The Relation Between Child Versus Parent Report of Chronic Fatigue and Language/Literacy Skills in School-Age Children With Cochlear Implants

Krystal L. Werfel\(^1\) and Alison Eisel Hendricks\(^1\)

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Address for correspondence: Krystal L. Werfel, University of South Carolina, 1224 Sumter Street, Suite 300, Columbia, SC 29201, USA. Phone: 803-777-5052. Fax: 803-777-3081. Email: werfel@sc.edu.

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\(^1\) Department of Communication Sciences and Disorders, University of South Carolina, Columbia, South Carolina, USA
ABSTRACT

Objectives: Preliminary evidence suggests that children with hearing loss experience elevated levels of chronic fatigue compared to children with normal hearing. Chronic fatigue is associated with decreased academic performance in many clinical populations. Children with cochlear implants as a group exhibit deficits in language and literacy skills; however, the relation between chronic fatigue and language and literacy skills for children with cochlear implants is unclear. The purpose of this study was to explore subjective ratings of chronic fatigue by children with cochlear implants and their parents, as well as the relation between chronic fatigue and language and literacy skills in this population.

Design: Nineteen children with cochlear implants in grades 3 through 6 and one of their parents separately completed a subjective chronic fatigue scale, on which they rated how much the child experienced physical, sleep/rest, and cognitive fatigue over the past month. Additionally, children completed an assessment battery that included measures of speech perception, oral language, word reading, and spelling.

Results: Children and parents reported different levels of chronic child physical and sleep/rest fatigue. In both cases, parents reported significantly less fatigue than did children. Children and parents did not report different levels of chronic child cognitive fatigue. Child report of physical fatigue was related to speech perception, language, reading, and spelling. Child report of sleep/rest and cognitive fatigue was related to speech perception and language but not to reading or spelling. Parent report of child fatigue was not related to children’s language and literacy skills.
Conclusions: Taken as a whole, results suggested that parents under-estimate the fatigue experienced by children with cochlear implants. Child report of physical fatigue was robustly related to language and literacy skills. Children with cochlear implants are likely more accurate at reporting physical fatigue than cognitive fatigue. Clinical practice should take fatigue into account when developing treatment plans for children with cochlear implants, and research should continue to develop a comprehensive model of fatigue in children with cochlear implants.

INTRODUCTION

The issue of fatigue in individuals with hearing loss has been the topic of increased discussion in recent years. Bess and Hornsby (2014a) recently called for more research that advances our understanding of the relation between fatigue and learning in children with hearing loss. They suggested that children with hearing loss are “physically and mentally spent” by the end of the school day (p. 592). This fatigue is proposed to be, in part, a result of sustained listening effort in non-optimal noise environments such as noisy classrooms (Crandell & Smaldino 2000; Knecht 2002; Shield & Dockrell 2008; Walinder et al. 2007). Researchers have hypothesized that the effort required to perceive and understand speech at school leads to fatigue which in turn leads to increased listening effort, resulting in a cyclical process, and that fatigue subsequently has a negative effect on children’s ability to learn at school (Hughes & Galvin 2013; Bess & Hornsby 2014b; Hornsby et al. 2014). Empirical evidence to support this hypothesis, however, is lacking. The purpose of the current study, therefore, was to explore subjective ratings of chronic fatigue by children with cochlear
implants and their parents, as well as to explore the relation between chronic fatigue and language and literacy skills.

Defining Fatigue

Fatigue is complex and multidimensional; thus, defining fatigue in a standard, operationalized manner has proven elusive among researchers to date (Shen et al. 2006; Bess & Hornsby 2014a). Definitions of fatigue have tended to follow dichotomies in thinking about fatigue, including (a) acute versus chronic fatigue and (b) physical versus cognitive fatigue.

Acute fatigue is generally considered a protective physiological process that occurs in healthy individuals (Aaronson et al. 1999). Acute fatigue has an identifiable cause, is of short duration, and is alleviated using techniques such as rest or stress management. Piper (1989) proposed that the effect of acute fatigue on daily functioning is minimal. In contrast, chronic fatigue is generally considered an abnormal physiological process that occurs primarily in clinical populations (Aaronson et al. 1999). Chronic fatigue often has an unknown cause, persists over time, and is not alleviated by general therapeutic techniques. Chronic fatigue is of interest in the current study, because the negative effects of hearing loss hypothesized to be related to fatigue are not alleviated over time.

Physical fatigue refers to bodily tiredness, including specific muscle tiredness as well as general feelings of weariness/drowsiness (Oginska & Pokorski 2006). In contrast, cognitive fatigue refers to mental tiredness experienced as a result of prolonged or taxing periods of mental activity (Boksem & Tops 2008). No research to date has addressed the relation between fatigue and language and literacy.
achievement in children with cochlear implants; therefore, both physical and cognitive fatigue are of interest in the current study.

