Measuring listening-related fatigue in children

Hornsby, B., Davis, H., Camarata, S. & Bess, F.

International Collegium of Rehabilitative Audiology Meeting
May 17-19, 2019, Hong Kong
Acknowledgements

Lab Members and Collaborators

- Fred Bess
- Stephen Camarata
- Sun-Joo Cho
- Hilary Davis
- Ben Hornsby
- Sasha Key

- Caitlin Dold
- Aimee Grisham
- Keren Rosario-Ortiz
- Sam Sekator
- Maureen Virts
Disclosures

• All authors are employed by Vanderbilt University (VU) and Vanderbilt University Medical Center (VUMC)

• Financial Disclosures- this work has been supported by federal and industry grant mechanisms
  – IES #R324A110266 (Bess, PI)
  – IES #R324A150029 (Bess, PI)
  – NIH R21 DC012865-01A1 (Hornsby, PI)
  – Starkey, Inc (Hornsby, PI)

• Nonfinancial Disclosures
  – None
What is listening-related fatigue?

- **Subjective fatigue** is an ongoing “state”, a mood or feeling of tiredness, exhaustion or lack of energy, a reduced desire or motivation to continue a task.
  - Quantified using surveys and questionnaires.
- **Listening-related fatigue** is simply a type of subjective fatigue resulting from the continued application of effort during listening tasks.
  - Pichora-Fuller et al., 2016

See Hornsby, Naylor & Bess, 2016 for review.
Quantifying Fatigue Subjectively

• Some pediatric fatigue scales exist:
  • Pediatric Quality of Life- Multidimensional Fatigue Scale
    – PedSQL-MFS; Varni, et al. 2002
  • Childhood Fatigue Scale
    – CFS; Hockenberry et al. 2003
  • Fatigue Scale-Adolescent
    – Hinds et al. 2007

• But none are specific to hearing loss or focus on listening-related fatigue
Development of The Vanderbilt Fatigue Scale for Children with Hearing Loss (VFS-CHL)

- Phase I- Defining the issues
  - Literature review, focus groups and interviews
- Phase II- Creation of initial item pool
- Phase III- Initial data collection
  - Item analysis, item reduction and preliminary data collection and scale assessment
- Phase IV- Additional validation and preliminary data analyses
Phase I: Defining the Issues

- Literature review provided background theory & relevant constructs
- Focus groups & interviews
  - CHL (N=23)
  - Parents of CHL (N=17)
  - Teachers/School service providers (N=28)

Example Prompts from our Moderator's Guide

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you feel physically or emotionally tired due to difficulty listening?</td>
</tr>
<tr>
<td>Is fatigue from listening a problem for your student?</td>
</tr>
<tr>
<td>How many different kinds of listening situations cause you (your student) to feel physically or emotionally tired?</td>
</tr>
<tr>
<td>What coping strategies do you (or your student) use to recover from fatigue?</td>
</tr>
</tbody>
</table>

- Focus groups lasted ~60 minutes
- Interviews lasted ~10-45 minutes based on the child's age and interest
Talking to kids about fatigue is not straight forward….

• Moderator: “So... 'fatigue', what do you think of when you hear that word?”

• Child: “I never heard that word, so, like, fatigue
  – sounds like phantom,
  – so maybe a squid?”
Phase 1: Defining the issues

“First thing I do when I get home is take my hearing aids out. I just need a break.”
- Student with hearing loss

“My child will withdraw at the end of a long day of listening.”
- Parent of a child with hearing loss

“Trying harder to listen and understand drains me and makes me feel down.”
- Student with hearing loss

“My child will zone out or go into a bubble when she needs a break from listening.”
- Parent of a child with hearing loss

“My brain needs a rest from listening.”
- Student with hearing loss

“It’s like my brain’s getting, um, very tired of hearing things.”
- Student with hearing loss

Social-Emotional (External-Internal Behaviors)

Physical (Sleep/Rest)

Cognitive (Attention)

Listening-Related Fatigue

“It’s like my brain’s getting, um, very tired of hearing things.”
- Student with hearing loss

“Yeah, you wanna give up... you put all of your focus on what they're trying to say and you still can't hear them.”
- teen with bilateral hearing aids
Development of The Vanderbilt Fatigue Scale for Children with Hearing Loss (VFS-CHL)

- Phase I- Defining the issues
  - Literature review, focus groups and interviews
- Phase II- Creation of initial item pool
Phase II: Item Development

Range of Listening-Related Fatigue

MILD

Social-Emotional (Internal-External Behaviors)

Physical (Sleep/Rest)

Cognitive (Attention)

