Variability of Early Literacy Skills

In Children with Hearing Impairment

by

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ABSTRACT

Children with hearing impairment are at risk for poor attainment in reading decoding and reading comprehension, which suggests they may have difficulty with early literacy skills prior to learning to read. The first purpose of this study was to determine if young children with hearing impairment differ from their peers with normal hearing on early literacy skills and also on three known predictors of early literacy skills – non-verbal cognition, executive functioning, and home literacy environment. A second purpose was to determine if strengths and weaknesses in early literacy skills of individual children with hearing impairment are associated with degree of hearing loss, non-verbal cognitive ability, or executive functioning.

I assessed seven children with normal hearing and 10 children with hearing impairment on assessments of expressive vocabulary, expressive morphosyntax, listening comprehension, phonological awareness, alphabet knowledge, non-verbal cognition, and executive functioning. Two children had unilateral hearing loss, two had mild hearing loss and used hearing aids, two had moderate hearing loss and used hearing aids, one child had mild hearing loss and did not use hearing aids, and three children used bilateral cochlear implants. Parents completed a questionnaire about their home literacy environment.

Findings showed large between-group effect sizes for phonological awareness, morphosyntax, and executive functioning, and medium between-group effect sizes for expressive vocabulary, listening comprehension, and non-verbal cognition. Visual analyses provided no clear pattern to suggest that non-verbal cognition or degree of

hearing loss were associated with individual patterns of performance for children with hearing impairment; however, three children who seemed at risk for reading difficulties had executive functioning scores that were at the floor.

Most prekindergarten and kindergarten children with hearing impairment in this study appeared to be at risk for future reading decoding and reading comprehension difficulties. Further, based on individual patterns of performance, risk was not restricted to one type of early literacy skill and a strength in one skill did not necessarily indicate a child would have strengths in all early literacy skills. Therefore, it is essential to evaluate all early literacy skills to pinpoint skill deficits and to prioritize intervention goals.

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Introduction

Strong reading decoding skills and high reading comprehension achievement are needed for academic success. Unfortunately, children with hearing impairment, regardless of the degree of hearing loss, are at risk for having low reading proficiency (Antia, Jones, Reed, & Kreimeyer, 2009; Easterbrooks & Beal-Alvarez, 2012; Traxler, 2000). Antia, Jones, Reed, and Kreimeyer (2009) reported on reading comprehension outcomes for children from Arizona and Colorado with varying degrees of hearing loss that ranged from minimal to profound. They assessed children in grades two to eight at the start of their study and annually for five years or until the student's state no longer required standardized testing, which was the 10th grade for Arizona and the 11th grade for Colorado. According to their findings 32% percent to 42% of students performed below average on standardized reading comprehension assessments.

Others have documented reading decoding and reading comprehension deficits in third-grade children with cochlear implants. Spencer, Barker, and Tomblin (2003) found that nine-year-old children with cochlear implants performed significantly poorer than their peers with normal hearing on a reading comprehension assessment, while Geers (2003) found that the mean standard score was 85.6 on an assessment of reading decoding and reading comprehension in 8- and 9-year-old children with cochlear implants. When Geers and Hayes (2011) assessed children in high school from Geers' (2003) study, two-thirds of the children scored within the average range on a silent reading comprehension assessment; however, seventeen percent of the children had grade equivalent reading scores below the fourth grade.

Children with minimal hearing loss are also at risk for poor reading achievement. Children with minimal hearing loss have generally been defined as having unilateral hearing loss, bilateral high frequency hearing loss above 2000 Hz, or thresholds in each ear between 20 dB HL and 40 dB HL (e.g., Bess, Dodd-Murphy, & Parker, 1998; Porter, Sladen, Ampah, Rothpletz, & Bess, 2013). Researchers have reported that children with minimal hearing loss are at risk for experiencing academic difficulties and grade retention (Bess et al., 1998; Oyler, Oyler, & Matkin, 1988) and oral language deficits (Lieu, Tye-Murray, & Fu, 2012; Lieu, Tye-Murray, Karzon, & Piccirillo, 2010).

Porter, Sladen, Ampah, Rothpletz, and Bess (2013) assessed 27 children, ages four to nine years, on psychoeducational measures annually for three years. Each child with hearing impairment was matched to a peer with normal hearing by age (within six months) and maternal level of education. They found that children with minimal hearing loss had mean scores above the normative sample mean and did not differ from the peers with normal hearing on assessments of phonological awareness, oral language, reading decoding, and reading comprehension.

The results from Porter et al. (2013) are encouraging, but yet two-thirds of the children in the study came from homes in which the parents had a college degree or graduate education. Because maternal level of education is associated with strong oral language skills and academic success in children, this may have been factor in the lack of significant findings between children with minimal hearing loss and their peers with normal hearing. Furthermore, Porter et al. suggested that, unlike other earlier studies of children with minimal hearing loss, children in this study were identified with hearing

loss before study participation, and thus they may have been provided with earlier access to intervention services than children in previous studies.

Given the poor reading outcomes of many children with hearing impairment, there is a need to determine how children with hearing impairment perform early in development on skills important for reading success. Two factors shown to be significantly associated with early literacy skill development in children with normal hearing are executive function skills and children's home literacy environments (e.g, Burgess, Hecht, & Lonigan, 2002; Martini and Sénéchal, 2012; McClelland et al., 2014). Assessing early literacy skills directly in young children with hearing impairment and understanding factors associated with early literacy skill acquisition is an initial step in determining which early literacy skill interventions are important for children with hearing impairment.

Early Literacy Skills Are Important for Reading Decoding and Reading Comprehension

Alphabet knowledge, phonological awareness, and oral language skills, which will be collectively referred to as early literacy skills in this study, form the foundation for reading decoding in children with normal hearing (Kendeou, van den Broek, White, & Lynch, 2009; Storch & Whitehurst, 2002; Wagner et al., 1997). In 626 children with normal hearing, Storch and Whitehurst (2002) found that kindergarten phonological awareness and understanding of print principles (alphabet knowledge and print concept knowledge) were separate constructs, which they termed code-related skills. Phonological awareness and print principles each predicted first grade reading, which

included word reading and word attack of pseudowords, and also mediated the relationship between kindergarten oral language skills and first grade reading decoding and word attack.

Alphabet knowledge, phonological awareness, and oral language skills also make important contributions to reading decoding in children with hearing impairment (Cupples, Ching, Crowe, Day, & Seeto, 2014; Nittrouer, Caldwell, Lowenstein, Tarr, & Holloman, 2012). Cupples, Ching, Crowe, Day, and Seeto (2014) investigated the relationship between alphabet knowledge and reading decoding, phonological awareness and reading decoding, and receptive vocabulary and reading decoding in 100 five-year-old children with hearing impairment. The children had varying degrees of hearing loss, used hearing aids or cochlear implants, and used total communication or oral communication. Results of a regression analysis indicated that alphabet knowledge significantly predicted 18% of the variance in real word reading, phonological awareness significantly predicted 16% of the variance in real word reading, and receptive vocabulary predicted 4% of the variance in real word reading, although this relationship was not significant. Alphabet knowledge significantly accounted for 25% of the variance in word attack skills and phonological awareness significantly accounted for 7% of the variance in word attack skills, but receptive vocabulary skills did not predict word attack.

Nittrouer, Caldwell, Lowenstein, Tarr, and Holloman (2012) investigated the relationship between phonological awareness and reading decoding and oral language skills and reading decoding in children with cochlear implants who had recently completed kindergarten. They found that scores on an investigator-designed syllable

counting task and an analysis of personal narratives predicted word reading. These findings, combined with the findings by Cupples et al. (2014), suggest that alphabet knowledge, phonological awareness, and oral language skills underlie reading decoding in children with hearing impairment.

Good reading comprehension depends on strong oral language skills in children with normal hearing (Kendeou, et al., 2009; Muter, Hulme, Snowling, & Stevenson, 2004; National Early Literacy Panel, 2008; Storch & Whitehurst, 2002). Muter, Hulme, Snowling, and Stevenson (2004) found in a sample of 90 children in England that receptive vocabulary knowledge in year one of formal schooling and grammatical knowledge and word recognition in year two of formal schooling predicted reading comprehension at the start of year three of formal schooling. Letter knowledge and phonological awareness at year two, however, did not predict year three reading comprehension. These findings suggested that while reading comprehension relies on word recognition skills, multiple components of language, including morphological knowledge and vocabulary, underlie children's ability to derive meaning from written text.

Another component of oral language skills, listening comprehension, is essential for reading comprehension. In 1986 Gough and Tunmer (1986) put forth the Simple View of Reading. The tenet of this view was that reading decoding and linguistic comprehension (or listening comprehension) are both complex processes necessary for skilled reading comprehension. Multiple studies have supported this view (e.g., Catts, Adlof, & Weismer, 2006; Kendeou, et al., 2009), but with listening comprehension taking

on a greater role in reading comprehension than reading decoding beyond early childhood (Oakhill & Cain, 2012; Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009; Torppa et al., 2016).

Investigators have also found that oral language skills predict reading comprehension in children with cochlear implants (Connor & Zwolan, 2004; Nittrouer et al., 2012). Connor and Zwolan (2004) examined whether communication mode, pre-implant speech detection threshold, socioeconomic status, length of implant use/age in years, pre-implant vocabulary, age of cochlear implantation, and post-implant vocabulary predicted reading comprehension outcomes in 97 children with cochlear implants. The children had a mean age of 11 years when assessed on reading comprehension and used oral communication or total communication. Length of implant use/age in years, socioeconomic status, age of implantation, and post-implant expressive vocabulary each had a direct relationship with reading comprehension in a structural equation model.

Overall, studies indicate that early literacy skills are important precursors to reading success in children with normal hearing and in children with hearing impairment who use spoken language. Because of the underlying relationships early literacy skills share with conventional reading skills, deficits in early literacy skills impact how well children with hearing impairment decode and understand written text. Therefore, it is important to identify whether children with hearing impairment have early literacy skills that are age-appropriate, which may in turn support future reading achievement.

The Early Literacy Skills of Children with Normal Hearing

Children with normal hearing begin to acquire alphabet knowledge before formal reading instruction begins (Lonigan et al., 2000; Worden & Boettcher, 1990). Piasta, Petscher, and Justice (2012) assessed preschool children on letter name knowledge and reported that preschool children knew, on average, 18 uppercase letter names and 15 lowercase letter names. Worden and Boettcher (1990) assessed 180 children, ages three to seven years, on letter name knowledge, letter sound knowledge, and letter writing in a cross-sectional study. They found that three-year-old children knew between zero to five letter sounds, wrote zero to five uppercase letters, and wrote zero to five lowercase letters. Approximately 75% of the three-year-old children named between zero and five uppercase letters and approximately 80% named between zero and five lowercase letters letter. Performance improved with increasing age, and in the seven-year-old cohort near ceiling performance was reached by at least 92% of the children on each of the tasks. These results indicate that letter name knowledge, letter sound knowledge, and letter writing are emerging in preschool children, and may not be fully acquired by seven years of age in some children.

Phonological awareness also begins to emerge in preschool children with normal hearing (Lonigan et al., 2000; Lonigan, Burgess, Anthony, & Barker, 1998; Wagner, Torgesen, & Rashotte, 1994). Lonigan, Burgess, Anthony, and Barker (1998) assessed two groups of children with normal hearing, ages two to five years, on a battery of phonological awareness tasks. One group of children came from homes with low socioeconomic status and the other group of children came from homes with middle

socioeconomic status. The phonological awareness tasks included rhyme oddity, alliteration oddity, blending, and elision tasks. The blending and elision tasks were comprised of items at the word, syllable, and phoneme level. At two and three years of age, there were children who performed above chance on the phonological awareness tasks. With increasing age children from both groups showed improvement on each task, except for rhyme oddity in children from homes with low socioeconomic status. Furthermore, age was associated with elision and blending task complexity, except on the blending task for children who came from homes with low socioeconomic status. These findings suggest that age and task complexity impact how well children with normal hearing perform on phonological awareness tasks.

