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Disparate Oral and Written Language Abilities in Adolescents With Cochlear Implants: Evidence From Narrative Samples

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ABSTRACT

Purpose: In spite of improvements in language outcomes for children with hearing loss (HL) arising from cochlear implants (CIs), these children can falter when it comes to academic achievement, especially in higher grades. Given that writing becomes increasingly relevant to educational pursuits as children progress through school, this study explored the hypothesis that one challenge facing students with CIs may be written language.
Method: Participants were 98 eighth graders: 52 with normal hearing (NH) and 46 with severe-to-profound HL who used CIs. Oral and written narratives were elicited and analyzed for morphosyntactic complexity and global narrative features. Five additional measures were collected and analyzed as possible predictors of morphosyntactic complexity: Sentence Comprehension of Syntax, Grammaticality Judgment, Expressive Vocabulary, Forward Digit Span, and Phonological Awareness.
Results: For oral narratives, groups performed similarly on both morphosyntactic complexity and global narrative features; for written narratives, critical differences were observed. Compared with adolescents with NH, adolescents with CIs used fewer markers of morphosyntactic complexity and scored lower on several global narrative features in their written narratives. Adolescents with NH outperformed those with CIs on all potential predictor measures, except for Sentence Comprehension of Syntax. Moderately strong relationships were found between predictor variables and individual measures of morphosyntactic complexity, but no comprehensive pattern explained the results. Measures of morphosyntactic complexity and global narrative features were not well correlated, suggesting these measures are assessing separate underlying constructs.
Conclusions: Adolescents with CIs fail to show writing proficiency at high school entry equivalent to that of their peers with NH, which could constrain their academic achievement. Interventions for children with CIs need to target writing skills, and writing assessments should be incorporated into diagnostic assessments.
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Developments in cochlear implants (CIs) and early interventions over the previous 30 years have resulted in tremendous improvements to spoken language outcomes for young children with hearing loss (HL). Although CIs do not provide the exact properties of the acoustic signal accessed by children with normal hearing (NH), with appropriate early interventions, children with CIs can acquire early oral language skills that show little difference from those of children with NH (Boons et al., 2013a; Bradham et al., 2018; Leigh et al., 2013; Nittrouer et al., 2014). Nonetheless, there is some evidence to suggest that these early gains in language are not necessarily translating into comparable gains in academic achievement later in childhood (Marschark et al., 2007, 2015; Qi & Mitchell, 2012; Sarant et al., 2015). Possible reasons that have been

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examined for this continued academic curtailment include deficits in processing complex language structures (Geers & Hayes, 2011; Nittrouer & Lowenstein, 2021; Nittrouer et al., 2018; Smith et al., 2019), poor executive functioning (Arfé et al., 2014; Kronenberger et al., 2014; Pisoni & Kronenberger, 2021), and diminished sensitivity to phonological structure, as needed for processes such as verbal working memory and efficient lexical access (Bell et al., 2019; Lowenstein & Nittrouer, 2021; Nittrouer et al., 2017; Wang et al., 2021). The purpose of this study was to examine an additional skill that could account for some part of the continued limitations on academic performance by adolescents with HL who receive CIs but has received relatively little attention: the ability to write in a style and with sufficient sophistication to meet academic purposes.

Oral Language and Academic Achievement of Children With HL

Writing development depends upon and stems from initial oral language development (Ravid & Tolchinsky, 2002). The oral language development of children with HL has been studied for decades, and recent research has examined the impact of CIs on that development, with an emphasis on young children as they are leaving the intensive intervention of the preschool years and entering mainstream educational environments. Children with CIs who receive early intervention are demonstrating significantly better outcomes by the end of preschool compared with outcomes of children with HL prior to the availability of CIs (Boothroyd et al., 1991; Spencer et al., 2004; Svirsky et al., 2000; Tomblin et al., 1999), and these improvements appear to continue through elementary school. In standardized tests measuring general language abilities, as many as two thirds of children with CIs at late elementary school age can be found to perform within the normal range, defined as better than 1 *SD* below the normative mean (Boons et al., 2013a; Geers & Nicholas, 2013; Geers et al., 2016; Nittrouer et al., 2018). However, as encouraging as these outcomes are, available data suggest that academic achievement during the school years may not be benefitting greatly from these advances in general language performance.

