VANDERBILT UNIVERSITY MEDICAL CENTER

Measures of Fatigue in Children With and Without Hearing Loss

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INTRODUCTION

Fatigue is a common complaint of individuals with a wide range of chronic health conditions and is associated with a variety of negative social and psycho-educational outcomes.[1,2] Fatigue in children is especially important given its well-known negative effects on academic performance.[3,4] Anecdotal reports and recent empirical work suggest that **children with hearing loss (CHL)** are at increased risk for fatigue and its negative effects.[5, 6, 7]

Despite growing evidence of a link between hearing loss and fatigue, our understanding of the mechanisms behind this relationship are limited. Substantial research suggests that individuals with hearing loss increase their mental effort to detect and process auditory information (e.g. speech) and, as a result of this increased effort, have fewer resources available for other tasks.[6,8,9] Anecdotal reports and qualitative research suggest that sustained increased mental effort may lead to subjective reports of fatigue.[10,11] Here we report preliminary results from our efforts to quantify fatigue related to speech processing in CHL and **children with normal hearing (CNH)**.

PURPOSE

The purpose of this study was to examine the relationship between demanding listening effort tasks and measures of fatigue (subjective and objective) in school-age CHL and CNH.

Research Questions:
1) Does cognitively demanding and sustained listening lead to increases in subjective or objective fatigue in CHL loss compared to CNH?
2) Does amplification reduce subjective and/or objective fatigue in CHL?

METHODS

Participants:
Children aged six to twelve years completed these measures as part of a larger ongoing study examining listening effort and fatigue in school-age CNH and CHL. Exclusion criteria included cognitive impairment, autism, and other developmental disorders. This study was conducted at the Listening and Learning Lab at the Vanderbilt Bill Wilkerson Center. Visits were approximately 2 ½ – 3 ½ hours long. CNH completed only one visit, while CHL completed up to two visits, one with the use of hearing aids (aided) and one without the use of hearing aids (unaided).

Demographics					Testing Conditions		
Group	N	Mean Age (years)	Female (n)	Hearing Aid Usage	Unaided (n)	Aided (n)	Both (n)
CNH	25	8.56	10	N.A.	25	N.A.	N.A.
CHL	13	10.38	7	12	12	10	9

Table 1. Description of CNH and CHL groups. Total number of subjects, mean age, gender, hearing aid usage information, and total number of subjects completing the following testing conditions: Unaided, Aided, and Both (Unaided AND Aided) are provided for each group.

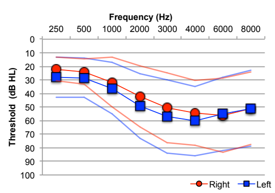

Figure 1. Mean audiometric thresholds +/- one standard deviation for CHL group. CHL had sensorineural or mixed hearing loss that ranged from mild to severe. Mild hearing loss was defined as average pure tone air conduction thresholds at 0.5, 1, & 2 kHz between 20 and 40 decibels hearing level (dB HL) or pure tone air conduction thresholds greater than 25 dB HL at two or more frequencies above 2 kHz[12].

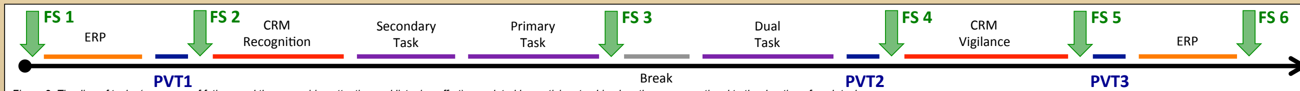

Figure 2. Timeline of tasks (measures of fatigue and those requiring attention and listening effort) completed by participants. Line lengths are proportional to the duration of each task.

METHODS

A series of tasks requiring sustained attention and listening effort were completed by each participant to simulate situations similar to those experienced during the school day. Subjective and objective measures of fatigue were obtained at specified intervals during the visit.

Tasks Requiring Attention and Listening Effort: *(Note: Results from these tasks are not discussed in this poster).*

Coordinated Response Measure (CRM) Tasks: 1) Recognition – Participants chose the call sign, color, and number they heard in multi-talker babble. ***2) Vigilance*** – Sustained attention task where participants performed the CRM recognition task when a random target number was heard.

Dual Task Paradigm Tasks: 1) Primary Task – Verbal repetition task with Consonant-Vowel-Consonant (CVC) words heard at three signal to noise ratios in multi-talker babble. ***2) Secondary Task*** – Visual/motor reaction time task in in multi-talker babble. ***3) Dual Task*** – Participants performed primary and secondary tasks simultaneously.

Measures of Fatigue Used:

Subjective: Fatigue Scale (FS) – Five-item questionnaire with a five-point rating scale [range: 0 (not at all fatigued) – 4 (very fatigued)]. A mean fatigue score was calculated by averaging responses across the five items. The FS was administered six times over the course of the visit.

Objective: Psychomotor Vigilance Task (PVT)[13] – Visual/motor reaction time task in quiet. This task required sustained visual attention over a five-minute interval. Median reaction time and lapses of attention are sensitive measures of the effects of fatigue. A lapse of attention was defined as a response occurring greater than 500ms after stimulus onset. The PVT was completed three times over the course of the visit.

Event-related potentials (ERP) – Oddball paradigm with syllables (gi/gu) in noise. *(Results from ERP not discussed in the poster).*

PRELIMINARY RESULTS

Subjective Measure of Fatigue

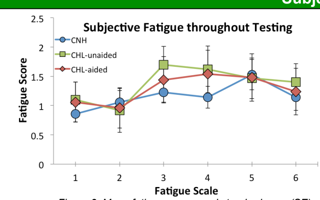

Figure 3. Mean fatigue scores and standard error (SE) six times throughout the visit.

