Single Word-level and Sentence-Level Intelligibility Measures in Children with Cochlear Implants

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Speech Intelligibility

Definition:
- "The degree to which a speaker’s intended message can be recovered by other listeners" (Kent, Weismer, Kent, & Rosenbeck, 1989; p. 493).
- Joint product of a speaker and a listener.
- Factors that may affect intelligibility include:
  - Language competency of the speaker.
  - Nature of the spoken material.
  - Listener's familiarity with the speaker.
  - Clarity of the acoustic and visual signals of speech.
  - Contextual cues.

Assessment of Intelligibility

A single intelligibility score cannot be ascribed to a given individual apart from listener and listening situation.
- A particular talker has a range of intelligibility potentials (Kent, 1993)
Because intelligibility levels are frequently used in making clinical decisions for children, measures of intelligibility need to be accurate, reliable, and valid (Gordon-Brannan & Hodson, 2000).

Measure of Intelligibility

Intelligibility measures fall into two main categories:
- Calculation of percentage of words understood.
  - More accurate.
  - Time consuming.
- Impressionistic measures (e.g., rating scales).
  - Routinely done by most SLPs.
  - Low interjudge reliability.

Intelligibility and Cochlear Implants

- Studies agreed that the following factors improve the intelligibility scores of children with CI:
  - Amount of implant experience.
  - Earlier implantation.

(p.e.g. Tye Murray et al. 1995; Miyamoto et al. 1997; Osberger et al. 1994)

Purposes of the Present study

- 1. To compare intelligibility scores across two linguistic levels: single words, including open and closed sets, and sentences.
- 2. To compare intelligibility scores with chronological age, age of implantation and implantation experience of the children.
Rationale of the Study

- Most studies have examined development of speech intelligibility using only a single measure.
- No study to date appears to have compared open-set sentences with open-set single word tasks for children with cochlear implants.

Participants

- The speech samples were obtained from a group of 17 children (4M; 13F)
  - Prelingually deaf
  - Severe to profound binaural hearing loss (90+dB HL).
  - Age ranged from 4.8 to 11.1 (mean=7.11) at the time of testing.
  - Age of implantation ranged from 1.2 to 8.4 (mean=3.6)
  - Amount of implant experience 1.0 to 7.10 (mean=4.5).
  - Children were implanted by Nucleus (n=7), Clarion (n=9) and Med-el (n=1).

Data Collection Procedures

- **Children Speech Intelligibility Measure (CSIM, Wilcox & Morris, 1999)**
  - for single word production.
  - Each child imitated 50 words randomly chosen from 50 lists of 12 similar sounding words.
- **Beginner's Intelligibility Test (BIT, Osberger, Robbins, Todd, & Riley, 1994)**
  - for sentence production.
  - Each child imitated the 10 sentences from the BIT list.
- Both tests were administered by the same examiner for all children. One session for each child with CSIM given first.

Data Collection Procedures

- All sessions were recorded in a sound treated booth.
- Each of the 50 single-words and 10 sentences were isolated into an independent digital file using CSL 4400.
- All files were amplitude normalized (to average amplitude) using Cool Edit Pro.

Judges

- A group of undergraduate students at UT (n=105)
  - 51 for the CSIM, and a different set of 51 for the BIT
  - Listening sessions were made individually or in groups of 2 to 3.
  - For the CSIM, judges orthographically transcribed the 50 items from one speaker and then judged a second speaker using multiple-choice format
  - For the BIT, the judges transcribed the 10 sentences from each of 3 different speakers (3 unique lists).

Data Analysis

- Percentage understood values were calculated for each listener for each task.
  - For BIT, the number of words correct was calculated from the total number of actual words produced by each child.
  - Scores were averaged across the listeners.
  - This yielded three scores for each speaker (CSIM-transcription; CSIM-multiple choice; BIT).
  - Differences and correlations between the tasks were calculated.
Inter-judge reliability

- Obtained by comparing the highest vs. the lowest score of the three judges for each intelligibility task.

<table>
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<tbody>
<tr>
<td>CSIM (open-set)</td>
<td>0.98</td>
</tr>
<tr>
<td>CSIM (closed-set)</td>
<td>0.98</td>
</tr>
<tr>
<td>BIT</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Implant in Right Ear vs. in Left Ear

- Compared chron. age, age of imp. and amount of imp. ex. of children implanted in their right ear (n = 11) with those of children implanted in their left ear (n = 6).
- A series of Mann-Whitney tests.
- No significant difference was found.
  - Chron. age (p = 0.427)
  - Age of imp. (p = 0.054)
  - Amount of imp. exp. (p = 0.212)
- Therefore, the ear of implant should not have confounded the current findings.

Results

BIT vs. CSIM Open-set
- A strong positive correlation was found (r = .73, p < .05).
- A significant difference between scores on the two tasks (t = 7.99; p < .001).
- Values for sentence production intelligibility (BIT) were higher than CSIM (open-set) for all participants.

BIT vs. CSIM Closed-set
- A strong positive correlation was found (r = .81; p < .05).
- No significant difference was found between scores on the two tasks (t = .125; p > .05).
- Children had a high intelligibility score in BIT also had a high one in closed-set CSIM and vice versa.

Results cont.

CSIM Open-set vs. CSIM Closed-set
- A strong positive correlation was found (r = .85; p < .05).
- A significant difference between the scores of the two tasks (t = -12.25; p < .001)
- Values of closed-set task of (CSIM) were higher than their counterparts on the open-set task of (CSIM) for all the participants.
Intel. vs CA, AI and IE

<table>
<thead>
<tr>
<th></th>
<th>Chronological Age</th>
<th>Age of Implantation</th>
<th>Amount of Implant Exp.</th>
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</thead>
<tbody>
<tr>
<td>BIT</td>
<td>0.47</td>
<td>0.20</td>
<td>0.59</td>
</tr>
<tr>
<td>CSIM (closed-set)</td>
<td>0.32</td>
<td>0.41</td>
<td>0.67</td>
</tr>
<tr>
<td>CSIM (open-set)</td>
<td>0.28</td>
<td>0.34</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Discussion

- Positive correlations indicate that high scores in one task would predict high scores in the other task and vice versa.
  - Similar to the correlations obtained by Chin et al. (2001)
  - BIT, MP1, MP2
- Contextual cues offer an advantage in sentence production measures (BIT)
- CSIM (closed set) offers no meaning cues but the multiple choice task narrows the field of choices for the listener.
- No contextual cues or narrow choices in CSIM (open-set)
  - consistent with Yorkston and Beukelman (1978)
  - reported lowest scores on transcription tasks and, and highest scores on multiple-choice tasks.

The developers of the CSIM recommend the use of the closed-set format
- addition of BIT for intel. asses. would seem redundant.
- However;
  - CSIM (open-set) values were sig. diff. from both the CSIM (closed-set) and the BIT values
  - supports the notion that all speakers really have a range of intelligibility potentials (Kent et al., 1994).

Both single word productions and sentence productions would give us a better sense of their intelligibility range.
- It is recommended that both should be open-set tasks
- Kent’s (1993) a “triangulation” model
  - conversational speech assessment
  - better reflect the overall communicative ability for children

Consistent with the previous studies, only amount of implant experience had a significant correlation with the three intelligibility measures used in the current study.
- Highlights the critical role of auditory input in the development of intelligible speech.

References