Listening-Related Fatigue

SEVERE
<table>
  <thead>
    <tr>
      <th>Fatigue Severity</th>
      <th>Domain: Cognitive (Attention)</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <td>Severe</td>
      <td><strong>Behaviors:</strong> becomes unfocused, <em>unwillng/unable to maintain effort and attention</em> when completing even routine mental activities; <em>decides</em> to disengage- <strong>Shuts down, gives up</strong> -observed in a <em>wide range</em> of listening situations</td>
    </tr>
    <tr>
      <td>Moderate</td>
      <td><strong>Behaviors:</strong> must apply <em>substantial mental effort</em> to overcome difficulties remaining attentive. May involuntarily <strong>tune/zone out</strong>. May need prompting. -observed in <strong>moderately challenging</strong> listening situations</td>
    </tr>
    <tr>
      <td>Mild</td>
      <td><strong>Behaviors: Some difficulty</strong> following fast-paced conversation and remaining attentive. -observed <strong>ONLY</strong> in very challenging situations</td>
    </tr>
  </tbody>
</table>
Phase II: Item List Development

- ~550 items created (range: 157-212/group)
  - Reduced to **60 items/group** via expert panel review

<table>
<thead>
<tr>
<th></th>
<th>Cognitive</th>
<th>Physical</th>
<th>Social/Emotional</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Moderate</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>Mild</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>20</strong></td>
<td><strong>20</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>

- Cognitive Interviews (N=23)
  - 9 Children; 7 Parents; 7 Teachers
Sample items from the VFS-CHL

- My brain gets tired after listening all day
  - Item from the Child scale

- Listening takes a lot of effort for my child
  - Item from the Parent scale

- The student seems to get worn out from listening all day at school
  - Item from the Teacher scale
Development of The Vanderbilt Fatigue Scale for Children with Hearing Loss (VFS-CHL)

• Phase I- Defining the issues  
  – Literature review, focus groups and interviews

• Phase II- Creation of initial item pool

• Phase III- Preliminary data collection  
  – item analysis, item reduction and initial evaluation of scale characteristics
Phase III: Preliminary Data Collection

- Data collected online and paper/pencil from >900 respondents
  - ~75-80% with HL

- N=393 parents
  - 296 CHL
  - 94 without HL
  - 3 unknown

- N=214 children
  - 160 CHL
  - 51 without HL
  - 3 unknown

- N=304 teachers
  - 243 CHL
  - 61 without HL

VANDERBILT
SCHOOL OF MEDICINE
Phase III: Initial Item Assessment

- Analyzed data to identify & select high quality items for the final scale:
  - Quantitative: Item Response Theory- IRT
    - Want high information items across a range of severities
    - Items with appropriate threshold order and good separation between response thresholds (good discrimination)
    - Items that were stable across age and gender groups
      - Used differential item functioning (DIF) to examine item stability
        » Across age (7-12 vs 13-18 y.o.) & gender
  - Qualitative: Expert review
    - Removed redundant items via expert review
Phase III: Initial Item Assessment

- **Child & Teacher EFA** suggests unidimensional model of listening-related fatigue
  - Unidimensional
    - Cognitive, Social-Emotional, Physical
  - Listening-Related Fatigue

- **Parent EFA** suggests a 2-factor model of listening-related fatigue
  - Factor 1
    - Social-Emotional, Cognitive
  - Factor 2
    - Physical
  - Listening-Related Fatigue
Phase III: Item Reduction

• Final versions selected for validation:
  – Parent scale- 12 items, 2 factors
    • 7 cognitive/social-emotional items
    • 5 physical items
  – Child scale- 10 items
  – Teacher scale- 8 items
Development of The Vanderbilt Fatigue Scale for Children with Hearing Loss (VFS-CHL)

- Phase I- Defining the issues
  - Literature review, focus groups and interviews
- Phase II- Creation of initial item pool
- Phase III- Preliminary data collection
  - Item analysis, item reduction and preliminary data collection and scale assessment
- Phase IV- Additional validation and preliminary data analyses
Phase IV: VFS-CHL Validation

• Data collection and analyses are ongoing
  – N= 840 respondents (376 Parents; 128 Children; 336 Teachers)
• Initial analyses suggest the scales are valid and provide a reliable estimate of listening-related fatigue
  – Test-retest reliability
  – Concurrent validity
  – Construct Validity
VFS-CHL: Test-retest reliability

- Strong correlations and absolute agreement between test-retest VFS scores
  - Spearman’s rho ranged from .70 -.86

<table>
<thead>
<tr>
<th></th>
<th>N=37</th>
<th>N=157</th>
<th>N=72</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VFS-CHL: Concurrent Validity

- Examined associations bw VFS’s and generic fatigue (PedsQL-MFS) and depression (Child Depression Inventory-CDI) measures

- Analysis of additional ~150 participants (50/group- children, parents, teachers) reporting on CHL only

- Across respondent groups, VFS scores show
  - weak/moderate associations with various PedsQL scales
    - r values ranged from -0.22 to -0.74
  - and with various CDI results
    - r values ranged from 0.24-0.64
VFS-CHL: Associations w/ PedsQL