**Measuring Fatigue**

Measurement of fatigue has been highly variable across studies, determined by subjective and objective measures. The most frequently used subjective measures of fatigue are self-report scales or structured interviews. Objective measures of fatigue have included physiological (e.g., salivary cortisol measures) and behavioral (e.g., reaction times) tasks. As an initial step toward modeling fatigue in children with cochlear implants, we chose to focus on subjective ratings because we judged this knowledge to be of immediate benefit to the field, in particular to practitioners. Practitioners may be able to incorporate a subjective fatigue scale into existing assessment protocols but may not have the resources to collect salivary cortisol measures or reaction time recordings.

Subjective fatigue ratings have been used widely with children who have chronic medical conditions. Two prominent fatigue scales in the literature are the Childhood Fatigue Scale (CFS; Hockenberry et al. 2003) and the Pediatric Quality of Life Multidimensional Fatigue Scale (PedsQL MFS; Varni 1998). The CFS was developed for use with children who have cancer. The CFS is a 14-item scale that assesses fatigue experienced during the past week. Example items include “My body has felt different” and “I have been tired in the morning.” The PedsQL MFS has been used with a wider range of clinical populations, including children who have cancer, obesity, type 1 diabetes, and pediatric rheumatology, among others. The PedsQL MFS is an 18-item scale that assesses fatigue experienced during the past month (standard version) or
during the past week (acute version). Example items include “I feel too tired to spend time with my friends” and “It is hard for me to think quickly.” Children rate their experience with each item on a 5-point scale ranging from “never” to “almost always.” Internal consistency estimates for the *PedsQL MFS* range from 0.89 – 0.95 for the aforementioned chronic medical conditions (Varni et al. 2002; 2004; 2009; 2010). The *PedsQL MFS* additionally has a parent version of the scale, allowing parents to rate their child’s fatigue.

One issue that has been raised in measuring subjective fatigue, and merits discussion here, is children’s conceptualization of fatigue (e.g., Hinds et al., 1999). Hinds et al. reported that 7- to 12-year-old children with cancer primarily perceived fatigue as a physical sensation. In contrast, parents’ perception of fatigue was broad and encompassed cognitive factors in addition to physical ones. Accurate perception of how fatigue is experienced is essential for determining when one is experiencing fatigue. This awareness of fatigue is essential for a child to learn to take steps to alleviate it. The present study included a comparison of child fatigue ratings to parents’ ratings of their child’s fatigue because of the differences in conceptualization of fatigue across the two groups.

**Fatigue and Hearing Loss**

**Adults with hearing loss.** Evidence from adults with hearing loss suggests that increased listening effort leads to increased fatigue. Across studies, adults with hearing loss exert more effort in completion of the dual tasks, as well as tasks in background noise, than adults with normal hearing. Performance of adults with hearing loss on dual task paradigms that involve a primary speech listening task and secondary memory
and/or visual task is decreased compared to adults with normal hearing (Rakerd et al. 1996). Additionally, as adults with hearing loss progress through such tasks, they experience increased fatigue, as measured by subjective fatigue ratings as well as objective measures of fatigue (Hornsby 2013). Finally, adults with hearing loss exhibit more difficulty than adults with normal hearing when completing language tasks such as word recall and reading comprehension in noisy environments (Jahncke & Halin 2012).

**Children with hearing loss.** Similarly, Hicks and Tharpe (2002) reported that children with hearing loss perform more poorly on dual task paradigms than children with normal hearing. School-age children with hearing loss experience listening effort demands over a much longer period of time than measured in the aforementioned adult studies. Therefore, it is reasonable to predict that this population experiences substantial fatigue and that the fatigue experienced by school-age children with cochlear implants has negative consequences on learning.

Salivary cortisol levels provide additional insight into fatigue of children with hearing loss. Hicks and Tharpe (2002) collected cortisol samples during the school day and reported no differences between children with hearing loss and children with normal hearing. When examining the cortisol awakening response (the sharp increase in cortisol levels upon wakening seen under normal conditions), however, Bess, Gustafson, and Hornsby (2014) reported differing patterns for children with hearing loss and children with normal hearing. Bess et al. concluded that these differing profiles are indicative of increased stress, which can lead to increased fatigue.

Hicks and Tharpe (2002) reported that children with hearing loss did not report higher levels of fatigue than children with normal hearing; however, the subjective
measure they used to assess fatigue was not validated for measuring fatigue. Recent research, in contrast, suggests that school-age children with hearing loss self-report experiencing significantly more fatigue than age-matched children with normal hearing (Hornsby et al. 2014). Even children with minimal hearing loss report lower levels of energy than children with normal hearing (Bess et al. 1998). Additionally, children with hearing loss, including children with cochlear implants, report greater fatigue than children with normal hearing across physical, sleep/rest, and cognitive categories of fatigue on the *PedsQL MFS*, a measure developed and validated to measure fatigue. The largest differences between children with hearing loss and children with normal hearing were seen in reports of physical fatigue; the smallest differences were seen in cognitive fatigue (Hornsby et al. 2014).

