Vocabulary: Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007)

• Language: Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF-4; Semel et al., 2003) Core Language Score

• Speech Perception

• Thoughts, behaviors, and emotional control: Clinical Evaluation of Language Fundamentals, Spatial Organization 0.36 0.53 0.44 0.79

• Sentence: Hearing In Noise Test for Children (HINT-C; Watson et al., 1996) in Quiet and Noise (+5 dB)

• Statistical analysis

• Identify LEAF EF items that differed significantly between CI and NH groups

• Cross-Validation Procedure: Divide CI and NH samples randomly into 2 subsamples (25 CI and 25 NH each) for cross-validation

• Compute CI subsample 1 with NH subsample 1 and CI subsample 2 with NH subsample 2

• Select items that test significantly different at p<0.05 in both subsamples

• Subsamples did not differ on age, sex, family income, or nonverbal IQ (all p>0.10)

• Use this cross-validation procedure to provide further evidence that differences between CI and NH groups found in the correction procedure were stable and not due to chance because of the large number of comparisons across 40 items

• Derive a CI-specific EF scale (CIEF Index) based on the LEAF EF items that are significantly higher in CI sample using the correction procedure described above

• Correlate scores on this LEAF-CIEF Index with measures of language and speech perception and investigation relationships between EF and spoken language

RESULTS/CONCLUSIONS

Table 1: Sample Characteristics

<table>
<thead>
<tr>
<th>CI</th>
<th>NH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>12.54 ± 2.68</td>
</tr>
<tr>
<td>Age at Implant (months)</td>
<td>28.05 ± 13.83</td>
</tr>
<tr>
<td>Years of CI use</td>
<td>7.53 ± 2.24</td>
</tr>
</tbody>
</table>

Table 2: CI vs. NH Item Analyses

- Cluster 1: Comprehension and Novel Learning
  - Doesn’t understand that long material is said 6.116 0.001 0.001 0.001
  - Understand that long material is said 4.362 0.001 0.007 0.001

- Cluster 2: Memory and Complex Processing
  - Doesn’t believe that a statement is true 3.824 0.001 0.001 0.055
  - Doesn’t believe that a statement is true 3.086 0.003 0.092 0.006

- Cluster 3: Controlled Attention
  - Doesn’t resist known facts being changed 2.757 0.007 0.055 0.062
  - Doesn’t resist known facts being changed 3.779 0.001 0.001 0.053

• With CI use: 10 years, 2.3 months, 3.2 years

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• With CI use: 10 years, 2.3 months, 3.2 years

Figure 1: CI-Specific EF Items

- Cluster 1: Comprehension and Novel Learning
  - Doesn’t understand that long material is said
  - Understands that long material is said

- Cluster 2: Memory and Complex Processing
  - Doesn’t believe that a statement is true
  - Believes that a statement is true

- Cluster 3: Controlled Attention
  - Doesn’t resist known facts being changed
  - Resists known facts being changed

Figure 2: CIEF Scores, Speech, and Language