Understanding listening-induced fatigue in school-age children with hearing loss

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What is fatigue?

- No universally accepted definition exists
  - Occurs in the physical and mental domains
- **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
- **Behavioral (Cognitive) fatigue** is an outcome, a decrement in performance
  - Physical or mental performance
- **Physiologic measures** can be used as indirect markers of subjective and behavioral fatigue

“I recommend that the term fatigue be absolutely banished from precise scientific discussion”.

----Muscio (1921)
Who Has Fatigue?

Everybody!

Complaints of **mild transient** fatigue are common even in healthy populations.

**Severe, recurrent fatigue** is not common in healthy populations.
- Common in many chronic health conditions
  - Cancer, HIV AIDs, Parkinson’s, MS
- Almost no work on hearing loss and fatigue—Especially Kids!
Consequences of severe, recurrent fatigue

**Adults**—
- Inattention, lack of concentration, poor mental processing and decision-making skills
- Less productive and more prone to accidents
- Less active, more isolated, less able to monitor own self-care

**Children w/ Chronic Illnesses**—
- Inattention, concentration, distractibility
- Poorer school achievement, higher absenteeism

Amato, et al. 2001; van der Linden et al. 2003; DeLuca, 2005; Eddy and Cruz, 2007; Ricci et al. 2007
Is fatigue a problem for people with hearing loss?

“....... I can attest to the FATIGUE caused by prolonged intensive listening in noise through hearing aids.......”.

Mark Ross, 2006, 2012
Pediatric Audiologist
Hearing Loss, Listening Effort and Fatigue- Child and Parent Report

“First thing I do when I get home is take my hearing aids out. I just need a break.”
- Student 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 child will withdraw at the end of a long day of listening.”
- Parent of a child with hearing loss

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

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

A variety of approaches have been used:

**Subjectively** —
- Using questionnaires and survey instruments

**Behaviorally** —
- A decline in (cognitive) task performance due to sustained (mental) demands

**Physiologically** —
- Physiologic changes or biomarkers associated with mental fatigue
Quantifying Fatigue Subjectively

- Subjective measures include surveys, rating scales and questionnaires that ask about mood or feelings.
- Fatigue scales may be:
  - Uni-dimensional: Assess “general” fatigue
    - a composite fatigue measure
  - Multidimensional: Assess various dimensions of fatigue
- Many options, none specific to hearing loss or focus on listening-related fatigue

see e.g., Dittner et al., 2004 for review
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For more information check out Hilary Davis’s poster at tonight’s poster session!

see e.g., Dittner et al., 2004 for review
The PedsQL MFS: Pediatric Quality of Life Multidimensional Fatigue Scale

- Assesses general, sleep/rest, and cognitive fatigue and provides a “Total” fatigue score
  - Parent version also available
  - Asks about persistent fatigue- over the past month

*In the past ONE month, how much of a problem has this been for you …*

<table>
<thead>
<tr>
<th>Item</th>
<th>Never</th>
<th>Almost Never</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost Always</th>
<th>Construct</th>
<th>General</th>
<th>Sleep/Rest</th>
<th>Cognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel tired</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>Construct</td>
<td>General</td>
<td>Sleep/Rest</td>
<td>Cognitive</td>
</tr>
<tr>
<td>I sleep a lot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is hard for me to keep my attention on things</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This version is for children 8-12 years  

Varni et al., 2002
The PedsQL MFS: Pediatric Quality of Life Multidimensional Fatigue Scale

• Assesses general, sleep/rest, and cognitive fatigue and provides a “Total” fatigue score
  • Parent version also available
  • Version for younger children also available

Think about how you have been doing for the past few weeks. Please listen carefully to each sentence and tell me “How much of a problem this is for you?”

<table>
<thead>
<tr>
<th>Item</th>
<th>Not at all</th>
<th>Sometimes</th>
<th>A lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you feel tired</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Do you sleep a lot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is it hard for you to keep your attention on things</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Varni et al., 2002
Subjective fatigue in age matched children with and without HL: Preliminary Data

- Used PedsQL-MFS to quantify fatigue
- Participants:
  - 10 CNH (Mean = 10 y.o., range 6–12 years)
  - 10 CHL (Mean = 10 y.o., range 6–12 years)
- Wide range of losses and amplification
  - 4 symmetric mild-moderate losses; bilateral hearing aids
  - 2 asymmetric losses; unilateral hearing aids
  - 4 bilateral profound losses
    » 2 bilateral CI users
    » 1 CI(R)/HA(L)
    » 1 CI(R)/Unaided(L)

Hornsby, Werfel, Camarata, and Bess (2014). Subjective Fatigue in Children with Hearing Loss, AJA.
Preliminary Results (n=10/group)

- CHL reported significantly more fatigue.
  Pervasive across domains

PedsQL-MFS: Pediatric Quality of Life-Multidimensional Fatigue Scale (Varni et al., 2002)

17-30 point differences!

* p < 0.05

Full Data Set (n=60 CHL; 43 CNH)

• Preliminary analyses shows **main effect of HL** but much smaller effects- data analyses are ongoing

• 6-12 year old CHL & CNH
  – CHL had mild to mod-severe losses AU
  – No CI users

![Bar chart showing PedsQL score differences between CHL and CNH in different domains: General, Sleep/Rest, Cognitive, Overall. The chart indicates ~2-6 point differences.](chart.png)
Why the smaller effect of hearing loss?

