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Parent-Reported Attention-Deficit/Hyperactivity Disorder–Linked Behaviors, Fatigue, and Language in Children Who Are Deaf and Hard of Hearing

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ABSTRACT

Purpose: The purpose of this study was to find out if children who are deaf and hard of hearing (DHH), particularly those without substantially delayed language, appear to be at risk for overreporting of inattentive and hyperactive behaviors and if attention-deficit/hyperactivity disorder (ADHD) measures are influenced by the presence of language-based items, by child language skills, and by child and parent report of fatigue.

Method: This study included 24 children with typical hearing, 13 children with hearing aids (HA), and 16 children with cochlear implants (CI) in second through sixth grade. Parents of children in each group completed a measure reporting on inattentive and hyperactive behaviors, social and academic outcomes, and general fatigue for their child. Children participated in a norm-referenced language assessment and completed a self-report of fatigue.

Results: Analyses revealed an effect of hearing status on overall inattention ratings and social/academic performance: Children with CI had significantly lower ratings of inattention, and children with HA had more social/academic performance deficits. Differences in inattention scores for children with CI remained even when items biased toward language skills were removed from the measure, but differences in performance for children with HA disappeared. Omnibus language scores significantly correlated with academic and social outcomes, whereas parent report of fatigue significantly correlated with inattention and hyperactivity.

Conclusions: Parent report of behaviors linked with ADHD, including inattention and hyperactivity, is likely influenced by child language knowledge and overall fatigue. Comorbid diagnosis of ADHD in children who are DHH must consider these factors.

Children who are deaf or hard of hearing (DHH) and use spoken language often struggle with language and literacy in comparison to their typical-hearing (TH) peers (Lund, 2016; Werfel et al., 2021). These language deficits are often linked to overall academic achievement, especially for children with more severe degrees of hearing loss (Sarant et al., 2015; Tomblin et al., 2020). However, given the improvements in hearing technology over previous decades, children who use hearing aids (HA) and cochlear implants (CI) are also frequently able to attain spoken language scores in the range of normal on norm-referenced measures (e.g., Lund et al., 2022; Tomblin et al., 2020). Omnibus norm-referenced assessments may not capture nuanced linguistic difficulties experienced by children who are DHH (Breland et al., 2022; Lund, 2020). Subtle difficulties with language may manifest behaviorally and be interpreted by professionals as comorbid disorders like attention-deficit/hyperactivity disorder (ADHD), particularly if a child does not appear to be struggling substantially with listening (Stevenson et al., 2010). Other

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populations that struggle with language, like children with specific language impairment, appear at risk for overdiagnosis of ADHD based on test-item construction on across common measures (Redmond, 2002; Redmond et al., 2019). The purpose of this study is to examine parent report of ADHD behaviors in children who are DHH and use spoken language and to evaluate if language biases are likely to play a role in suspicion of ADHD.

ADHD and Co-Occurrence With Language Disorder

ADHD is one of the most common neurodevelopmental diagnoses in childhood. Hallmark symptoms of ADHD include elevated inattention, hyperactivity, and impulsivity (Barkley, 2018). In 2016, the Centers for Disease Control and Prevention reported that 6.1 million children have been diagnosed with ADHD (9.8% prevalence rate) at some point in their childhood; of those children, six in 10 had co-occurrence of another mental, emotional, or behavioral disorder (Bitsko et al., 2022). ADHD is most commonly measured in terms of behaviors, such as being off-task, being impulsive, and not following directions (American Psychiatric Association [APA], 2013). However, ADHD is not the only underlying condition that could result in these surface-level behaviors.

Children with language disorders often also demonstrate ADHD-like behaviors, which then could lead to misidentification of ADHD. Children with language disorders are twice as likely to develop and demonstrate behavioral difficulties, including behaviors linked to attention deficit (Chow & Wehby, 2018; Yew & O'Kearney, 2013). These higher levels of problem behaviors could be attributed to avoidance strategies by children with a language disorder. These children may use ADHD-like problem behaviors to avoid academic interactions; when they successfully avoid the academic demand, the problem behavior is reinforced (Kevan, 2003; Sutherland & Morgan, 2003). Similarly, language skills have been found to play a role in self-regulation and active participation during academic activities; children with language disorders may be less engaged during academic instruction, which may be perceived as inattention (Chow & Wehby, 2019).