As with alphabet knowledge and phonological awareness skills, early childhood is a critical time period in which children with normal hearing demonstrate increases in oral language skills. Morphosyntactic use and accuracy are increasing (Rice & Oetting, 1993; Rice, Wexler, & Hershberger, 1998). Vocabulary knowledge is improving, narrative skills are developing, and listening comprehension skills are increasing (Eisenberg et al., 2008; Kendeou et al., 2009). Furthermore, researchers have found that oral language skills predict future oral language skills and are correlated with alphabet knowledge and phonological awareness during early childhood; however, they develop, for the most part, independently from alphabet knowledge and phonological awareness skills (Dickinson & Snow, 1987; Kendeou et al., 2009; Lonigan et al., 2000; Storch & Whitehurst, 2002).

In summary, an essential time for children with normal hearing to develop alphabet knowledge, phonological awareness, and oral language skills is the preschool

and kindergarten years. Acquisition of these skills sets the stage for future achievement in reading decoding and reading comprehension.

The Early Literacy Skills of Children with Hearing Impairment

Alphabet knowledge may be deficient in children with bilateral hearing impairment (Cupples et al., 2014; Kyle & Harris, 2011). In a study that included 100 children, Cupples et al. (2014) assessed children who used hearing aids with varying degrees of hearing loss or cochlear implants on the Letter Knowledge subtest from the Phonological Abilities Test (PAT; Muter, Hulme, & Snowling, 1997). For this subtest, children were presented with each letter of the alphabet and asked to give its name or sound. The findings indicated that the median performance on this subtest was the 24th percentile.

Other studies that have included smaller samples of children than the number included in Cupples et al. (2014) indicate that children with hearing impairment may perform at or above the mean on standardized letter-word identification assessments (Desjardin, Eisenberg, & Ambrose, 2009; Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008). For example, Easterbrooks, Lederberg, Miller, Bergeron, and Connor (2008) found that 40 children with moderate to profound degrees of hearing loss, who were recruited from preschool, kindergarten, and first-grade classrooms, had standard mean scores on a letter-word identification assessment of 108 and 110 in the fall and spring, respectively, of a school year. Given the nature of the assessment, separate scores were not reported for letter identification and for word identification.

Ambrose, Fey, and Eisenberg (2012) reported on print knowledge in 24 preschoolers with cochlear implants and their peers with normal hearing. A significant difference was not found between children with cochlear implants and their peers with normal hearing. The assessment included both alphabet knowledge and print concept knowledge items, and thus did not assess only alphabet knowledge. Werfel, Lund, and Schuele (2014) found that eight children, ages three and four years, who used cochlear implants or hearing aids with varying degrees of hearing loss did not differ from their peers with normal hearing on letter name knowledge and on letter sound knowledge. Werfel et al. (2014), however, did not report whether the two groups differed on socioeconomic status, which is a variable that can impact early literacy outcomes.

Phonological awareness is another area in which children with hearing impairment demonstrate difficulties. Studies have demonstrated that phonological awareness deficits are evident in children in children with varying degrees of hearing loss, ranging from mild to profound (Cupples et al., 2014) and moderate to profound (Easterbrooks et al., 2008) and in children with mild hearing loss (Walker et al., 2015). Cupples et al. (2014) reported that the median performance of 101 five-year-old children with bilateral hearing impairment was the 25th percentile on a blending words assessment, the 25th percentile on a sound matching assessment, and the 16th percentile on an elision assessment, although the children's relative performance to same-aged peers was not reported. Walker et al. (2015) found that children, ages five to seven years, with mild hearing loss who did not use hearing aids scored, on average, approximately five points below the standardized mean on standardized assessment of phonological awareness

while part-time and full-time users of hearing aids scored, on average, one and eleven points, respectively, higher than the standardized mean.

Children with cochlear implants are at considerable risk for having phonological awareness deficits (Ambrose et al., 2012; Nittrouer et al., 2012). According to Ambrose et al. (2012), 21 of 24 preschool children with cochlear implants scored below the mean score of the children in the control group on the phonological awareness subtest of the Test of Preschool Early Literacy (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007). Nittrouer et al. (2012) reported effects sizes of 1.74 on an initial consonant task and 2.33 on final consonant task when comparing kindergarten children with cochlear implants to their peers with normal hearing.

Children with cochlear implants also tend to have poorer expressive and receptive vocabulary knowledge compared to their peers with normal hearing (Ambrose et al., 2012; Nittrouer et al., 2012). Findings from Ambrose et al. (2012) indicated that preschool children with cochlear implants had a mean score of 91 and their peers with normal hearing had a mean score of 114 on a standardized receptive vocabulary measure. Similarly, in Nittrouer et al. (2012), 19 six to seven-year-old children with cochlear implants had a mean standardized score on the Expressive One-Word Picture Vocabulary Test (Brownell, 2000) of 89 (SD = 18) while peers with normal hearing had mean standardized score of 110 (SD = 11). Children in both Ambrose et al. and Nittrouer et al. were reported as not having additional disabilities. Ambrose et al. did not assess children on a non-verbal cognitive assessment whereas Nittrouer et al. found no difference in

performance between children with cochlear implants and their peers with normal hearing.

Geers, Moog, Biedenstein, Brenner, and Hayes (2009) assessed children with cochlear implants on both receptive and expressive vocabulary measures. They reported that 153 five to six-year-old children with cochlear implants achieved standard scores that were, on average, nine points below the normative sample mean for expressive vocabulary and 14 points below the normative sample mean for receptive vocabulary, which indicated that children with cochlear implants had, on average, scores that fell within the average range on standardized vocabulary measures. In this study the authors also found that children's scores on a performance intelligence quotient assessment predicted the most variance in their expressive and receptive vocabulary scores in a model that included gender, maternal level of education, and age of implantation. It accounted for 16% of the variance in expressive vocabulary and 19.4% of the variance in receptive vocabulary.

Sarant, Holt, Dowell, Rickards, and Blamey (2009) investigated receptive vocabulary skills in preschool children with varying degrees of hearing loss who used spoken English. They assessed 37 children, ages 39 to 75 months, with mild, moderate, severe, and profound hearing loss who used hearing aids and children with profound hearing loss who used cochlear implants on the Peabody Picture Vocabulary Test-Third Edition (PPVT-3; Dunn & Dunn, 1997). Their mean score on the PPVT-3 was eight points lower than the normative sample mean, which is similar to findings from other studies investigating receptive vocabulary skills in children with cochlear implants. The

variable that contributed the greatest variance to children's receptive vocabulary scores was degree of hearing loss, which accounted 28% of the variance in a model that also included family participation in early intervention and cognitive ability.

In a study by Fitzpatrick, Crawford, Ni, and Durieux-Smith (2011), the authors compared receptive vocabulary scores among children with normal hearing, children with cochlear implants, and children with hearing aids whose hearing loss ranged from mild to profound. There was not a significant difference between children with cochlear implants and children with hearing aids on a standardized measure of receptive vocabulary; however, both children with cochlear implants and children with hearing aids scored lower than their peers with normal hearing on the measure.

Nicholas and Geers (2013), in contrast to previous studies, found that four-year-old children with cochlear implants implanted before 12 months of age had average receptive vocabulary standard scores of 103 while children implanted between 12 and 18 months of age had average standard scores of 94. Likewise, Tomblin et al. (2015) reported that children with mild hearing loss had a mean receptive vocabulary score of 105 and children with moderate to severe hearing loss had a mean receptive vocabulary score of 98 on the Peabody Picture Vocabulary Test-Fourth Edition (PPVT-4; Dunn & Dunn, 2007). In both of these studies, children tended to come from homes in which maternal level of education was high and a control group was not included in either study. According to a meta-analysis by Lund (2016), the differences in scores on vocabulary measures between children with cochlear implants and peers with normal

hearing was greater when a control group was included in the study than when children with cochlear implants were compared to the normative sample of a measure.

Morphosyntactic skills are also deficient in young children with cochlear implants (Guo, Spencer, & Tomblin, 2013) and in children with mild to severe hearing loss (Koehlinger, Van Horne, & Moeller, 2013). Koehlinger, Van Horne, and Moeller (2013) found that three-year-old children and six-year-old children with bilateral mild to severe hearing loss performed more poorly than their same-aged peers on verb morphology accuracy and mean length of utterance in words. Furthermore, three-year-old children performed more poorly than six-year-old children. These results suggest that verb morphology production is difficult for children with bilateral hearing impairment, but accuracy may improve during the preschool years.

Guo, Spencer, and Tomblin (2013) examined verb morphology use in young children with cochlear implants. Researchers collected narrative retells from nine children with cochlear implants at three, four, and five years post-implantation. All children with cochlear implants used oral language or total communication and were implanted by 19 months of age, except for one child who was implanted at 26 months of age. At three years post-implantation children with cochlear implants did not differ from their peers with normal hearing on tense marking errors, but they had more tense marking errors than their peers with normal hearing at four and five years post-implantation, which suggests that persistent morphological delays may occur in early childhood in children with cochlear implants.

Auditory comprehension deficits have been documented in preschool and kindergarten children with cochlear implants (Ambrose et al., 2012; Nicholas & Geers, 2013; Nittrouer et al., 2012) and in children with mild to severe hearing loss (Tomblin et al., 2015). Fitzpatrick et al. (2011) compared auditory comprehension skills among three groups of four to five-year-old children – children with normal hearing, children with cochlear implants, and children with hearing aids whose hearing loss ranged from mild to profound. The findings indicated that on a standardized measure of auditory comprehension children with cochlear implants scored lower than their peers with normal hearing and children with hearing aids scored lower than their peers with normal hearing. Children with cochlear implants and children with hearing aids, on average, had scores that did not differ significantly. The auditory comprehension measures used in this study and other studies assessing auditory comprehension in children with hearing loss did not assess comprehension of spoken passages at the discourse level. Thus, we still do not have a clear understanding of how young children with hearing impairment perform on listening comprehension measures compared to their peers with normal hearing.

To summarize, children with hearing impairment, as a group, may have deficits in alphabet knowledge (Cupples et al., 2014) and lag behind their peers with normal hearing on phonological awareness (Ambrose et al., 2012; Nittrouer et al., 2012) and oral language skills (Koehlinger et al., 2013; Nittrouer et al., 2012). Degree of hearing loss and non-verbal intelligence quotient may also be a factor in early literacy outcomes in children with hearing impairment; however, few studies have evaluated early literacy skills and non-verbal cognition in a single group of children with hearing impairment.

The present study contributes to the literature by investigating how young children with hearing impairment perform on a range of early literacy skills, a non-verbal cognitive assessment, an executive function task, and score on a home literacy questionnaire relative to same-age peers. Both executive function and home literacy activities have been shown to be positively associated with early literacy skill development in children with normal hearing (McClelland et al., 2014; Martini & Sénéchal, 2012), and may be considered important for children with hearing impairment.

Executive Functioning and Early Literacy Skills

In preschool children with normal hearing, studies have demonstrated that there is an association between executive function, oral language skills, and early literacy development (McClelland et al., 2014; McClelland et al., 2007). Executive function is used to describe cognitive processes responsible for controlling an individual's ability to shift attention, update changing information, and maintain inhibitory control (Huizinga, Dolan, & van der Molen, 2006; Miyake et al., 2000). In studies by McClelland and colleagues (e.g., Cameron Ponitz, McClelland, Matthews, & Morrison, 2009; McClelland et al., 2014; McClelland et al., 2007), researchers used the term behavioral self-regulation as an index of executive function. They assessed behavioral self-regulation by observing children's responses to tasks that draw on working memory, attention, and inhibitory control.

One such task was the Head-to-Toes task (Cameron et al., 2008). This task requires children to perform the opposite action to either "touch your toes" or "touch your head". McClelland et al. (2007) assessed over 300 four-year-old children in the fall and

spring of an academic year on this task. In addition to the executive function task, researchers administered assessments of mathematics, vocabulary, and letter-word identification in the child's home language, which was English or Spanish. Findings indicated that fall scores on the Head-to-Toes task were significantly correlated with fall assessments of mathematics, vocabulary, and letter-word identification, $r = .47$, $r = .35$, and $r = .25$, respectively, and spring assessments of mathematics, vocabulary, and letter-word identification, $r = .39$, $r = .32$, and $r = .23$, respectively. Spring scores on the Head-to-Toes task were significantly correlated with fall assessments of mathematics, vocabulary, and letter-word identification, $r = .41$, $r = .27$, and $r = .18$, respectively, and spring assessments of mathematics, vocabulary, and letter-word identification, $r = .37$, $r = .30$, and $r = .22$, respectively. Additionally, children's growth on the behavioral regulation task was associated with growth in mathematics, vocabulary, and letter-word identification.