**Fatigue and Academic Performance**

In contrast to the limited study of fatigue in children with hearing loss, fatigue in children with chronic medical conditions, such as cancer or chronic fatigue syndrome, has been widely discussed. Fatigue symptoms in school-age children are as prevalent as fatigue symptoms adults who work full-time jobs (Oginska & Pokorski 2006). Negative consequences of fatigue in children include physical effects, social effects, and academic effects (Krilov et al. 1998; Hicks et al. 2003; Elliott et al. 2005; Meeske et al. 2007). Of particular interest in the current study was the relation between fatigue and language and literacy skills.

Despite improvements in amplification over the past several decades, including the advent of the cochlear implant, children with hearing loss continue to experience difficulties in language and literacy skills. The advent of the cochlear implant has led to
marked improvements in speech perception and language skills for children with profound hearing loss (e.g., Vermeulen et al. 1999; Geers 2003; Leigh et al. 2011). Children with cochlear implants, however, continue to exhibit poor speech perception in noise compared to peers with normal hearing (Caldwell & Nittrouer 2013). Likewise, as a group, children with cochlear implants demonstrate poorer language skills such as vocabulary than children with normal hearing (Fagan 2015). In terms of literacy, 18-year-olds with hearing loss scored at a median third grade reading level in the 1970s; the same is true today (Qi & Mitchell 2012). Over 50% of high school students with cochlear implants still perform below the average range on measures of reading and writing (Geers & Hayes 2011); these deficits span word recognition/spelling and reading comprehension/written expression. Providing greater access to sound alone has not been effective in alleviating much of the language and literacy difficulties experienced by this population. Therefore, it is vital to explore the role that factors such as fatigue play in language and literacy acquisition for children with cochlear implants, and the interactions between these factors.

A Theoretical Framework

The Capacity Theory of Attention provides a theoretical framework for exploring fatigue and academic performance in children with cochlear implants. The Capacity Theory states that cognitive resources are finite and can be allocated by an individual with relative freedom to multiple tasks simultaneously (Kahneman 1973). Relevant to the current work, Kahneman proposed that (a) an individual’s available cognitive resources for any given tasks can be influenced by outside factors (in this case, fatigue), (b) some tasks require more cognitive resources than others (in this case,
language-based tasks), and (c) strategies exist that determine allocation of resources to various tasks.

The increased fatigue experienced by children with hearing loss is proposed to result in decreased amount of cognitive resources available to this population when completing speech understanding and academic tasks. Likewise, the increased cognitive resources needed by children with cochlear implants to process a degraded speech signal may negatively affect the amount of cognitive resources available for academic learning during the school day. In support of such a hypothesis, Lewis et al. (2015) reported that children with hearing loss utilized cognitive resources inefficiently during a complex listening comprehension task that simulated the classroom environment. This inefficient use of cognitive resources is likely related to the elevated fatigue as well as decreased academic performance experienced by children with hearing loss. Finally, Boksem and Tops (2008) proposed that individuals weigh the energy costs of a task against its perceived rewards when choosing whether to engage in it. When an individual deems a task’s rewards not worth the amount of energy that will be exerted, the task is abandoned. It is possible that children with cochlear implants repeatedly engage in this strategy for allocation of cognitive resources throughout the school day and are likely to deem many academic tasks not worth the energy required to complete them.

Thus, a more complete understanding of subjective experiences of fatigue in school-age children with cochlear implants may elucidate a possible underlying cause of language and literacy difficulties for this population, one that has been rarely considered to date. This study is an initial step toward developing a comprehensive model of the
relation between fatigue and language and literacy skills for children with cochlear implants. The purpose, therefore, was (a) to compare child and parent report of fatigue and (b) to evaluate the relation between subjective ratings of fatigue with language and literacy skills of school-age children with cochlear implants. Based on Hinds et al. (1999), we hypothesized that subjective ratings of fatigue would be similar for children and parents on responses pertaining to physical fatigue but that children would report lower fatigue than their parents for responses pertaining to cognitive fatigue. Additionally, we hypothesized that each category of fatigue would be related to language and literacy skills.

**MATERIALS AND METHOD**

All study procedures were approved by the university’s Institutional Review Board.

**Participants**

Nineteen parent-child dyads (9 girls, 10 boys; 18 mothers, 1 father) participated in this study. Child participants used cochlear implants and were in grades 3 through 6 (M age = 10;6; SD = 14.8 months; range = 8;9 to 12;7). All children used spoken English as their primary mode of communication and attended classrooms in which instruction occurred in spoken English only. All children had nonverbal intelligence within the average range (M = 99.16; SD = 8.56; range = 87 to 115) as measured by the *Test of Nonverbal Intelligence—4th Edition* (TONI-4; Brown et al. 2010). Maternal education was reported for 18 of the 19 participants. Mean maternal education was 16.06 years (SD = 2.26; range = 12 to 22). Table 1 displays audiologic information for each child.
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< Insert Table 1 about here >

Measures

Participants completed the following measures that were analyzed in the present study as part of a larger ongoing study on language and literacy of children with cochlear implants.