To be sure, data are scant regarding academic performance in deaf children with CIs. In one study involving children who were recipients of the first generation of CIs, Spencer et al. (2004) assessed academic achievement for 15 high school students with CIs using the Woodcock-Johnson Tests of Achievement (Woodcock & Johnson, 1990). Those adolescents were found to perform close to the normative mean, which was taken as evidence that CIs can support improved academic performance in deaf children. However, other studies have not reached the same conclusion. In a review of outcomes from the Stanford Achievement Test, Qi and Mitchell (2012) found little improvement in the academic performance of school-age children with HL (8–18 years of age) over the 3 decades from 1974 to 2003. The samples of children included in that large-scale investigation were not restricted to those with CIs, but neither were children with CIs excluded from testing. Consequently, if the advent of CIs was associated with significant improvements in outcomes for children with HL overall, that effect should have been evident in these outcomes, but it was not. Findings similar to those of Qi and Mitchell were reported by Marschark et al. (2015), who evaluated approximately 500 adolescents with HL in high school for academic achievement using the Woodcock-Johnson III Tests of Achievement (Woodcock et al., 2001). Again, these investigators did not target children with CIs for their study, but neither did they exclude them. In fact, these authors specifically noted that having CIs was not associated with better outcomes on any of the four achievement measures examined: mathematics calculations, passage comprehension, science, and social studies. Results of this investigation were notable for two findings. First, mean achievement scores for the 500 adolescents with HL were well below 85 (−1.0 *SD*) on three of the four areas assessed; only mathematics calculations were within the normal range, with a mean standard score of 92.0. Second, academic performance was not strongly correlated with general language proficiency. So, even though neither Qi and Mitchell nor Marschark et al. focused their data collection on children with CIs, their outcomes reveal that children with HL still struggle academically. This study examined one potential source of these continuing academic challenges for students with HL, specifically those with CIs: the ability to write cohesive and grammatically sophisticated texts. This approach was predicated on the notion that writing becomes progressively more important as children proceed through school, but skills in this communication modality do not seem to be demonstrating the same improvements as oral language abilities for children with CIs.

Written Language Develops Its Own Style

In Ravid and Tolchinsky's (2002) model of linguistic literacy, acquiring proficiency in written language involves developing two distinct abilities: writing as a simple notation of oral language and writing as a separate discourse, with its own form and style. Initially, learning to write is mostly associated with learning written language as a notational system. At this early stage, written language is no more than a graphical representation of the child's oral language. However, even as young children are first discovering how to produce graphemes and make sound–symbol connections, they are developing some early genre distinctions associated with writing, as separate from oral language (Ravid & Tolchinsky, 2002). General language acquisition continues to influence writing acquisition throughout childhood, but with relative contributions from specific skills changing over the course of development and with diminishing weight overall. Furthermore, enhanced specificity in writing style leads to a "writing voice" that is generally distinct from one's style of oral language. Continued refinement of this writing voice is also spurred by academic requirements that increase in early adolescence, leading children at this age to consciously control their written language structures (Brimo & Hall-Mills, 2019). Mastery of an academic writing style becomes an important component of navigating the classroom. This academic writing is characterized by specialized vocabulary, abstraction, discourse-structuring devices, and density of information expressed through complex syntactic constructions and lexical precision (Barnes et al., 2016; Barr et al., 2019; Snow, 2010; Snow & Uccelli, 2009). Looking across studies, these characteristics can be seen to emerge over childhood. In a study by Scott and Windsor (2000), for example, morphosyntactic complexity did not differ between oral and written samples obtained from children with NH aged 8–11 years. In a later study, however, Galloway and Uccelli (2015) observed greater morphosyntactic complexity in the written samples of eighth graders, compared with their oral language samples.

With high school comes the emergence of even longer, more elaborate noun and verb phrases in writing (Berman, 2014). This opens up the use of complex language options that would be highly marked in oral language but are more common in written language because they help to communicate effectively in written academic registers. At some point along the way, the ongoing development of a writing voice comes to depend less on scaffolding from oral language and more on enhancement and manipulation of written language itself. The emergence of these written language skills are strongly associated with academic achievement through high school (Scott & Balthazar, 2010), especially as most assessments come to be administered through written formats.