McClelland et al. (2014) recruited 208 children in preschool to participate in four waves of assessments – fall of preschool, spring of preschool, fall of kindergarten, and spring of kindergarten. One purpose of their study was to determine if fall scores on the Head-Toes-Knees-Shoulders task (McClelland et al., 2007; Cameron Ponitz et al., 2009; Cameron Ponitz et al., 2008) predicted spring scores on early mathematics, vocabulary, and early literacy (letter-word identification) in each grade. This task, appropriate for children ages 4 to 8 years, requires children to perform an opposite action to "touch your head", "touch your toes", "touch your knees", and "touch your shoulders." There are three parts to the task, and in the last part the rules change so that children are required to

change the opposite response. The authors determined that fall prekindergarten scores on the Head-Toes-Knees-Shoulders task predicted spring early mathematics and fall kindergarten scores on the Head-Toes-Knees-Shoulders task predicted spring kindergarten early mathematics and spring vocabulary. These findings and those by McClelland et al. (2007) by suggest that difficulties with executive function could underlie problems with oral language and early literacy development.

Executive Functioning in Children with Hearing Impairment

Studies of executive function in preschool and kindergarten-age children with hearing impairment have included children with cochlear implants. Kronenberger, Beer, Castellanos, Pisoni, and Miyamoto (2014) found that preschool children with cochlear implants had, on average, lower scores on a parent checklist of executive function relative to peers with normal hearing in the areas of comprehension and conceptual learning, factual memory, attention, sequential processing, working memory, and problem solving, but not on the Behavior Rating Inventory of Executive Function (BRIEF; Goia, Isquith, Guy, & Kenworthy, 2000). Beer et al. (2014) also found no differences between preschool children with cochlear implants and their peers with normal hearing on the BRIEF when the authors controlled for language ability.

Beer et al. (2014) and Nittrouer et al. (2012) also reported on behavioral measures of cognitive functions, which they deemed executive functioning. Beer et al. found that children with cochlear implants, ages three to six years, had lower scores than their peers with normal hearing on The Attention Sustained subtest of the Leiter International Performance Scale—Revised (Roid & Miller, 1997), but not on the Beery

Developmental Test of Visual-Motor Integration (Beery VMI; Beery & Beery, 2004) or the Memory for Designs subtest of the NEPSY–II (Korkman, Kirk, & Kemp, 2007). Nittrouer et al. found that kindergarten-age children with cochlear implants performed poorer than their peers with normal hearing on an investigator designed verbal short-term memory task and standardized measures of rapid serial naming for colors and objects. The present study will provide a preliminary investigation into performance by children with hearing impairment on an executive function task, The Head-Toes-Knees-Shoulders task (McClelland et al., 2007; Cameron Ponitz et al., 2009; Cameron Ponitz et al., 2008) that draws on attention, inhibition, and working memory.

The Home Literacy Environment and Early Literacy Skills

Researchers have documented that activities between parent and child that center around book reading activities and the formal teaching of literacy predict early literacy skill outcomes in children with normal hearing (Evans, Shaw, & Bell, 2000; Sénéchal & LeFevre, 2002). Sénéchal and LeFevre (2002) reported on the relationship between parents' self-report of home literacy activities and their children's literacy and language outcomes in predominantly middle-class families in Canada. Parents completed questionnaires about home literacy experiences when their children were enrolled in the study, which was either year one or year two of kindergarten. Their report of teaching print-related skills to their children predicted children's emergent literacy skills (print awareness and alphabet knowledge) in the first grade, controlling for children's analytic intelligence, parents' own print exposure, phonological awareness, and receptive language (receptive vocabulary and listening comprehension). They also found that

parents' report of sharing books with their children predicted first-grade receptive language skills, controlling for children's initial kindergarten grade level, parent educational level, phonological awareness, and emergent literacy.

More recently, Martini and Sénéchal (2012) investigated the relationship that children's literacy outcomes share with home literacy practices and beliefs in middle-class families in Canada. Scores on a parent questionnaire were used as variables to predict children's alphabet knowledge and emergent reading, which consisted of a word reading task for five consonant-vowel-consonant words. In their regression model, the authors found that parent socioeconomic status, child nonverbal intelligence, parental teaching of alphabet knowledge, parental teaching of formal reading, parents' expectations about children reaching literacy milestones before first grade, and their children's interest in literacy predicted 44% of children's alphabet knowledge, although parent teaching of alphabet knowledge was not statistically significant in that model. Parent socioeconomic status, child nonverbal intelligence, parental teaching of formal reading, parents' expectations about children reaching literacy milestones before first grade, and their children's interest in literacy predicted 34% of children's emergent reading. These findings highlight the important contribution parent-child literacy activities make in the acquisition of early literacy skills in young children.

The Home Literacy Environment in Children with Hearing Impairment

While reduced auditory input and poor frequency selectivity may contribute to poor alphabet knowledge, phonological awareness, and oral language skills in children with hearing impairment, home literacy activities may mitigate the effects hearing loss

has on the acquisition of early literacy skills (Aram, Most, & Mayafit, 2006; Desjardin, Ambrose, & Eisenberg, 2011). Aram, Most, and Mayafit (2006) examined whether dialogic reading and writing mediation predicted alphabet knowledge, phonological awareness, and receptive vocabulary in 30 kindergarten children from Israel with varying degrees of hearing loss. The authors calculated a dialogic reading score by counting the number of reading cycles that occurred during shared book reading between mother and child. A reading cycle consisted of the parent asking the child a question, the child answering, the parent praising the child, and the adult expanding on the child's utterance. Mother's writing mediation was coded for graphophonemic mediation, or the amount of autonomy given to the child by the mother as the child wrote spoken words.

Aram et al. (2006) found that mother's writing mediation and dialogic reading between mother and child were variables that predicted alphabet knowledge, phonological awareness, and receptive vocabulary. Mother's writing mediation predicted 36% of the variance in children's letter knowledge, partialling out dialogic reading, age, and degree of hearing loss. Dialogic reading predicted 22% of the variance in phonological awareness skills, partialling out child age, degree of hearing loss, and mother's writing mediation. Dialogic reading, but not writing mediation, predicted children's receptive vocabulary. These results suggest that foundational skills acquired before formal reading instruction in children with hearing impairment are influenced by home literacy activities between parent and child.

Purpose of Present Study

The first purpose of this study was to determine if young children with hearing impairment differ from their peers with normal hearing on early literacy skills and also on three known predictors of early literacy skills – non-verbal cognition, executive functioning, and home literacy environment. A second purpose was to determine if the strengths and weaknesses in early literacy skills of individual children with hearing impairment are associated with their degree of hearing loss, non-verbal cognitive ability, or executive functioning.

To accomplish my first purpose I evaluated the degree to which scores on assessments of expressive vocabulary, expressive morphosyntax, listening comprehension, phonological awareness, alphabet knowledge, executive function, and home literacy differed between young children with hearing impairment who use spoken English and their peers with normal hearing. I hypothesized that children with hearing impairment would have lower scores than their peers with normal hearing on measures of expressive vocabulary, expressive morphology, listening comprehension, phonological awareness, and alphabet knowledge because these are areas of concern for children with hearing impairment. I hypothesized that scores on the executive function task for children with hearing impairment and normal hearing would not differ, given the mixed results in studies of executive functioning in children with cochlear implants, but that scores on the non-verbal cognitive assessment may differ because directions are given verbally. Finally, I hypothesized that scores on the home literacy questionnaire would not differ between children with hearing impairment and children with normal hearing. To my

knowledge there are not reports that parents of children with hearing impairment engage in fewer literacy activities than parents of children with normal hearing.

To accomplish my second purpose I examined patterns of performance by plotting scores of individual children with and without hearing impairment on assessments of expressive vocabulary, expressive morphosyntax, listening comprehension, phonological awareness, alphabet knowledge, non-verbal cognition, and executive function. I anticipated finding that the more severe the hearing loss, the lower the scores on early literacy measures.

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Variability of Early Literacy Skills in Children with Hearing Impairment

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Abstract

Purpose: Children with hearing impairment are at risk for poor attainment in reading decoding and reading comprehension, which suggests they may have difficulty with early literacy skills prior to learning to read. The first purpose of this study was to determine if young children with hearing impairment differ from their peers with normal hearing on early literacy skills and also on three known predictors of early literacy skills – non-verbal cognition, executive functioning, and home literacy environment. A second purpose was to determine if the strengths and weaknesses in the literacy skills of individual children with hearing impairment were associated with their degree of hearing loss, non-verbal cognitive ability, or executive functioning.

Method: Seven children with normal hearing and 10 children with hearing impairment completed expressive vocabulary, expressive morphosyntax, listening comprehension, phonological awareness, alphabet knowledge, non-verbal cognition, and executive functioning assessments. Children were enrolled in prekindergarten or kindergarten and used spoken English at home. Two children had unilateral hearing loss, two had bilateral mild hearing loss and used hearing aids, two had bilateral moderate hearing loss and used hearing aids, one child had bilateral mild hearing loss and did not use hearing aids, and three children used bilateral cochlear implants. Parents completed a questionnaire about their home literacy environment.

Results: Findings showed large between-group effect sizes for phonological awareness, morphosyntax, and executive function and medium between-group effect sizes for expressive vocabulary, listening comprehension and non-verbal cognition. Visual

analyses did not suggest that non-verbal cognition or degree of hearing loss was associated with individual patterns of performance for children with hearing impairment; however, three children had executive functioning scores that were at the floor.

Conclusions: Most children with hearing impairment in this study, regardless of degree of hearing loss and despite coming from homes in which parents were engaging in literacy activities with their children, appeared to be at risk for future reading decoding and reading comprehension difficulties. Further, based on individual patterns of performance, risk was not restricted to one type of early literacy skill; a strength in one skill did indicate strengths in all early literacy skills. Therefore, it is essential to evaluate all early literacy skills to pinpoint skill deficits and to prioritize intervention goals.

Keywords: hearing impairment, deaf, hard-of-hearing, early literacy, emergent literacy, preschool, and kindergarten

Strong reading decoding skills and reading comprehension skills are needed for academic success. Unfortunately, children with hearing impairment, regardless of their degree of hearing loss, are at risk for having low reading proficiency (Antia, Jones, Reed, & Kreimeyer, 2009; Easterbrooks & Beal-Alvarez, 2012; Traxler, 2000). Researchers have documented reading decoding and reading comprehension deficits in third-grade children with cochlear implants (Geers, 2003; Spencer, Barker, & Tomblin, 2003) and reading comprehension deficits in high school students with cochlear implants (Geers & Hayes, 2011). Antia, Jones, Reed, and Kreimeyer (2009) reported on five years of reading comprehension outcomes in children from Arizona and Colorado with varying degrees of hearing loss that ranged from minimal to profound. According to their findings, 32% to 42% of students performed below average on standardized reading comprehension assessments.

Children with minimal hearing loss are also at risk for experiencing academic difficulties, grade retention (Bess et al., 1998; Oyler, Oyler, & Matkin, 1988), and oral language deficits (Lieu, Tye-Murray, & Fu, 2012; Lieu, Tye-Murray, Karzon, & Piccirillo, 2010); however, Porter, Sladen, Ampah, Rothpletz, and Bess (2013) found encouraging findings in a sample of four to nine-year-old children with minimal hearing loss. Children with minimal hearing loss had mean scores above the normative sample mean and did not differ from the peers with normal hearing on assessments of phonological awareness, oral language, reading decoding, and reading comprehension. These results are promising, but two-thirds of the children in the Porter et al. (2013) study came from homes in which the parents had a college degree or graduate education.

Because maternal level of education is associated with strong oral language skills and academic success in children, this may have been factor in the lack of significant findings between children with minimal hearing loss and their peers with normal hearing. Furthermore, Porter et al. suggested that, unlike other earlier studies of children with minimal hearing loss, children in this study were identified with hearing loss before study participation, and thus they may have been provided with earlier access to intervention services than children in previous studies.