Fatigue. Subjective fatigue was measured using the PedsQL MFS (Varni 1998) because it includes parallel parent and child versions, allowing for direct comparisons of parent and child report of fatigue. The PedsQL MFS contains statements that correspond to one of three categories of fatigue: general fatigue, sleep/rest fatigue, and cognitive fatigue. The general fatigue section asks participants to report their fatigue as it relates to physical fatigue. The general fatigue section includes statements such as “I feel physically weak (not strong),” “I feel too tired to do things that I like to do,” and “I feel too tired to spend time with my friends.” The sleep/rest fatigue section asks participants to report their fatigue as it relates to sleep. The sleep/rest fatigue section includes statements such as “I feel tired when I wake up in the morning,” “I take a lot of naps,” and “It is hard for me to sleep through the night.” The cognitive fatigue section asks participants to report their fatigue as it relates to concentration and memory. The cognitive fatigue section includes statements such as “It is hard for me to keep my attention on things,” “It is hard for me to think quickly,” and “It is hard for me to remember things I just heard.” Internal consistency reliability is .89 - .95.

Standardized administration protocols for the PedsQL MFS were followed: the examiner asked participants to rate how much the child experienced each fatigue problem in the past month using a 5-point scale. For example, the child was asked to
respond to the statement “I take a lot of naps” as “never”, “almost never”, “sometimes”, “often”, or “almost always.” Children and parents completed their rankings separately. Following the standard administration protocol for children with suspected reading difficulties, the investigators read the statements aloud to the child participants in order to measure fatigue independently from reading ability.

According to the standard scoring protocol of the PedsQL MFS, responses were converted to scores on a 100-point scale, with never = 100; almost never = 75; sometimes = 50; often = 25; and almost always = 0. Thus, lower scores on the PedsQL MFS indicate higher levels of fatigue, and higher scores on the PedsQL MFS indicate lower levels of fatigue.

**Speech Perception.** Speech perception skills were measured using list 4A of the NU-6. We selected the NU-6 to avoid potential ceiling effects, particularly among our older participants, and we selected list 4A because the authors (a certified speech-language pathologist and a psycholinguist) subjectively judged the words on this list most likely to be in the lexicon of children with hearing loss in the age range of this study. Children listened to an audio recording (male voice) of each word in a carrier phrase, “say the word [target].” The recording was played on a tablet placed one meter from the child. Immediately prior to administration, the sound level was calibrated to 60 dB SPL to allow for standardized administration at conversational speech levels. Child responses were recorded on-line by the examiner. Child responses were scored as correct or incorrect based on the whole word. Responses in which (a) a phoneme was incorrect, (b) a phoneme was omitted, or (c) a phoneme was added were scored as incorrect.
**Language.** Oral language skills were measured using the Core Language Score of the *CELF-5*. Subtests that contribute to the Core Language Score included Word Classes, Formulated Sentences, Recalling Sentences, and Semantic Relationships. Word Classes requires children to identify two words from a pool of three or four that go together best. Formulated Sentences requires children to make up a sentence based on a picture using a specified word. Recalling Sentences requires children to repeat sentences read aloud by the examiner. Semantic Relationships requires children to select two correct responses to complete a sentence. All subtests on the *CELF-5* were administered and scored according to published procedures in the test manual. Test-retest reliability is .80 -.92.

**Literacy.** Reading was measured using the *Test of Word Reading Efficiency—2nd Edition* (TOWRE-2; Torgesen et al. 2012). The *TOWRE-2* overall score is calculated using performance on two subtests: Sight Word Efficiency and Phonemic Decoding Efficiency. The Sight Word Efficiency subtest measures how many real words children can read in 45 seconds. The Phonemic Decoding Efficiency subtest measures how many nonwords children can read in 45 seconds. All subtests on the *TOWRE-2* were administered and scored according to published procedures in the test manual. Test-retest reliability is .89 -.93.

Spelling was assessed using the *Test of Written Spelling—5th Edition* (TWS-5; Larsen et al. 2013). The *TWS-5* evaluates spelling in isolation and requires children to spell single words. The examiner says a word, uses it in a sentence, and then repeats the word. Administration of the *TWS-5* deviated from standardized procedures: all 50 words were administered instead of following basal and ceiling guidelines for the
purposes of an analysis in the larger study but not reported here. Standard scores were calculated for the present study according to the test manual guidelines. Basals and ceilings were identified for the purpose of calculating standard scores. Test-retest reliability is .95.

