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Research Article

Developmental Outcomes in Early School-Age Children with Minimal Hearing Loss

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Purpose: Previous research suggests that school-age children with minimal hearing loss (CMHL) are at risk for a variety of psychoeducational problems. However, CMHL are a heterogeneous group, and the profile of at-risk children is unknown. Data regarding the characteristics of early school-age CMHL are needed to extend previous findings and determine potential risk factors associated with psychoeducational difficulties.
Method: Psychoeducational outcomes were evaluated at baseline and longitudinally in age-matched groups of 27 CMHL (ages 4–10 years) and 26 children with normal hearing (CNH) using assessments of language, reading, behavior, speech recognition in noise, and cognition. Additional analyses were used to identify demographic characteristics among CMHL that are associated with psychoeducational difficulties.
Results: At the earliest age tested, CMHL had greater teacher-rated attention difficulties in the classroom than CNH. Differences in the rate of psychoeducational development were not observed between groups. Among CMHL, psychoeducational difficulties were associated with delays in identification of hearing loss and low maternal education.
Conclusions: Classroom attention abilities should be monitored for early school-age CMHL. Late-identified CMHL and CMHL with low maternal education levels may be in particular need of academic and social support. Continued efforts for early identification of CMHL should be made to improve outcomes for these children.

Key Words: minimal hearing loss, children, outcomes

During the past few decades, a number of investigators have reported that some children with minimal hearing loss (CMHL), including children with unilateral losses, are at risk for a variety of psychoeducational problems, such as communicative deficits (e.g., Bess & Tharpe, 1984; Bess, Tharpe, & Gibler, 1986; Boney & Bess, 1984; Hartvig Jensen, Borre, & Angaard Johansen, 1989; Crandell, 1993), social and emotional problems (e.g., Bess, Dodd-Murphy, & Parker, 1998; Culbertson & Gilbert, 1986; Stein, 1983), and academic difficulties (e.g., Bess et al., 1986; Bess et al., 1998; Bovo et al., 1988; Most, 2004, 2006; Oyler, Oyler, & Matkin, 1988). Historically, much of this research has focused on the associational relationships between minimal hearing loss and psychoeducational problems in older school-age children. For example, Hartvig Jensen et al. (1989) reported that CMHL (ages 10–16 years) had poorer performance than children with normal hearing (CNH) on verbal assessments, including those of comprehension, digit span, and rapid stimulus naming. Furthermore, Bess et al. (1998) found that among third, sixth, and ninth graders, CMHL had more difficulty than CNH on measures of teacher-reported communication skills and self-reported measures of stress, self-esteem, social support, and energy. In contrast, another study showed that the performances of first- and fifth-grade CMHL were similar to those of same-age CNH on standardized assessments of language, reading, and behavior (Wake et al., 2006). Collectively, these studies demonstrate that some, but not all, CMHL experience psychoeducational difficulties and suggest that some mediating factors may exist.

Underlying factors that contribute to psychoeducational difficulties among some CMHL have not been clearly identified. As a result, it is difficult to predict which CMHL will experience significant psychoeducational problems and need early intervention services and which children will not. The problem is critical, given that intervention provided early in childhood is known to result in better outcomes than intervention provided later in childhood. Substantial evidence supports the notion that early intervention of delays

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improves language outcomes in children with hearing loss (Holzinger, Fellinger, & Beitel, 2011; Moeller, 2000; Yoshinaga-Itano, 2003). In fact, the importance of early intervention extends into many domains. Studies with children with normal hearing indicate that early intervention can improve performance in mathematics and reading in children who experience difficulty in those areas (Denton et al., 2010; Fuchs, Fuchs, & Compton, 2012). Moreover, research suggests that interventions that begin in early childhood can result in positive effects on cognitive development and educational attainment that are sustained through adulthood (Campbell et al., 2012; Reynolds et al., 2007).