Given the poor reading outcomes of many children with hearing impairment, there is a need to determine how these children perform early in development on skills important for reading success. Two factors shown to be significantly associated with early literacy skill development in children with normal hearing are executive function skills and the children's home literacy environment (e.g, Burgess, Hecht, & Lonigan, 2002; Martini & Sénéchal, 2012; McClelland et al., 2014). Assessing early literacy skills directly in young children with hearing impairment and understanding factors associated with early literacy skill acquisition is an initial step in determining which early literacy skill interventions are important for children with hearing impairment.

Early Literacy Skills Are Important for Reading Decoding and Reading Comprehension

Alphabet knowledge, phonological awareness, and oral language skills, which will be collectively referred to as early literacy skills in this study, form the foundation for reading decoding skills in children with normal hearing (Kendou, van den Broek, White, & Lynch, 2009; Storch & Whitehurst, 2002; Wagner et al., 1997). In 626 children

with normal hearing, Storch and Whitehurst (2002) found that kindergarten phonological awareness and understanding of print principles (alphabet knowledge and print concept knowledge) were separate constructs, which they termed code-related skills. Researchers used subtests from a battery of tests to assess phonological awareness, alphabet knowledge, and print concept knowledge. To evaluate print concept knowledge researchers assessed children's ability to recognize individuals who were reading, identify parts of written language, differentiate print and letters from other text, and determine print functions. Phonological awareness and print principles each predicted first grade reading, which included word reading and word attack of pseudowords, and also mediated the relationship between kindergarten oral language skills and first grade reading decoding and word attack.

Alphabet knowledge, phonological awareness, and oral language skills also make important contributions to reading decoding in children with hearing impairment (Cupples Ching, Crowe, Day, & Seeto, 2014; Nittrouer, Caldwell, Lowenstein, Tarr, & Holloman, 2012). Cupples, Ching, Crowe, Day, and Seeto (2014) investigated the relationship between alphabet knowledge and reading decoding, phonological awareness and reading decoding, and receptive vocabulary and reading decoding in 100 five-year-old children with varying degrees of bilateral hearing loss. Alphabet knowledge and phonological awareness significantly predicted real word reading and word attack, but receptive vocabulary did not predict word reading or word attack.

Nittrouer, Caldwell, Lowenstein, Tarr, and Holloman (2012) found that an investigator-designed syllable counting task and personal narratives predicted word

reading in kindergarten children with cochlear implants who used spoken English. These findings and the findings by Cupples et al. (2014) suggest that alphabet knowledge, phonological awareness, and oral language skills underlie reading decoding in children with hearing impairment.

Good reading comprehension depends on strong oral language skills in children with normal hearing (Kendeou, van den Broek, White, & Lynch, 2009; Muter, Hulme, Snowling, & Stevenson, 2004; National Early Literacy Panel, 2008; Storch & Whitehurst, 2002). In a sample of 90 children in England Muter, Hulme, Snowling, and Stevenson (2004) found that receptive vocabulary knowledge in year one of formal schooling and grammatical knowledge and word recognition in year two of formal schooling predicted reading comprehension at the start of year three of formal schooling. Letter knowledge and phonological awareness at year two, however, did not predict year three reading comprehension. These findings suggested that while reading comprehension relies on word recognition skills, multiple components of language, including morphological knowledge and vocabulary, underlie children's ability to derive meaning from written text.

Another component of oral language skills, listening comprehension, is essential for reading comprehension. In 1986 Gough and Tunmer (1986) put forth the Simple View of Reading. The tenet of this view was that reading decoding and linguistic comprehension (or listening comprehension) are both necessary for skilled reading comprehension. Multiple studies have supported this view (e.g., Catts, Adlof, & Weismer, 2006; Kendeou, et al., 2009) and have also shown that listening comprehension

takes on a greater role in reading comprehension than reading decoding beyond early childhood (Oakhill & Cain, 2012; Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009; Torppa et al., 2016).

Investigators have also found that oral language skills predict reading comprehension in children with cochlear implants (Connor & Zwolan, 2004; Nittrouer et al., 2012). Connor and Zwolan (2004) examined whether communication mode, pre-implant speech detection threshold, socioeconomic status, length of implant use/age in years, pre-implant vocabulary, age of cochlear implantation, and post-implant vocabulary predicted reading comprehension outcomes in 97 children with cochlear implants. The children had a mean age of 11 years when assessed on reading comprehension and used oral communication or total communication. Length of implant use/age in years, socioeconomic status, age of implantation, and post-implant expressive vocabulary each had a direct relationship with reading comprehension in a structural equation model.

Overall, studies indicate that early literacy skills are important precursors to reading success in children with normal hearing and in children with hearing impairment who use spoken language. Because of the underlying relationships between these skills and conventional reading skills, deficits in early literacy skills impact how well children with hearing impairment decode and understand written text. Therefore, it is important to identify whether children with hearing impairment have early literacy skills that are age-appropriate, which may in turn support future reading achievement.

The Early Literacy Skills of Children with Normal Hearing

Children with normal hearing begin to acquire alphabet knowledge before formal reading instruction begins (Lonigan et al., 2000; Worden & Boettcher, 1990). Piasta, Petscher, and Justice (2012) assessed preschool children in the spring of the academic year on letter name knowledge. They reported that children knew, on average, 18 uppercase letter names and 15 lowercase letter names. The range of performance was 0 to 26 for both uppercase letter names and lowercase letter names. In a cross-sectional study of children with normal hearing, ages three to seven years, Worden and Boettcher (1990) found that letter name knowledge, letter sound knowledge, and letter writing were emerging in preschool children and tended to be acquired by children who were seven years of age.

Phonological awareness also begins to emerge in preschool children with normal hearing (Lonigan et al., 2000; Lonigan, Burgess, Anthony, & Barker, 1998; Wagner, Torgesen, & Rashotte, 1994). Lonigan, Burgess, Anthony, and Barker (1998) assessed two groups of children with normal hearing, ages two to five years, on a battery of phonological awareness tasks. One group of children came from homes with low socioeconomic status and the other group of children came from homes with middle socioeconomic status. The phonological awareness tasks included rhyme oddity, alliteration oddity, blending, and elision tasks. The blending and elision tasks included items at the word, syllable, and phoneme level. At two and three years of age there were children who performed above chance on the phonological awareness tasks. With increasing age children from both groups showed improvement on each task, except for

rhyme oddity for children from homes with low socioeconomic status. Additionally, age was associated with task complexity for elision and blending, except on the blending task for children who came from homes with low socioeconomic status. These findings suggest that age and task complexity impact how well children with normal hearing perform on phonological awareness tasks.

As with alphabet knowledge and phonological awareness skills, early childhood is a critical time period in which children with normal hearing demonstrate increases in oral language skills. Morphosyntactic use and accuracy are increasing (Rice & Oetting, 1993; Rice, Wexler, & Hershberger, 1998). Vocabulary knowledge is improving, narrative skills are being acquired, and listening comprehension skills are developing (Eisenberg et al., 2008; Kendeou et al., 2009). Furthermore, researchers have found that oral language skills predict future oral language skills and are correlated with alphabet knowledge and phonological awareness during early childhood; however, they develop, for the most part, independently from alphabet knowledge and phonological awareness skills (Dickinson & Snow, 1987; Kendeou et al., 2009; Lonigan et al., 2000; Storch & Whitehurst, 2002).

In summary, an essential time for children with normal hearing to develop alphabet knowledge, phonological awareness, and oral language skills begins in the preschool years. Acquisition of these skills sets the stage for future achievement in reading decoding and reading comprehension.

The Early Literacy Skills of Children with Hearing Impairment

Alphabet knowledge may be deficient in children with bilateral hearing impairment (Cupples et al., 2014; Kyle & Harris, 2011). Cupples et al. (2014) assessed

100 children with varying degrees of hearing loss who used hearing aids or cochlear implants on the Letter Knowledge subtest from the Phonological Abilities Test (PAT; Muter, Hulme, & Snowling, 1997). For this subtest, children were presented with each letter of the alphabet and asked to give its name or sound. Findings indicated that the median performance on this subtest was the 24th percentile.

Other studies with fewer children than Cupples et al. (2014) indicate that children with hearing impairment may perform at or above the mean on standardized letter-word identification assessments (Desjardin, Eisenberg, & Ambrose, 2009; Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008). For example, Easterbrooks, Lederberg, Miller, Bergeron, and Connor (2008) found that 40 children with moderate to profound degrees of hearing loss, who were recruited from preschool, kindergarten, and first-grade classrooms, had mean standard scores on a letter-word identification assessment of 108 and 110 in the fall and spring, respectively, of a school year. Given the nature of the assessment, separate scores were not reported for letter identification and for word identification.

Ambrose, Fey, and Eisenberg (2012) reported on print knowledge in 24 preschoolers with cochlear implants. A significant difference was not found between children with cochlear implants and their peers with normal hearing; however, the assessment included both alphabet knowledge and print concept knowledge items. Werfel, Lund, and Schuele (2014) found that eight children, ages three and four years, with varying degrees of hearing loss who used cochlear implants or hearing aids, did not differ from their peers with normal hearing on letter name knowledge and on letter sound

knowledge. Werfel et al. (2014), however, did not report whether the two groups differed on socioeconomic status, which is a variable that can impact early literacy outcomes.

Phonological awareness is another area in which children with hearing impairment demonstrate difficulties. Studies have demonstrated that phonological awareness deficits are evident in children with hearing loss that ranged from mild to profound (Cupples et al., 2014), in children with hearing loss that ranged from moderate to profound (Easterbrooks et al., 2008), and in children with mild hearing loss (Walker et al., 2015). Cupples et al. (2014) reported that the median performance of 101 five-year-old children with bilateral hearing impairment was the 25th percentile on a blending words assessment, the 25th percentile on a sound matching assessment, and the 16th percentile on an elision assessment, although the children's relative performance to same-aged peers was not reported. Walker et al. (2015) found that children with mild hearing loss who did not use hearing aids scored, on average, approximately five points below the standardized mean on a standardized assessment of phonological awareness while part-time and full-time users of hearing aids scored, on average, one and eleven points, respectively, higher than the normative mean.

Children with cochlear implants are at considerable risk for having phonological awareness deficits (Ambrose et al., 2012; Nittrouer et al., 2012). According to Ambrose et al. (2012), 21 of 24 preschool children with cochlear implants scored below the mean score of the children in the control group on the phonological awareness subtest of the Test of Preschool Early Literacy (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007). Nittrouer et al. (2012) reported effects sizes of 1.74 on an initial consonant task

and 2.33 on a final consonant task when comparing kindergarten children with cochlear implants to their peers with normal hearing.

Children with hearing impairment also tend to have poorer expressive and receptive vocabulary knowledge relative to their peers with normal hearing. This has been reported in four and five-year-old children with hearing aids whose hearing loss ranged from mild to profound (Fitzpatrick, Crawford, Ni, & Durieux-Smith, 2011) and in preschool and kindergarten-age children with cochlear implants (Ambrose et al., 2012; Nittrouer et al., 2012). Children in both Ambrose et al. and Nittrouer et al. were reported as not having additional disabilities. Ambrose et al. did not assess children on a non-verbal cognitive assessment whereas Nittrouer et al. did and found no difference in performance between children with cochlear implants and their peers with normal hearing.

Nicholas and Geers (2013), in contrast to previous studies of vocabulary outcomes, found that four-year-old children with cochlear implants implanted before 12 months of age had average receptive vocabulary standard scores of 103 while children implanted between 12 and 18 months of age had average standard scores of 94; however, children in this study were not representative of all children with cochlear implants because they came from homes in which maternal level of education was high and the children had received at least one cochlear implant by 18 months of age. Furthermore, a control group was not included in this study.

Likewise, Tomblin et al. (2015) reported that children with mild hearing loss had a mean receptive vocabulary score of 105 and children with moderate to severe hearing

loss had a mean receptive vocabulary score of 98 on the Peabody Picture Vocabulary Test-Fourth Edition (PPVT-4; Dunn & Dunn, 2007); however, their scores were not compared to scores by children in a control group. According to a meta-analysis by Lund (2016), the differences in scores on vocabulary measures between children with cochlear implants and peers with normal hearing are greater when a control group is included in the study than when children with cochlear implants are compared to the normative sample of the measure.

