Article

Exceptional Children
2018, Vol. 84(4) 420–436

DOI: 10.1177/0014402918773316
journals.sagepub.com/home/ecx
SAGE

Language Abilities, Phonological Awareness, Reading Skills, and Subjective Fatigue in School-Age Children With Mild to Moderate Hearing Loss

Stephen Camarata[1], Krystal Werfel[1,2], Tonia Davis[1], Benjamin W.Y. Hornsby[1], and Fred H. Bess[1]

Abstract

Although reading outcomes for children with hearing loss are improving, too many of these children continue to display persistent reading difficulties. Because of these difficulties, there is an ongoing need to understand the nature of the relationships among decoding abilities, language skills, and reading achievement in this population more fully. Coincidentally, there has also been an emerging literature on the subjective fatigue in children with hearing loss, which could be directly or indirectly linked to reading ability. The purpose of this study was to examine associations among language abilities, reading skills, and subjective fatigue in 56 children with mild to moderate hearing loss (CMMHL). The results indicated that both phonological awareness and receptive language ability predicted reading achievement in CMMHL, which replicates findings for children without hearing loss. The results also indicated that CMMHL who had poor reading skills reported significantly higher levels of subjective fatigue relative to the other children with mild to moderate hearing loss in the sample.

Research on reading outcomes of children with mild to moderate hearing loss (CMMHL) has long shown potential weaknesses in these students (e.g., Davis, Elfenbein, Schum, & Bentler, 1986), and despite advances in hearing aid technology and medical management (e.g., improved hearing aid technology, cochlear implants), CMMHL continue to have widely variable outcomes in regard to reading abilities, especially phonological awareness and language abilities (Nittrouer & Caldwell-Tarr, 2016; Park, Lombardino, & Ritter, 2013). Moreover, there continues to be a significant risk for poor reading outcomes in all children with hearing loss, including those with mild to moderate hearing loss (see Cupples, Ching, Crowe, Day, & Seeto, 2013; Wake, Hughes, Poulakis, Collins, & Richards, 2004; Werfel, 2017). The research we report focuses on CMMHL exclusively, children who traditionally have been understudied (Bess, Dodd-Murphy & Parker, 1998) but represent approximately 40% of all who experience permanent hearing loss and importantly, a group whose members are likely to be served in inclusive educational settings (e.g., Porter, Bess, & Tharpe, 2016).

[1]Vanderbilt University School of Medicine
[2]University of South Carolina

Corresponding Author:
Stephen Camarata, Vanderbilt University School of Medicine, Department of Hearing & Speech Sciences, Department of Hearing & Speech Sciences, Bill Wilkerson Center Vanderbilt University School of Medicine, Room 8310, Medical Center East, South Tower, 1215 21st Ave. South, Nashville, TN 37232-8242, USA.
E-mail: stephen.camarata@vanderbilt.edu

These children are overwhelmingly using verbal communication so that the issues that often arise in children with severe to profound hearing loss—such as severely attenuated access to verbal input, sign language access, total communication, difficulties in oral language development (Fitzpatrick et al., 2015; Goldwin-Meadow & Mayberry, 2001)—are not nearly as pronounced in CMMHL. To be sure, one could argue that because CMMHL do have restricted access to auditory input, this could be viewed as, in some respects, akin to the more extensive deprivation seen in profound hearing loss. But it is certainly the case that CMMHL have much more extensive access to auditory information (albeit attenuated to some extent even with assistance provided by hearing aids or cochlear implants) and are overwhelmingly served in oral, regular classrooms (Porter et al., 2016). Thus, we do not include a review of severe auditory deprivation, sign language, or total communication as these relate to reading or subjective fatigue in this study and no children with profound to severe hearing loss were included herein.

There continues to be considerable variation in the reported reading outcomes of CMMHL, and the relationships among oral language, phonological awareness, and reading abilities remain unclear.

There continues to be considerable variation in the reported reading outcomes of CMMHL, and the relationships among oral language, phonological awareness, and reading abilities remain unclear, with mixed findings in the literature. For example, although the literature does include some studies reporting that reading skills in CMMHL do not significantly differ from peers with normal hearing, with some students actually achieving in the above average range (e.g., Porter et al., 2016), other studies suggest that mean reading skills in CMMHL fall in the low average range (e.g., Wake et al., 2004), and there are also studies reporting mean reading skills in CMMHL that are more than 1.5 *SD* below peers with normal hearing (e.g., Park et al., 2013). A potential source of this variability is that many of these studies do not include simultaneous measures of language, phonological awareness, and reading in the same children. Clearly, additional research is needed to elucidate the reading performance of CMMHL in the context of a within-students approach as a potential means for better understanding the wide individual variation observed in the literature. Hence, the purpose of this study is to evaluate the associations between language abilities, phonological awareness, and reading skills in school-age CMMHL.

In addition, there is an emerging literature indicating that CMMHL are experiencing elevated levels of subjective fatigue, leading us to speculate whether relative weaknesses in language, phonological awareness, and reading ability could potentially be associated with higher levels of reported fatigue. That is, as with language, phonological awareness, and reading, because there is considerable variability in reported fatigue in CMMHL (see Bess, Gustafson, & Hornsby, 2014), it is perhaps likely that those students struggling with language, decoding (phonological awareness), and reading may be particularly susceptible to fatigue relative to peers without hearing loss and relative to peers also with mild to moderate hearing loss, but who have more advanced language, decoding, and reading abilities. There is one correlational study in the literature that explores the possible influence of subjective fatigue on achievement for CMMHL with cochlear implants that suggests a relationship between these domains (Werfel & Hendricks, 2016), but this study did not directly test whether CMMHL who were poor readers reported higher levels of fatigue. Because there is a relatively extensive literature on the adverse consequences of fatigue on learning in other chronic health conditions (e.g., Krilov, Fisher, Friedman, Reitman, & Mandel, 1998) and because Bess and Hornsby (2014) have shown even mild to moderate hearing loss can be associated with greater levels of subjective fatigue, a study simultaneously examining the relations among language ability, decoding (phonological awareness) fatigue, and reading ability is warranted. Thus, a secondary purpose is to examine an additional parameter, subjective fatigue, which may be exacerbated in CMMHL who are also poor readers.

Phonological Awareness, Language, and Reading

There is a relatively extensive literature examining the relationship between language abilities, decoding skills, and reading in children without hearing loss, and it is clear that many dimensions of oral language and reading are interconnected (e.g., Catts et al., 2014). Another factor contributing to reading performance in children without hearing loss is the ability to decode text using phonological awareness skills. Gough and Tunmer (1986) conceptualized reading in the simple view of reading as consisting of two component parts: decoding words and understanding the verbal language. Further, this simple view is directional; oral language is the linguistic basis required to understand what is read, but decoding ability is necessary for accessing text. If a child can decode text (i.e., transduce print into spoken language), the text can be understood, at least to the extent a child comprehends oral language. Therefore, even if a child's oral language comprehension is high, an inability to decode will preclude comprehension of the text. To be sure, there are more nuanced (and complex) models of reading (e.g., Savage, Burgos, Wood, & Piquette, 2015), and even Gough and Tunmer acknowledged sublevels within a simple view of reading, but it is useful to examine decoding and comprehension in CMMHL because of the effect of auditory attenuation on these skills, and it is perhaps noteworthy that there is continued support in the literature for studying this dichotomy in typical development as well (Savage et al., 2015).