**Procedure**

Testing took place in a quiet room in the first author’s lab or a local public library. Testing time for the entire assessment battery was approximately two to two-and-a-half hours, completed in one visit. Measures were administered in a predetermined, randomized order for each participant.

Testing sessions were audio recorded to allow for calculation of reliability of written recording of child responses on tests that required a verbal response. Child responses on the *NU-6* were video recorded so that scorers had access to visual information of speech production. Due to the fact that speech sound errors are common in children with hearing loss, all written recording of child responses was double-scored to ensure accuracy. The authors resolved disagreements by consensus. To assure reliability in scoring (items, raw scores, standard scores), all test forms were double-scored by a research assistant trained in test scoring. Again, any disagreements were resolved by mutual consensus.

**Analysis**

To address the first research question, paired samples *t* tests (two-tailed) were used to compare subjective ratings of fatigue by children with cochlear implants and their parents. A Bonferroni correction was used to adjust for multiple comparisons, resulting in a significance level of $\alpha = 0.017$. To explore the nature of the relation
between child and parent report of fatigue, Pearson correlation coefficients were calculated. For the second research question, a series of Pearson correlation coefficients were calculated to address the relation between child fatigue to child language and literacy skills. Pearson correlation coefficients were calculated between both child and parent report of fatigue and the following language and literacy variables: Speech Perception, Language, Literacy: Reading, and Literacy: Spelling.

**RESULTS**

**Descriptive Results**

Participants showed a wide range of scores across all fatigue, speech perception, language, and literacy measures. Table 2 presents the mean, standard deviation, and range of scores for each measure.

< Insert Table 2 about here >

**Comparison of Child Versus Parent Report of Child Fatigue**

Figure 1 presents the results child and parent report of fatigue by category of fatigue. The paired samples t-tests indicated that children reported significantly higher levels of general and sleep/rest fatigue than parents (General Fatigue: $t(18) = -2.66, p = 0.016, d = 0.73$; Sleep/Rest Fatigue: $t(18) = -4.52, p < .001, d = 1.48$). There was not a significant difference between child and parent report of cognitive fatigue, ($t(18) = -1.60, p = .127$). Overall these results indicate that parents report that their children experience less fatigue than children themselves report that they experience.

<Insert Figure 1 about here>

The results of the correlation analysis, displayed in Table 3, lend further support to the finding that child and parent report of child fatigue are not related. Pearson
correlation coefficients were calculated between child and parent report of each of the categories of fatigue: general fatigue, sleep/rest fatigue, and cognitive fatigue. These analyses indicated that within child report, all fatigue categories were related. Likewise, within parent report, all fatigue categories were related. Across groups, however, child and parent report of child fatigue largely were not correlated. There was one exception to this trend: child report of general fatigue was positively related to parent report of cognitive fatigue \( r (17) = 0.596, p = 0.007 \). See Figure 2 for scatterplots of significant relationships between child and parent report of fatigue. Taken together, the results of the comparison of means and the correlations suggest that child report of their own fatigue and parent report of their child’s fatigue are significantly different and largely unrelated.

Relation between Report of Fatigue and Language and Literacy Skills

A series of Pearson correlation coefficients were calculated to determine whether subjective reports of fatigue were related to language and literacy scores. Lower scores on the PedSQL MFS indicate higher levels of fatigue; thus, positive correlations between fatigue and language and literacy scores indicate that children with lower fatigue have higher language and literacy skills. Conversely, negative correlations indicate that children with higher fatigue have higher language and literacy skills. See Tables 4 and 5 for correlation coefficients between language and literacy skills and child and parent report of fatigue, respectively.
There were significant positive correlations between child report of all three categories of fatigue and speech perception, as well as language. In terms of literacy, there were significant positive correlations with child report of general fatigue and reading and spelling; however, child report of sleep/rest and cognitive fatigue were not significantly correlated with reading or spelling. There were no significant correlations between parent report of child fatigue and the child’s speech perception, language, reading, or spelling.

**DISCUSSION**

Even with the advent of the cochlear implant, children with profound hearing loss continue to demonstrate language and literacy outcomes that lag behind those for their peers with normal hearing. In recent years, there was been increased attention given to the issue of fatigue in children with hearing loss, and we hypothesized fatigue as a potential contributing factor to the language and literacy difficulties observed in children with profound hearing loss. Overall, findings indicated that children with cochlear implants and their parents differed in subjective ratings of child fatigue, child and parent report of fatigue was largely unrelated, and child report of fatigue was positively correlated with language and literacy skills. The present study extended the existing knowledge base on fatigue in children with hearing loss in several ways.