Given the important role that writing ability plays in academic achievement, it is critical to have a sensitive and valid metric of writing proficiency. Investigators have employed various methods of measuring that proficiency, with different methods more or less suitable at different stages of development. For example, overall length of text rises sharply and then plateaus through the school years (Durrant et al., 2020), making it a less useful feature for tracking the ongoing writing development of adolescents. Instead, researchers tend to evaluate emerging skill with written language by increases in length of separate clauses or utterances (Scott & Windsor, 2000). C-units have commonly been used in language sampling research (e.g., Brimo & Hall-Mills, 2019; Nippold et al., 2017). C-units can be defined as an independent clause and all associated dependent clauses (Loban, 1976). They can also consist of sentence fragments under certain conditions, such as when the intonation contour indicates that a complete thought has been expressed. Thus, one C-unit would be "The girl, the boy, and the dog went to the lake." However, two C-units can be found in "The girl, the boy, and the dog/they went to the lake." Analyzing the composition of C-units supports examination of the syntactic development that occurs with increases in use of related functional lexical items such as subordinators, coordinators, and adverbs (Brimo & Hall-Mills, 2019).

A related skill that develops through adolescence involves the application of appropriate clause structures to various writing genres (Brimo & Hall-Mills, 2019; Nippold et al., 2008; Ravid & Tolchinsky, 2002). Skill with syntactic complexity in writing is not defined so much by a general ability to produce long clauses but rather by the metalinguistic insight needed to apply them appropriately across contexts (Durrant et al., 2020). For example, Berninger et al. (2011) showed evidence of increased use of subordinate clauses, particularly adverbial clauses, in narratives compared with nonnarratives in children's writing. In order to advance in writing skill and find a writing voice, a student must develop written genre and register conventions apart from their typical oral language use. An appraisal of developing writing proficiency then should include a genre-sensitive evaluation of natural language samples.

Written Language of Children With CIs

Spencer et al. (2003) highlighted the bifurcation in oral and written language that typically occurs across childhood as explanation for the opposing patterns of writing skill and language scores observed for children with NH and children with CIs (mean age of 9 years 10 months). In that study, no significant correlations were found between written language and standardized language measures for children with NH. This lack of correlation supports the proposal that written language eventually becomes a skill separate from oral language, at least for typically developing children. For children with CIs in that study, scores of written language proficiency were strongly related to standardized language measures, indicating that a separation of writing style from oral language abilities had not yet occurred. Written language was largely a transcription of their oral language.

In spite of that harbinger that something may be awry for children with CIs when it comes to writing development, research in this area has not kept up with research on the acquisition of other language skills. For example, Mayer and Trezek (2018) conducted a review of articles reporting reading or writing outcomes for children with CIs. These authors noted that, of the 21 articles meeting their review criteria, 18 of these focused on reading and only three focused on writing; of those three, two reported lower achievement in writing than in reading. One of those three studies was by Mayer et al. (2016) and showed that 56% of the 32 children with CIs who were tested (between 9 and 16 years of age) were below average in writing abilities; in comparison, these children largely performed at or above average on the other language and reading skills assessed.

A study not included in the Mayer and Trezek (2018) review involved 45 children with CIs in second to sixth grades (Wu et al., 2015). These authors found that the children with CIs exhibited poorer morphosyntactic complexity in their written narratives than their peers with NH. These children, however, all received their CIs after the age of 2 years (M = 4.1 years), which is late by many standards. Thus, investigation of children receiving CIs earlier in life is warranted. Although a subsequent study by Çizmeci and Çiprut (2018) did not involve children who received their CIs any earlier in life, it did examine both reading and writing skills in a group of 20 students with CIs in sixth to eighth grades. These investigators used standardized measures of reading and writing and observed that the children with CIs performed more poorly on both measures than their age-matched peers with NH; the effect size was larger, however, for the measure of writing than reading proficiency. Additionally, these investigators did not find any effect of age of receiving a first CI on writing scores.