Much research has been undertaken to identify specific linguistic predictors of decoding and comprehension for reading, and there is an extensive body of research on the development of phonological awareness (see Gillon 2017) and oral language development (see Lervåg, Hulme & Melby-Lervåg, 2017) as these relate to reading. Scarborough (2001) proposed a theoretical model that highlighted the importance of linguistic skills for decoding and reading comprehension that are woven together to support successful long-term literacy achievement. In Scarborough's model, phonological awareness is one important skill that supports word decoding (e.g., Bradley & Bryant, 1983; Scarborough et al. 2009), and oral language skills such as syntax and vocabulary also support comprehension (e.g., Kamhi & Catts, 2013). Although these relations are dynamic and not discrete (e.g., phonological awareness contributes indirectly to comprehension through decoding skill), a large research literature with children with normal hearing supports the broad theoretical approach that informed our study design (see e.g., Kamhi & Catts, 2013).

Phonological Awareness and Word Decoding

Phonological awareness (PA), the ability to analyze and manipulate the sounds of spoken words, has long been recognized as an important factor in decoding skills in children without hearing loss (e.g., Gillon, 2017; Wagner & Torgesen, 1987). Converging evidence over several decades has led to the conclusion that children who demonstrate higher levels of PA are better word readers than children who demonstrate lower levels of PA (Gillon, 2017; Wagner & Torgesen, 1987). In fact, some studies have indicated that PA plays a larger role than vocabulary in children's decoding skills even through high school (MacDonald & Cornwall, 1995). Multiple meta-analyses have provided evidence that PA training leads to increased decoding outcomes (e.g., Bus & Van IJzendoorn, 1999), and children who are nonresponders to gold standard early reading interventions display persistent PA deficits (Al Otaiba & Fuchs, 2002), which highlights the contributions of phonological awareness to reading ability.

For children with hearing loss, phonological awareness skills appear to be significantly delayed but develop in the same general order of acquisition as in children with normal hearing (James et al., 2005; Nittrouer & Caldwell-Tarr, 2016); however, they appear to use different auditory cues than children without hearing loss to acquire PA (Gifford et al. in press; Nittrouer & Lowenstein, 2015). Despite the longer acquisition process children with hearing loss, as with children with normal hearing, PA is related to word decoding through primary grades and into middle school (Briscoe, Bishop, & Norbury, 2001; Geers & Hayes, 2011; Harris & Beech, 1998; Kyle & Harris, 2011; Nittrouer et al., 2014).

There are several studies that directly address subskills of PA in CMMHL. Briscoe et al. (2001) compared word decoding scores of CMMHL with "phonological impairments," defined as deficits in phonological awareness, phonological memory, phonological discrimination, and speech production, to those without phonological impairments; Cohen's d was 0.91, indicating a large group-wide effect of phonological impairments on word decoding. It is unclear from their data, however, how many of those children had specific PA impairments. Similarly, Nittrouer et al. (2014) reported varied proficiency in subtypes of PA skills as these related to word knowledge and degree of hearing loss (see also Moberly, Lowenstein, & Nittrouer, 2016). These studies suggest that PA is likely a key factor in decoding, word knowledge, and ultimately, reading ability in CMMHL, as the simple view of reading predicts. Because of this, we hypothesize that this will be an important factor when PA is examined relative to oral language ability in CMMHL.

Oral Language and Reading Comprehension

Similar to the role of PA in decoding, the role of oral language in reading comprehension has been widely established (e.g., Cain & Oakhill, 2006; Nation, Clarke, Marshall, & Durand, 2004; Nation & Norbury, 2005; Storch & Whitehurst, 2002). Children who exhibit specific reading comprehension impairments can present with at least subclinical oral language deficits even when displaying typical PA skills (e.g., Catts, Adlof, & Ellis-Weismer, 2006; Nation et al., 2004). Language deficits of children with poor reading comprehension encompass difficulties in semantic and syntactic skills (Adlof & Catts, 2015; Nation et al., 2004). Additionally, although oral language deficits in this population span expressive and receptive domains, children with poor reading comprehension display particular difficulties in *understanding* spoken language (for a review, see Nation, 2005). Adlof and Catts (2015) reported effect sizes almost twice as large for receptive compared to expressive language measures. Importantly, oral language predicts reading comprehension skills beyond children's decoding skills (Nation & Snowling, 2004; Storch & Whitehurst, 2002).

Additional support for the role of oral language in reading comprehension comes from studies of children with language impairment. Children who exhibit deficits in oral language are approximately 18 times more likely to exhibit reading comprehension deficits than children with typical language skills (Werfel & Krimm, 2017). But as with the relation of PA and word decoding, research on the relation of oral language and reading comprehension for CMMHL has been limited. Vocabulary skills of children with even mild levels of hearing loss are significantly lower than children with normal hearing (e.g., Wake et al., 2004). There is some evidence that the relation between vocabulary and reading comprehension is strong in CMMHL as well (Davis et al., 1986). Also, Connor and Zwolan (2004) reported that early vocabulary directly predicted reading comprehension in a group of children with cochlear implants. These studies suggest that also in accord with predictions from the simple view of reading, oral language and reading are interrelated in CMMHL along with PA and decoding, but there is a clear need to directly examine the relationship between oral language and reading in CMMHL simultaneously with PA and decoding.

Fatigue and Reading in Children With and Without Hearing Loss

The effect of fatigue on learning in children with chronic health conditions such as cancer has recently gained recognition as a high-priority research topic, and it is not surprising these investigations have indicated that fatigue often adversely affects academic performance (Barsevick et al., 2013). Importantly, fatigue in children with chronic illnesses is associated with reduced learning and school performance, school absences, increased stress, and negative effects on life quality, so there has also been interest in studying the effect of fatigue on the academic performance of people without chronic health conditions (Adams & Umbach, 2012). Interestingly, children with normal hearing who experience chronic fatigue also report difficulties in academic performance, with the decline in their academic performance occurring after the onset of fatigue, as seen in chronic health conditions (Krilov et al., 1998).

Recent research has shown that children with hearing loss are also at increased risk for subjective fatigue (Hornsby, Werfel, Camarata, & Bess, 2014; Werfel & Hendricks, 2016). In fact, children with hearing loss reported fatigue levels that are quite severe in magnitude and can be comparable to the fatigue of children with other chronic illnesses. Bess and Hornsby (2014) theorized that in addition to the inherent disadvantage of reduced access to auditory information resulting from hearing loss, the increased listening effort, stress, and subsequent fatigue might compromise the ability of children with hearing loss to learn in noisy classroom conditions. Werfel and Hendricks (2016) tested this hypothesis with children with cochlear implants. The children with cochlear implants exhibited wide individual variation in reading performance, ranging from significantly below average to slightly above average, with standard scores ranging from 53 to 119. Within this group, children with hearing loss who reported higher fatigue displayed lower reading outcomes than children with hearing loss who reported less fatigue, providing support to the consideration of fatigue within a theoretical model of reading in children with hearing loss. Their results led us to hypothesize that CMMHL who are poor readers are likely to report higher levels of fatigue than CMMHL who are reading at levels comparable to peers without hearing loss because poorer readers may be struggling with multiple cognitive processes—language skills, decoding, *and* reading—and that the cumulative effect of these factors could be higher levels of reported fatigue than CMMHL who do not display reading difficulties.

We tested four theoretical predictions regarding the relation of language abilities, PA, and reading performance in CMMHL.