Findings from previous studies of CMHL using cross-sectional designs differ on whether psychosocial difficulties in CMHL abate over time or whether they increase as children get older. For example, Bess et al. (1998) examined the academic performance of elementary-school, middle-school, and high-school CMHL. Third-grade CMHL exhibited poorer abilities than their peers with normal hearing in reading, spelling, and science, but sixth- and ninth-grade CMHL showed performance in these areas that was similar to that of their peers with normal hearing. These findings suggest that the psychosocial problems that CMHL experience may lessen over time. However, Bess et al. (1998) also found an increased incidence of school retention rates with increasing grade level, suggesting that global academic deficits for CMHL may be more apparent in older children. Also supporting the notion that difficulties for CMHL may be more apparent in older children, Most (2006) reported that children with hearing loss in sixth grade showed greater teacher-rated deficits relative to students with normal hearing than children with hearing loss in first grade. Although this study included children with varying degrees of hearing loss, CMHL were noted to have poorer performance than children with moderate to severe hearing losses. As such, it is reasonable to consider that the performance of CMHL significantly contributed to group results showing increasing difficulty with increasing grade level. Adding to the disparate evidence, Wake et al. (2006) found that CMHL and CNH had similar language, reading, and phonologic memory abilities, whether measured in first- or fifth-grade children. It is clear that there is little consensus among previous studies regarding the developmental trajectory of CMHL.

The present study was designed to extend previous findings by determining the psychoeducational status of early school-age CMHL relative to CNH using matched-control participant selection and longitudinal analyses. It was anticipated that this study would support past research indicating academic and psychosocial deficits among CMHL. A second goal of this study was to quantify developmental trends of psychoeducational abilities in young CMHL by testing them annually for 2 years after an initial assessment period. Finally, this study was designed to identify associations between demographic characteristics and psychoeducational performance for CMHL. It was anticipated that the findings from this study would result in a descriptive profile of CMHL who are at an increased risk for developing academic and/or psychosocial problems. To this end, questionnaires, teacher ratings, and standardized tests were administered to a group of early school-age CMHL, their parents, and their teachers. These measures were used to obtain demographic information (e.g., educational services) and probe language and reading ability, behavior, speech recognition abilities in noise, and general learning and memory. Specific test measures were selected on the basis of previous research indicating that CMHL experience (a) higher grade retention rates, (b) greater academic risk as judged by teachers, (c) behavior problems as reported by parents, and (d) poorer achievement than CNH in multiple academic domains.

Method

Participants

Twenty-seven CMHL (ages 4;4 [years; months]–9;3) and 26 CNH (ages 4;6–9;8) participated in the initial assessments. Each child with minimal hearing loss was individually matched with a child with normal hearing based on age within 6 months and maternal level of education. Follow-up assessment 1 year later was completed for 22 CMHL and 19 CNH. The third year and final assessment was completed for 27 CMHL and 15 CNH. Twenty-nine CMHL initially consented to participate, but 2 were not included because of changes in hearing thresholds ($n = 1$) and subsequent diagnosis of significant health problems ($n = 1$). Five CNH who participated in the first assessment did not return for subsequent testing because the families could not be contacted ($n = 1$) or the families had time constraints ($n = 4$). Four participants ($n = 2$ CMHL and $n = 2$ CNH) did not return for the second-year assessment, and 6 participants ($n = 6$ CNH) did not return for the third-year assessment because of family time constraints. Demographic information obtained at study entry for children included in the study is shown in Table 1. Unilateral hearing loss was present for the majority of CMHL ($n = 15$), with similar numbers of right-sided ($n = 8$) and left-sided ($n = 7$) impairments observed. Severity of hearing loss ranged from mild to profound in participants with unilateral hearing losses (see Table 1). The remainder of CMHL had either high-frequency ($n = 4$) or flat bilateral ($n = 8$) hearing loss. The age of identification of hearing loss ranged from the newborn period to 8 years of age (M_{age} = 4;2, SD = 1;8), with the majority of CMHL identified between 3 and 5 years of age. Five of the 27 CMHL used amplification, defined as the use of hearing aid(s) or an FM system. Finally, 10 CMHL received special education services at school at some point during the course of this study.

Eligibility Criteria

Audiometric eligibility criteria for CMHL included the following: (a) unilateral sensorineural hearing loss, defined as hearing thresholds in the good ear no poorer than 15 dB HL through the frequency range of 500–4000 Hz, with hearing levels in the impaired ear no better than 45 dB HL through the same frequency range of the better hearing ear;

Table 1. Demographic information for children with minimal hearing loss (CMHL) and children with normal hearing (CNH) obtained at study entry.