When researchers have investigated variables that contribute to vocabulary outcomes in children with hearing impairment, they found performance intelligence quotient and degree of hearing loss are important predictors of variance (Fitzpatrick et al., 2011; Geers, Moog, Biedenstein, Brenner, & Hayes, 2009; Sarant et al., 2009). Geers, Moog, Biedenstein, Brenner, and Hayes (2009) found that children's scores on a performance intelligence quotient assessment predicted the most variance in their expressive and receptive vocabulary scores in a model that included gender, maternal level of education, and age of implantation. It accounted for 16% of the variance in expressive vocabulary and 19.4% of the variance in receptive vocabulary. Sarant et al. (2009) found that the variable that contributed the greatest variance to children's receptive vocabulary scores was degree of hearing loss, which accounted 28% of the variance in a model that also included family participation in early intervention and cognitive ability.

Morphosyntactic skills are also deficient in young children with bilateral mild to severe hearing loss hearing (Koehlinger, Van Horne, & Moeller, 2013) and in young

children with cochlear implants (Guo, Spencer, & Tomblin, 2013). Koehlinger, Van Horne, and Moeller (2013) found that three-year-old children and six-year-old children with bilateral mild to severe hearing loss performed more poorly than their same-aged peers on verb morphology accuracy and mean length of utterance in words. Furthermore, three-year-old children performed more poorly than six-year-old children. These results suggest that verb morphology production is difficult for children with bilateral hearing impairment, but accuracy may improve during the preschool years.

Auditory comprehension deficits have been documented in preschool and kindergarten children with cochlear implants (Ambrose et al., 2012; Fitzpatrick et al., 2011; Nicholas & Geers, 2013; Nittrouer et al., 2012), in children with mild to severe hearing loss (Tomblin et al., 2015), and in children with mild to profound hearing loss (Fitzpatrick et al., 2011). The measures used in these studies, however, did not assess comprehension of spoken passages at the discourse level. Thus, we still do not have a clear understanding of how young children with hearing impairment perform on listening measures compared their peers with normal hearing.

To summarize, children with hearing impairment, as a group, have deficits in alphabet knowledge (Cupples et al., 2014) and lag behind their peers in phonological awareness (Ambrose et al., 2012; Nittrouer et al., 2012) and oral language skills (e.g., Koehlinger et al., 2013; Nittrouer et al., 2012); however, few studies have evaluated early literacy skills in a single group of children with hearing impairment.

The present study contributes to the literature by investigating how young children with hearing impairment perform on a range of early literacy skills, a non-verbal

cognitive assessments, an executive function task, and score on a home literacy questionnaire relative to same-age peers. Both executive function and home literacy activities have been shown to be positively associated with early literacy skill development in children with normal hearing, and may be considered important for children with hearing impairment (McClelland et al., 2014; Martini & Sénéchal, 2012).

Executive Functioning and Early Literacy Skills

In preschool children with normal hearing there is an association between executive function, oral language skills, and early literacy development (McClelland et al., 2014; McClelland et al., 2007). Executive function is used to describe cognitive processes responsible for controlling an individual's ability to shift attention, update changing information, and maintain inhibitory control (Huizinga, Dolan, & van der Molen, 2006; Miyake et al., 2000). In studies by McClelland and colleagues (e.g., Cameron Ponitz, McClelland, Matthews, & Morrison, 2009; McClelland et al., 2014; McClelland et al., 2007), researchers used the term behavioral self-regulation as an index of executive function. They assessed behavioral self-regulation by observing children's responses to tasks that draw on working memory, attention, and inhibitory control.

One such task was the Head-to-Toes task (Cameron et al., 2008). This task requires children to perform the opposite action to either "touch your toes" or "touch your head". McClelland et al. (2007) assessed over 300 four-year-old children in the fall and spring of an academic year on this task. In addition to the executive function task, researchers administered assessments of mathematics, vocabulary, and letter-word identification in the child's home language, which was English or Spanish. Findings

indicated that fall scores on the Head-to-Toes task were significantly correlated with fall assessments of mathematics, vocabulary, and letter-word identification, $r = .47$, $r = .35$, and $r = .25$, respectively, and spring assessments of mathematics, vocabulary, and letter-word identification, $r = .39$, $r = .32$, and $r = .23$, respectively. Spring scores on the Head-to-Toes task were significantly correlated with fall assessments of mathematics, vocabulary, and letter-word identification, $r = .41$, $r = .27$, and $r = .18$, respectively, and spring assessments of mathematics, vocabulary, and letter-word identification, $r = .37$, $r = .30$, and $r = .22$, respectively. Additionally, children's growth on the behavioral regulation task was associated with growth in mathematics, vocabulary, and letter-word identification.

McClelland et al. (2014) recruited 208 children in preschool to participate in four waves of assessments – fall of preschool, spring of preschool, fall of kindergarten, and spring of kindergarten. One purpose of their study was to determine if fall scores on the Head-Toes-Knees-Shoulders task (McClelland et al., 2007; Cameron Ponitz et al., 2009; Cameron Ponitz et al., 2008) predicted spring scores on early mathematics, vocabulary, and early literacy (letter-word identification) in each grade. This task, appropriate for children ages 4 to 8 years, requires children to perform an opposite action to "touch your head," "touch your toes," "touch your knees," and "touch your shoulders." There are three parts to the task, and in the last part the rules change so that children are required to change to the opposite response. The authors determined that fall prekindergarten scores on the Head-Toes-Knees-Shoulders task predicted spring early mathematics and fall kindergarten scores on the Head-Toes-Knees-Shoulders task predicted spring

kindergarten early mathematics and spring vocabulary. These findings and those McClelland et al. (2007) by suggest that difficulties with executive function could underlie problems with oral language and early literacy development.

Executive Functioning in Children with Hearing Impairment

Studies of executive function in preschool and kindergarten-age children with hearing impairment have included children with cochlear implants. Kronenberger, Beer, Castellanos, Pisoni, and Miyamoto (2014) found that preschool children with cochlear implants had, on average, lower scores on a parent checklist of executive function relative to peers with normal hearing in the areas of comprehension and conceptual learning, factual memory, attention, sequential processing, working memory, and problem solving, but not on the Behavior Rating Inventory of Executive Function (BRIEF; Goia, Isquith, Guy, & Kenworthy, 2000). Beer et al. (2014) also found no differences between preschool children with cochlear implants and their peers with normal hearing on the BRIEF when the authors controlled for language ability.

Beer et al. (2014) and Nittrouer et al. (2012) also reported on behavioral measures of cognitive functions, which they deemed executive functioning. Beer et al. found that children with cochlear implants, ages three to six years, had lower scores than their peers with normal hearing on The Attention Sustained subtest of the Leiter International Performance Scale—Revised (Roid & Miller, 1997), but not on the Beery Developmental Test of Visual-Motor Integration (Beery VMI; Beery & Beery, 2004) or the Memory for Designs subtest of the NEPSY–II (Korkman, Kirk, & Kemp, 2007). Nittrouer et al. found that kindergarten-age children with cochlear implants performed

poorer than their peers with normal hearing on an investigator designed verbal short-term memory task and standardized measures of rapid serial naming for colors and objects. The present study will provide a preliminary investigation into performance by children with hearing impairment on an executive function task, The Head-Toes-Knees-Shoulders task (McClelland et al., 2007; Cameron Ponitz et al., 2009; Cameron Ponitz et al., 2008) that draws on attention, inhibition, and working memory.

The Home Literacy Environment and Early Literacy Skills

Activities between parents and children that center around book reading activities and the formal teaching of literacy predict early literacy outcomes in children with normal hearing (Evans, Shaw, & Bell, 2000; Sénéchal & LeFevre, 2002). Martini and Sénéchal (2012) investigated the relationship that children's literacy outcomes share with home literacy practices and beliefs in middle-class families in Canada. Parent questionnaire scores were used as predictors for children's alphabet knowledge and emergent reading, which consisted of a word reading task for five consonant-vowel-consonant words. In their regression model, the authors found that parent socioeconomic status, child nonverbal intelligence, parental teaching of alphabet knowledge, parental teaching of formal reading, parents' expectations about children reaching literacy milestones before first grade, and children's interest in literacy predicted 44% of children's alphabet knowledge, although parent teaching of alphabet knowledge was not statistically significant in that model. Parent socioeconomic status, child nonverbal intelligence, parental teaching of formal reading, parents' expectations about children reaching literacy milestones before first grade, and their children's interest in literacy

predicted 34% of children's emergent reading. These findings highlight the contribution that parent-child literacy activities make in the acquisition of early literacy skills in young children.

The Home Literacy Environment in Children with Hearing Impairment

While reduced auditory input and poor frequency selectivity may contribute to poor alphabet knowledge, phonological awareness, and oral language skills in children with hearing impairment, home literacy activities may mitigate the effects hearing loss has on the acquisition of early literacy skills (Aram, Most, & Mayafit, 2006; Desjardin, Ambrose, & Eisenberg, 2011). Aram, Most, and Mayafit (2006) examined whether dialogic reading and writing mediation, which was the amount of autonomy given to the child by the mother as the child wrote spoken words, predicted alphabet knowledge, phonological awareness, and receptive vocabulary in 30 kindergarten children from Israel with varying degrees of hearing loss. They found that mother's writing mediation predicted 36% of the variance in children's letter knowledge, partialling out dialogic reading, age, and degree of hearing loss. Dialogic reading predicted 22% of the variance in phonological awareness skills, after partialling out child age, degree of hearing loss, and mother's writing mediation. Dialogic reading, but not writing mediation, predicted children's receptive vocabulary. These results suggest that foundational skills acquired before formal reading instruction in children with hearing impairment are influenced by home literacy activities between parent and child.

Purpose of Present Study

The first purpose of this study was to determine if young children with hearing impairment differed from their peers with normal hearing on early literacy skills and also on three known predictors of early literacy skills – non-verbal cognition, executive functioning, and home literacy environment. A second purpose was to determine if the strengths and weaknesses in the early literacy skills of individual children with hearing impairment were associated with their degree of hearing loss, non-verbal cognitive ability, or executive functioning.

To accomplish the first purpose I evaluated the degree to which scores on assessments of expressive vocabulary, expressive morphosyntax, listening comprehension, phonological awareness, alphabet knowledge, executive function, and home literacy differed between young children with hearing impairment who use spoken English and their peers with normal hearing. Based on previous literature, I hypothesized that children with hearing impairment would have lower scores than their peers with normal hearing on measures of expressive vocabulary, expressive morphology, listening comprehension, phonological awareness, and alphabet knowledge because these are areas of concern for children with hearing impairment. I hypothesized that scores on the executive function task for children with hearing impairment and normal hearing would not differ, given the mixed results in studies of executive functioning in children with cochlear implants, but that scores on the non-verbal cognitive assessment may differ because directions are given verbally. Finally, I hypothesized that scores on the home literacy questionnaire would not differ between children with hearing impairment and

children with normal hearing. To my knowledge there are not reports that parents of children with hearing impairment engage in fewer literacy activities than parents of children with normal hearing.

To accomplish my second purpose I examined patterns of performance by plotting scores of individual children with and without hearing impairment on assessments of expressive vocabulary, expressive morphosyntax, listening comprehension, phonological awareness, alphabet knowledge, non-verbal cognition, and executive function to assess. I anticipated finding that the more severe the hearing loss, the lower the scores on early literacy measures.

Method

Participants

The Institutional Review Board of Arizona State University approved this study. Before participating in the study a parent provided consent to participate and provided consent for their child to participate. Children provided assent before participating and received small prizes, such stickers, pencils, and small plastic toys, after each testing session. Children received a gift card after the final testing session.