**Focus on Children with Cochlear Implants**

This investigation focused exclusively on children who use cochlear implants. Previous reports of subjective fatigue of children with hearing loss have included a wide
range of hearing losses (i.e., mild to profound) and a variety of amplification types (i.e., hearing aids and cochlear implants; Hornsby et al. 2014). Our findings replicated those of Hornsby et al. The school-age children with cochlear implants in the present study reported similar mean levels of fatigue on all three subscales of the PedsQL MFS as the school-age children who used a variety of amplification types in Hornsby et al.: general fatigue: 60.96 and 55.0, sleep/rest fatigue: 56.14 and 52.5, and cognitive fatigue: 53.56 and 53.3, respectively. These similar scores indicate that children with hearing loss, regardless of level of hearing loss and amplification type, experience increased fatigue compared to children with normal hearing, whose mean scores were 85.0, 72.5, and 70.83, respectively.

Comparison of Child and Parent Report of Fatigue

Motivated by Hinds et al. (1999), who reported differences in conceptualization of fatigue across children and parents for pediatric cancer patients, we included a comparison of child and parent report of child fatigue. Our findings indicated that parents reported significantly less fatigue than their children reported in general fatigue, as well as sleep/rest fatigue. Additionally, the results of the correlation analyses indicated that child and parent reports of the child’s fatigue were largely unrelated. These findings could be interpreted in one of three ways: (a) parents under-estimate their children’s fatigue, (b) children over-estimate their own fatigue, or (c) neither parents nor children accurately estimate child fatigue. We suggest that our findings are best interpreted as parents under-estimating their children’s general and sleep/rest fatigue.
Our data provide converging evidence in favor of this interpretation. First, the results of the current study closely parallel the results of previous research showing that children with hearing loss experience and report higher levels of fatigue than children with normal hearing (Hornsby et al. 2014). The children with cochlear implants in this study reported fatigue levels very similar to those reported by children with hearing loss in Hornsby et al. Second, in the present study parents reported less general fatigue (physical tiredness) and sleep/rest fatigue than their children (Cohen’s $d$ indicated medium and large effects, respectively). Parents may lack insight into their child’s physical fatigue. For example, the general fatigue section includes an item about fatigue keeping children from participating in activities that they enjoy. Perhaps these activities occur at school (e.g., recess or lunchtime conversations) and parents are unaware that their children are not participating. It is also possible that if children choose not to participate in activities, they simply are not explaining to their parents that fatigue is their reason for doing so. Similarly, the sleep/rest fatigue section includes an item about sleeping through the night. It is possible that parents are unaware of the sleep quality of their child. We suggest that future research employ methods that can provide further insight and test these hypotheses.

Additionally, because of the previous work demonstrating the relation between fatigue and academic performance across clinical pediatric populations (e.g., Krilov et al. 1998; Elliott et al. 2005; Meeske et al. 2007), we anticipated that there would be a significant relation between the fatigue of children with cochlear implants and their language and literacy scores. This hypothesis was supported in the child report of fatigue, but not in the parent report. We interpret this as further evidence that parents
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are under-estimating their child’s physical fatigue. That is, it is more likely that children accurately report their own fatigue and that there is a significant relation between fatigue and language and literacy than that parents accurately report fatigue and that there is no relation between fatigue and language and literacy. Together, these preliminary data suggest that parents do not accurately report their children’s general and sleep/rest fatigue; however, additional research is needed to confirm this hypothesis.

In contrast to general and sleep/rest fatigue, parents’ report of their children’s cognitive fatigue did not differ from the children’s self-report of cognitive fatigue. This finding on its own seems to suggest that parents and children are both accurate reporters of children’s cognitive fatigue. However, of all categories of fatigue, cognitive fatigue is theorized to play the largest role in language and literacy skills, and yet the results indicated that parent report of cognitive fatigue was not related to any language or literacy skills and child report of cognitive fatigue was related only to speech perception and language skills.

We propose three possible interpretations of our data. First, it is possible that children are not accurate reporters of cognitive fatigue. Based on Hinds et al.’s (1999) model, it would not be surprising if children do not accurately report cognitive fatigue because their conceptualization of fatigue does not appear to contain cognitive factors. Second, the present study addressed only chronic fatigue. It is possible that literacy skills are affected by acute cognitive fatigue but not chronic cognitive fatigue. Perhaps literacy is affected by acute fatigue that children experience as the result of the use of cognitive resources throughout the day. Third, it is possible that cognitive fatigue and literacy skills are not related in children with cochlear implants. Research across clinical
populations, however, suggests this interpretation is unlikely (Krilov et al. 1998; Elliott et al. 2005; Meeske et al. 2007). Future research is needed to elucidate this relation.

**Relation Between Fatigue to Language and Literacy Skills**

Finally, this study is the first to report on the relation between fatigue and language and literacy skills in children with hearing loss, in general, and children with cochlear implants, in particular. Overall, our findings support the hypothesis that fatigue and language and literacy skills are related in children with cochlear implants. This relation is particularly apparent in child report of general fatigue: all language and literacy skills were positively correlated with general fatigue, meaning that children who reported higher levels of general fatigue scored lower on standardized assessments of language and literacy. For child report of sleep/rest and cognitive fatigue, however, the relation was limited to speech perception and language skills. Interestingly, language and literacy skills of children were not related to parent report of fatigue across any category.