Characteristic	No. of CMHL (n = 27)	No. of CNH (n = 26)
Gender		
Male	14	14
Female	13	12
Age at initial assessment (years;months)		
4;0–5;11	9	3
6;0–7;11	12	14
8;0–9;11	6	9
Maternal level of education		
Less than high school	2	1
High school graduate	5	3
Some college	2	4
College graduate	12	15
Graduate education	6	3
Type of hearing loss (amplification use[a])		
Unilateral	15 (11)	0
	Left / Right	
Mild	3 / 2	
Moderate	1 / 2	
Severe	2 / 0	
Profound	3 / 2	
Bilateral	12 (6)	0

[a]Amplification use was defined as use of hearing aid(s) and/or an FM system.

(b) minimal bilateral sensorineural hearing loss, defined as hearing thresholds no better than 20 dB HL or poorer than 40 dB HL through the frequency range of 500–4000 Hz; or (c) bilateral high-frequency sensorineural hearing loss, defined as hearing levels no poorer than 15 dB HL for frequencies 500–2000 Hz, with hearing levels at frequencies above 2000 Hz greater than 25 dB HL. These definitions were similar to those adopted at the National Workshop on Mild and Unilateral Hearing Loss in Breckenridge, CO, in 2005. Audiometric eligibility criteria for CNH included hearing sensitivity no poorer than 15 dB HL at 500–4000 Hz bilaterally.

General Procedures

The study design included matched control and longitudinal cohort components. Psychoeducational outcomes were evaluated using a battery of standardized and nonstandardized measures (see Table 2). These measures were chosen to quantify language and reading skills, behavior, speech understanding in noise, general learning and memory skills, and educational services. These specific tests were of interest because they were administered in previous studies, thus allowing comparisons to be made to the current data set (e.g., Bess et al., 1998; Hartvig Jensen et al., 1989; Most, 2006). Language and reading measures included tests of auditory language comprehension (Test of Auditory Comprehension of Language—Third Edition [TACL–3; Carrow-Woolfolk, 1999]), phonological awareness (Phonological Awareness Test—First Edition [PAT; Robertson & Salter, 1997]), receptive vocabulary (Peabody Picture Vocabulary Test, Third Edition [PPVT–III; Dunn & Dunn, 1997]), and basic reading skills (Woodcock Reading Mastery Test—Revised; Woodcock, 1998). Behavior and classroom performance were characterized by parent survey (Child Behavior Checklist; Achenbach & Edelbrock, 1991) and teacher surveys querying behavior problems (Conners' Teacher Rating Scale [CTRS; Conners, 1997]; Screening Instrument for Targeting Educational Risk [SIFTER; Anderson, 1989]). Only results from teacher surveys are reported here. Speech recognition ability in noise was measured using an adaptive sentence recognition in noise task with speech and noise presented from 0° azimuth at 65 dB SPL (Hearing in Noise Test for Children [HINT–C; Gelnett, Sumida, Nilsson, & Soli, 1995]). Cognitive skills were measured using verbal (Wide Range Assessment of Memory and Learning [WRAML; Sheslow & Adams, 1990]) and nonverbal assessments (Leiter International Performance Scale—Revised [Leiter; Roid & Miller, 1997]). Last, educational services were quantified by a parent survey that was designed in house for the purposes of this study.

Assessments were administered at the time of study entry and then annually for 2 years after the initial assessment. All annual assessments were completed in one or two visits, depending on child fatigue and/or parent preference. If two visits were required during an annual assessment interval, they were scheduled within a 1-month time period. Assessments were administered by certified audiologists, certified speech-language pathologists, and trained graduate-level research assistants. Auditory measures were completed within a custom-built sound-treated room suitable for audiometric threshold measurements. All CMHL who used hearing aids wore them at typical user settings for all assessments with the exception of the HINT–C, which was assessed unaided. Other amplification devices (i.e., FM systems) were not used during any assessment. Nonauditory measures were given either in a sound-treated room or in a speech therapy treatment room. The Institutional Review Board at Vanderbilt Medical Center approved the study, and written informed parental consent was obtained for each participant.