After consenting to the study parents completed a questionnaire about their educational background and their child's development, medical history, educational history, and home literacy environment. The questions regarding home literacy activities came from the questionnaire used in Martini and Sénéchal (2012). Each item was answered on a Likert scale that ranged from 1 to 5. Questions related to how frequently parents engage in literacy activities, how frequently they use certain items, e.g. shopping

lists, when teaching literacy skills, and the importance they place on their child acquiring early literacy benchmarks before first grade with five rated as very often or very important. One question asked if they felt they had limited knowledge to teach their child literacy skills and another question asked if they have the time to teach their child to read and write words. For this study, scores on the home literacy questionnaire were computed by adding the parents' answers to questions that asked about their frequency of engaging in literacy activities and using certain items to teach literacy activities, and the importance they place on their child acquiring early literacy benchmarks before first grade. These items on the questionnaire were related to early outcomes in children with normal hearing from Martini and Sénéchal (2012). The range of scores for these questions was 35 to 180.

Martini and Sénéchal (2012) determined that the inter-item reliability using Cronbach's alpha for questions concerning formal literacy teaching activities was .91. The inter-item reliability for questions concerning parents' expectations for their children reaching specific literacy benchmarks before first grade was .87. For questions concerning the use of certain items when teaching (referred to as teaching contexts by the authors) the inter-item reliability was .87.

It required 18 months to recruit children with hearing impairment. I contacted schools, clinics, and hospitals that served children with hearing loss. Seventeen sites agreed to distribute consent packets and eight facilities agreed to distribute study flyers. I distributed 167 consent packets to distribute to families of children with hearing

impairment and, over a four month period, 275 consent packets to schools with children with normal hearing.

I received 19 consents from families of children with hearing impairment. Seven children did not participate in the assessments. Two children were not yet enrolled in prekindergarten and thus did not qualify for the study and five families could not be reached to schedule research sessions. Two children did not qualify because of low IQ scores. I received 17 consents from families of children with normal hearing. Eight children with normal hearing did not participate in the assessments because they (a) were not yet enrolled in prekindergarten (b) had a history of receiving speech-language services; or (c) could not be reached. Two children did not qualify for the study because of low language scores.

The recruitment and assessment process resulted in seven children with normal hearing (2 girls, 5 boys) and ten children with hearing impairment (3 girls, 7 boys) qualifying for inclusion. Children with hearing impairment came from one southwestern state and one mid-western state and children with normal hearing came from one southwestern state. Children with hearing impairment attended public, private, or public charter schools. Children with normal hearing attended public and public charter schools. One of the children with hearing impairment had repeated kindergarten.

To be included children were required to be enrolled in prekindergarten (the year immediately kindergarten) or kindergarten, use spoken English at least 80% of the time at home, and have normal vision or vision corrected to normal with the use of corrective lenses, according to a parent questionnaire. Children with hearing impairment ranged in

age from 59 to 87 months and children with normal hearing ranged in age from 56 to 81 months. The exclusionary criteria for all children were as follows: presence of phonological processes of final consonant deletion, syllable reduction, or cluster simplification following scoring of the Sounds-in-Words subtest of the Goldman-Fristoe Test of Articulation, Second Edition (GFTA-2; Goldman & Fristoe, 2000) with The Khan-Lewis Phonological Analysis, Second Edition (KLPA-2; Khan & Lewis, 2002) that would preclude accurate scoring of the phonological awareness task and a non-verbal intelligence quotient < 78 on the Matrices subtest from Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 2004) to rule out cognitive deficits. No child was excluded based solely on results from scoring the GFTA-2 with the KLPA-2. Table 1 lists characteristics of the children.

To be classified as having typically developing language, children with normal hearing were not enrolled in speech-language services and achieved a standard score of 95 or higher on the SPELT-3. A cut-off score of 95 was used because Perona, Plante, and Vance (2005) found that the sensitivity and specificity of the SPELT-3 in identifying specific language impairment in four and five-year-old children was 90.6% and 100%, respectively. According to a questionnaire completed by each child's parent, none of the children with normal hearing had a history of being diagnosed with a developmental disability.

Children with normal hearing passed a pure tone screening at 20 dB HL for 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz in both ears, but 500 Hz was not included as a passing criterion if room noise was high. Inter-octave frequencies above 2000 Hz and

8000 Hz were tested if children could tolerate longer screening. One child passed the hearing screening at 25 dB HL at 2000 Hz in one ear, but he was included in the study because he was not attentive during the screening and background noise from the home environment was present during the screening. Children with hearing impairment had a permanent bilateral or unilateral hearing loss. Hearing loss was defined as a pure tone average ≥ 25 dB HL across three of the four octave frequencies from 500 Hz to 4000 Hz. Type and degree of hearing loss was documented via audiologic records obtained from the parent or from the child's school or audiology clinic if parents chose to sign a release of information. Pure tone thresholds were not available for one child; however, the audiological records indicated the child's speech recognition thresholds were consistent with the pure tone average in both ears, so the speech recognition thresholds were used to classify degree of hearing loss. Two children had children unilateral hearing loss and eight children had bilateral hearing loss. For the purpose of this study, minimal hearing loss will be used to classify degree of hearing loss for children with unilateral hearing loss.

According to a parent questionnaire, children were diagnosed with hearing loss between one and 47 months of age. The average length of hearing aid or cochlear implant use for the seven children who used devices was 40 months (*SD* = 20.56). Three children did not use amplification: one with a unilateral conductive hearing loss secondary to atresia, one with a profound unilateral sensorineural hearing loss, and one with bilateral conductive hearing loss. Four children used bilateral hearing aids: two with mild sensorineural hearing loss and two with moderate sensorineural hearing loss. Three

children used bilateral cochlear implants. By parent report via the questionnaire nine children were not diagnosed with auditory neuropathy spectrum disorder and one parent did not give a response to that question. One child had a diagnosis of attention deficit hyperactivity disorder.

The children's ethnicity and race were reported by their parent via the questionnaire. In the group of children with hearing impairment one child was Hispanic and eight children were non-Hispanic. One parent reported that their child was Hispanic and non-Hispanic. Nine children were white and one child was more than one race. In the group of children with normal hearing, one child was Hispanic, six were non-Hispanic. Six were white and one was more than one race. Three children with hearing impairment came from homes in which English and another spoken language were used.

Data Collection Procedures

Data collection with children took approximately two hours to complete over two or three sessions. All children who used hearing aids and/or cochlear implants wore their devices during assessment. Data collection on Day 1 included completion of a child assent form, The Matrices subtest from KBIT-2, The Sounds-in-Words subtest of the GFTA-2, The Listening Comprehension subtest of the Assessment of Language and Literacy (ALL; Lombardino, Lieberman, & Brown, 2005), and The Letter Knowledge subtest of the ALL. Children with normal hearing also had their hearing screened on Day 1 of data collection.

On Day 2 of data collection children were assessed on the SPELT-3, the Expressive Vocabulary Test, Second Edition (EVT-2 Williams, 2007), the Sound

Matching, Elision, and Blending subtests from the Comprehensive Test of Phonological Processing, Second Edition (CTOPP-2; Wagner, Torgesen, Rashotte, & Pearson, 2013), and The Head-Toes-Knees-Shoulders task (McClelland, et al., 2007; Cameron Ponitz et al., 2009; Cameron Ponitz et al., 2008). To avoid an order effect, researchers administered the assessments in one of four different order combinations. Two children with hearing impairment completed assessments over three sessions.

Children with hearing impairment completed the assessments in a quiet room in the child's home, at a community location, such as in a study room in a public library, or in a quiet laboratory at Arizona State University. Children with normal hearing completed the assessments in their parent's home, a room in their school, or the library in their school. Prior to the start of the session a Radio Shack 33-2055 sound level meter was used to record an A-weighted sound pressure level in the room when the heating, venting, and air conditioning system was on and when it was off, if applicable, to screen for noise levels in the room above 50 dB SPL A-weighted. The level never exceeded 50 dB SPL for children with hearing impairment. When it exceeded 50 dB SPL for children with normal hearing it was during times of school dismissal or when conversations were occurring in the home. Thus, the noise was generally not present during the entire session. The assessor screened the child's hearing when possible when noise was not present. If brief intermittent noise occurred during the session, testing was paused.

Researcher and research assistants. The first author of this paper or trained research assistants administered and scored the assessments. The first author or trained

research assistants post-scored via an audio-recording the Sounds-in-Words subtest of the GFTA-2 using the KLPA-2 and the Listening Comprehension subtest of the ALL.

Cognitive measure. All children completed the Matrices nonverbal subtest from the KBIT-2. This subtest consists of 46 items that evaluate children's understanding of conceptual relationships and patterns. Instructions were given orally and children responded by pointing to their answer.

Articulation measure. All children completed the Sounds-in-Words subtest of the GFTA-2 to assess speech production. This assessment was post-scored to identify the phonological processes of cluster simplification, final consonant deletion, and syllable reduction according to the scoring procedures in the KLPA-2.

Oral language measures. Three norm-referenced, standardized oral language measures were administered. One assessed morphosyntax, another assessed expressive vocabulary, and a third assessed listening comprehension.

Morphosyntax measure. The SPELT-3 evaluated children's morphosyntax. This assessment elicited morphological and syntactic structures by asking children questions about pictures.

Expressive vocabulary measure. The EVT-2 was used to assess children's expressive vocabulary skills. Children give single word responses to provide synonyms of and to name actions, nouns, and adjectives of words depicted in pictures.

Listening comprehension measure. The Listening Comprehension subtest of the ALL consisted of a sample story and three additional stories read by the examiner. Children were asked to retell each story and then to answer three explicit questions and

one inferencing question about the story. The sample story and first story were presented with picture support but the last two stories had no picture support.

Alphabet knowledge measure. The Letter Knowledge subtest has three portions. Children pointed to 12 different letters, named 10 letters that were either uppercase or lowercase, and wrote eight letters.

Phonological awareness measure. The Elision, Blending, and Sound Matching subtests from the CTOPP-2 assessed children's phonological awareness skills. Prior to the start of the study, the lowest sound pressure level and the highest sound pressure within each word on the Blending subtest was determined and recorded by the first author with a Class 2 Minilyzer ML1 sound level meter set to A-weighted, slow averaging .5 meter away from the speaker with the laptop volume set to 50% and the volume for Windows Media Player set to 50%. Across all 33 words in the Blending subtest, the sound pressure level (digital read out) ranged from 57 dB SPL to 69 dB SPL. On average, the highest sound pressure level within a word was 66.55 dB SPL and the lowest sound pressure level within a word was 59.24 dB SPL.

Following manual instructions, the stimuli for the Sound Matching and Elision subtests were given orally. The Sound Matching subtest consisted of a picture book to which the children could respond orally or by pointing to the picture that corresponded with their response. The stimuli for the Blending subtest was presented with a compact disc using a Dell laptop computer and one Inspire T12 speaker. Prior to the administration of the Blending subtest, the researcher placed the speaker .5 meter from the child, set the laptop volume to 50%, and set the volume for Windows Media Player to

50%. The level of the speaker was set at the same marked position for all children. Each child listened to three non-words from the Non-word Repetition subtest from the CTOPP-2 to report if the volume was loud enough. No child asked for an increase in volume.

Executive function measure. The Head-Toes-Knees-Shoulders task is a test of executive function. It was developed to assess behavioral regulation, attention, and memory in preschool to first-grade children (Cameron & McClelland, 2011; McClelland, 2015). It consisted of 30 items that asked children to perform an opposite action to the commands of "touch your head," "touch your shoulders," "touch your knees," and "touch your toes." The opposite paired response was taught to the child in training trials. Children were given scores of 0 for an incorrect action, 1 for a self-corrected action, and 2 for a correct action. Scores for this task can range from 0 to 60 (McClelland et al., 2014).

Reliability

A second research assistant scored the expressive vocabulary, expressive morphosyntax, listening comprehension, phonological awareness, alphabet knowledge, non-verbal cognition, and executive functioning assessments to establish inter-rater reliability. Thirty-three percent of these assessments for children with hearing impairment and 29% of these assessments for children with normal hearing were scored. The research assistant was trained in test administration and scoring and was not aware of the participant's scores recorded by the assessor (Mellenbergh, 2011), except on portions of the phonological awareness test that required the assessor to give feedback on the correctness of some items to the participant. Each assessment was double-scored an equal

number of times except the phonological awareness and listening comprehension assessments, which were scored one additional time for children with hearing impairment. This occurred because on two different occasions with a child with hearing impairment a research session ended before the assessments were completed, but the assessments that were completed were calculated into the reliability. Inter-scorer agreement was calculated with Cohen's coefficient kappa (Cohen, 1960). Inter-rater reliability ranged from .74 to 1.0 for children with hearing impairment and from .70 to 1.0 for children with normal hearing.