To understand true co-occurrence rates for language disorders and ADHD, it is important to understand the diagnostic criteria for each disorder individually. "Developmental language disorder" (DLD) describes children who have difficulty producing or understanding language that impacts everyday functioning; the language disorder is not due to unfamiliarity with the local language or an associated biomedical condition (e.g., brain injury, autism spectrum disorder, Down syndrome, or sensorineural hearing loss) and may co-occur with a low level of nonverbal ability (Bishop et al., 2017). In turn, ADHD refers to difficulty with attention, hyperactivity, and impulsiveness that impacts social, academic, and occupational functioning; these difficulties are not better accounted for by a different psychiatric or behavioral disorder (APA, 2013). When the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5) behavioral criteria for ADHD are reviewed, many of the examples can also be observed in children with DLD, such as poor listening skills, difficulty completing schoolwork, problems following directions, and forgetfulness. The most current co-occurrence rate for ADHD and DLD is 22.3% (Redmond, 2020), which is much higher than the 9.8% prevalence rate of ADHD in the United States. It is possible that children with DLD are much more likely to have ADHD than children without DLD, but it is also possible that DLD makes a diagnosis of ADHD more likely. Current research evaluates the co-occurrence between ADHD and primary language disorder; however, there is a need for similar critical inquiry to evaluate the diagnosis of ADHD alongside secondary language disorders (i.e., language disorders stemming from other diagnoses such as Down syndrome, hearing loss, or autism spectrum disorder).

The research on co-occurrence of ADHD and hearing loss is minimal. Many factors impact language outcomes for children who are DHH. Hearing history variables such as early age at and consistent use of amplification, shorter duration of deafness before amplification, greater residual hearing, and use of auditory–oral communication likely contribute to higher spoken language outcomes (Geers & Sedey, 2011).

Children who are DHH demonstrate weaker semantic, lexical, and phonological language skills than those of their peers when matched on age and socioeconomic status (Lund, 2016; Pisoni et al., 2011), and these deficits persist as a child who is DHH ages (Nittrouer et al., 2018; Tomblin et al., 2015). Language outcomes appear to correlate with academic outcomes for children who are DHH who perform more poorly than their TH peers (Tomblin et al., 2020); these deficits include phonological awareness and emergent literacy skills (Lund, 2020). Children who are DHH often attain scores on measures of language that fall within the "range of normal" (e.g., Geers et al., 2016); however, that does not indicate that children who score in the normative range do not struggle with more subtle aspects of language: There may be areas of particular weakness that do not show up on tests that measure skills across a broad domain (e.g., Lund, 2020). Language difficulties, even subtle ones, may predispose children who are DHH to an ADHD diagnosis similar to children with DLD.

ADHD and Hearing Loss

In its 2009–2010 national survey, Gallaudet Research Institute found only a 5.4% co-occurrence of hearing loss and ADHD, which was lower than the 8%–10% diagnosis rate of ADHD in children with TH (Gallaudet Research Institute, 2013). Although parents of school-age children who are DHH have been found to report more ADHD symptoms than parents of children with TH (Theunissen, Rieffe, Kouwenberg, et al., 2014), reports of attention difficulties in children with DHH have been overall inconclusive (Theunissen, Rieffe, Netten, et al., 2014). Thus, it is difficult to predict whether children who are DHH are likely to be identified as also having symptoms of ADHD.

The American Academy of Pediatrics (AAP) and DSM-5 provide guidelines for evaluation and diagnosis of ADHD. ADHD can be classified into three subtypes: inattentive, hyperactive–impulsive, and combined. A diagnosis of ADHD is made if symptoms are present in at least two settings (APA, 2013). The AAP practice guideline recommends the use of ADHD questionnaires to get reports from parents, teachers, and other school staff (Wolraich et al., 2019), often via standardized behavioral scales, such as the National Institute for Children's Health Quality Vanderbilt Assessment Scales (NICHQ; AAP et al., 2002).

There exist two well-documented reasons that parents and professionals might be likely to attribute hearing loss–linked behaviors to a comorbid ADHD diagnosis. First, there is an inherent problem in the use of the scales that identify ADHD, which has the potential to impact the overdiagnosis of ADHD in children with primary or secondary language disorders. Heavily linguistic and academic items are present on the questionnaires themselves, blurring the line between language and attention (Redmond, 2002). Examples of linguistically based behaviors measured by ADHD checklists include not talking, having speech problems, poor schoolwork, poor spelling, not listening, and difficulty completing work. When removing such items from ADHD questionnaires, there was a positive impact on specificity between DLD and ADHD and a very little impact on discrimination between ADHD and children who were typically developing (Redmond & Ash, 2014). By removing language and academic items across different behavioral subscales, the specificity for discriminating cases of ADHD and DLD can be improved (Redmond et al., 2019).

A second reason ADHD symptoms might appear present in children who are DHH, beyond measurement-related issues, is listening fatigue. Behaviors that may manifest as inattention actually could be due to listener fatigue, a phenomenon well documented and identified in children who are DHH. Listening fatigue can be considered a type of cognitive fatigue, which is characterized by difficulties in concentration, increased distractibility, anxiety, inattention, and decreases in mental energy and efficiency (Boksem & Tops, 2008; Lieberman, 2007). Listening effort is considered the use of attention and cognition for auditory tasks, such as detecting, decoding, processing, and responding to speech (Bess & Hornsby, 2014). Understandably, school-age children who are DHH experience greater listening effort than those with TH (Hicks & Tharpe, 2002). Due to this increased effort, children who are DHH report more fatigue than their normal-hearing peers (Hornsby et al., 2014). Also, higher rates of listener fatigue were found for children who are DHH who had poor reading skills than higher achieving children who are DHH (Camarata et al., 2018), meaning that listener fatigue has a real impact on academic achievement. Interestingly, parents of CI users report lower levels of chronic fatigue than do the CI users themselves (Werfel & Hendricks, 2016). Thus, parents may not be fully aware of the fatigue their children experience and therefore may attribute inattentive (or even hyperactive) behaviors to a cause outside of hearing loss.