Statistical Analysis

Test scores obtained at study entry were examined to assess performance differences between CMHL and CNH using Wilcoxon rank sum tests following covariate adjustment (i.e., maternal level of education). Mixed-effects models were used to compare the longitudinal psychoeducational development of the CMHL cohort with that of the CNH cohort. These analyses included a covariate to adjust for variability between the two groups in maternal education. In addition, analyses performed on the data from the CMHL group included mixed-effects models to identify associations between demographic characteristics and performance on psychoeducational measures. The demographic characteristics examined were age at identification of minimal hearing loss, maternal level of education, and use of amplification (i.e.,

Table 2. Description of assessments administered to project participants.

Measure	Characteristic/Skill assessed
Research Study Information Form[a]	Family and child demographics including brief medical history and child's educational environment
Audiometry[b]	Hearing sensitivity for octave frequencies from 500 to 4000 Hz bilaterally
Hearing in Noise Test for Children (Gelnett, Sumida, Nilsson, & Soli, 1995)[b]	Threshold for speech recognition in noise
Test of Auditory Comprehension of Language—Third Edition (Carrow-Woolfolk, 1999)[b]	Auditory comprehension of vocabulary, grammatical morphemes, and elaborated phrases and sentences
Phonological Awareness Test, First Edition (Robertson & Salter, 1997)[b]	Phonological awareness (e.g., rhyming, segmentation)
Peabody Picture Vocabulary Test, Third Edition (Dunn & Dunn, 1997)[b]	Receptive vocabulary
Woodcock Reading Mastery Test—Revised (Woodcock, 1998)[b]	Basic reading skills (i.e., word identification, word attack) and reading comprehension (i.e., word comprehension, passage comprehension)
Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990)[b]	Memory functions
Leiter International Performance Scale—Revised (Roid & Miller, 1997)[b]	Nonverbal intelligence quotient
Screening Instrument for Targeting Educational Risk (Anderson, 1989)[c]	Risk of academic failure
Conners' Teacher Rating Scale (Conners, 1997)[c]	Problem behavior in children (i.e., ADHD-like behaviors)

Note. ADHD = attention-deficit/hyperactivity disorder.
[a]Measure completed by parent or caregiver. [b]Measure completed by study personnel. [c]Measure completed by teacher.

hearing aid[s] and/or an FM system). All analyses were performed with open-source R software and the nonlinear and linear mixed-effects model package (Pinheiro, Bates, DebRoy, Sarkar, & R Development Core Team, 2011; R Development Core Team, 2011).

Results

Between-Groups Analyses

Between-groups analyses were used to determine the psychoeducational status of early school-age CMHL relative to CNH using data obtained at the initial assessment interval and across assessment intervals to estimate longitudinal growth trajectories. Average scores for CMHL and CNH for assessments administered at the time of study entry are listed in Table 3. On average, scores for CNH and CMHL were within normal limits for all standardized assessments. The performance of CMHL tended to be poorer than that of CNH by 1 to 6 points (e.g., standard score) on most of the assessments. A statistically significant difference was noted between CMHL and CNH on the SIFTER Attention subscale. Specifically, CMHL scored 2.63 points lower at the time of study entry than CNH on the SIFTER Attention subscale after adjusting for maternal level of education, $p \leq .01$. Statistically significant differences were not observed for any other measure at the time of study entry. Furthermore, no difference in the longitudinal trajectories of any psychoeducational assessment was observed between CMHL and CNH.

Within-Group Analyses: CMHL

Within-group analyses were used to identify associations between demographic characteristics and psychoeducational performance among CMHL. Mixed-effect models were used to assess the potential influence of age at identification of hearing loss, maternal level of education, and use of amplification on psychoeducational outcomes. Scores for the CTRS worsened for every month in delay of identification of hearing loss, $p \leq .05$. Scores for the SIFTER, TACL–3, WRAML, CTRS, Leiter, PPVT–III, and PAT improved for every year higher in maternal level of education, $p \leq .05$. Last, children who used amplification had poorer SIFTER and CTRS growth rates than children who did not, $p \leq .05$.