Writing development in children with HL viewed more broadly can be understandably problematic. Beginning writers are translating from an oral to a written modality, so progress in writing depends almost entirely upon oral language representations at the outset (Mayer & Trezek, 2019; Ravid & Tolchinsky, 2002). As explained in Albertini and Schley (2003), children with HL may not be transcribing into written form, a linguistic system they know well, particularly when it comes to phonological representations. Degraded linguistic representations at this initial stage can have cascading effects on language and literacy. In particular, diminished phonological representations in children and adolescents with CIs have been found to contribute significantly to lower performance in some language processes, especially those that are important to learning (Geers & Hayes, 2011; Kronenberger & Pisoni, 2019; Lowenstein & Nittrouer, 2021). Furthermore, HL can impact working memory, which, in turn, can impact the writing system. Research by Arfé et al. (2014) showed that variability among children with HL in working memory (as measured by digit span tasks) correlated with differences in writing performance (as measured by a written narrative task). Working memory performance helped to explain variability in spelling, mistakes in verbal morphology such as noun–verb agreement, and composition of grammatically correct clauses. Arfé et al. argued that the ability to hold and refresh the phonological traces of words while writing contributed to fewer spelling errors for the "high" working memory group in their study, and rehearsal skills associated with working memory may explain the ability to maintain verbal information and appropriately link verbs with their arguments to assemble grammatically correct clauses.

The review of research reported in Mayer and Trezek (2018) showed better outcomes for reading than writing in children with CIs, although available outcomes for written language were sparse. In particular, fewer children with CIs were found to be performing at or above grade level in writing, compared with reading. A study by Geers and Hayes (2011) exemplifies this trend. These authors measured the reading abilities of adolescents with CIs and collected written expository essays from those same adolescents. When it came to reading, 47% or 66% (depending on the test used) of the adolescents with CIs were found to score within normal limits. When it came to the written essays, however, only 38% of those adolescents were within normal limits. Thus, looking across these reports, it appears that children with CIs are progressing relatively well in oral language development and even reading comprehension, but this is not the case for writing. As children with CIs become adolescents and are subjected to increasing academic demands, are they taking the next step in writing development? Or has the lack of access to phonological representations constrained their ability to develop the complex morphosyntactic structures and sensitivity to genre that characterize writing at adolescence? The study reported here addressed these questions.

Narratives as Familiar Genre

Many studies evaluating the natural language abilities of children with CIs have collected narrative samples (e.g., Arfé et al., 2014; Crosson & Geers, 2001; Huttunen & Ryder, 2012; Spencer et al., 2003; Tomblin et al., 1999), with good reason. Narratives provide useful material for examining productive language, because they are a form of extended discourse by a single talker; consequently, utterances cannot be partial reformulations of something a communication partner said, as can happen in conversations. To produce a narrative, the talker or writer must be able to integrate ideas, retain those ideas across a relatively long temporal span, and generate linguistic structure that is both locally correct and includes reference across the length of the narrative. Narratives are a genre familiar even to young children (Botting, 2002; Ravid & Tolchinsky, 2002). They are a good source of complex clauses caused by subordination (Berninger et al., 2011; Nippold et al., 2017). They are sensitive to language impairments in children (Botting, 2002; Fey et al., 2004; Gillam & Gillam, 2016). Students encounter this genre throughout their schooling, even in early elementary school years. Narratives as natural language samples provide a familiar genre for both researchers and participants—a genre that is readily analyzed for elements of morphosyntactic complexity and global narrative features, alike.

Crosson and Geers (2001) were the first to analyze oral narrative samples from children with CIs, and their results would foreshadow findings from future investigators examining narrative abilities in similar samples of children. Crosson and Geers analyzed narratives at two levels. First, they used a narrative structure scale to assess how well children could construct a story with a classic pattern of orienting the audience to the situation, describing complicated interactions, and finally reaching resolution. Next, they used a conjunction scale to assess how well children used linguistic devices such as conjunctions and subordinators to provide cohesion across their stories. Although scores for these scales were combined to create one narrative ability score, it was clear that, relative to children with NH, the children with CIs performed more poorly on the conjunction scale than on the narrative structure scale.

More recent analyses of narrative abilities by deaf children in general (Jones et al., 2016; Zamani et al., 2018) or by deaf children with CIs specifically (Boons et al., 2013b) describe these two levels of structure as macro- and microlevels, with the first term referring to the organization of the narrative at a global level and the latter term referring largely to constructions of individual sentences. Overall, deaf children—both those with CIs and those without CIs—demonstrated more typical skill with macrolevel structure than with microlevel structure. In this study, the term *morphosyntactic complexity* is largely synonymous with the microlevel of structure, and global narrative features refer to structures at the macrolevel.