The purpose of this study was to evaluate the associations between language abilities, phonological awareness, and reading skills in school-age CMMHL using a within-subjects approach. We also compared self-reported subjective fatigue of CMMHL who were poor readers to peers (also with CMMHL) whose reading levels were at least within the typical range. Based on the literature reviewed, we tested four theoretical predictions regarding the relation of language abilities, PA, and reading performance in CMMHL. First, we hypothesized that PA skills would predict word decoding skills in CMMHL and that CMMHL with word decoding difficulties would exhibit poorer PA skills than CMMHL who have typical word decoding skills. Second, we hypothesized that receptive oral language skills would predict reading comprehension skills even after controlling for word decoding in CMMHL. We also predicted that CMMHL with reading comprehension difficulties would exhibit poorer receptive oral language skills than CMMHL who have typical reading comprehension skills. Third, we hypothesized that CMMHL who have both below average word decoding and reading comprehension skills would display deficits both in phonological awareness and receptive oral language. Fourth, because of the combination of reduced access to auditory input *and* increased effort to read, we hypothesized that CMMHL who have poor reading comprehension or decoding ability (or both) would report significantly more fatigue than CMMHL who are good readers.

Method

The Institutional Review Board at the research site approved the study procedures. Participants were recruited from the audiology clinics at the center the research was completed, through an advertisement in a local parenting magazine, and through a recruitment website at the center. Informed parental consent and child assent were obtained from all participants before the study procedures began. The data from this study were obtained in the course of a more extensive study designed to examine the effects of listening effort and fatigue in children with hearing loss.

Participant Characteristics

Participants included 56 CMMHL. All participants were between the ages of 6 and 12 years; had no parent-reported diagnosis of learning disability, cognitive impairment, or autism spectrum disorder; and spent at least two hours per day in a general education classroom. In addition, children were excluded from this study based on ancillary factors known to affect fatigue. These criteria resulted in the exclusion of (a) children who were bilingual or whose primary language in the home was not listening and spoken language, (b) children with linear metabolic or endocrine disorders (e.g., diabetes or hypothyroidism), (c) children with a chronic medical condition other than hearing loss (e.g., leukemia), and (d) children who utilized medications that might alter hypothalamic-pituitary-adrenal axis responses (e.g., stimulant medications). Exclusionary information was based on parent report. Children were compensated for their participation in the study.

For the purposes of this study, *mild* hearing loss (HL) was defined as a pure-tone average (PTA) between 25 and 40 dB HL or thresholds greater than 25 dB HL at two or more frequencies above 2.0 kHz. *Moderate* hearing loss was defined as a PTA of 41 to 70 dB HL in the better ear. Children exhibiting a conductive component were included in the data set as long as the sensorineural hearing loss fit our criteria and the hearing loss did not fluctuate. Children also had to receive scores within two standard deviations of the mean, or above, on a test of nonverbal intelligence. After initial recruitment, certified audiologists and speech-language pathologists or graduate students supervised by certified personnel obtained all measures.

Demographic and audiologic information. Demographic information was collected through parent report and included maternal education level (quantified using a 1–7 ordinal scale), race, and age. Participants received comprehensive audiologic examinations including air and bone conduction threshold testing and tympanometry. In some cases, standard audiologic information was obtained through clinic data if the child had received an audiogram within the previous 60 days. Speech recognition data were collected as part of an experiment in the ongoing study. Children were seated in a reverberant room (RT60 = 0.6 seconds) and asked to repeat words presented from a loudspeaker located at a 0° azimuth. Verbal responses were recorded using a head-worn microphone. Word recognition was assessed using the AB Isophonemic word lists from the Computer-Assisted Speech Perception Assessment (CASPA; Boothroyd, 2008). A 20-talker speech babble noise was presented continuously throughout the task at a fixed level of 56 dBA from loudspeakers situated at 45°, 135°, 225°, and 315° (in the corners of the room). The level of the speech stimuli was adjusted to create three preselected signal-to-noise ratios (SNR), which varied in 4 dB steps (three lists per SNR condition). SNRs for CMMHL were individually selected to minimize floor and ceiling effects and ranged from −4 to +12 dB. Word and phoneme recognition scores, in percentage correct, were calculated using data from the most favorable SNR condition. CMMHL completed speech testing with hearing aids if they owned hearing aids and without hearing aids if they did not own or use hearing aids. Age of identification and age of fitting of hearing aids were derived from parent report. If parents listed a range (i.e., "between 2 and 3 years"), the mean was entered. Table 1 displays demographic and audiologic information.

Table 1. Demographic and Audiological Information for Children With Mild to Moderate Hearing Loss.

Demographic information	
Mean age in years;months (*SD*)	10;0 (2;0)
Range	6;3–12;11
Race	28% traditionally underrepresented
Median maternal education category[a]	College degree
Audiological Information	**Mean (*SD*) Range**
Better ear PTA (in dB HL)	36.2 (15.5) 5–68
Speech recognition in noise (% correct)	33.8 (17.8) 0–70
Reported age of identification (in years; months)	4;11 (3;0) 0–11
Reported age of HA fitting (in years; months)	5;9 (3;0) 1–12
Reported HA use at school (in hours)	6.33 (3.03) 0–16

Note. HA = hearing aid; PTA = pure tone average; HL = hearing loss.
[a]Median descriptive term.

Speech, language, reading, and cognitive measures. Children received a battery of speech, language, phonological awareness, reading, and cognitive testing as part of the larger, ongoing study. A licensed speech-language pathologist or a graduate student supervised by a licensed speech-language pathologist collected the data herein on a non-schoolday morning. Children received the following measures: Test of Nonverbal Intelligence, 4th edition (TONI-4; Brown, Sherbenou, & Johnsen, 2010), an untimed test of cognitive-spatial reasoning; Clinical Elements of Language Fundamentals, 4th edition (CELF-4; Semel, Wiig, & Secord, 2003), an omnibus test of receptive and expressive language; the Comprehensive Test of Phonological Processing (CToPP; Wagner, Torgeson, & Rashotte, 1999), a test of phonological awareness, memory, and decoding; and the Woodcock Johnson Reading Mastery Test, 3rd edition (WRMT-III; Woodcock, 2011), a measure of reading skills including comprehension and decoding. Standard scores are reported for all measures. The TONI-4 is an untimed test of spatial reasoning. It can be administered completely nonverbally and requires no reading, writing, speaking, or listening. The TONI-4 was used for two primary reasons. First, reading achievement is correlated with overall intelligence in typical populations and is needed as a covariate. Second, a nonverbal intelligence test is necessary for children with hearing loss because verbal intelligence testing is likely to be artificially deflated due to hearing loss or language factors (Meinzen-Derr, Wiley, Phillips, Altaye, & Choo, 2017).

Outcome Variables for Reading Achievement

Three composite scores from the WRMT-III were chosen as outcome measures of reading proficiency because it tests skills similar to annual school reading assessments and is norm-referenced. The Basic Skills Composite consists of Word Identification and Word Attack. This composite was used to evaluate our theoretical predictions concerning word decoding and PA. The Reading Comprehension Composite consists of Word Comprehension and Passage Comprehension. This composite was used to evaluate our theoretical predictions concerning reading comprehension and oral language. The Total Score is a composite that includes each previously mentioned subtest and Oral Reading Fluency.