Discussion

The primary objectives of this study were to compare the longitudinal performance of young school-age CMHL and CNH on a variety of psychoeducational measures, and to identify specific characteristics of CMHL that place them at risk of developing psychoeducational difficulties. Significant differences in performance between CMHL and CNH were not apparent for most psychoeducational assessments at the initial assessment period after accounting for differences among the two groups in maternal level of education. One exception was the Attention subscale of the SIFTER, which indicated that CMHL were judged by their teachers to have had greater attention problems than CNH, despite having scored within normal limits. This finding suggests

Table 3. Means and standard deviations for developmental tests administered to CMHL and CNH at the time of study entry.

Measure	No. of CMHL (n = 27) M (SD)	No. of CNH (n = 26) M (SD)
Hearing in Noise Test for Children (Gelnett et al., 1995)	2.0 (2.3)[a]	0.9 (1.6)[a]
Test of Auditory Comprehension of Language—Third Edition (Carrow-Woolfolk, 1999)	104.7 (19.0)[b]	110.7 (11.5)[b]
Phonological Awareness Test—First Edition (Robertson & Salter, 1997)	109.8 (16.0)[b]	110.9 (14.5)[b]
Peabody Picture Vocabulary Test—III (Dunn & Dunn, 1997)	100.7 (18.7)[b]	106.0 (14.1)[b]
Woodcock Reading Mastery Test—Revised (Woodcock, 1998)	115.1 (20.8)[b]	114.3 (19.0)[b]
Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990)	100.1 (14.7)[b]	102.9 (14.8)[b]
Leiter International Performance Scale—Revised (Roid & Miller, 1997)	107.2 (16.9)[b]	106.5 (17.9)[b]
Screening Instrument for Targeting Educational Risk (Anderson, 1989) subscale scores		
Academics	11.3 (3.4)[c]	12.3 (2.5)[c]
Attention	9.4 (2.8)[c]	12.1 (2.8)[c]
Communication	10.2 (3.3)[c]	11.3 (2.9)[c]
Class Participation	11.4 (2.5)[c]	12.4 (2.9)[c]
School Behavior	11.8 (3.0)[c]	13.3 (3.0)[c]
Conners' Teacher Rating Scale (Conners, 1997) subscale scores		
Oppositional	50.6 (9.6)[d]	48.0 (4.5)[d]
Cognitive Problems/Inattention	51.2 (10.4)[d]	48.3 (8.0)[d]
Hyperactivity	48.8 (7.5)[d]	46.6 (5.7)[d]
Attention-Deficit/Hyperactivity Disorder	48.7 (6.3)[d]	47.0 (8.2)[d]

[a]Indicates value shown in dB signal-to-noise ratio. [b]Indicates value shown in standard score. [c]Indicates value shown as raw point total. [d]Indicates value shown as T score.

that CMHL may have greater difficulties with selective attention as compared with CNH. Consequently, CMHL may be at a disadvantage in the classroom because selective attention problems may confound learning opportunities and negatively affect psychoeducational achievement. In fact, children with attention difficulties are known to be at greater risk for learning disabilities, academic underachievement, repeated grades, placement in special classes, and behavioral problems (Faraone et al., 1993).

Another interesting finding from this study was that the rate of development of CMHL and CNH did not differ on the various psychoeducational measures as they aged and repeated the assessments—that is, in terms of psychoeducational progression, CMHL showed similar developmental trajectories as their peers with normal hearing. These results differ from those of past studies in which multiple significant psychoeducational difficulties were observed in school-age children (i.e., 6–18 years of age) with mild and minimal hearing loss (e.g., Bess et al., 1998; Culbertson & Gilbert, 1986; Hartvig Jensen et al., 1989; Oyler et al., 1988). Potential reasons for differences between the results from this study and those of past studies may be attributed, in part, to changes in the ages of identification and management of CMHL that have occurred over the past several decades. It has now been more than 2 decades since the first studies reported psychoeducational difficulties among children with mild and minimal hearing loss. It is possible that increased awareness of potential psychoeducational difficulties in CMHL have led to increased monitoring and intervention efforts. In addition, unlike previous studies, children in this study were born since the widespread implementation of newborn hearing screening (Harrison, Roush, & Wallace, 2003). As a result, it is possible that some CMHL in this study were identified at an earlier age than the CMHL in previous studies. However, many of the children in the current study were identified with hearing loss between 3 and 5 years of age, and it is unlikely that earlier identification of hearing loss is the sole explanation for the differences between findings from the current study and previous studies.