These findings have interesting theoretical implications. In general, children with cochlear implants who reported more fatigue performed more poorly on language and literacy tasks, as predicted by the Capacity Theory of Attention. However, the directionality of this relation is unclear from the present data. It is possible that fatigue negatively influences language and literacy skills. On the other hand, it is also possible that language and literacy skills negatively influence fatigue. A third possibility is that the relation between fatigue and language and literacy skills is bidirectional.

Bess and Hornsby (2014b) proposed a conceptual model of fatigue wherein communication breakdown, which is influenced in large part by speech perception and
language skills, leads to increased fatigue and increased fatigue, in turn, leads to communication breakdown, resulting in a cyclical process. For literacy and fatigue, the Bess and Hornsby model proposes a unidirectional relation, wherein increased fatigue leads to poorer academic performance. The correlational data of the present study that show a relation between fatigue and speech perception, language, and literacy for children with cochlear implants lend preliminary support to this model. Future studies specifically identifying the directionality of the relation between fatigue and speech perception, language, and literacy are necessary to test this model further.

**Implications for Measurement of Fatigue**

In light of issues of measurement of fatigue, it is important that there was not a significant relation between parent report of any category of fatigue and language and literacy skills, and that the relation between child report of sleep/rest and cognitive fatigue was limited to speech perception and language scores. Previously we suggested that parents generally are unaware of, or at least underestimate, their child’s experience of fatigue. In clinical practice, we often rely on parent report of child skills such as vocabulary, and research has demonstrated that parent report of such skills is valid (Dale 1991). The current findings, however, suggest that relying on parent report of child fatigue may not be best practice. Instead, our findings suggest that child report of fatigue more accurately captures children’s fatigue experience.

In addition, we propose that, taken as a whole, our findings indicate that children most accurately report their fatigue when considering physical rather than cognitive aspects of it. Child report of physical fatigue was positively correlated with all aspects of language and literacy assessed in this study. In contrast, child report of cognitive fatigue
was positively correlated with only speech perception and language but not reading and spelling. Fatigue is associated with academic outcomes across other clinical child populations (e.g., Krilov et al. 1998; Elliott et al. 2005; Meeske et al. 2007), and children conceptualize fatigue as physical and not cognitive (Hinds et al. 1999); therefore, we propose fatigue of children with cochlear implants is best measured subjectively by asking children to report about physical aspects of it.

**Limitations and Future Directions**

Additional research clearly is needed to further refine our understanding of the differences and similarities of conceptualization of fatigue across children and parents, as well as the adequacy of subjective ratings to measure cognitive fatigue. A limitation of the current study is that we did not include an objective measure of fatigue, as we were most interested in subjective ratings of fatigue by children and parents. Future research should evaluate the use of objective measures of fatigue and their relation to language and literacy performance for children with hearing loss. Additionally, our sample size was small and limited to the southeastern US, which limited our ability to account for covariates such as socioeconomic status, age at implantation, vocabulary, and nonverbal intelligence. Additionally, we did not include reading comprehension, written expression, or mathematics measures, which would provide a more complete picture of the relation between fatigue and academic performance. Future research should employ larger, nationwide samples and utilize research methodologies that allow for such analyses. Finally, we measured child and parent report of fatigue in the current study. As the study of the relation between fatigue and academic performance continues, it will be important to include measures of teacher report of child fatigue.
Future research should address teacher’s conceptualization of children’s fatigue and its relation to academic outcomes. It is possible that professional development in this area may be warranted. Our findings add to a growing preliminary research base that warrants further study in the area of fatigue of children with hearing loss.

Conclusion

The study of chronic fatigue and its relation to academic performance of children with hearing loss has been largely neglected. Given the long-standing poor language and literacy outcomes for children with hearing loss, it is vital that research expands its scope to include factors such as fatigue. This investigation replicates findings of increased subjective experiences of fatigue in children with hearing loss in general and extends this finding to children with cochlear implants in particular. Additionally, we provide initial empirical evidence of differences in child and parent report of child fatigue, as well as the relation between subjective chronic fatigue to language and literacy skills for children with cochlear implants. Clearly, the relation between chronic fatigue and academic performance is complex. More research is needed to further specify a comprehensive model of fatigue and its relation to learning in children with cochlear implants.
References


Hornsby, B. (2013). The effects of hearing aid use on listening effort and mental fatigue associated with sustained speech processing demands. *Ear Hear, 34*, 523-534. doi:

Hughes, K., & Galvin, K. (2013). Measuring listening effort expended by adolescents and young adults with unilateral or bilateral cochlear implants or normal hearing. *Cochlear Implants Int, 14*, 121-129. doi: 10.1179/1754762812Y.0000000009