The Receptive Language Index of the CELF-4 was used to measure oral language because children with poor reading comprehension may exhibit particular deficits in understanding language (e.g., Nation, 2005). The CELF-4 measures a variety of receptive language tasks, including sentence comprehension, following directions, and word classification. Depending on a child's age, different subtests contribute to the Receptive Language Index. In our sample, Concepts & Following Directions, Word Classes-Receptive, and Sentence Structure contributed for children ages 6 to 8, and Concepts & Following Directions and Word Classes-Receptive contributed for children ages 9 to 12. The Phonological Awareness Composite on the CTOPP was used to measure PA. Two subtests contribute to the Phonological Awareness Composite: Elision and Blending Words. On the Elision subtest, children are asked to delete a portion of a spoken word (ranging from a syllable in earlier items to a phoneme in later items) to create a new spoken word. On the Blending Words subtest, children hear a string of individual sounds (again, ranging from syllable in earlier items to phonemes in later items) and are asked to determine the word that is formed by combining the individual sounds in order.

Fatigue measure. The Pediatric Quality of Life Inventory Multidimensional Fatigue Scale (PedsQL MFS) was used to assess self-reported perceptions of fatigue for the children with hearing loss. The PedsQL MFS and its measurement properties have been reviewed elsewhere (Bess & Hornsby, 2014; Hornsby et al., 2014; Varni & Limbers, 2008). In short, the 18-item PedsQL MFS is a standardized fatigue measure comprised of three subscales, each containing six items: (1) general fatigue, 6 items (e.g., "I feel tired"); (2) sleep-rest fatigue, 6 items (e.g., "I rest a lot"); and (3) cognitive fatigue, 6 items (e.g., "It is hard for me to think quickly"). The focus of the current study is cognitive fatigue because we judged these items as being most relevant to academic performance. The instrument uses a 5-point Likert scale, which is transformed into a scale from zero to 100 (1 = 100, 2 = 75, 3 = 50, 4 = 25, 5 = 0). This measure is part of a broader group of tests designed to assess quality of life. Consistent with scoring on other quality of life measures (higher scores reflect fewer health problems), higher scores on the PedsQL MFS indicate less fatigue. The PedsQL MFS possesses good internal consistency, reliability, and construct validity (Varni, Burwinkle, Limbers, & Szer, 2007; Varni, Burwinkle, & Szer, 2004) for ages 5 to 18 years.

Table 2. Language and Reading Scores.

Variable	Average score (*SD*) Range
Nonverbal intelligence	101.8 (12.1) 73–134
Receptive language	95.3 (19.2) 58–128
Phonological awareness	89.4 (16.7) 61–124
Reading, basic skills	95.8 (18.2) 56–138
Reading, comprehension	97.9 (16.9) 65–143
Total reading score	98.4 (18.4) 55–145

Statistical Design and Analysis

Correlational analyses were employed to examine the relationships among the key parameters of interest (e.g., reading ability, language ability, and phonological awareness), and stepwise linear regression was used to estimate the relative contributions of language, PA, and fatigue to overall reading outcome when controlling for age and nonverbal intelligences. Because hearing level (better ear PTA) was not significantly correlated with any of these measures (indeed, the absolute values of these correlations were uniformly less than .20, and most were less than .10), data were pooled across mild and moderate hearing loss groups. Because the PedsQL yields rank scores for fatigue, a Mann-Whitney U nonparametric test (MacFarland & Yates, 2016; Mann & Whitney, 1947) was used to compare performance on the subjective fatigue measure between CMMHL who were good readers to those who were poor readers.

Table 3. Correlation Matrix for Study Variables.

	1	2	3	4	5	6	7
1. Reading, basic skills	—						
2. Reading, comprehension	.796**	—					
3. Age	−.333*	−.302*	—				
4. Nonverbal intelligence	.561**	.590**	−.320*	—			
5. Receptive language	.683**	.801**	−.177	.549**	—		
6. Phonological awareness	.655**	.710**	−.127	.385**	.775**	—	
7. Cognitive fatigue	.177	.273*	−.155	.152	.310*	.178	—

*$p < .05$. **$p < .01$.

Table 4. Reading Performance of Good and Poor Comprehension Readers (Children With Mild to Moderate Hearing Loss).

		Reading comprehension level[a]		
		Good comprehension reader	Poor comprehension reader	Totals
Decoding level[b]	Good decoder	40	4	44
	Poor decoder	5	7	12
Totals		45	11	56

[a]Classification as a good comprehension reader or poor comprehension reader based on Reading Comprehension Composite of the Woodcock Johnson Reading Mastery Test, 3rd edition (WRMT-III; Woodcock, 2011).
[b]Classification as a good decoder or poor decoder based on Basic Skills Composite of the WRMT-III.

Results

The performance of CMMHL on measures of language and reading are displayed in Table 2. Although mean performance was in the low average to average range on each study measure, standard deviations indicated large variability in performance. Indeed, on each language, phonological awareness and reading measure, performance ranged from far below mean normative levels to above average with standard scores on the low end of the distribution between 55 and 65 to standard scores between 124 and 145 on the higher end. Table 3 displays correlations among study parameters.

For the purposes of the analyses, the CMMHL were divided into good readers and poor readers. These divisions were made on the basis of total reading, basic skills, or reading comprehension. Table 4 displays the breakdown of reader types among CMMHL in this sample. Twenty-nine percent (n = 16) of the CMMHL were poor readers in at least one category: 5 were poor readers in basic skills only, 4 were poor readers in comprehension only, and 7 were poor readers in both. Children who had scores in the average or above average range on the Basic Skills Composite of the WRMT-III are referred to as good decoders, and children who had scores in the below average range on the Basic Skills Composite are referred to as poor decoders. Children who had scores in the average or above average range on the Reading Comprehension Composite of the WRMT-III are referred to as good comprehension readers, and children who had scores in the below average range on the Reading Comprehension Composite are referred to as poor comprehension readers. Children who had scores in the average or above average range on the Total Score of the WRMT-III are simply referred to as good readers, and children who had scores in the below average range on the Total Score are referred to as poor readers.

Table 5. Regression Models for Reading Basic Skills[a] and Reading Comprehension[b].

Model	Adjusted R^2		B	$SE\ B$	β	t	p
1[a]	.316	Age	−.131	.090	−.171	−1.454	.152
		Nonverbal intelligence	.718	.167	.506	4.295	.000
2[a]	.552	Age	−.133	.073	−.174	−1.816	.075
		Nonverbal intelligence	.466	.148	.324	3.147	.003
		Phonological awareness	.543	.105	.508	5.148	.000
3[a]	.543	Age	−.134	.075	−.175	−1.793	.079
		Nonverbal intelligence	.467	.150	.325	3.110	.003
		Phonological awareness	.544	.107	.509	5.073	.000
1[b]	.333	Age	−.094	.087	−.126	−1.085	.283
		Nonverbal intelligence	.768	.162	.550	4.748	.000
2[b]	.645	Age	−.007	.065	−.010	−0.114	.910
		Nonverbal intelligence	.290	.138	.208	2.109	.040
		Reading basic skills	.666	.097	.676	6.833	.000
3[b]	.749	Age	−.041	.055	−.054	−0.739	.463
		Nonverbal intelligence	.122	.121	.121	1.009	.318
		Reading basic skills	.408	.098	.415	4.151	.000
		Reading, receptive language	.414	.087	.460	4.745	.000
4[b]	.745	Age	−.037	.056	−.049	−0.655	.515
		Nonverbal intelligence	.125	.122	.089	1.021	.312
		Reading basic skills	.412	.099	.419	4.152	.000
		Reading, receptive language	.401	.091	.445	4.388	.000

PA and Word Decoding Skills in CMMHL

In Hypothesis 1, we hypothesized that PA skills would predict word decoding skills in CMMHL and that CMMHL with word decoding difficulties would exhibit poorer phonological awareness skills than CMMHL who have typical word decoding skills. The observed results support both hypotheses. First, Table 5 displays a series of multiple regression models to predict reading basic skills. In Model 1a, only age and nonverbal intelligence were entered. This model explained 32% of the overall variance: Nonverbal intelligence but not age predicted unique variance in word decoding skills of CMMHL. In Model 2a, phonological awareness was additionally entered. This model explained 55% of the overall variance, and nonverbal intelligence and PA but not age predicted unique variance in word decoding skills of CMMHL. Second, an independent samples t test was used to compare PA skills of CMMHL who were good decoders compared to poor decoders. The poor decoders (M = 78.00, SD = 12.62) scored significantly lower on the PA measure than the good decoders (M = 94.12, SD = 15.96; F = 13.54; p < .01). Cohen's d effect size was 1.12, indicating a large group difference (Cohen, 1988).

