Measuring listening effort: Convergent validity, sensitivity, and links with cognitive and personality measures

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**BACKGROUND AND METHOD**

- Listening effort (LE) describes the attentional or cognitive requirements for successful speech understanding.
- LE has been evaluated using various subjective, behavioral, and physiological measures.
- Research aims: 1) Compare the sensitivity of LE measures to changes in task difficulty; 2) Assess correlations among seven previously used measures of LE; 3) Evaluate relationships between LE and cognitive abilities and personality traits.
- Participants: 111 members of the Carleton College community with normal hearing and vision.

**LE MEASURES**

LE tasks were completed in speech-shaped noise in Easy (SNR = +5) and Hard (SNR = -2) conditions.

<table>
<thead>
<tr>
<th>Subjective measure</th>
<th>NASA Task Load Index</th>
<th>NASA (NACIA)</th>
<th>Behavioral (reaction time) measures</th>
<th>Complex Dual-Task (CDT)</th>
<th>Semantic Dual-Task (SDT)</th>
<th>Behavioral (memory) measures</th>
<th>Cognitive tasks</th>
<th>Environmental measures</th>
<th>Physiological measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective ratings of performance, mental demand, effort exerted, and frustration</td>
<td></td>
<td></td>
<td>Hear and repeat words, respond to visually presented numbers</td>
<td>Hear and repeat words, judge whether each word is a noun</td>
<td>Hear and repeat words, judge whether each word is a noun</td>
<td>Hear digits, keep track of high/lowest or odd/even</td>
<td>Make word or nonword judgments on letter strings</td>
<td>Run familiar words, recall list three at the end of a series</td>
<td>Hear and repeat sentences while pupil size is monitored</td>
</tr>
</tbody>
</table>

**INDIVIDUAL DIFFERENCE MEASURES**

**Audiological measure**

PTA at 250, 500, 1000, 2000, 4000, 8000 Hz for both ears

**Cognitive tasks**

- **Reading span**
  - Read sentences, repeat final word, make predictability judgment, recall all final words in a series
- **Letter memory**
  - See strings of letters, recall last four
- **Lexical Decision Task**
  - Make word or nonword judgments on letter strings
- **Simon task**
  - Respond to red and blue rectangles via right and left button presses
- **Text Reception**
  - Read masked sentences

**Personality measures**

- **Big Five Inventory-2**
  - Self-report personality questionnaire to measure extraversion
- **Highly-Sensitive Person Scale (HSPS)**
  - Sensitivity

**Aim 1: Sensitivity**

<table>
<thead>
<tr>
<th>NASA</th>
<th>CDT</th>
<th>SDT</th>
<th>CSCT</th>
<th>LS</th>
<th>RM</th>
<th>Pupillometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s $d$</td>
<td>0.77</td>
<td>0.19</td>
<td>0.31</td>
<td>0.07</td>
<td>0.33</td>
<td>0.44</td>
</tr>
</tbody>
</table>

**Aim 2: Convergent Validity**

**Aim 3: Individual Difference Predictors**

**References & Acknowledgements**


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**DISCUSSION**

- Relatively weak relationships among LE measures (average $r = .22$).
- Intercorrelations between behavioral measures, but generally not between behavioral and subjective/physiological measures.
- Tasks that require deep processing (e.g., SDT) are more sensitive than those that require shallow processing (e.g., CDT).
- Pupillometry was not correlated with performance on any other task or with any cognitive or personality measure.
- Greater cognitive capacity tends to be associated with less LE.
- These results suggest caution when drawing conclusions across studies that use different tasks to measure LE.