In summary, children who are DHH have two characteristics that may result in behaviors that look like ADHD: (a) poorer language outcomes and (b) greater listening effort and fatigue. Although these difficulties can manifest in ways that appear to be behaviors associated ADHD, they are often part of the hearing loss—not a separate disorder such as ADHD. The surface manifestation of disorders/disabilities such as hearing loss and ADHD may all appear as the same behaviors, but the root of the issue and the treatment for these behaviors are very different. This fact, along with the difficulties in measuring ADHD in language-disordered populations (i.e., the presence of language-based items), suggests a possible risk for overdiagnosis of ADHD in the DHH population.

The primary purpose of this study was to find out if children who are DHH, particularly those without substantially delayed language, appear to be at risk for overdiagnosis of ADHD and if ADHD measures are influenced by the presence of language-based items. The following research questions were addressed:

1. Do parents completing the NICHQ (a measure assessing ADHD behaviors) identify greater prevalence of ADHD behaviors in children who are DHH who do not have an official ADHD diagnosis versus children with TH?
2. Do children who are DHH score differently on the NICHQ when language-based items are removed compared to peers with TH?

3. Do measures of fatigue and language correlate with parent reports of ADHD behaviors?

Based on the extant literature, it was hypothesized that parents would report greater ADHD prevalence in children who are DHH, reflecting the possible effects of language biases in measurement (Redmond et al., 2019) and listening fatigue (Hicks & Tharpe, 2002). An additional hypothesis was that only children who are DHH would have a different profile of performance when language-based items were removed (Redmond & Ash, 2014). The final hypothesis is that measures of fatigue and language will correlate with parent reports of ADHD behaviors, especially for children who are DHH (Geers & Sedey, 2011; Hornsby et al., 2014).

Method

Participants

All procedures in this study were approved by the University of South Carolina Institutional Review Board (as institutional review board of record), with Texas Christian University in agreement. Students in this study are participants in a larger longitudinal study investigating language and literacy acquisition in children who are DHH (Emergent Language and Literacy Acquisition in Children with Hearing Loss [ELLA]; R01 DC017173 funding from the National Institutes of Health/National Institute on Deafness and Other Communication Disorders). Children with TH, children with HA, and children with CI are recruited to participate in the ELLA study. To participate in the ELLA study, children who have hearing loss must be developing spoken language as a communication modality; that is, no child can only be using a signed language (e.g., American Sign Language). Additional inclusion criteria require children to not have additional diagnosed disabilities known to affect cognitive and/or language development (e.g., Down syndrome).

Participants in the ELLA study who at the time of testing were enrolled in second through sixth grade in schools across the United States were considered to participate in this study. As a result, this analysis included the parents of 53 children who met that grade criterion from three groups: 24 children with TH, 13 children with HA, and 16 children with CI. It is important to note that the children in this study did not have a medical diagnosis of ADHD at study entry, as was required to meet eligibility criteria for the ELLA study. The grade range of second to sixth was specifically chosen for this study. Whereas the median age of diagnosis for ADHD is 6.2 years, that of diagnosis for mild ADHD is around 7 years (Visser et al., 2014). We expected reported symptoms to be "mild," at most, as none of the participants had an early diagnosis of ADHD. U.S. state policies require that a child need only be 6 years of age by the beginning of first grade (Education Code, 2014). By setting an eligibility criterion of second grade, this study highlighted the participants in the age range of 7+ years, where mild but notable ADHD-like behaviors were likely to be reported. Table 1 lists the demographic characteristics of the child participants by hearing status.

Procedure

Participants in the ELLA study were assessed one-on-one with an examiner in a quiet space (i.e., university laboratories, conference rooms, local public libraries,

Table 1. Participant demographics (means and standard deviations) by group.