Receptive Language and Reading Comprehension Skills in CMMHL

In Hypothesis 2, we hypothesized that receptive oral language skills would predict reading comprehension skills after controlling for word decoding and CMMHL with reading comprehension difficulties would exhibit poorer receptive oral language skills than CMMHL who have good reading comprehension skills. Our findings support both hypotheses. First, Table 5 displays a series of multiple regression models to predict reading comprehension. In Model 1b, only age and nonverbal intelligence were entered. This model explained 33% of the overall variance: Nonverbal intelligence but not age predicted unique variance in reading comprehension skills of CMMHL. In Model 2b, reading basic skills was additionally entered. This model explained 65% of the overall variance, and nonverbal intelligence and reading basic skills, but not age, predicted unique variance in reading comprehension skills of CMMHL. In Model 3b, receptive language was additionally entered. This model explained 75% of the overall variance, and reading basic skills and receptive language, but not age or nonverbal intelligence, predicted unique variance in reading comprehension skills of CMMHL. Second, an independent samples *t* test was used to compare receptive language skills of CMMHL who were good comprehenders compared to poor comprehenders. The poor comprehension readers (M = 71.73, SD = 10.00) scored significantly lower on the receptive language measure than the good comprehenders (M = 101.11, SD = 16.32; $p < .001$). Cohen's d effect size was 2.17, indicating a large group difference (Cohen, 1988).

PA and Receptive Language in CMMHL Who Are Poor Decoders and Poor Comprehension Readers

In Hypothesis 3, we hypothesized that CMMHL who have below average word decoding and poor reading comprehension skills would display deficits in both PA and oral receptive language. This hypothesis was confirmed. CMMHL who were poor decoders and poor comprehenders (M = 76.43; SD = 10.74) performed lower on PA than CMMHL who were good decoders and good comprehenders (M = 92.67; SD = 16.37; $p < .05$). Likewise, CMMHL who were poor decoders and poor comprehenders (M = 67.43; SD = 9.24) performed lower on verbal receptive language than CMMHL who were good decoders and good comprehenders (M = 99.33; SD = 16.84; $p < .001$).

Fatigue and Reading in CMMHL

In Hypothesis 4, we hypothesized that CMMHL who are poor readers would report more fatigue than CMMHL who are good readers. This hypothesis was confirmed. An independent samples nonparametric test was used to compare cognitive fatigue in CMMHL who were good readers compared to poor readers. Total Reading Score was used to categorize participants for this analysis. The Mann-Whitney U analysis indicated that CMMHL who are poor readers (M = 39.24; SD = 25.28) reported significantly more fatigue than CMMHL who were good readers (M = 56.25; SD = 25.91; U = 157, $p < .05$). Cohen's d effect size was 0.66, indicating a medium-large group effect (Cohen, 1988).

Discussion

Relationships Among Language, Phonological Awareness, and Reading Abilities in CMMHL

It is not surprising that the results of this study show that phonological awareness and receptive language are *both* significant concurrent predictors of reading outcomes in CMMHL. As the simple view of reading (Gough & Tunmer, 1986) predicts, decoding and oral language comprehension are both key contributors to reading competence, and this was verified in CMMHL as well. Scarborough's (2001) model of reading predicts that skills such as phonological awareness are important components of decoding skills and skills such as oral language are important components of reading comprehension skills. These theoretical models were developed with children without hearing loss in mind, and the results herein lend support to their validity for CMMHL as well.

It is not surprising that the results of this study show that phonological awareness and receptive language are both significant concurrent predictors of reading outcomes in CMMHL.

Our findings indicated that PA was a unique predictor of decoding ability within this sample of CMMHL. Additionally, CMMHL who were poor decoders demonstrated lower PA skills than CMMHL who were good decoders. It is interesting that CMMHL display similar patterns to children with normal hearing with regard to PA and decoding because CMMHL do not process auditory information the same as children with normal hearing even when auditory access to the speech signal is quite viable (Gifford et al., in press; Nittrouer & Lowenstein, 2015). PA has long been reported as a highly important predictor of decoding ability in the general population and in children with severe to profound hearing loss, and our findings lend further support to the conclusion that phonological awareness is important for reading ability in CMMHL (Briscoe et al., 2001; Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008; Harris & Beech, 1998; Miller, 1997). And this variability in how CMMHL deploy access to the auditory stream to develop PA is a promising line of research on reading development in CMMHL (Gifford et al., in press; Lowenstein & Nittrouer, 2015).

Also, receptive language ability was a unique predictor of reading comprehension in CMMHL, and those who were poor readers exhibited lower receptive language abilities than good readers. As with PA and decoding, these findings parallel findings in children with normal hearing (for a review, see Nation, 2005). It is unsurprising that receptive language abilities would so strongly predict reading ability in CMMHL because there is no reason to hypothesize that the act of comprehending written language would differ for children with hearing loss who use spoken English as their primary language. The current study also replicated previous reports showing considerable variability in language ability in CMMHL (e.g., Harris, Terlektsi, & Kyle, 2016); the CMMHL in our study ranged from significantly below average to well above average.

A third finding was that approximately 13% of our CMMHL sample demonstrated deficits in both decoding *and* reading comprehension. We predicted that these children would display corresponding deficits in PA and language comprehension, which was confirmed. This finding lends further support to the theoretical model proposed for analyzing reading abilities in CMMHL such that deficits in both domains are associated with lower performance in reading.

CMMHL, Poor Reading Comprehension, and Fatigue

Another intriguing finding in these data is that CMMHL who were poor readers also reported significantly higher levels of fatigue than their peers who were classified as good readers. We posit, therefore, that CMMHL who struggle to read perhaps deploy more cognitive resources (e.g., attention, memory; see Nittrouer, Caldwell-Tarr, Low, & Lowenstein, 2017) during academic tasks, potentially making them more susceptible to cognitive fatigue. Bess and Hornsby (2014) posited a bidirectional relation of fatigue and spoken communication such that breakdowns in communication result in cognitive fatigue and in turn fatigue leads to additional communication breakdowns. With respect to fatigue and academic performance, however, Bess and Hornsby proposed a unidirectional relation such that fatigue leads to compromised academic skills.

CMMHL who were poor readers reported higher levels of cognitive fatigue than CMMHL who were good readers. Thus, this study provides support for testing a unidirectional relation in which difficulty in reading processes potentially leads to increased fatigue for CMMHL.