Statistical Analyses

To evaluate whether there were group differences for scores on the assessments of alphabet knowledge, phonological awareness, expressive vocabulary, expressive morphosyntax, listening comprehension, non-verbal cognition, executive functioning, and the home literacy environment questionnaire, I conducted a series of independent samples *t* tests. The magnitude of the effect size was classified as small (≥.20), medium (≥ .50), and large (≥ .80) using Cohen's *d* (Cohen, 1988). Using a Bonferroni correction, alpha was set at 0.006 (.05/8) (Thompson, 2006).

I plotted z-scores to show each child's scores on the early literacy assessments, the non-verbal cognitive assessment, and the executive functioning task to visually analyze whether degree of hearing loss, non-verbal cognition, and executive functioning were associated with patterns of performance on early literacy skills. To compute the z-scores on the executive functioning task I used mean scores and standard deviations obtained from a sample of children with normal hearing whom McClelland et al. (2014)

assessed on the Head-Toes-Knees-Shoulders task. McCllelland et al. reported mean scores and standard deviations for samples of children in the fall of prekindergarten (N = 204), in the spring of prekindergarten (N = 197), in the fall of kindergarten (N = 157), and in the spring of kindergarten (N = 154). The children in the fall preschool sample ranged in age from 36 to 65 months of age and were assessed in the subsequent semesters, however, not all children from the fall prekindergarten wave participated in all semesters. Half of the children in preschool were enrolled in Head Start and 14% of the children spoke Spanish and were assessed in Spanish. The authors described the preschool children's racial/ethnic background as follows: 61% White, 18% Latino, 0.5% African-American, 1% Middle Eastern, 13% multiracial, and 1% other.

For the current study I obtained the difference between each child's score on the Head-Toes-Knees-Shoulders task and the mean score in the group of children from McClelland et al. that corresponded to the child's grade and semester. That difference score was divided by the standard deviation for the sample of children in McClelland et al. that also corresponded to the grade and semester in which the child in the study was enrolled.

Results

The hearing impaired and normal hearing group scores did not differ significantly for expressive morphosyntax $t(15) = 1.932$, $p = .072$, Cohen's $d = 3.33$ or phonological awareness $t(15) = 2.670$, $p = .017$, Cohen's $d = 1.47$, although the between-group effect sizes were large. The hearing impaired and normal hearing group scores did not differ significantly for expressive vocabulary $t(15) = 1.301$, $p = .213$, Cohen's $d = .78$;

listening comprehension $t(15) = 1.589$, $p = .133$, Cohen's $d = .62$; or non-verbal cognition, $t(15) = 1.359$, $p = .194$, Cohen's $d = .64$; however, these showed medium between-group effect sizes. These effect sizes suggest that if the study were fully powered significant between-group differences might emerge. In contrast to the large and medium effect sizes for other measures, the between-group effect size for alphabet knowledge was very small Cohen's $d = .12$ and the means were not significantly different, $t(15) = .219$, $p = .830$.

No between-group differences were found for executive functioning, $t(15) = 1.284$, $p = .219$, Cohen's $d = .81$, although the effect size was large. Mean scores on the home literacy environment questionnaire did not differ, $t(15) = .327$, $p = .748$, Cohen's $d = .18$ and the effect size was very small.

Two items on the home literacy questionnaire that were not included in the parents' total scores for the home literacy questionnaire were whether parents felt they had the knowledge to teach literacy skills and whether they had the time to teach their child to read and write words. They were not included because neither question was used to predict early literacy and emergent reading outcomes in the study by Martini and Sénéchal (2012) from which this questionnaire comes. Eight of ten parents of children with hearing impairment and six of seven parents of children with normal hearing reported that they agreed or definitely agreed that they had the knowledge to teach literacy skills to their children. Two parents of children with hearing impairment, one of whom reported having limited knowledge to teach skills, did not agree that they have time to teach their child literacy skills and all of the parents of children with normal

hearing reported that they had the time to teach their child literacy skills. Figure 1 shows individual scores for all children on the EVT-2, SPELT-3, Listening Comprehension subtest from the ALL, the CTOPP-2, the Letter Knowledge subtest from the ALL, and the Head-Toes-Knees Shoulders task. There was no clear pattern to suggest that degree of hearing loss or nonverbal cognition scores were associated with specific patterns of performance on early literacy skills. Executive functioning scores were low, however, in three children who scored below the mean on assessments of expressive vocabulary, expressive morphosyntax, listening comprehension, and phonological awareness.

Discussion

A large body of research indicates that alphabet knowledge, phonological awareness, and oral language skills underlie future success in literacy achievement for children with normal hearing. These same skills are critical for children with hearing impairment who use spoken language to develop conventional reading skills. Most studies have revealed that, as a group, children with hearing impairment have deficits in early literacy skills (e.g., Cupples et al., 2014; Easterbrooks et al., 2008), although some studies have found that children with hearing impairment perform on par with their peers with normal hearing on print knowledge or alphabet knowledge (Ambrose et al., 2012; Werfel et al., 2014) and similarly to the mean scores on standardized assessments of phonological awareness (Walker et al., 2015) and vocabulary (Nicholas & Geers, 2013).

Group Differences

Children with hearing impairment scored, on average, 13 points below their peers with normal hearing on a norm-referenced expressive morphosyntax assessment. The

large between-group effect size was driven by lower variability in scores in children with normal hearing and higher variability in children with hearing impairment. Researchers have documented morphological deficits, such as omissions of plural *–s*, possessive *–s*, inaccurate use of verb tense, and smaller mean length of length of utterances in words in children with hearing impairment (Guo et al., 2013; Koehlinger et al., 2013; McGuckian & Henry, 2007). Walker et al. (2015) also found that expressive morphosyntactic deficits are evident in children with mild bilateral hearing loss who do not use amplification relative to children with mild bilateral hearing loss who use hearing aids part-time or all of the time. The assessment used in the current investigation provides further evidence that in addition to morphological markers, syntactic forms may be deficient in children with hearing impairment.

Children with hearing impairment scored, on average, 21 points lower than their peers with normal hearing on the phonological awareness assessment. The large between-group effect size found in this study is consistent with other studies comparing scores on phonological awareness measures between children with cochlear implants and their peers with normal hearing (Ambrose et al., 2012; Nittrouer et al., 2012). The difference between the current study and studies by Ambrose et al. (2012) and Nittrouer et al. (2012) was that the majority of children in this study had minimal to moderate hearing loss, which suggests that regardless of the degree of hearing loss, children are at risk for difficulties with phonological awareness.

The between-group effect size for executive functioning was large. The difference between the two groups in this study was driven by two prekindergarten and one

kindergarten child with hearing impairment who scored at the floor. Explanations and demonstrations of the task were provided during training trials but none of the three children who scored at the floor correctly responded to any of the training trials.

Children with hearing impairment scored, on average, one standard deviation below the mean on the listening comprehension measure that required children to listen to three stories, one of which had picture support, and retell the story. Children's stories were scored based on whether they recalled three major points of the story. After retelling the story, children listened to the story again and answered four questions about the story. The retell portion of this assessment required children to remember and recount the characters, setting, and sequence of events in the story. The question answering portion of this assessment asked that children recall major points of the story, such as literal information, and make inferences to answer the questions, which requires children have knowledge of the vocabulary used in the stories, use background knowledge, and engage in comprehension monitoring, all of which are also important for reading comprehension (Oakhill & Cain, 2012).

Children with hearing impairment, as a group, had expressive vocabulary scores eight points lower than their peers with normal hearing. Their mean score of 102.30 (*SD* = 13.48) was similar to vocabulary scores in other studies for children with cochlear implants and children with mild to severe hearing loss (e.g., Nicholas & Geers, 2013; Tomblin et al., 2015; Walker et al., 2015). The medium between-group effect size in this study was smaller than effect sizes in studies of vocabulary outcomes in children with cochlear implants (e.g., Ambrose et al., 2012; Nittrouer et al., 2012). These results show

that it is not wise to assume that children with hearing impairment will have strong vocabularies. Geers (2016) found that that 41 of 60 children with cochlear implants had language delays at 4.5 years of age, and 19 of those children continued to have language delays at 10.5 years of age. For this reason vocabulary assessment in children with hearing impairment is warranted.

Alphabet knowledge was a strength for children with hearing impairment in this study. All children scored at or above the normative mean on the alphabet knowledge assessment, which consisted of letter-name knowledge and letter writing skills, both of which are a finite set of skills. Letter-name knowledge has also been found to be a strength in other investigations (Kyle & Harris, 2011; Werfel et al., 2014).

In this study families of children with hearing impairment and families of children with normal hearing engaged in similar levels of literacy activities and placed similar importance on children reaching literacy benchmarks before first grade. Prior research by Desjardin et al. (2017) indicated that parents of children with cochlear implants may use fewer literacy strategies when reading to their children when assessed at three time points from 12 to 36 months of age; however, in this study scores and score ranges were similar for both groups of children, suggesting that when the mean number of years of education did not differ between the groups, parents of children with hearing impairment engaged in literacy activities and held the same beliefs about the importance of reaching literacy benchmarks before first grade as parents of children with normal hearing. Further, the majority of parents with hearing impairment reported that they had the knowledge to teach literacy skills and the time to teach their child to read and write words.

Patterns of Performance

Degree of hearing loss was not associated with a particular pattern of performance on early literacy skill assessments. This suggests that knowing a child's degree of hearing loss cannot tell clinicians whether that child is at risk for poor early literacy skill development. Similarly, non-verbal cognition was not associated with specific patterns of performance. In contrast three of the four children who had the lowest performance on the early literacy skills also scored at the floor on the executive functioning task. This suggests that executive function screening could serve as an indicator of risk when evaluating early literacy skills.

Limitations

One limitation of this study was that the assessments of non-verbal cognition and executive functioning both rely to some extent on a child's language knowledge and thus their performance on these assessments can be related to language knowledge. For example, the Head-Toes-Knees Shoulders task requires children to perform opposite actions and thus have an understanding of the concepts of "different," "opposite," and "instead of." A second limitation was the small sample size in each of the groups. The original intent of this study was to obtain a large sample of children with varying degrees of hearing loss to determine profiles of performance on early literacy skills and to identify variables that predict children's membership in profiles. Despite recruitment efforts to reach children with hearing impairment in two states, the number of children who participated in this study was not large enough to accomplish this goal. Further, the sample size yielded a lack of power to detect significant between group differences and

also limited the generalizability of results. Nevertheless, these results provide evidence that comprehensive early literacy assessment is important for young children with hearing impairment.

Conclusions

The majority of prekindergarten and kindergarten children with hearing impairment in this study, regardless of degree of hearing loss and despite coming from homes in which parents were engaging in literacy activities with their children, appeared to have low early literacy skills which places them at risk for future reading difficulties. Further, based on individual patterns of performance, risk was not restricted to one type of early literacy skill; thus, children with hearing impairment appeared to be at risk for future reading decoding and reading comprehension problems. It was apparent that for individual children a strength in one skill did not necessarily indicate a child would have strengths in all early literacy skills; therefore, the early literacy skills of all children with hearing impairment should be evaluated early in preschool to pinpoint skill deficits and to prioritize intervention goals.

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Table 1

Characteristics of Children with Hearing Impairment and Children with Normal Hearing

	HI Group (n = 10)	NH Group (n = 10)		
Characteristics	*M(SD)*	*M(SD)*	*p*	*t*
Age (months)	70.50 (9.47)	71.57 (8.14)	.812	.243
Maternal level of education (years)	16.20 (2.57)	17.83 (2.57)	.297	.082
Better ear PTA[a] (dB HL)	51.33 (33.8)			
Length of hearing aid/cochlear implant use (months)[c]	40.00 (20.56)[d]			

Note. HI = Hearing impaired; NH = Normal hearing; PTA = pure tone average for 500 Hz, 1000 Hz, and 2000 Hz.