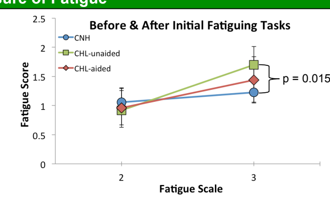

Figure 4. Mean fatigue scores and SE for FS2 and FS3.

Objective Measure of Fatigue

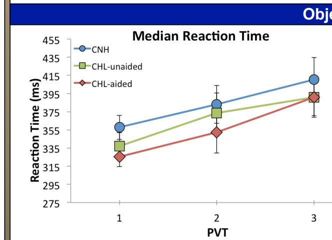

Figure 5. Median reaction time and SE for PVT completed at three time points over the course of the visit.

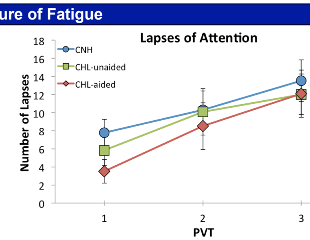

Figure 6. Average number of lapses and SE for each group on a PVT completed at three different time points over the course of the visit.

PRELIMINARY RESULTS

Subjective Measure of Fatigue

Fatigue scores throughout testing:
A series of mixed-model analyses of variance (ANOVAs) revealed a significant main effect of time for all groups ($p < 0.01$; Fig. 3) and a significant group x time interaction when comparing CNH and CHL-unaided ($p = 0.044$; Fig. 3). The main effect of time indicated that our series of tasks increased subjective fatigue for all groups. The significant interaction indicated the pattern of change over time for CNH and CHL-unaided differed. No significant differences in fatigue patterns were observed between CNH and CHL-aided, or between CHL when unaided or aided.

Fatigue scores before and after initial fatiguing tasks:
Post hoc analyses using a series of mixed model ANOVAs suggest the source of the interaction was a larger increase in fatigue between FS2 and FS3 for CHL-unaided compared to CNH ($p = 0.015$; Fig. 4). FS3 was administered following the first long period (approx. 1 hour) of tasks requiring substantial sustained attention and listening effort. These initial demanding tasks appear to have fatigued CHL while unaided more than CNH. No other group x time interactions were significant.

Objective Measure of Fatigue

PVT throughout testing:
A series of mixed-model ANOVAs showed significantly increased median reaction times and lapses ($p < 0.01$; Fig. 5 & 6) over time for all groups. No time x group interactions were observed for any PVT measure, suggesting similar patterns of increased fatigue for all groups.

KEY FINDINGS

- CNH and CHL (regardless of of amplification) showed increased fatigue over time during demanding tasks requiring attention and listening effort. This was consistent for both subjective and objective measures.
- When CHL were not using amplification, they showed greater change in subjective fatigue than CNH after a fatiguing task.
- Fatigue in school-age children can be measured objectively and subjectively with these tools.

KEY REFERENCES

1. Hardy, S. E., & Studenski, S. A. (2010). Qualities of fatigue and associated chronic conditions among older adults. *Journal of Pain Symptoms and Management, 39*(6), 1033-1042.
2. Eddy, L., & Cruz, M. (2007). The relationship between fatigue and quality of life in children with chronic health problems: A systematic review. *Journal for Specialists in Pediatric Nursing, 12*(2), 105-114.
3. Ravid, S., Afek, I., Suraiya, S., Shahar, E., & Pillar, G. (2009). Sleep disturbances are associated with reduced school achievements in first-grade pupils. *Developmental Neuropsychology, 34*(5), 574-587.
4. Ravid, S., Afek, I., Suraiya, S., Shahar, E., & Pillar, G. (2009). Kindergarten children's failure to qualify for first grade could result from sleep disturbances. *Journal of Child Neurology, 24*(7), 816-822.
5. Bess, F.H., Dodd-Murphy, J., & Parker, R.A. (1998). Children with minimal sensorineural hearing loss: Prevalence, educational performance, and functional status. *Ear and Hearing, 19*(5), 339-354.
6. Hicks, C. B. & Tharpe, A. M. (2002). Listening effort and fatigue in school-age children with and without hearing loss. *Journal of Speech, Language, and Hearing Research, 45,* 573-584.
7. Hornsby, B. W., Werfel, K., Camarata, S., & Bess, F. H. (2013). Subjective fatigue in children with hearing loss: Some preliminary findings. *American Journal of Audiology, 22.*
8. McCoy, S. L., Tun, P. A., Cox, L. C., Colangelo, M., Stewart, R. A., & Wingfield, A. (2005). Hearing loss and perceptual effort: Downstream effects on older adults' memory for speech. *The Quarterly Journal of Experimental Psychology Section A, 58*(10), 22-33.
9. Rabbitt, P. (1991). Mild hearing loss can cause apparent memory failures which increase with age and reduce with IQ. *Acta Otolarynogol (Stockh),* Suppl. 476:167-176.
10. Hetu, R., Riverin, L., Lalande, N., Getty, L., & St-Cyr, C. (1988). Qualitative analysis of the handicap associated with occupational hearing loss. *British Journal of Audiology, 22*(4), 251-264.
11. Copithorne, D. (2006). The fatigue factor: How I learned to love power naps, meditation, and other tricks to cope with hearing-loss exhaustion. *Healthy Hearing*, August 21, 2006. Retrieved from http://www.healthyhearing.com/content/articles/Hearing-loss/Treatments/7844-The-fatigue-factor-how
12. National workshop on mild and unilateral hearing loss: Workshop proceedings. (2005). In *Centers for Disease Control and Prevention*. Breckenridge (CO).
13. Dinges, D., & Powell, J. (1985). Microcomputer analyses of performance on a portable, simple visual RT task during sustained operations. *Behavior Research Methods, 17*(6), 652-655.

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