The findings of the present study suggest that the relation of fatigue and academic performance may in fact be unidirectional in the opposite direction: CMMHL who were poor readers reported higher levels of cognitive fatigue than CMMHL who were good readers. Thus, this study provides support for testing a unidirectional relation in which difficulty in reading processes potentially leads to increased fatigue for CMMHL. In contrast, it is possible that CMMHL who readily comprehend what they read may be able to harness and use the visual information received through text, thus reducing cognitive demands, in a way that CMMHL who are poor readers can not

(Trezek, Wang, Woods, Gampp, & Paul, 2007). An important related consideration is that poor reading comprehension in CMMHL was strongly associated with poor oral receptive language levels and poor decoding skills. Hence, it is reasonable to speculate that cognitive load may be compounded (Nittrouer et al., 2017) as these children struggle to comprehend spoken language and written language as compared to CMMHL with higher receptive language levels and better decoding skills.

Limitations and Future Directions

Two major limitations exist within the current study, one of which leads directly to future research. One key limitation of the data, in terms of testing causal relationships among study variables, is that it represents a concurrent sample. Because the relationship of language and reading is measured within a concurrent sample, it is unclear if better language leads to better reading or if these two variables increase in relation to a third variable such as PA. In addition, it is possible that hearing loss affects earlier language (the children in this sample are school-aged), whereas later language level affects reading outcomes. These questions are measureable and can be answered within the context of a longitudinal design and within the context of intervention studies, albeit not in the current (cross-sectional) sample. A longitudinal assessment of hearing, language, PA, reading, and fatigue in CMMHL would allow for a better representation of the effect each variable at an earlier time point has on other variables at a later time point. Longitudinal studies of children with profound to severe HL have yielded important insights into the interplay among these factors as they contribute to overall reading ability (see e.g., Kyle, Campbell & MacSweeney, 2016; Kyle & Harris, 2006, 2011; Kyle, Harris & Terlekski, 2016) so that such are also warranted in CMMHL as well. Indeed, in a review of 57 studies on reading of Deaf and Hard of Hearing (DHH) children. Mayberry, Del Giudice, and Lieberman (2011) reported that language ability predicted 35% of the variance in reading comprehension. More importantly, this proportion was greater than the contributions of other reading skills, which indicates the importance of language skills for the DHH population. Similarly, an intervention design could increase performance on one parameter, such as PA, using targeted training to test whether there is a causal link to other parameters such as language and/or reading ability. Another path that could be tested using an intervention design is whether gains in language, PA, and/or reading have incidental improvements in cognitive fatigue in CMMHL.

A second limitation in the current study is that reading, PA, and language comprehension were measured using standardized assessments, precluding more nuanced examination of subskills within these domains. Although this study is a reasonable first step in gaining a better understanding of these skills in CMMHL, future studies should be completed that delve more deeply into the narrow abilities in each of these domains (e.g., vocabulary, grammar, and complex syntax comprehension in language; subskills in PA such as syllable counting, initial and final consonant discrimination, and nonword repetition; see Nittrouer & Caldwell-Tarr, 2016).

There are a number of additional potential future directions. First, these results warrant replication with a longitudinal sample of poor readers with CMMHL. Because the parent project was not designed to delve into the relationship between reading, language, PA, and fatigue in poor readers specifically, a study designed to target this population directly across a wide age span is an important next step. Similarly, intervention studies that target these abilities in "at risk" children with CMMHL are needed. This will permit directional moderator/mediator analyses to begin exploring causal linkages among PA, language, and reading in CMMHL and developing effective classroom interventions to support those that are poor readers. In addition, there is a clear need to study fatigue in greater depth not only in CMMHL but other populations of children with disabilities as well. The results herein suggest a cascade or cumulative effect of hearing loss combined with poor achievement on reported fatigue that can be explicitly tested within the context of longitudinal-intervention designs. Future research is needed to gain additional insight into factors that contribute to fatigue and poor academic performance in CMMHL.

References

Adams, M. J., & Umbach, P. D. (2012). Nonresponse and online student evaluations of teaching: Understanding the influence of salience, fatigue, and academic environments. *Research in Higher Education*, *53*, 576–591. doi:10.1007/s11162-011-9240-5

Adlof, S., & Catts, H. (2015). Morphosyntax in poor readers. *Reading and Writing*, *28*, 1051–1070. doi:10.1007/s11145-015-9562-3

Al Otaiba, S., & Fuchs, D. (2002). Characteristics of children who are unresponsive to early literacy intervention a review of the literature. *Remedial and Special Education*, *23*, 300–316. doi:10.1177/07419325020230050501

Barsevick, A. M., Irwin, M. R., Hinds, P., Miller, A., Berger, A., Jacobsen, P., . . . Lai, J. S. (2013). Recommendations for high-priority research on cancer-related fatigue in children and adults. *Journal of the National Cancer Institute*, *105*, 1432–1440. doi:10.1093/jnci/djt242

Bess, F. H., Dodd-Murphy, J. D., & Parker, R. A. (1998). Children with minimal sensorineural hearing loss: Prevalence, educational performance and functional status. *Ear & Hearing*, *19*, 339–354.

Bess, F. H., Gustafson, S., & Hornsby, B. W. Y. (2014). How hard can it be to listen? Fatigue in school-age children with hearing loss. *Journal of Educational Audiology*, *20*, 1–14. doi:10.1044/2015_AJA-15-0024

Bess, F. H., & Hornsby, B. W. Y. (2014). Commentary: Listening can be exhausting—Fatigue in children and adults with hearing loss, *Ear & Hearing*, *35*, 592–599. doi:10.1097/AUD.0000000000000099

Boothroyd, A. (2008). *Computer-assisted speech perception assessment (CASPA) 5.0 software manual*. San Diego, CA: CASPA.

Bradley, L., & Bryant, P. E. (1983). Categorizing sounds and learning to read—a causal connection. *Nature*, *301*(5899), 419–421. doi:10.1038/301419a0.

Briscoe, J., Bishop, D. V., & Norbury, C. F. (2001). Phonological processing, language, and literacy: A comparison of children with mild-to-moderate sensorineural hearing loss and those with specific language impairment. *Journal of Child Psychology and Psychiatry*, *42*, 329–340. doi:10.1111/1469-7610.00726

Brown, L., Sherbenou, R., & Johnsen, S. (2010). *Test of nonverbal intelligence* (4th ed.). Austin, TX: Pro-Ed.

Bus, A. G., & Van IJzendoorn, M. H. (1999). Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology*, *91*, 403–414. doi:10.1037/0022-0663.92.2.284

Cain, K., & Oakhill, J. (2006). Profiles of children with specific reading comprehension difficulties. *British Journal of Educational Psychology*, *76*, 683–696. doi:10.1348/000709905X67610

Catts, H. W., Adlof, S. M., & Ellis-Weismer, S. (2006). Language deficits in poor comprehenders: A case for the simple view of reading. *Journal of Speech, Language, and Hearing Research*, *49*, 278–293. doi:10.1044/1092-4388(2006/023)

Catts, H. W., Fey, M. E., Weismer, S. E., Bridges, M. S., Tomblin, J. B., & Nippold, M. A. (2014). The relationship between language and reading abilities. In J. B. Tomblin, & M. Nippold (Eds.), *Understanding individual differences in language development across the school years* (pp. 144–165). New York: Taylor & Francis.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.