Differences in the results from this investigation and past research may also be related to methodological factors, including the selection of assessment measures, age of participants, and recruitment procedures. In the current study, we measured the performance of CMHL using standardized assessments, which might not have been sensitive enough to detect subtle difficulties that CMHL could experience. Like the current study, a handful of other recent studies have also shown comparable performance for children with and without hearing loss using standardized tests of expressive language, reading, math, and behavior (Antia, 2007; Antia, Jones, Reed, & Kreimeyer, 2009; Wake et al., 2006). Another possible reason why the current study found less psychosocial problems in CMHL than other previous studies may be that the current study enrolled younger children than in previous studies. Specifically, 33% of the children enrolled in this study were under the age of 6 years at the initial assessment period. In contrast, previous studies that found multiple psychoeducational differences between CMHL and CNH enrolled older children who were in later elementary grades than children in the current investigation (e.g., Bess et al., 1998; Hartvig Jensen et al., 1989; Most, 2006). It is possible that additional differences in performance between CMHL and CNH may begin to emerge as these children get older and social and academic environments become more complex. Finally, differences between the findings from the current study and previous studies may be attributed to the fact that CMHL in this study were known to have hearing loss before being recruited, whereas other studies identified

CMHL during the study as part of large population screenings. Consequently, many of the CMHL in past studies were identified with hearing loss for the first time upon enrollment. Children in the current study may have been at an advantage because they were already known to have hearing loss, which would have allowed for adjustments and compensations in their day-to-day routines. Thus, differences in the results from this investigation and past studies may have been influenced by differences in subject selection.

Characteristics of CMHL, including age at identification of hearing loss, maternal level of education, and use of amplification were examined as potential predictors of psychoeducational performance. Similar to previous studies examining CNH, maternal level of education was positively correlated with the majority of psychoeducational assessments administered to CMHL (e.g. Burchinal, Peisner-Feinberg, Pianta, & Howes, 2002; Christian, Morrison, & Bryant, 1998). This finding suggests that CMHL of parents who have fewer years of formal schooling may benefit from psychoeducational interventions. The second demographic factor that emerged as a correlate to psychoeducational performance in CMHL was age of identification of hearing loss. Specifically, among CMHL, scores on the CTRS were poorer for every month in delay of identification of hearing loss. This finding indicates that late-identified or undiagnosed minimal hearing loss may be associated with later oppositional behaviors, inattention, and hyperactivity. Thus, children with later identified minimal hearing loss should be monitored for attention and behavior problems. Finally, recall that the longitudinal analyses included the calculation of average monthly growth rates from annual assessment scores. Improvements in growth rates for CMHL who did not use amplification were apparent for ratings of academic success and classroom behavior. This result seems counterintuitive, as one might expect to observe improvements for CMHL who use amplification. However, it is important to note that this finding is based on findings from five CMHL. Small sample size notwithstanding, it is possible that these findings could have been influenced by the provision of amplification following the identification of significant psychoeducational difficulty. Further investigation is warranted to determine the effect of providing amplification interventions for CMHL.

Performance Trends

Our overall observations did not indicate that CMHL had significantly poorer performance than CNH on most psychoeducational assessments. On some tests, however, the CMHL had scores that fell 1.5 *SD* below normative means at a greater rate than those of CNH. Specifically, whereas no CNH scored below normative means on the TACL–3, PPVT–III, WRAML or the PAT, 12–20% of CMHL had scores that fell 1.5 *SD* below normative means for these tests across all three assessment intervals. Thus, even though statistically significant differences were not observed between groups, this data trend indicates a potential need to monitor CMHL for delays in auditory comprehension of language, receptive vocabulary acquisition, general learning and memory, and phonemic awareness.