The adolescents who served as subjects in this study had all been participants in a longitudinal study, and results from analyses of earlier oral narrative samples have been reported elsewhere (Lowenstein & Nittrouer, 2021; Nittrouer et al., 2012, 2017, 2018). In those analyses, morphosyntactic complexity was analyzed by transcribing the entire sample and submitting the first 100 utterances (i.e., C-units) to analysis using Systematic Analysis of Language Transcripts (SALT; Miller & Iglesias, 2010, 2016). Several morphosyntactic structures were analyzed, such as mean length of utterance (MLU) in morphemes, personal pronouns, and conjunctions. Global narrative features were analyzed by assessing the entire narrative using a scoring rubric with 12 categories, including features such as how well an introduction was constructed, how strong referencing was across the narrative, and how strong the conclusion was. Each feature was given a score between 0 and 3, making the maximum total score of 36. Although the procedure used for obtaining the narrative differed across test age, effect sizes between children with NH and those with CIs generally diminished as these children got older (to sixth grade) for both morphosyntactic complexity and global narrative features. Based on these developmental trends, it was predicted that the oral narratives of these children with CIs would continue to be progressively more similar to those of their peers with NH up to these eighth-grade samples.

Fewer investigators have analyzed written narrative samples from children with CIs. Spencer et al. (2003) collected written narrative samples as a measure of writing productivity and found that 9- to 10-year-old children with CIs produced shorter narratives overall, with shorter utterances, than their peers with NH. These narratives by children with CIs also contained fewer instances of several grammatical categories, including pronouns and adverbs, than those of children with NH. Zamani et al. (2018) compared oral and written narrative abilities for three groups of children: those with NH, those with HL who used hearing aids, and those with HL who used CIs. Children in that study were in fourth or fifth grade, so were similar in age to the subjects of Spencer et al. Assessments were performed at both the micro- and macrolevels. Children with HL, regardless of auditory prosthesis used, scored more poorly than children with NH on microlevel components but scored similarly on macrolevel components. None of the three groups showed differences in their performance on oral and written narratives, suggesting that none of them had yet developed a distinct writing voice. All those children, however, were still in elementary school. The emergence of a writing voice may only occur at older ages, which this study was in a position to assess with the participation of 14-year-old adolescents. It was anticipated that at least adolescents with NH would show greater morphosyntactic complexity for written than oral narratives, as is characteristic of a writing voice. We were unable to make predictions for adolescents with CIs due to the scarcity of relevant data.

This Study

Overall, the available data regarding writing skills in children with CIs reveal deficits but do not address whether writing skills are commensurate with oral language skills and whether children with CIs are moving past the early stage of writing, which primarily involves transcribing oral language to a written form. This study was able to address this gap in our collective knowledge by assessing differences in spoken and written language produced by adolescents with NH and those with CIs through elicited oral and written narratives. Narratives were collected and subsequently analyzed in two ways. First, they were transcribed according to conventions for SALT

(Miller & Iglesias, 2016), with the aim of testing predictions related to patterns of morphosyntactic complexity in oral and written language. Second, global narrative features were examined through a narrative scoring rubric. Both kinds of analyses were performed to determine if there are differences in morphosyntactic complexity or global narrative features attributable to group (CI vs. NH), modality (oral vs. written), or interactions across group and modality. Even as children with CIs close the gap with children with NH in oral language abilities, they may not be advancing past the early stage of written language during adolescence. Written narratives should feature more markers of morphosyntactic complexity as a reflection of writing style separating from oral language. If this developmental milestone is delayed in adolescents with CIs, they are expected to produce fewer features of morphosyntactic complexity than found in the written language of adolescents with NH. Additionally, global narrative features for written narratives should favor adolescents with NH, as they acquire the ability to construct a narrative that is cohesive and detailed across its entirety. If adolescents with CIs are struggling to develop a writing voice, this should be reflected in written narrative samples that are less cohesively developed, with fewer details. Overall, the patterns of similarity and difference in oral and written language between adolescents with NH and CIs will inform us about advanced language development in children with CIs. This language is essential to academic success.

Finally, we measured basic language (lexical and morphosyntactic) skills, working memory, and phonological awareness for these adolescents, largely using tests that would be part of assessment in a school setting. The goal of collecting these additional measures was to evaluate the extent to which such typically administered instruments might be predictive of the productive language capacities of adolescents with CIs, whether oral or written. To achieve this goal, these potentially predictive measures were correlated with measures of morphosyntactic complexity obtained from the narrative samples. Correlational analyses were not performed between these additional measures and the measures of global narrative features, because those additional measures largely assessed skill at the word or sentence level, and there was no expectation that measures of such basic language functions would inform metrics of broader productive language abilities, termed *global narrative features*.