Variable	TH	HA	CI
Age	112.71 (12.17) months	114.38 (14.11) months	115.44 (14.78) months
Gender	Male: 9 Female:15	Male: 6 Female: 7	Male: 6 Female:10
Race and ethnicity	White: 22 Asian: 1 Hispanic or Latino/a: 2 Prefer not to respond: 1	White: 11 Black: 2 Hispanic or Latino/a: 3	White: 16 Hispanic or Latino/a: 2
Caregiver education level	17.54 (2.62) years	16.92 (3.57) years	15.75 (1.95) years
Hearing loss severity	N/A	Mild: 1 Mild–moderate: 1 Moderate: 3 Moderately severe: 5 Severe: 2 Not reported: 1	Severe: 1 Severe–profound: 4 Profound: 11
Age at diagnosis	N/A	15.63 (17.78) months	3.42 (6.41) months
Age at amplification	N/A	18.67 (17.22) months	6.82 (8.25) months

Note. TH = children with typical hearing; HA = children with hearing aids; CI = children with cochlear implants; N/A = not applicable.

schools, or their home). Examiners were American Speech-Language-Hearing Association–certified speech-language pathologists (SLPs) with experience in test administration. Participants' listening devices (i.e., HA or CI) were in working condition at the time of testing. Children were allowed breaks as needed to encourage continued participation. Test administration was video- and audio-recorded to calculate scoring reliability and procedural fidelity. A parent of each participant completed questionnaires, including the NICHQ measure. Study data were managed using Research Electronic Data Capture tools hosted at the University of South Carolina and at Boys Town National Research Hospital (Harris et al., 2009). Participants completed a battery of language and literacy testing during testing sessions that lasted approximately 2 hr. Breaks were allowed as needed, and testing could be spread over multiple days.

Measures

Attention Measure

The NICHQ (AAP et al., 2002) parent rating form was given to the parent of each participant. Designed to be used in combination with other measures to diagnose ADHD in children between the ages of 6 and 12 years, the NICHQ questionnaire is based on daily observations of a child. The NICHQ has a symptom assessment and impairment in performance assessment. The first nine questions of the NICHQ capture symptoms of inattention, and the second set of nine questions captures symptoms of hyperactivity. In addition, the remaining symptom-based items (19–47) capture behaviors associated with oppositional defiant disorder, conduct disorder, and anxiety/depression. The impairment in performance questions (48–55) measure potential impairment caused by the symptoms, including academic and social skills.

On the NICHQ, symptoms (Items 1–47) are rated as occurring "never," "occasionally," "often," or "very often" when applied to the child's behavior; items were scored 0–3, with "never" being scored 0 and "very often" being scored 3. Responses were considered "positive" if they were scored 2 or 3. On the impairment in performance items, parents rate items as "excellent," "above average," "average," "somewhat of a problem," or "problematic," scoring 1–5, respectively. Responses were considered "positive" for these items if they had a score of 4 or 5.

For diagnostic purposes, children must meet two criteria. First, they must have six out of nine positive responses in the inattention section for an ADHD-inattentive diagnosis, six out of nine positive responses in the hyperactivity section for an ADHD-hyperactive/impulsive diagnosis, or six out of 18 positive responses for an ADHD-combined diagnosis. Second, they must have a positive response on one of the performance questions. For this study, four scores were collected for each participant from the NICHQ: inattention subtest score (Items 1–9), hyperactivity subtest score (Items 10–18), total symptom score (TSS; Items 1–47), and average performance score (APS; the average score on Items 48–55).

Alternative Scoring

Each item on the NICHQ was categorized as language based versus non–language based, following the example provided by Redmond on similar assessment tools (Redmond, 2002; Redmond et al., 2019). In these previous studies, items were removed that were "symptomatic of a primary language impairment or representative of a secondary academic consequence" (Redmond et al., 2019). A list of the items that Redmond removed in his studies was used as a reference tool for three SLPs to judge whether items on the NICHQ should or should not be removed. Agreement across SLPs was above 80% in point-by-point comparison, and the first author's designations were used for the study. Table 2 shows the items removed from the NICHQ for the alternative scoring. In total, 15 items were removed.

Language Measure

The Clinical Evaluation of Language Fundamentals–Fifth Edition (CELF-5; Wiig et al., 2013) was used as the omnibus language measure. Subtest scaled scores resulted in the Core Language score. Standardized administration and scoring procedures were followed, as outlined in the manual.

Fatigue Measure

The Pediatric Quality of Life Inventory: Multidimensional Fatigue Scale (PedsQL-MFS; Varni, 1998) was used to measure child- and parent-reported fatigue. The young child (5–7 years of age) and child (8–12 years of age) self-report forms were used. Each self-report form has 18 statements: six regarding general fatigue (e.g., "I feel tired."), six regarding sleep and rest fatigue (e.g., "I sleep a lot."), and six regarding cognitive fatigue (e.g., "It is hard for me to keep my attention on things."). These statements are rated from "never" or "not at all" to "always" or "a lot" with scores ranging from 0 to 4, respectively. These ratings are then converted to scores, with higher scores indicating lower levels of fatigue. Children under the age of 8 years were asked to respond by pointing to a visual to rate the statement (smiling face for "not at all," straight expression for "sometimes," and frowning face for "a lot"). Children over 8 years of age answered verbally. Parent report forms were also used, containing the same 18

Table 2. Items removed from National Institute for Children's Health Quality Vanderbilt Assessment Scales due to language bias.