- Differences reflect **less** fatigue in children with HL and **more** fatigue in our normal hearing children.
Fatigue in CHL and children with other chronic health conditions

Our larger group of CHL reports *similar, or more, fatigue* compared to children with other chronic conditions.
Limitations of Subjective Measures

• Subjective measures alone provide an incomplete assessment of fatigue
  – Subject to bias
  – The physiologic mechanisms responsible for the rating may be variable or unknown
  – Often uncorrelated with severity of conditions associated with the fatigue
    • And other fatigue measures (e.g., behavioral, physiologic)

• Highlights the need for alternative measures
A variety of approaches have been used:

**Subjectively**—
• Using questionnaires and survey instruments

**Behaviorally**— a performance decrement
• A decline in (cognitive) task performance due to sustained (mental) demands

**Physiologically**—
• Physiologic changes or biomarkers associated with mental fatigue
Physiologic Markers of Fatigue

• Monitor physiologic changes associated with mental fatigue
  – Cortisol measures
    • Hicks and Tharpe, 2002; Tops et al., 2006; Bess, et al., 2016
  – EEG measures
    • Murata et al., 2005; Trejo et al., 2004
  – Skin Conductance
    • Darrow and Solomon, 1934; Segerstrom and Nes, 2007
  – fMRI measures
    • Caseras et al., 2006; Caldwell et al., 2010

• Provide important physiologic correlates to acute/transient and persistent/long term fatigue
• Stress is the body’s reaction to change that requires a physical, mental or emotional response
  • Stress can be caused by good experiences
    • and bad experiences
• **Cortisol** levels provide a physiologic/objective measure of stress that is associated with fatigue
  • Regulated by the hypothalamic-pituitary-adrenal (HPA) axis
  • Cortisol levels are not a direct indicator of fatigue
“Typical” Diurnal Salivary Cortisol Patterns During the Day

• In non-fatigued individuals, cortisol levels have a typical diurnal pattern
  – Build-up of cortisol during sleep
  – Rapid rise upon awakening
    • Cortisol Awakening Response; CAR
  – Slow decline in cortisol throughout the day

“Abnormal” Diurnal Salivary Cortisol Patterns During the Day

• Sustained stress or fatigue can lead to abnormal diurnal cortisol patterns
  
  – Reduced response with “Chronic Fatigue Syndrome”

“Abnormal” Cortisol Awakening Response

- Sustained stress or fatigue can lead to abnormal diurnal cortisol patterns
  - Reduced response with “Chronic Fatigue Syndrome”
  - “Elevated” CAR in patients with depression

“Abnormal” Cortisol Awakening Response

• Sustained stress or fatigue can lead to abnormal diurnal cortisol patterns
  – Reduced response with “Chronic Fatigue”
  – “Elevated” CAR in patients with depression
  – And high burnout
    • On sick leave due to burnout

Measuring Salivary Cortisol Levels in CHL & CNH

• Study Questions:
  – Do overall cortisol levels/patterns differ in CHL and CNH?
  – Does the CAR differ between groups?

Measuring Salivary Cortisol Levels in CHL & CNH

Bess et al., (2016)

• Participants: CHL (n=32) & CNH (n=28)
  – Age range: 6-12 year old
  – CHL: Mild-Severe SNHL

• Inclusion/Exclusion:
  – No cochlear implant users
  – General education classroom
  – Monolingual English speakers
  – No diagnosis of cognitive impairment, autism or developmental disorder
Measuring Salivary Cortisol Levels in CHL & CNH

- Six samples taken: awakening*, 30*, & 60* min post, 10am, 2pm, 8pm*
  - Procedure repeated a second time several weeks later

- Cortisol levels can be “easily” obtained from saliva samples
  - Easier to collect than some other biologic materials (e.g., hair, urine)

*Samples taken by parents at home-
Other samples taken at school by research staff

Bess et al., (2016)
Diurnal Salivary Cortisol Patterns in CHL & CNH

Age range 6-12 years

- CHL have elevated cortisol levels at awakening

CNH (N=28)
CHL (N=32)

Bess et al., (2016)
Diurnal Salivary Cortisol Patterns in CHL & CNH

- And a reduced CAR

Bess et al., (2016)
Age, Hearing Loss and Cortisol

- Cortisol levels increase with age for CHL
  - But not CNHL
- Sustained stress due to HL **MAY** be affecting their HPA system, potentially increasing risk for fatigue over time

Bess et al., (2016)
Take Home Points

• School-age children with mild-moderately severe HL
  – Report more fatigue compared to control groups
    • Although, the magnitude is much less than seen in our prior report (i.e., Hornsby et al., 2014).
    – Their fatigue is comparable, or greater, than that reported by children with other chronic health conditions

• These CHL also display an abnormal stress response
  – Elevated cortisol levels upon awakening and a reduced CAR
  – Cortisol levels appear to increase with age in our CHL
    • Consistent with sustained stress exposure
Implications for Practice

• Be on the lookout for fatigue!

  – Fatigue can manifest itself in a variety of ways
    • tiredness
    • sleepiness in the morning
    • inattentiveness and distractibility
    • mood changes (irritability, frustration, etc.)
    • changes in classroom contributions
    • difficulty following instructions

Implications for Practice

• Help us educate the community & the students
  – Discuss with families, general education teachers, and other service providers that children with hearing loss are at increased risk for fatigue
    • Importance of listening breaks
    • Arrange lessons so cognitively demanding material is early in the day
  – Help students with hearing loss recognize signs of fatigue so they can learn how and when to take listening breaks

Implications for Practice

• Look for ways to potentially reduce stress/fatigue

  – Evidence in adults suggests that properly fitted hearing aids can reduce listening effort and cognitive fatigue (Hornsby, 2013)

  – Promote strategies to cope with the increased stress of children with hearing loss
    • Relaxation, avoidance of high-fat diets, and regular exercise can all help reduce the negative effects of stress (McEwen, 1998; Ratey, 2008)
Thanks for Listening!

Visit the Listening and Learning Lab’s website at http://my.vanderbilt.edu/listeninglearninglab