VANDERBILT UNIVERSITY MEDICAL CENTER

Objective 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.[1,2,3,4]
- Anecdotal reports and recent empirical work suggest that children with hearing loss are at increased risk for fatigue and its negative effects,[5,6,7] because potentially individuals with hearing loss exert greater mental effort to detect and process auditory information (e.g. speech) compared to individuals with normal hearing.
- Despite growing evidence of a link between hearing loss and fatigue, our understanding of the mechanisms behind this relationship are limited.[10,11] Fatigue resulting from increased listening effort may manifest as a reduction in resources available for performance of other tasks[6,8,9] and could be reflected in self-report and changes in performance over time. Recent studies noted that event-related potentials (ERPs) in an oddball task are also sensitive to the effects of listening effort and fatigue.[12,13]

PURPOSE

In this study we examine the relationship between measures of fatigue (subjective and objective) resulting from sustained listening effort in school-age **children with hearing loss (CHL)** and **children with normal hearing (CNH)**.

Research Questions:

1) Does cognitively demanding and sustained listening lead to increases in subjective and/or objective fatigue in CHL compared to CNH?
2) Does amplification reduce subjective and/or objective fatigue in CHL?
3) What is the relationship between measures of fatigue in CNH and CHL?

HYPOTHESIS

We anticipated that fatigue due to completion of following tasks requiring sustained attention and listening effort would be reflected in increased scores on the Fatigue Scale (FS), prolonged reaction time in the Psychomotor Vigilance Task (PVT), and reduced amplitude on the P300 brain response in an auditory oddball task (ERP).

METHODS

Participants:

Children aged six to twelve years completed these measures as part of a larger ongoing study at the Listening and Learning Lab at the Vanderbilt Bill Wilkerson Center (VBWC) examining listening effort and fatigue in school-age CNH and CHL. Exclusion criteria included cognitive impairment, autism, and other developmental disorders. 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).

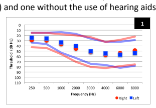


Figure 1. Mean audiometric thresholds +/- one standard deviation for CHL group.

Demographics					Testing Conditions		
Group	N	Mean Age (years; SD)	Female (n)	Hearing Aids	Unaided (n)	Aided (n)	Both (n)
CNH	26	9.3 (2.3)	12	N.A.	26	N.A.	N.A.
CHL	17	10.9 (1.8)	9	16	15	11	10

Table 1. Description of CNH and CHL groups.

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 (Fig. 2).

Data analysis for each measure included repeated measures analysis of variance (ANOVA) - mixed-model when appropriate. Post-hoc analysis included Wilcoxon Signed-ranks test for FS measures.

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

Coordinated Response Measure (CRM) Tasks:

1. **Recognition** – Closed-set recognition of speech in multi-talker babble. Participants selected a call sign, color, and number.
2. **Vigilance** – Sustained attention task. Participants performed the CRM Recognition task only when a target number was heard.

Dual Task Paradigm Tasks:

1. **Primary Task** – Verbal repetition task in multi-talker babble. Participants repeated consonant-vowel-consonant words at three signal-to-noise ratios.
2. **Secondary Task** – Visual/motor reaction time task. Participants pressed a button when visual stimuli were shown.
3. **Dual Task** – Primary and secondary tasks performed simultaneously.

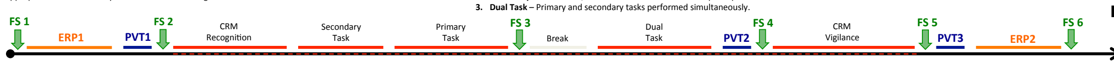


Figure 2. Timeline of tasks (measures of fatigue and those requiring attention and listening effort) completed by participants. Line lengths are proportional to the duration of each task.

FATIGUE MEASURES

Fatigue Scale (FS) – Subjective Measure of Fatigue

A five-item questionnaire with a five-point rating scale [range: 0 (not at all fatigued) – 4 (very fatigued)] was developed by the VBWC for the purpose of this study.

Q1. I feel tired.
Q2. It is easy for me to do these things.
Q3. My head hurts.
Q4. It's hard for me to pay attention.
Q5. I have trouble thinking

The FS was administered six times over the course of the visit.

A mean fatigue score was calculated by averaging responses across the five items (Q4 was reverse scored). A baseline score was generated using FS1 and FS2.

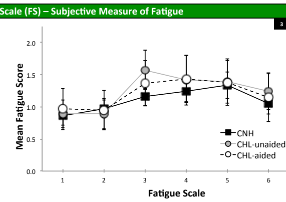


Figure 3. Mean fatigue scores and standard error (SE).