Responder	Section	Language items
Parent	Inattention	• Does not pay attention to details or makes careless mistakes with, for example, homework • Has difficulty keeping attention to what needs to be done • Does not seem to listen when spoken to directly • Does not follow through when given directions and fails to finish activities (not due to refusal or failure to understand) • Has difficulty organizing tasks and activities • Avoids, dislikes, or does not want to start tasks that require ongoing mental effort • Is forgetful in daily activities
	Hyperactivity	• Talks too much • Blurts out answers before questions have been completed • Has difficulty waiting his or her turn • Interrupts or intrudes in on others' conversations and/or activities
	Academic performance	• Reading • Writing • Mathematics
	Social performance	• Relationship with peers • Participation in organized activities (e.g., teams)

statements and ratings (0 = *never* to 4 = *almost always*), and were read and answered by hand.

Results

Means and standard deviations for the NICHQ, CELF-5 Core Language score, and PedsQL-MFS overall fatigue score are all reported by group in Table 3. Upon overall descriptive review of NICHQ results, one child with TH and two children with HA met the diagnostic criteria for ADHD on the NICHQ (which is not an official diagnosis of ADHD and would need to be confirmed; the NICHQ is only a piece of an overall test battery, and additional information such as a teacher report is necessary for a diagnosis of ADHD). All 53 participants had complete NICHQ parent reports, 50 participants had complete CELF-5 assessments (those not completed were eliminated from the testing battery because the participant ran out of time in the battery or became noncompliant after participating in the large test battery), 43 had complete PedsQL-MFS self-reports (again, some were eliminated from the battery because the participant ran out of time), and 48 had complete PedsQL-MFS parent reports (five parents never turned in the form). Missing reports included the following: Two children with TH and one child with CI had a missing CELF-5 Core Language score; five children with TH, three children with CI, and two children with HA had missing PedsQL-MFS child reports; and three children with TH and two children with HA had missing PedsQL-MFS parent reports.

The first research question asked if parents identified a greater prevalence of ADHD behaviors in children who are DHH than in children with TH. Prior to conducting an analysis of variance (ANOVA), multiple assumptions were tested, and the dependent variables (Inattention subscale, Hyperactivity subscale, TSS subscale, and APS subscale) violated assumptions of normality and homogeneity of variances. To address these violated assumptions, nonparametric testing was conducted.

The Kruskal–Wallis one-way ANOVA was conducted with hearing status group (TH, HA, CI) as the independent variable and Inattention, Hyperactivity, TSS, and APS subscale scores as the dependent variables. There was a main effect of group on Inattention, $H(2) = 6.05$, $p =. 048$, with a small effect size ($\eta^2 = .04$); TSS, $H(2) = 6.24$, $p = .044$, with a small effect size ($\eta^2 = .05$); and APS, $H(2) = 8.1$, $p = .017$, with a moderate effect size ($\eta^2 = .08$). There was not a main effect of group on Hyperactivity, $H(2) = 2.59$, $p = .274$. Pairwise comparisons between hearing status groups with Bonferroni correction found a significant difference between CI and HA for the Inattention ($p = .044$) and TSS ($p = .048$) subscales. TH and HA were also significantly different for APS ($p = .02$).

Table 3. Descriptive information and assessments (means and standard deviations) by group.

Assessment	TH	HA	CI
Inattention (unaltered)	7.67 (6.13)	9.69 (5.71)	4.5 (3.08)
Hyperactivity (unaltered)	6.21 (6.14)	7.31 (6.51)	3.31 (2.33)
Total symptom score (unaltered)	23.13 (19.01)	25.69 (14.11)	12.25 (7.33)
Average performance score (unaltered)	1.88 (0.54)	2.45 (0.66)	1.95 (0.53)
Inattention (language-biased items removed)	1.96 (1.37)	2.54 (1.51)	1.25 (0.77)
Hyperactivity (language-biased items removed)	2.46 (3.23)	4.00 (4.22)	0.88 (0.81)
Total symptom score (language-biased items removed)	13.67 (11.62)	15.15 (8.66)	6.69 (4.48)
Average performance score (language-biased items removed)	1.67 (0.82)	1.81 (0.75)	1.56 (0.68)
CELF-5 Core Language score	114.82 (22.47)	95.38 (13.52)	96.93 (18.87)
PedsQL-MFS overall fatigue score: child self-report	64.83 (13.62)	62.9 (16.16)	59.3 (11.77)
PedsQL-MFS overall fatigue score: parent report	83.60 (15.29)	74.24 (13.01)	85.00 (12.65)

Note. Standard deviations in parentheses. TH = children with typical hearing; HA = children with hearing aids; CI = children with cochlear implants; CELF-5 = Clinical Evaluation of Language Fundamentals–Fifth Edition (Wiig et al., 2013); PedsQL-MFS = Pediatric Quality of Life Inventory: Multidimensional Fatigue Scale (Varni, 1998).

The second research question asked whether children who are DHH score differently than children with TH on the NICHQ measure when language-based items were removed. A Kruskal–Wallis one-way ANOVA was again conducted with hearing status group (TH, HA, CI) as the independent variable and the altered scores for the Inattention, Hyperactivity, TSS, and APS subscales as the dependent variables.