Fatigue and Literacy in Children with CIs

10.1097/AUD.0000000000000092


10.1002/pbc.20923


10.1016/j.smrv.2005.05.004


Table 1

**Audiologic Information by Participant**

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age at testing</th>
<th>ID</th>
<th>Amp.</th>
<th>Age at Hearing</th>
<th>Left Ear</th>
<th>Right Ear</th>
<th>Age at 1&lt;sup&gt;st&lt;/sup&gt; Implant</th>
<th>Age at 2&lt;sup&gt;nd&lt;/sup&gt; Implant</th>
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</table>

*Note.* * Progressive Hearing Loss; ** Meningitis; ID, Identification; Amp, Amplification.
Table 2

*Descriptive Results of Study Measures*

<table>
<thead>
<tr>
<th>Category</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech Perception (% Correct)</td>
<td>59.26</td>
<td>22.75</td>
<td>14 - 88</td>
</tr>
<tr>
<td>Language (Standard Score)</td>
<td>83.53</td>
<td>25.75</td>
<td>43 - 127</td>
</tr>
<tr>
<td>Literacy: Reading (Standard Score)</td>
<td>90.63</td>
<td>19.31</td>
<td>53 - 119</td>
</tr>
<tr>
<td>Literacy: Spelling (Standard Score)</td>
<td>94.95</td>
<td>23.26</td>
<td>45 - 128</td>
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<td>General Fatigue: Child Report</td>
<td>60.96</td>
<td>22.45</td>
<td>25.00 – 91.67</td>
</tr>
<tr>
<td>Sleep/Rest Fatigue: Child Report</td>
<td>56.14</td>
<td>21.04</td>
<td>25.00 – 87.50</td>
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<tr>
<td>Cognitive Fatigue: Child Report</td>
<td>53.56</td>
<td>22.27</td>
<td>4.17 – 100.00</td>
</tr>
<tr>
<td>General Fatigue: Parent Report</td>
<td>77.27</td>
<td>22.09</td>
<td>29.17 – 100.00</td>
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<tr>
<td>Sleep/Rest Fatigue: Parent Report</td>
<td>82.98</td>
<td>14.76</td>
<td>54.17 – 100.00</td>
</tr>
<tr>
<td>Cognitive Fatigue: Parent Report</td>
<td>63.59</td>
<td>23.76</td>
<td>25.00 – 100.00</td>
</tr>
</tbody>
</table>

*Note.* SD, standard deviation
Table 3

*Correlation Coefficients for Child- and Parent-Report of Child Fatigue*

<table>
<thead>
<tr>
<th></th>
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<th>5</th>
<th>6</th>
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<td>1. Child General Fatigue</td>
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<td></td>
<td></td>
<td></td>
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<td>2. Child Sleep/Rest Fatigue</td>
<td>.745**</td>
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<td>3. Child Cognitive Fatigue</td>
<td>.670**</td>
<td>.682**</td>
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<td></td>
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<tr>
<td>4. Parent General Fatigue</td>
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<td>.039</td>
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<td>5. Parent Sleep/Rest Fatigue</td>
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<td>.021</td>
<td>.597**</td>
<td>—</td>
<td></td>
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<tr>
<td>6. Parent Cognitive Fatigue</td>
<td>.596**</td>
<td>.449</td>
<td>.297</td>
<td>.814**</td>
<td>.627**</td>
<td>—</td>
</tr>
</tbody>
</table>

*Note.* *Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).
Table 4

Correlation Coefficients for Child Report of Fatigue and Language and Literacy Scores

<table>
<thead>
<tr>
<th></th>
<th>General Fatigue</th>
<th>Sleep/Rest Fatigue</th>
<th>Cognitive Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech Perception</td>
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<td>.506*</td>
<td>.457*</td>
</tr>
<tr>
<td>Language</td>
<td>.684**</td>
<td>.478*</td>
<td>.522*</td>
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<tr>
<td>Reading</td>
<td>.613**</td>
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<td>.386</td>
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<tr>
<td>Spelling</td>
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<td>.393</td>
<td>.448</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).
Table 5

Correlation Coefficients for Parent Report of Fatigue and Language and Literacy Scores

<table>
<thead>
<tr>
<th></th>
<th>General Fatigue</th>
<th>Sleep/Rest Fatigue</th>
<th>Cognitive Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech Perception</td>
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<td>-.082</td>
<td>.164</td>
</tr>
<tr>
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<td>.016</td>
<td>.371</td>
</tr>
<tr>
<td>Reading</td>
<td>.209</td>
<td>.086</td>
<td>.449</td>
</tr>
<tr>
<td>Spelling</td>
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<td>-.011</td>
<td>.225</td>
</tr>
</tbody>
</table>

*Note. All ps > .05.*
Figure 1. Comparison of child and parent report of fatigue by category. Error bars indicate 1 standard deviation. Higher scores indicate lower fatigue.
Figure 2. Scatterplots for significant relations of fatigue and language and literacy skills.