Connor, C. M., & Zwolan, T. (2004). Examining multiple sources of influence on the reading comprehension skills of children who use cochlear implants. *Journal of Speech, Language, and Hearing Research*, *47*, 509–526. doi:10.1044/1092-4388(2004/040)

Cupples, L., Ching, T., Crowe, K., Day, J., & Seeto, M. (2013). Predictors of early reading skill in 5-year-old children with hearing loss who use spoken language. *Reading Research Quarterly*, *49*, 85–104. doi:10.1002/rrq.60

Davis, J., Elfenbein, J., Schum, R., & Bentler, R. (1986). Effects of mild and moderate hearing impairments on language, educational, and psychosocial behavior of children. *Journal of Speech and Hearing Disorders*, *51*, 53–62. doi:10.1044/jshd.5101.53

Easterbrooks, S. R., Lederberg, A. R., Miller, E. M., Bergeron, J. P., & Connor, C. M. (2008). Emergent literacy skills during early childhood in children with hearing loss: Strengths and weaknesses. *The Volta Review*, *108*, 91–114. doi:10.1179/1557069X12Y.0000000018

Fitzpatrick, E. M., Hamel, C., Stevens, A., Pratt, M., Moher, D., Doucet, S.P., . . . Na, E., (2015).

Sign language and spoken language for children with hearing loss: A systematic review. *Pediatrics*, *137*, e20151974. doi:10.1542/peds.2015-1974

Geers, A., & Hayes, H. (2011). Reading, writing, and phonological processing skills of adolescents with 10 or more years of cochlear implant experience. *Ear & Hearing*, *32*, 49S–59S. doi:10.1097/AUD.0b013e3181fa41fa

Gifford, R., Noble, J., Camarata, S., Sunderhaus, L., Dwyer, R., Dawant, B., Dietrich, M., & Labadie, R. (in press). The relationship between spectral modulation detection and speech recognition: Adult versus pediatric cochlear implant recipients. *Trends in Hearing*.

Gillon, G. T. (2017). *Phonological awareness: From research to practice*. New York: Guilford Publications.

Goldwin-Meadow, S. G., & Mayberry, R. L. (2001). How do profoundly deaf children learn to read? *Learning Disabilities Research and Practice*, *16*, 222–229.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, *7*, 6–10. doi:10.1177/074193258600700104

Gustafson, S. J., Davis, H., Hornsby, B. W. Y., & Bess, F. H. (2015). Factors influencing hearing aid use in the classroom: A pilot study. *Journal of Audiology*, *24*, 563–568. doi:10.1044/2015_AJA-15-0024

Harris, M., & Beech, J. R. (1998). Implicit phonological awareness and early reading development in prelingually deaf children. *Journal of Deaf Studies and Deaf Education*, *3*, 25–216. doi:10.1017/S0142716409990063

Harris, M., Terlektsi, E., & Kyle, F. E. (2016). Literacy outcomes for deaf and hard of hearing primary school children: A cohort comparison study. *Journal of Speech, Language, and Hearing Research*, *60*, 701–711. doi:10.1044/2016_JSLHR-H-15-0403

Hornsby, B. W., Werfel, K., Camarata, S., & Bess, F. H. (2014). Subjective fatigue in children with hearing loss: Some preliminary findings. *American Journal of Audiology*, *23*, 129–134. doi:10.1044/1059-0889(2013/13-0017)

James, D., Rajput, K., Brown, T., Sirimanna, T., Brinton, J., & Goswami, U. (2005). Phonological awareness in deaf children who use cochlear implants. *Journal of Speech, Language, and Hearing Research*, *48*, 1511–1528. doi:10.1044/1092-4388(2005/105)

Krilov, L. R., Fisher, M., Friedman, S. B., Reitman, D., & Mandel, F. S. (1998). Course and outcome of chronic fatigue in children and adolescents. *Pediatrics*, *102*, 360–366. doi:10.1542/peds.2008-1879

Kyle, F., Campbell, R., & MacSweeney, M. (2016). The relative contributions of speechreading and vocabulary to deaf and hearing children's reading ability. *Research in Developmental Disabilities*, *48*, 13–24. doi:10.1016/j.ridd.2015.10.004

Kyle, F., & Harris, M. (2006). Concurrent correlates and predictors of reading and spelling achievement in deaf and hearing school children. *Journal of Deaf Studies and Deaf Education*, *11*, 273–288. doi:10.1093/deafed/enj037.

Kyle, F., & Harris, M. (2011). Longitudinal patterns of emerging literacy in beginning deaf and hearing readers. *Journal of Deaf Studies and Deaf Education*, *16*, 289–304. doi:10.1093/deafed/enq069

Kyle, F. E., Harris, M., & Terlektsi, E. (2016). Concurrent and longitudinal predictors of reading for deaf and hearing children in primary school. *Journal of Deaf Studies and Deaf Education*, *22*, 233–242. doi:10.1177/0271121417720015

Kamhi, A. G., & Catts, H. W. (2013). *Language and reading disabilities* (3rd ed.). Boston, MA: Pearson.

Lederberg, A. R., Schick, B., & Spencer, P. E. (2013). Language and literacy development of deaf and hard-of-hearing children: Successes and challenges. *Developmental Psychology*, *49*, 15–30. doi:10.1037/a0029558

Lervåg, A., Hulme, C., & Melby-Lervåg, M. (2017). Unpicking the Developmental Relationship Between Oral Language Skills and Reading Comprehension: It's Simple, But Complex. *Child Development*. doi:10.1111/cdev.12861.

Lowenstein, J. H., & Nittrouer, S. (2015). All cues are not created equal: The case for facilitating the acquisition of typical weighting strategies in children with hearing loss. *Journal of Speech, Language, and Hearing Research*, *58*(2), 466–480. doi:10.1044/2015_JSHLR-H-14-0254

Mann, H. B., & Whitney, D. R. (1947). On a test of whether one of two random variables is stochastically larger than the other. *The Annals of Mathematical Statistics*, *18*, 50–60.

Mayberry, R. I., Del Giudice, A. A., & Lieberman, A. M. (2011). Reading achievement in relation to phonological coding and awareness in deaf readers: A meta-analysis. *The Journal of Deaf Studies and Deaf Education*, *16*(2), 164–188. doi: 10.1093/deafed/enq049

MacDonald, G. W., & Cornwall, A. (1995). The relationship between phonological awareness and reading and spelling achievement eleven years later. *Journal of Learning Disabilities*, *28*, 523–527. doi:10.1177/002221949502800807

MacFarland, T. W., & Yates, J. M. (2016). Mann-Whitney U test. In *Introduction to nonparametric statistics for the biological sciences using R* (pp. 103–132). Boston, MA: Springer.