- VFS scores show weak to moderate negative correlations with generic fatigue (PedsQL) measures (lower value = more fatigue)
  - Data for cognitive fatigue shown

![Graphs showing correlations with PedsQL measures for Child, Parent, and Teacher perspectives with R² values: 0.2359, 0.3428, and 0.4761 respectively. N values: 48, 50, 50.]
VFS-CHL: Associations w/CDI

- VFS scores also show weak to moderate positive correlations with a depression scale (CDI)
  - Data for CDI Total score shown

Child

Parent

Teacher

N=50

R^2 = 0.1592

N=50

R^2 = 0.2625

N=44

R^2 = 0.1844
VFS-CHL: Construct Validity

• Construct validity is based, in part, on stakeholder input during the test development process

• In addition, our scale appears to sensitive to effects of hearing loss on listening-related fatigue, at least in adults
  – But sensitivity to hearing loss in children may (or may not) vary among respondent scales
VFS-AHL/CHL and self-reported HL

Error bars = 1 standard error

= significant differences

N=463
N=376
N=128
N=336

n=198 234 31
136 181 59
43 59 26
67 297 39

VANDERBILT
SCHOOL OF MEDICINE
• Disabilities *other than HL* may also increase listening-related fatigue
  – This can confound our results
• I.e., Ratio of children with/without disabilities may vary across samples

<table>
<thead>
<tr>
<th></th>
<th>Child</th>
<th>Parent-Proxy</th>
<th>Teacher-Proxy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CNHL</td>
<td>CHL</td>
<td>CNHL</td>
</tr>
<tr>
<td>Cognitive Disability</td>
<td>13% (2)</td>
<td>16% (10)</td>
<td>11% (5)</td>
</tr>
<tr>
<td>Visual Impairment</td>
<td>7% (1)</td>
<td>5% (3)</td>
<td>7% (3)</td>
</tr>
<tr>
<td>Behavioral/Emotional Problem</td>
<td>40% (6)</td>
<td>36% (22)</td>
<td>47% (21)</td>
</tr>
<tr>
<td>Physical Disability</td>
<td>20% (3)</td>
<td>5% (3)</td>
<td>9% (4)</td>
</tr>
<tr>
<td>Speech-Language Impairment</td>
<td>0% (0)</td>
<td>13% (8)</td>
<td>9% (4)</td>
</tr>
<tr>
<td>Genetic/Chromosomal Syndrome</td>
<td>7% (1)</td>
<td>8% (5)</td>
<td>7% (3)</td>
</tr>
<tr>
<td>Other</td>
<td>13% (2)</td>
<td>16% (10)</td>
<td>11% (5)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15</strong></td>
<td><strong>61</strong></td>
<td><strong>45</strong></td>
</tr>
</tbody>
</table>
VFS-CHL and additional disabilities

- Disabilities *other than HL* may also increase listening-related fatigue
  - This can confound our results
    - I.e., Ratio of children with/without disabilities may vary across samples

\[
\begin{array}{c|c|c}
\text{No Hearing Loss Group} & \text{Hearing Loss Group} \\
\hline
\text{78\%- No disability} & \text{57\%- No disability} \\
\text{22\%- ≥1 Disabilities} & \text{43\%- ≥1 Disabilities} \\
\end{array}
\]

- Error bars = 1 standard error
- I.e., Ratio of children with/without disabilities may vary across samples
VFS-CHL and additional disabilities

- Disabilities *other than HL* may also increase listening-related fatigue
  - This can confound our results
    - I.e., Ratio of children with/without disabilities may vary across samples

VFS-CHL and additional disabilities

- Disabilities *other than HL* may also increase listening-related fatigue
  - This can confound our results
    - I.e., Ratio of children with/without disabilities may vary across samples

![Graph showing IRT scale scores for No Hearing Loss Group and Hearing Loss Group](image)

- No Hearing Loss Group:
  - 79% - No disability
  - 21% - ≥1 Disabilities

- Hearing Loss Group:
  - 56% - No disability
  - 44% - ≥1 Disabilities

Error bars = 1 standard error
Disabilities other than HL may also increase listening-related fatigue. This can confound our results. I.e., Ratio of children with/without disabilities may vary across samples.
VFS-AHL/CHL and self-reported HL

May reflect confound of additional disabilities

Error bars = 1 standard error

= significant differences
Conclusions

• The VFS-CHL is an ecologically valid measure of listening-related fatigue in children based on child self-report or parent/teacher proxy report
  – All scales provide valid and reliable measure of listening-related fatigue for CHL
  • Presence of additional disabilities increases risk for fatigue
Thanks for Listening!

Questions?

For more information check out our lab websites:
https://my.vanderbilt.edu/listeninglearninglab/

https://my.vanderbilt.edu/hearingandcommunicationresearch/