Method

Participants

Data were collected for 103 adolescents: 52 with NH and 51 with CIs. It was determined, however, that collected natural language samples should consist of at least 10 C-units to be sufficient for analysis. For this reason, data were excluded from five adolescents with CIs (all male) because their writing samples consisted of fewer than 10 C-units. The resulting total sample sizes were 52 adolescents with NH (28 male) and 46 adolescents with CIs (18 male).

These participants were part of an ongoing longitudinal study on language acquisition and HL (e.g., Lowenstein & Nittrouer, 2021; Nittrouer, 2010; Nittrouer et al., 2017). All had been involved in the study since infancy and came from 17 cities and towns across the country. To be included in the study at the outset, children had to have had unremarkable births with no medical problem other than HL that would be expected to delay language acquisition on its own. English had to be the only language spoken to the child in the home. Parents had to have NH or hearing that was readily corrected to normal levels with hearing aids, if some HL was present. Intervention up to school age had to focus on spoken language, although it could include sign language as additional support. All parents confirmed that their goals for their children were that they could attend mainstream educational programs without the need for sign language interpreters, and all these children were in such programs from kindergarten until the time of this testing, at the end of eighth grade.

Demographic and audiometric data for these participants are provided in Table 1. Mean age at data collection was 14 years 4 months (SD = 5 months) for adolescents with NH and 14 years 7 months (SD = 5 months) for adolescents with CIs. This difference was statistically significant, $t = -2.863$, $p = .005$, showing that adolescents with CIs were, on average, a few months older than adolescents with NH. Because all participants had just completed eighth grade at the time of testing, this was not considered a problem. Moreover, if advanced age directly contributes to expression of syntactic development, then it would be

Table 1. Means, medians, and standard deviations for demographic and audiometric measures at eighth grade for adolescents with NH and adolescents with CIs.

	NH			CI		
Measure	*M*	*Mdn*	*SD*	*M*	*Mdn*	*SD*
Leiter brief IQ score	107	107	15	103	99	15
Socioeconomic status (out of 64)	36	36	14	33	35	10
Age at identification				6.0	3.0	6.8
Age at first implant				25	15	29
Age at second implant (n = 30)				52	45	34

Note. Age is given in months. NH = adolescents with normal hearing (n = 52); CIs = adolescents with cochlear implants (n = 46).

expected that the participants with CIs would have the advantage due to the age difference; however, this study predicted deficits for these adolescents.

All participants were given the Leiter International Performance Scale–Revised (Roid & Miller, 2002) to ensure that any group differences in narrative abilities were not a reflection of general differences in cognitive abilities. The strength of this assessment is that it is a nonverbal evaluation of cognitive ability, with no required verbal responses or instructions. Standard scores for the "brief IQ" are reported here, composed of results from four subtests: Figure-Ground Perception, Form Completion, Sequencing Abilities, and Repeated Patterns Recognition. Scores given in Table 1 show that the groups were similar in performance; the 4-point difference between groups was not statistically significant.

Participants in the two groups were similar in socioeconomic status (SES). This was assessed using a scale where occupation and highest educational attainment are ranked from 1 to 8—from lowest to highest. These scores are multiplied together, and the product serves as the SES index. An index was derived for each parent, and the highest value was used as the SES metric for the whole family (Nittrouer & Burton, 2005). SES scores in Table 1 indicate that the average participant had at least one parent with a 4-year university degree, and groups did not differ on SES.

At the time of testing, participants with NH all passed hearing screenings consisting of pure tones at octave frequencies between 0.25 and 8.0 kHz, presented at 20 dB HL to each ear separately. For participants with CIs, the mean aided four-frequency pure-tone average threshold was 17.4 dB HL (SD = 5.7 dB). Table 1 presents age of identification, age of first implant, and age of second implant for these participants. At the time of testing, 30 participants used two CIs, 13 used one CI, and three wore a CI on one ear and a hearing aid on the contralateral ear.

Information was collected from the parents of the adolescents with CIs regarding the interventions they were receiving in eighth grade. Of the 46 adolescents with CIs, 22 were receiving no specialized interventions. Nine of the other 24 adolescents with CIs were receiving academic tutoring only, and three were receiving services from a speech-language pathologist only. Twelve of the adolescents with CIs were receiving both academic tutoring and speech-language pathology services. For those adolescents receiving academic tutoring, a mean of 90 min per week was spent with their tutors. For those adolescents receiving speech-language pathology services, a mean of 30 min per week was spent with their clinicians.