Meinzen-Derr, J., Wiley, S., Phillips, J., Altaye, M., & Choo, D. I. (2017). The utility of early developmental assessments on understanding later nonverbal IQ in children who are deaf or hard of hearing. *International Journal of Pediatric Otorhinolaryngology*, *92*, 136–142. doi:10.1016/j.ijporl.2016.11.024

Miller, P. (1997). The effect of communication mode on the development of phonemic awareness in prelinquistically deaf students. *Journal of Speech, Language, and Hearing Research*, *40*, 1151–1163. doi:10.1044/jslhr.4005.1151

Moberly, A. C., Lowenstein, J.H., & Nittrouer, S. (2016). "Word recognition variability with cochlear implants: "Perceptual attention" versus "auditory sensitivity". *Ear and Hearing*, *37*, 14–26. doi: 10.1097/MAO.0000000000001001

Nation, K. (2005). Children's Reading Comprehension Difficulties. In M. J. Snowling & C. Hulme (Eds.), *Blackwell handbooks of developmental psychology. The science of reading: A handbook* (pp. 248–265). Malden, MA: Blackwell Publishing. doi:10.1002/9780470757642.ch14

Nation, K., Clarke, P., Marshall, C. M., & Durand, M. (2004). Hidden language impairments in children: Parallels between poor reading comprehension and specific language impairment? *Journal of Speech, Language, and Hearing Research*, *47*, 199–211. doi:10.1044/1092-4388(2004/017)

Nation, K., & Norbury, C. F. (2005). Why reading comprehension fails: Insights from developmental disorders. *Topics in Language Disorders*, *25*, 21–32. doi:10.1097/00011363-200501000-00004

Nation, K., & Snowling, M. J. (2004). Beyond phonological skills: Broader language skills contribute to the development of reading. *Journal of Research in Reading*, *27*(4), 342–356. doi:10.1111/j.1467-9817.2004.00238.x

Nittrouer, S., & Caldwell-Tarr, A. (2016). Language and literacy skills in children with cochlear implants: Past and present findings. In N. Young, & K. Kirk (Eds.) *Pediatric cochlear implantation* (pp. 177–197). New York, NY: Springer.

Nittrouer, S., Caldwell-Tarr, A., Low, K. E., & Lowenstein, J. H. (2017). Verbal working memory in children with cochlear implants. *Journal of Speech, Language, and Hearing Research*, *60*, 3342–3364. doi:10.1044/2017_JSLHR-H-16-0474

Nittrouer, S., & Lowenstein, J. H. (2015). Weighting of acoustic cues to a manner distinction by children with and without hearing loss. *Journal of Speech, Language, and Hearing Research*, *58*(3), 1077–1092. doi:10.1044/2015 JSLHR-H-14-0263

Nittrouer, S., Sansom, E., Low, K., Rice, C., & Caldwell-Tarr, A. (2014). Language structures used by kindergartners with cochlear implants: Relationship to phonological awareness, lexical knowledge and hearing loss. *Ear and Hearing*, *35*(5), 506–518. doi:10.1097/AUD.0000000000000051

Park, J., Lombardino, L. J., & Ritter, M. (2013). Phonology matters: A comprehensive investigation of reading and spelling skills of school-age children with mild to moderate sensorineural hearing loss. *American Annals of the Deaf*, *158*, 20–40.

Porter, H., Bess, F. H., & Tharpe, A. M. (2016). Minimal hearing loss in children. In A. M. Tharpe, & R. S Seewald (Eds.), *Comprehensive handbook of pediatric audiology* (2nd ed., pp. 887–914). San Diego, CA: Plural Publishing.

Savage, R., Burgos, G., Wood, E., & Piquette, N. (2015). The simple view of reading as a framework for national literacy initiatives: A hierarchical model of pupil-level and classroom-level factors. *British Educational Research Journal*, *41*, 820–844. doi:10.1002/berj.3177

Scarborough, H. (2001). Connecting early language and literacy to later reading disabilities: Evidence, theory, and practice. In S. Neuman & D. Dickinson (eds.), *Handbook for research in early literacy* (pp. 97–110). New York: Guilford Press.

Scarborough, H. S., Fletcher-Campbell, F., Soler, J., & Reid, G. (2009). Connecting early language and literacy to later reading (dis) abilities: Evidence, theory, and practice. In F. Fletcher-Campbell, J. Soler, & G. Reid (Eds.), *Approaching difficulties in literacy development: Assessment, pedagogy, and programmes* (pp. 23–39). London: Sage Publications.

Semel, E., Wiig, E., & Secord, W. (2003). *Clinical evaluation of language fundamentals* (4th ed.). San Antonio, TX: The Psychological Corporation.

Storch, S. A., & Whitehurst, G. J. (2002). Oral language and code-related precursors to reading: Evidence from a longitudinal structural model. *Developmental Psychology*, *38*, 934–947. doi:10.1037/0012-1649.38.6.934

Trezek, B. J., Wang, Y., Woods, D. G., Gampp, T. L., & Paul, P. V. (2007). Using visual phonics to supplement beginning reading instruction for students who are deaf or hard of hearing. *Journal of Deaf Studies and Deaf Education*, *12*, 373–384. doi:10.1093/deafed/enm014

Varni, J. W., Burwinkle, T. M., Limbers, C. A., & Szer, I. S. (2007). The PedsQL™ as a patient-reported outcome in children and adolescents with fibromyalgia: An analysis of OMERACT domains. *Health and Quality of Life Outcomes*, *5*(1), 9. doi:10.1186/1477-7525-5-9

Varni, J. W., Burwinkle, T. M., & Szer, I. S. (2004). The PedsQL Multidimensional Fatigue Scale in pediatric rheumatology: reliability and validity. *Journal of Rheumatology*, *31*, 2494–2500. PMID:15570657.

Varni, J. W., & Limbers, C. A. (2008). The PedsQL™ Multidimensional Fatigue Scale in young adults: Feasibility, reliability and validity in a university student population. *Quality of Life Research*, *17*, 105–114. doi:10.1007/s11136-007-9282-5.

Wagner, R., Torgesen, J., & Rashotte, C. (1999). *Comprehensive test of phonological processing (CToPP)*. Austin, TX: Pro-Ed.

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin*, *101*(2), 192–212. doi:10.1037/0033-2909.101.2.192

Wake, M., Hughes, E., Poulakis, Z., Collins, C., & Richards, F. (2004). Outcomes of children with mild-profound congenital hearing loss at 7 to 8 years: A population study. *Ear & Hearing*, *25*, 1–8. doi:10.1097/01.AUD.0000111262.12219.2F

Werfel, K. L. (2017). Emergent literacy skills in preschool children with hearing loss who use spoken language: initial findings from the Early Language and Literacy Acquisition (ELLA) Study. *Language, Speech, and Hearing Services in Schools*, *48*(4), 249–259. doi:10.1044/2017_LSHSS-17-0023

Werfel, K., & Hendricks, A. (2016). The relation between child versus parent report of chronic fatigue and language/literacy performance in school-age children with cochlear implants. *Ear & Hearing*, *37*, 216–224. doi:10.1097/AUD.0000000000000242.

Werfel, K., & Krimm, H. (2017). A preliminary comparison of reading subtypes in a clinical sample of children with specific language impairment. *Journal of Speech, Language, and Hearing Research*, *60*, 2680–2686. doi:10.1044/2017_JSLHR-L-17-0059.

Woodcock, R. (2011). *Woodcock Reading Mastery Test* (3rd ed.). Chicago, IL: Pearson.

Authors' Note

Stephen Camarata, Krystal Werfel, and Tonia Davis contributed equally to this research. The research reported herein was supported by the Institute of Education Sciences, U.S. Department of Education, Grant R324A110266 (Bess, PI, Camarata, CoI & Hornsby, CoI) to Vanderbilt University, by the Vanderbilt Institute for Clinical and Translational Research, Award 2UL1TR000445 from the National Institutes of Health, G. Bernard, PI, and by the Scottish Rite Masons Foundation of Nashville.

ORCID iDs

Stephen Camarata https://orcid.org/0000-0002-3342-1747
Tonia Davis https://orcid.org/0000-0002-8212-5813

Manuscript received December 2017; accepted April 2018.