Psychomotor Vigilance Task (PVT)[14] – Objective Measure of Fatigue

Visual/motor reaction time task in quiet. This task required sustained visual attention over a five-minute interval (50 trials during each 5 minute test). The PVT was completed three times over the course of the visit.

Median reaction time was used as a sensitive measure of the effects of fatigue.

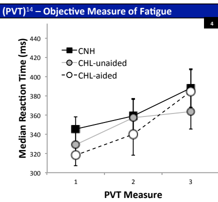


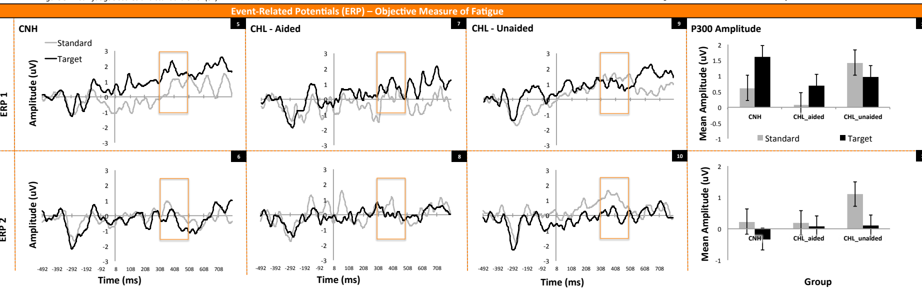
Figure 4. Median reaction time and SE for each task.

Event-Related Potentials (ERP) – Objective Measure of Fatigue

Centro-parietal P300 served as a brain-based measure of attention. It was recorded using a 128 channel Geodesic sensor net (EGI, Inc., Eugene, OR). Oddball paradigm (Standard: 70%; Target: 30%) with syllables [gi] and [gu] 610 milliseconds (ms) long at 75 dB SPL, were presented centered in multi-talker babble speech noise (1400 ms) at a 10 dB signal to noise ratio. Syllable-to-condition assignment was counterbalanced across participants. EEG Sampling Rate: 250 Hz. Low Pass Filter: 100 Hz. Average reference used for analysis of P300 response (300-500ms) at centro-parietal scalp location (Pz).

Figures 5 - 10. Grand average waveforms for ERP1 (top) and ERP2 (bottom) for each group and condition.

Figures 11-12: Mean amplitude (uV) and one standard deviation (SD) for ERP 1 (top) and ERP2 (bottom) for each group and condition .



PRELIMINARY RESULTS

Subjective Measure of Fatigue - FS:

Mean fatigue scores changed significantly over time ($p < 0.01$; Fig. 3) but differences between groups were not significant. FS3, FS4, and FS5 scores significantly increased relative to baseline ($p < 0.01$) consistent with greater levels of fatigue. FS6 did not differ from baseline levels and additionally, FS6 significantly decreased relative to FS4 and FS5 ($p < 0.05$). This pattern of results suggest that **subjective fatigue significantly increased following activities required sustained listening and attention, and returned towards baseline levels when sustained listening was no longer required.**

Objective Measure of Fatigue – PVT:

Median reaction times increased significantly over time ($p < 0.01$; Fig. 4) and did not reveal group differences. This pattern of results suggest that **cognitive processing (sustained attention) as measured with the PVT, was significantly reduced over time, an objective indication of fatigue, following activities requiring sustained effortful listening.**

Objective Measure of Fatigue – ERP:

Data from the CNH group was analyzed first to determine typical brain responses in an auditory attention task. P300 responses for CNH decreased significantly over time ($p = 0.019$; Fig. 5, 6, 11, & 12) reflecting a reduction in the brain response following fatigue-inducing tasks. Data from all groups did not yield any significant differences or interactions for stimuli, time point, or group, likely due to high inter-individual variability within the CHL group. Qualitative data review suggested the CHL-aided but not CHL-unaided group showed a similar ERP pattern as the CNH group. This pattern of results suggest **for CNH, amplitude of P300 responses significantly decreased with fatiguing activities.**

KEY FINDINGS

- CNH and CHL (regardless of of amplification) showed increased fatigue over time during demanding tasks requiring attention and listening effort. This was was consistent for both subjective (FS) and objective (PVT) measures.
- P300 brain responses did significantly decrease for CNH following fatiguing activities; findings for CHL when aided appear to show a similar pattern but did not reach significance.
- Fatigue in school-age children can be measured objectively and subjectively with these tools – more data are needed to assess the sensitivity of the ERP measure as a tool in children with hearing loss.

KEY REFERENCES

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