[a]Used speech recognition threshold for PTA for one child as pure tone thresholds were not available

[b]Used 90 dB HL as pure tone average for children with cochlear implants

[c]Exact age in months not provided by one family, so used 24 months to equate to family's report of two years

[d]Included the seven children in the study who used hearing aids or cochlear implants

Table 2

Means, Standard Deviations, and Effect Sizes for Between-group Differences

	HI Group	NH Group			
Measure	*M(SD)*	*M(SD)*	*p*	*t*	Cohen's *d*
EVT-2	102.30 (13.48)	110.14 (10.06)	.213	1.301	.78
SPELT-3	93.10 (17.96)	106.57 (4.04)	.072	1.932	3.33
LC[a]	7.00 (2.58)	9.57 (4.12)	.133	1.589	.62
PA	97.10 (17.50)	118.71 (14.66)	.017	2.670	1.47
LK[a,b]	12.10 (.99)	12.00 (.82)	.800	.219	.12
KBIT-2	100.50 (12.85)	109.42 (14.02)	.194	1.359	.64
HTKS	28.60 (22.29)	41.14 (15.42)	.219	1.284	.81
HLE[c]	133.20 (26.84)	137.29 (22.90)	.748	.327	.18

Note. EVT-2 = Expressive Vocabulary Test, Second Edition (Williams, 2007); SPELT-3 = Structured Photographic Expressive Language Test, Third Edition (Dawson, Stout, & Eyer, 2003); LC = Listening comprehension subtest from the Assessment of Literacy and Language (ALL; Lombardino, Lieberman, & Brown, 2005); LK = Letter knowledge subtest from the (ALL; Lombardino, Lieberman, & Brown, 2005); PA = Phonological awareness subtests from the Comprehensive Test of Phonological Processing, Second

Edition (CTOPP-2; Wagner, Torgesen, Rashotte, & Pearson, 2013); HTKS = Head-Toes-Knees-Shoulders task (McClelland et al., 2007; Cameron Ponitz et al., 2009; Cameron Ponitz et al., 2008); Kaufman Brief Intelligence Test, Second Edition (Kaufman & Kaufman, 2004); HLE = Home Literacy Environment questionnaire from Martini & Sénéchal, 2012.

[a]One child with normal hearing scored at the ceiling for grade

[b]Two children with hearing impairment scored at the ceiling for the grade

[c]Includes questions related to parents' frequency of participating in activities and importance they place on their child reaching literacy benchmarks before first grade

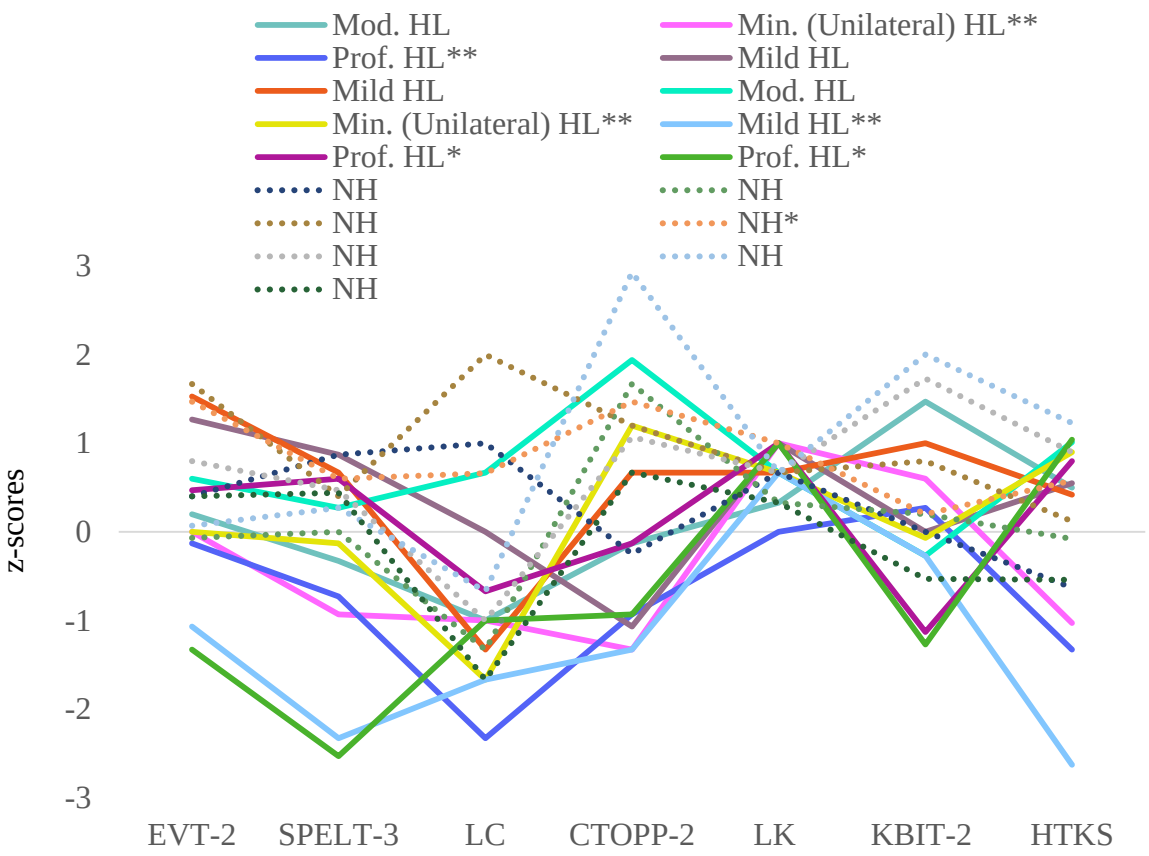

Figure 1. Visual analysis for all children with z-scores plotted for the assessments of early literacy skills, non-verbal cognition, and executive functioning. The z-scores for executive functioning were computed from means and standard deviations from McClelland et al. (2014). The dotted lines denote children with hearing normal and the solid lines denote children with hearing impairment. Degree of hearing loss is indicated for children with hearing impairment. NH = normal hearing; HL = hearing loss; Mod. = moderate; Prof. = profound; Min. = minimal; EVT-2 = Expressive Vocabulary Test, Second Edition (Williams, 2007); SPELT-3 = Structured Photographic Expressive Language Test, Third Edition (Dawson, Stout, & Eyer, 2003); LC = Listening Comprehension subtest from the Assessment of Literacy and Language (ALL; Lombardino, Lieberman, & Brown, 2005); CTOPP-2 = Comprehensive Test of Phonological Processing, Second Edition (CTOPP-2; Wagner, Torgesen, Rashotte, & Pearson, 2013); LK = Letter Knowledge subtest from the ALL (Lombardino, Lieberman, & Brown, 2005); KBIT-2 = Kaufman Brief Intelligence Test, Second Edition (Kaufman & Kaufman, 2004); HTKS = Head-Toes-Knees-Shoulders task (McClelland et al., 2007; Cameron Ponitz et al., 2009; Cameron Ponitz et al., 2008).
*Scored at the ceiling on the LK assessment
**Scored at the floor on the HTKS task

APPENDIX A

APPROVAL TO USE THE HEAD-TOES-KNEES-SHOULDERS TASK

Elizabeth Runnion <erunnion@uw.edu>

HTKS task

McClelland, Magan <megan.mcclelland@oregonstate.edu> Tue, Aug 18, 2015 at 2:36 PM
To: Elizabeth Runnion <erunnion@asu.edu>

Dear Elizabeth,

Thanks for your email. We are happy to share the HTKS measure for research purposes. If you would like to use the measure please complete the online research agreement and we will send you the updated version. We also have a training website and protocol that we can give you access to. If you can complete the form at this link, then we can send the protocols and training materials. [redacted]

The HTKS works best with children ages 4-7 or 8 years and takes about 5 minutes to administer. You will have some floor effects with younger children although I would suggest including the practice items in your overall scores to increase variability. The current task has 3 parts to enable longitudinal measurement up to ages 7 or 8. Here is the most recent article describing the 3-part version: http://journal.frontiersin.org/Journal/10.3389/fpsyg.2014.00599/abstract

I am also attaching a few other papers we've published using the task in the US and in other countries. The latest papers have 3 parts to the task and earlier papers describe the same task but with 1 or 2 parts. The Fuhs paper includes the practice items in the scoring.

Thanks,

Megan McClelland

http://health.oregonstate.edu/labs/kreadiness/resources

Megan McClelland, PhD.

Katherine E. Smith Healthy Children and Families Professor

Graduate Program Coordinator, Human Development and Family Sciences

Core Director, Healthy Development in Early Childhood

245 Hallie E. Ford Center for Healthy Children & Families

Oregon State University

Corvallis, OR 97331

Phone: 541-737-9225

Elizabeth Runnion <erunnion@uuedu>

HTKS task

McClelland, Megan <megan.mcclelland@oregonstate.edu> Wed, Aug 19, 2015 at 414 PM
To: Elizabeth Runnion <erunnion@asuedu>
Cc: Rlewis, Karley" <KarleyLewis@oregonstate.edu>

Dear Elizabeth,
Thank you for completing the HTKS request & registration form. Attached are the updated versions of the task in English (Form A & Fenn B), as well as the HTKS Training Packet. The current task has 3 parts to enable bngitudnal measurement up to ages 7 or 8.

To complete the [redacted] please print and review the attached training packet_ At the end of the online training, you will receive a link and password to our HTKS training video bank. The video bank contains four practice videos and answer keys On English & Spanish) that can be used for additional practice and/or training purposes.

Please do not share the HTKS Training Website without first requesting pennission. Your research agreement covers HTKS training for the project documented (Early Literacy Profiles in Children with Hearing Impairment). You may share the training website with members of your research team who are conducting research for this project. We recommend first completing the training website and then providing an addional in-person training with practice opportunities for your research team.

For the most up-to-date information on our research (and recent publications related to the HTKS task), please visit The Kindergarten Readiness Research Program Website.

I hope this is helpful. Please let us know how the measure works for you.

-Megan

Megan McClelland, Ph.D.
Katherine E. Smith Healthy Children and Families Professor
Human Development and Family Sciences
Core Director, Healthy Development in Early Childhood
245 Hallie E. Ford Center for Healthy Children & Families
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Corvallis, OR 97331
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Fax: 541-737-2072
E-mail: megan.mcclelland@oregonstate.edu
Faculty Link: http://www.hhs.oregonstateedu/megan-mcclelland
The Kindergarten Readiness Research Program

From: Elizabeth Runnion [mailTD:erunnion@asuedu]
5ent: Wednesday, August 19, 2015 3:13 PM
To: MtOelland, Megan
SUbject: Re: HTKS task

(Quoted text hidden)

3 attachments

htka-trainingpackat_ 13aug15.pdf
6694K

htkaa_1Nov11.pdf
509K

htkab_1Nov11.pdf
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APPENDIX B

APPROVAL FROM THE INSTITUTIONAL REVIEW BOARD

AT ARIZONA STATE UNIVERSITY

ASU Knowledge Enterprise Development

APPROVAL: EXPEDITED REVIEW

Shelley Gray
Speech and Hearing
480/965-6796
Shelley.Gray@asu.edu

Dear Shelley Gray:

On 9/1/2015 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Early Literacy Profiles in Children with Hearing Impairment
Investigator:	Shelley Gray
IRB ID:	STUDY00003097
Category of review:	(6) Voice, video, digital, or image recordings, (7)(b) Social science methods, (7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Authorization for Release of Audiological Information, Category: Other (to reflect anything not captured above); • ChildIdentificationForm_8.28.2015.pdf, Category: Other (to reflect anything not captured above); • Cover Letter, Category: Recruitment Materials; • Parent Questionnaire, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Protocol, Category: IRB Protocol; • Recruitment Flyer, Category: Recruitment Materials; • Parent Consent, Category: Consent Form; • Child Assent, Category: Consent Form;

The IRB approved the protocol from 9/1/2015 to 8/31/2016 inclusive. Three weeks before 8/31/2016 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 8/31/2016 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc:

Elizabeth Runnion
Farah Doulah
Justin Turverey