Data considered from individual participants showed that some CMHL tended to have consistently good performance, whereas others tended to have poor performance on assessments across all test intervals. The characteristics of individual children within these groups are of interest because they illustrate that many factors contribute to the psychoeducational development of CMHL. An interesting finding of this study was that there were several similarities between the consistently highest performing CMHL and the consistently lowest performing CMHL. Both children had right-sided profound unilateral hearing loss. Also notable was that these two children performed comparably on measures of speech recognition in noise (i.e., HINT–C). Specifically, they scored approximately +2 dB signal-to-noise ratio, which is poorer than thresholds expected for CNH (Gelnett et al., 1995). Finally, although neither child was receiving educational support at the first or second year of testing, both children were reported to be receiving academic assistance at the third annual test interval. Specifically, the child with consistently good performance began receiving some educational support within a resource room, whereas the child with consistently poor performance began support within a self-contained classroom.

Despite these similarities between the highest and lowest performing CMHL, there were also notable differences. First, the mother of the child with consistently good performance had more years of formal education than the mother of the child with consistently poor performance (16 years and 9 years, respectively). This is consistent with the overall findings showing a positive correlation between maternal education level and performance among the children with CMHL. In addition, CTRS scores of the child with consistently poor performance met the clinical criteria for attention-deficit/hyperactivity disorder (ADHD) at the first year of testing. In contrast, the child with consistently good performance did not meet clinical criteria for ADHD at any test interval. Finally, the age at onset of hearing loss for the child with consistently good performance was 3 years, as compared with the child with consistently poor performance who was presumed to have congenital hearing loss. It is possible that the child with consistently good performance had 3 years of unimpaired auditory input that were not afforded to the child with consistently poor performance.

Future Research Needs

Additional research within the domain of psychoeducational development for CMHL is necessary to examine the efficacy of intervention with this population. In addition, further research is needed to better understand the performance of CMHL who use amplification compared with CMHL who do not use amplification. A large multisite investigation designed to include greater numbers of CMHL who use amplification and examine intervention characteristics (e.g., reason for amplification, hours used) may reveal efficacy trends that inform clinical and classroom practice.

Future longitudinal research should also be undertaken to investigate young adults with minimal hearing loss. Although, some studies suggest that children with minimal to moderate degrees of hearing loss might overcome psychoeducational deficits as they get older (e.g., Bess et al., 1998; Moeller et al., 2010), it is possible that, as CMHL become young adults, they experience more difficulties because of increasingly demanding coursework in late high school and college. This notion is supported by observations of higher rates of grade repetition and poorer teacher-reported performance for older compared with younger CMHL (Bess et al., 1998; Most, 2006).

Future research may also consider measuring self-perceived listening difficulty and achievement. This would reveal instances in which CMHL may experience difficulty, even when these differences are not identified by standardized test measures. In addition, future research should consider using direct assessments of attention and executive function with this population, since ratings and surveys to quantify these domains can be influenced by parent and teacher expectations. It is also worthwhile to examine hearing-related fatigue and listening effort in CMHL, given that these issues are not probed by standardized assessments. Last, psychoacoustic assessments designed to examine auditory functions that underlie everyday listening experiences (e.g., temporal resolution, binaural masking release) may reveal performance differences for CMHL and CNH and inform our understanding of these processes for CMHL.

This study was limited by at least three factors that should be considered. First, a matched-pairs design was used in the current study to control for the possible influence of participant age, gender, and maternal level of education. Although, this recruitment method strengthened the internal validity of the study, it proved to be more difficult than anticipated and limited the number of children who qualified for the study. Second, the number of participants included in the current study was small. It is possible that recruiting a larger sample of CMHL would reveal psychoeducational difficulties or at-risk characteristics that were not uncovered in the present investigation. Third, as often found in longitudinal research, although efforts were made to retain participants for the entire study, this did not always occur. In addition, some children did not complete all assessments for annual visits. This occurred when children exhibited signs of fatigue requiring the termination of testing and/or did not return to complete testing for a given year. Consideration of these factors during the planning and implementation process may enhance the findings of future research.

Conclusion

In conclusion, systemic deficits in longitudinal psychoeducational performance were not observed for early school-age CMHL compared with CNH. However, at the youngest age tested, CMHL were reported by their teachers to be at greater risk than CNH for attention difficulties in the classroom. This is concerning, given that the ability to selectively direct one's attention can negatively affect psychoeducational achievement. Within the group of CMHL, delays in identification of hearing loss, low maternal education, and use of amplification were associated with psychoeducational difficulty. These results provide information regarding current characteristics of CMHL that may be monitored as potential indicators of need for psychoeducational intervention.

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