There was a main effect of group on Inattention, $H(2) = 7.11$, $p = .029$, with a small-to-moderate effect size ($\eta^2 = .06$), and TSS, $H(2) = 7.01$, $p = .03$, with a small-to-moderate effect size ($\eta^2 = .06$). There was no main effect of group on Hyperactivity, $H(2) = 4.03$, $p = .133$, or APS, $H(2) = 0.97$, $p = .62$. Pairwise comparisons between hearing status groups with Bonferroni correction found a significant difference between CI and HA for the Inattention ($p = .027$) and TSS ($p = .0035$) subscales.

The third research question asked whether there was a significant correlation in performance between the NICHQ subscales and omnibus language testing (CELF-5 Core Language standard score) or between the NICHQ subscales and fatigue assessments (child and parent reports). Prior to conducting a Pearson correlation analysis, multiple assumptions were tested, and the NICHQ scores violated normality assumptions. For this reason, correlation using Kendal's tau was used in the analysis.

Language

Core language scores were significantly negatively correlated with unaltered APS scores for all participants ($\tau_b = -.31$, $p = .002$), meaning lower CELF-5 scores correlated with higher reports of impaired academic and social performance. Language scores were not significantly correlated with any other NICHQ measure (both unaltered and altered). See Table 4 for all correlations with language.

Fatigue

First, correlations between NICHQ scores and PedsQL-MFS child self-report of overall fatigue were conducted. Self-report of fatigue was significantly negatively correlated with unaltered inattention scores ($\tau_b = -.334$, $p = .029$), unaltered APS scores ($\tau_b = -.42$, $p = .0005$), and altered inattention scores ($\tau_b = -.367$, $p = .015$). See Table 4 for all correlations with self-report of fatigue. A negative correlation indicates that children who reported more fatigue also presented with more behaviors associated with inattention and with impaired academic and social performance.

Next, correlations between NICHQ scores and PedsQL-MFS parent report of overall fatigue were

Table 4. Correlations between NICHQ and language and fatigue (Kendall's tau and *p* value).

Measure	Inattention (unaltered)	Hyperactivity (unaltered)	TSS (unaltered)	APS (unaltered)	Inattention (altered)	Hyperactivity (altered)	TSS (altered)	APS (altered)
CELF-5 Core Language	−.14 (.173)	−.05 (.595)	−.11 (.268)	−.31** (.002)	−.08 (.458)	−.05 (.654)	−.09 (.378)	−.07 (.509)
PedsQL-MFS child	−.25* (.022)	−.16 (.152)	−.18 (.095)	−.27* (.013)	−.25* (.033)	−.143 (.211)	−.15 (.160)	−.18 (.129)
PedsQL-MFS parent	−.47*** (< .001)	−.40*** (< .001)	−.49*** (< .001)	−.31** (.003)	−.425*** (< .001)	−.327** (.003)	−.48*** (<.001)	−.12 .267

Note. NICHQ = National Institute for Children's Health Quality Vanderbilt Assessment Scales (American Academy of Pediatrics et al., 2002); TSS = total symptom score; APS = average performance score; CELF-5 = Clinical Evaluation of Language Fundamentals–Fifth Edition (Wiig et al., 2013); PedsQL-MFS = Pediatric Quality of Life Inventory: Multidimensional Fatigue Scale (Varni, 1998).

**p* < .05. ***p* < .01. ****p* < .001.

conducted. Parent report of fatigue was significantly negatively correlated with all NICHQ measures except altered APS score. This negative correlation indicates that parents who reported more symptoms of fatigue in their children also reported more inattention and hyperactivity (even after language-based items were removed). See Table 4 for all correlations with self-report of fatigue.

Discussion

This study compared parent reports of ADHD-associated behaviors of children with HA, children with CI, and children with TH to determine if there were differences between groups and if these differences correlated with language skills and/or measures of fatigue. There was a significant effect of hearing status on the overall inattention ratings, TSS, and APS of the NICHQ. Analyses showed that children with CI had significantly lower ratings of inattention and overall symptoms than children with HA. In addition, children with HA had higher APS performance scores (i.e., greater levels of impaired academic/social performance) than children with TH, whereas children with CI did not. Thus, it appears that children with CI show fewer symptoms of inattention than children with HA. Although the overall group means (see Table 2) indicate that children with TH had inattention scores falling between the hearing loss groups, their scores were numerically more closely aligned with children with HA than children with CI. However, children with HA in this sample had more difficulty with academic and social performance than children with TH, and in this case, children with CI and children with TH had average performances and standard deviations that were more closely aligned. In other words, it appears children with CI had the fewest symptoms of inattention, and children with HA had the most difficulty with academic and social performance.