Equipment

All testing was conducted in a soundproof booth. Oral narratives were audio- and video-recorded using a Sony HDR-XR550V video camera so that scoring could be done later. Participants wore Sony FM transmitters in specially designed vests. The FM receivers provided direct-line input to the video camera to ensure good sound quality on the recordings.

The materials for the Comprehensive Assessment of Spoken Language subtests (CASL; Carrow-Woolfolk, 1999), Sentence Comprehension of Syntax and Grammaticality Judgment, were video-recorded by a female speaker and presented in audio–video format on a computer, rather than by live voice as is typically done in a clinical setting. Materials for the two phonological awareness tasks were video-recorded by a male speaker and presented in audio–video format. Using a recorded presentation mode ensured consistency of materials across subjects and allowed subjects with CIs to utilize visual cues for recognition. All audio signals were presented with a Creative Labs Sound Blaster soundcard and a Roland MA-12C–powered speaker placed 1 m in front of the child at 0° azimuth. This system had a 44.1-kHz sampling rate and 16-bit digitization. Video was presented on a widescreen monitor at a rate of 1,500-kilobits per second. Presentation level was 68 dB SPL for all materials. Responses of participants to these tasks were recorded using the same equipment as that used to record oral narratives.

Digits in the digit span task were presented in audio-only format at 68 dB SPL using the same soundcard and speaker as that used for other tasks. The ability of each participant to recognize each digit was checked before testing. Custom-written software controlled the presentation of the recorded digits. After the presentation of each list of digits, numerals appeared at the top of a touchscreen monitor, and responses were collected by having participants touch these numerals in the order recalled.

Procedure

Procedures all met the approval of the institutional review board of the University of Florida. Data were collected as part of a broader data collection effort. All study participants traveled to Gainesville, Florida, for a day and a half of testing during the summer after completing eighth grade. They visited the laboratory in groups of four to six participants. Tasks were administered in sessions lasting no longer than 1 hr, with 1-hr breaks between each session. This schedule was facilitated by testing half of the participants while the other half were on break.

Undergraduate students and students in the master's degree program for speech-language pathology collected the data, under the supervision of the second and third authors. Before these students could conduct the summer testing, they spent the spring being trained and practicing with local adolescents whose data are not included in the analyses reported here. Each student tester had to practice with five local adolescents before being permitted to collect data from study participants.

Narrative Language Samples

Oral and written narratives were collected from the participants. Stimulus materials were sets of pictures from Fey et al. (2004). There were four sets, each containing three pictures. The first picture in each set included all characters and setting aspects, without presenting any problem or conflict for the characters. The next picture showed a main character in a scenario that was a problem. The third and final picture showed the main character, taking some action that could potentially serve as a solution to the problem presented in the previous picture but without presenting a clear resolution.

Oral narratives were collected first, but before the participants were tasked with providing their own narratives, the examiner used one of the model picture sets (Blackie's apples) to provide an example of how to do this. First, the examiner pointed out all of the important elements in each picture in the set to encourage the participant to consider all of the elements that could contribute to the narrative. Next, the examiner read the model narrative, using the same wording for all participants. Then, the participant was asked to retell the narrative presented by the examiner, including as many details as possible. After retelling the model narrative, participants were able to select a set of pictures for generating their own narratives. The examiner pointed out all of the important elements in the picture set that the participant selected. Participants were given up to 5 min to generate their narratives and then were audio- and video-recorded telling the narrative to the examiner. After completing those narratives based on standardized prompts, participants were asked to recall through extended narratives experiences of their own that were similar to those of the pictured stories they had selected as prompts. These additional, personal narratives ensured that a total of 20 min comprised all samples.

Written narratives were elicited from one of the two remaining picture sets that had not yet been chosen by the participant. Before the participant began writing a narrative, the examiner listed the important elements in the picture set that the participant selected. Written narratives were handwritten by each participant. No length limit was assigned to written narratives, but participants were encouraged to write at least one page. Collection of written narratives always followed elicitation of oral narratives, so the participants were familiar with the picture sets and the level of detail encouraged by the examiner. Oral and written narratives were later scored by laboratory staff in order to assess morphosyntactic complexity and global narrative features.