To address the role of language in perceived differences in inattention, hyperactivity, and performance, we (a) removed language-based items for the NICHQ to evaluate differences in performance and (b) considered how omnibus language scores correlated with NICHQ results. When language-biased items were removed from the NICHQ, the children with CI continued to have significantly lower inattention and total symptom scores than children with HA. However, APSs were no longer significantly different between the TH and HA groups. Standard scores (which are indexed to a child's age) on the CELF-5, an omnibus language measure, correlated with the APSs on the unaltered NICHQ, meaning lower language scores were associated with greater levels of impaired academic and social performance. With the removal of language-biased items on the NICHQ, there was no longer a correlation between omnibus language knowledge and score on the NICHQ. Thus, it appears that language items on the NICHQ did not drive the significantly lower performance of children with CI on this subscale. However, differences in language performance did relate to the language and social performance deficits of children with HA.

Fatigue was another hypothesized contributor to symptoms of inattention or hyperactivity that might be observed in children who are DHH. Both child and parent reports of fatigue, via the PedsQL-MFS measure, correlated with inattention and average performance scores. That is, when parents or children reported higher levels of child fatigue, those children tended to have higher levels of inattention and impaired social and academic performance. Both parent and child report of fatigue was no longer significantly correlated with social/academic performance once language-based items were removed. Only parent reports of fatigue also correlated with hyperactivity and total symptom scores, even once language-based items were removed from those scales. In other words, there appeared to be a relation between parent reports of fatigue and parent reports of inattention and hyperactivity and a relation between child reports of fatigue and parent reports related to inattention. Any fatigue correlations related to APS appeared to be influenced by language-based items.

There are many possible shared symptoms between ADHD and levels of substantial fatigue, such as inattention, hyperactivity, and depression, and ADHD severity has been found to significantly predict fatigue intensity in both children and adults with chronic fatigue syndrome (Sáez-Francàs et al., 2012). Children who are DHH already are at an increased risk for difficulties with academics, and the increased levels of listening fatigue put them at a further disadvantage (Bess et al., 2020; Fitzpatrick et al., 2019). Correlations between fatigue and symptoms of inattention and hyperactivity were significant and highlight a possible area of clinical concern: Parents may be inclined to interpret signs of fatigue as symptoms of ADHD. For children at risk for high levels of fatigue (like children who are DHH), this is an important distinction for accurate diagnosis.

The removal of language-biased items on the NICHQ did not support the authors' original hypotheses. Given the findings with children with DLD (Redmond & Ash, 2014), it was expected that, for both HA and CI, removal of language items would result in fewer reported inattentive and hyperactive behaviors. Instead, in our sample, children with CI scored very low compared to children with HA on the NICHQ measures of inattention, especially after the language-biased items were removed. In addition, children with CI had a very small range of scores, reflected by a small standard deviation. Language level did not provide an explanation for the performance of children with CI on the Inattention subscale.

In addition, fatigue levels did not provide an explanation for the lower performance of children with CI on the Inattention subscale (with or without language-based items removed). That is not to say that children with CI did not experience cognitive fatigue; numerically, children with CI had the lowest self-reported average on the PedsQL-MFS (indicating higher levels of fatigue when compared to children with HA and children with TH). Children with CI may experience fatigue differently than children with HA. The effort involved in listening through a CI (i.e., the focused attention expended by children with CI to cope with difficulties in listening) may be what drives fatigue, rather than fatigue causing inattention. A final possibility is that another unknown factor beyond fatigue or language level makes it appear that children with CI have few symptoms of inattention.

The NICHQ's correlation with language was only significant for APS before language-based items were removed. The APS measures potential impairment caused by the ADHD symptoms, including deficits in academic and social skills. Low APS ratings on the NICHQ translate to better academic and social skills. Higher language scores correlated with lower APS ratings on the NICHQ. Language is highly related to academic and social success for all children (Chow & Hollo, 2022; Chow & Wehby, 2018; Kaiser et al., 2022) and is especially true for the DHH (Nittrouer et al., 2018; Tomblin et al., 2020). The correlation of language scores with academic and social performance items on the NICHQ reflects this known relationship between language and academic and social skills. Language scores did not correlate with the other "symptom-based" items on the NICHQ.

On the unaltered NICHQ, children with HA scored significantly higher on reports of impaired social and academic performance than TH peers. Children with HA can have social and academic deficits when compared to their TH peers (Lund et al., 2022; Tomblin et al., 2020). The higher APS scores for children with HA reflect the parents' perception of these difficulties and, again, highlight a potential clinical issue. If parents are encouraged to consider an ADHD diagnosis for their child with HA, it is possible that a measure, like the NICHQ, would incline parents to attribute difficulties with academic and social skills to something other than the hearing loss. Future work may consider how language difficulties and fatigue manifest behaviorally for children with HA.

This study chose to explore the possibility of ADHD symptom reporting in children who are DHH who use spoken language relatively well, that is, children who did not have other diagnoses likely to limit their language growth and who did not have diagnosed ADHD at study entry (and would likely only have mild ADHD behaviors, if any). Average scores of children in the CI and HA groups on the CELF-5 were well within the range of normal but below those of peers with TH, meaning any language struggles of children with CI and HA were often somewhat subtle (e.g., Lund, 2020). It seems likely that subtle difficulties are those most likely to be misinterpreted. These subtle differences may not result in an ADHD referral or diagnosis, but they can cause problematic judgments of child behavior. An adult may confuse fatigue for inattention, and the actions taken to correct the inattentive behavior will be ineffective. It is important that adults working with children who are DHH be aware of the relation between behavior, language, and fatigue and not jump to conclusions about a secondary diagnosis.

Because the inclusionary criteria for this study involved diagnoses at study entry, it is also possible that children in the sample actually did have later-emerging ADHD as a diagnosis comorbid with hearing loss. In fact, there were two children with HA and one child with TH in this sample who met diagnostic criteria for ADHD concern using the unaltered NICHQ score. A closer analysis of the performance of these children may give us an insight about the possibility of true co-occurrence with ADHD. The child with TH had high ratings in all areas—inattention, hyperactivity, and APS. He also scored high on the questions screening for oppositional defiant disorder. With the removal of language-based items, he still had high scores in all areas that were well above group means. For this child with TH, the findings between altered and unaltered NICHQ were comparable, and diagnostic accuracy is suggested. For one child with HA who met diagnostic criteria for ADHD, reports of inattention and academic and social performance drove the NICHQ elevated scores. On the altered form of the NICHQ (where language-biased items were removed), her inattention score fell within the range of overall group means; however, APS ratings were still high. For this child, NICHQ performance appears to have been heavily linked to language skills and academic performance. We believe this child's profile reflects language difficulty. In this case, an ADHD diagnosis should proceed with caution (and be administered by individuals familiar with hearing loss). For the second child with HA, hyperactivity scores drove the NICHQ results that indicated impairment. Even with the removal of language items, this child's hyperactivity scores were still well above the group mean. For this child, it seems there is possible true co-occurrence of ADHD with hearing loss. Looking at these two children shows that to measure true co-occurrence, language bias in measurement should at least be considered.

Limitations and Future Directions

This work provides avenues for future study of the link between comorbid diagnosis of ADHD and hearing loss and for the link between behavior, language, and fatigue. A limitation of this study is that the average age of participants was 9.5 years. Only 50% of children who will be diagnosed with ADHD are diagnosed by the age of 7 years (Kessler et al., 2005). A large number of children demonstrate symptoms of ADHD-like behaviors as academic demands increase. Language difficulties can persist as a child who is DHH ages, impacting academic performance at the higher grades (Nittrouer et al., 2018; Tomblin et al., 2020). As academic and language demands increase, mild ADHD-like behaviors may worsen and could change the findings of the study. Future research might consider a similar study with children from a higher age range, including middle and high school. In addition, future work might expand the participant population to include children who do have more severe struggles with language and/or signs of ADHD at an early age.

Another limitation of this work is that this study focuses solely on parent report. Teachers are often the first to suggest a diagnosis of ADHD even before parents (Sax & Kautz, 2003). In addition, teacher reports have been found to be more sensitive to identifying hyperactivity than parent reports (Goodman et al., 2000). Overall, there are low rates of agreement between parent and teacher reports of ADHD (Wolraich et al., 2004). It would be beneficial to compare teacher reports of ADHD behaviors with parent reports for this population.

In this sample, ADHD behaviors (inattention and hyperactivity) correlated with reports of fatigue. In future research, exploration of other possible reasons for the ADHD behavior differences between children who are DHH and children with TH would be beneficial. A possible explanation of group differences identified in this study relates to how fatigue manifests behaviorally in children with CI versus children with HA. Another possible explanation for differences in behavior is executive functioning. Attention, which was measured in this study, underlies all executive functioning skills, serving as a gateway to more complex abilities (Garon et al., 2008). By definition, ADHD is an associated disorder of executive functioning (Barkley, 1997). In addition, executive functioning is influenced by early auditory and linguistic experience and activity, aiding the brain in development of sequencing, memory, attention, and inhibition (Conway et al., 2009; Kronenberger & Pisoni, 2018). Future research may further explore the executive functioning connection, by using measures such as the Flanker task for inhibitory control and attention or a behavior rating inventory looking at all executive functioning skills to determine how those skills relate to perceived symptoms of ADHD.

Conclusions

Overall, this study provides knowledge that there is a difference in the reporting of ADHD-like behaviors in some children who are DHH versus children with TH. Children who use HA have significantly more academic and social behaviors reported than children who use CI, and children who use CI score significantly lower on inattention behaviors. Removal of language-based items only substantially impacted group differences on academic and social behaviors (but not inattention). Omnibus language scores were significantly correlated with academic and social performance ratings, and fatigue scores, especially as reported by parents, significantly correlated with inattentive and hyperactive behaviors. It is important that parents and teachers of children who are DHH are mindful of these differences and the unique needs of their children.

Data Availability Statement

The data sets generated and/or analyzed during this study are available from the corresponding author on reasonable request.

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