Potential Predictors

Five measures were obtained from participants and used as potential predictors of morphosyntactic complexity. These potential predictors were selected to assess morphosyntactic (grammatical) abilities, vocabulary, working memory, and phonological awareness. All assessments, except phonological awareness, were performed with standardized language measures. Phonological awareness was assessed with two tests that have been used extensively in the past and provide percent correct scores.

Sentence Comprehension of Syntax. Comprehension of syntactic structures was assessed through the Sentence Comprehension of Syntax subtest from the CASL (Carrow-Woolfolk, 1999). In this test, pairs of sentences that differ in syntactic structure are presented. Each of the 21 test items consists of two pairs of sentences (i.e., four sentences per item). The first sentence in each pair is the same, but the second sentences differ. After hearing a single pair of sentences the participant must indicate whether the sentences have the same meaning with a "yes" or "no" response. The participant must correctly respond to both pairs in an item to get credit for a correct item. Testing stops after five consecutive errors. This subtest is sensitive to comprehension of complex syntax, because the presented sentences typically differ in word order or clausal construction.

Grammaticality Judgment. The Grammaticality Judgment subtest from the CASL was administered. This test assesses syntactic competence but also includes measures of morphological abilities, especially as related to grammatical morphemes. In this task, participants are presented with single sentences and must state whether they are grammatically correct. If a sentence is judged to be grammatically incorrect, the participant must correct it by changing a single word in the presented sentence. Participants receive a point for accurately identifying a sentence as correct or incorrect, and a further point for providing a corrected version of an incorrect item. The test has 57 items (46 incorrect and 11 correct), making a total of 103 points. Testing is halted after errors on five consecutive items.

Expressive Vocabulary. The Expressive One-Word Picture Vocabulary Test–Fourth Edition (EOWPVT; Martin & Brownell, 2011) was administered to gauge expressive vocabulary. For this test, participants are shown a series of pictures that must be labeled with a single word. Testing stops after six consecutive errors.

Forward Digit Span. The Forward Digit Span test of the Wechsler Intelligence Scale for Children (Wechsler, 1991) was used as a measure of working memory. The test was presented through a computer program where recorded digits were presented auditorily. Then, the full set of digits was displayed on a touchscreen monitor. The participant tapped each digit in the order recalled. Each participant was given two practice sequences before testing commenced. The length of the longest digit sequence recalled correctly was used for analysis.

Phonological Awareness. Two tasks assessing phonological awareness were used in these analyses. First, participants were administered the Final Consonant Choice task (Nittrouer et al., 2013), in which they were presented with a target word that they needed to repeat. Then, they were presented with three words, and they needed to choose the one that ended in the same sound. Second, participants were administered the Backwards Words task (Nittrouer et al., 2016), in which they were presented with a target word that they needed to repeat. Then, they needed to produce that word with the order of phonemes reversed, which created another real word. Both tasks had 48 items, organized from easiest to hardest. The rule for discontinuation of testing was six consecutive errors. Scores from both tasks are percentage of correct words. Scores from the two tests were combined to form a composite score for Phonological Awareness.

Scoring and Analyses

Morphosyntactic Complexity

Two staff members transcribed each oral narrative sample, segmented the transcribed sample into C-units, and coded those C-units for analysis in SALT, excluding mazes (e.g., false starts, repetitions, reformulations, and hesitations). These staff members alternated roles as transcriber and segmenter/coder across samples, such that if one person transcribed a narrative sample, another person segmented the sample into separate C-units and coded them for SALT. In this way, the reliability of transcriptions was ensured. Written narratives were typed into transcripts with spelling and other errors preserved. Transcripts were then segmented into C-units and coded for SALT analysis, with spelling errors tagged in a way that would allow the intended words to be accurately counted by the software. The first and second authors checked SALT coding of all oral and written narratives to ensure all conventions were appropriately followed.

The number of C-units in oral and written narratives varied across participants, but written narratives were generally shorter. Therefore, counts of all measures were normalized to 50 C-units, using the following formula:

$$\text{Count}_{\text{normalized}} = (50/\text{Number of C-units}) \times \text{Count}_{\text{actual}}. \quad (1)$$

Using those normalized counts, the following seven measures of morphosyntactic complexity were analyzed.

MLU in both words (MLUw) and morphemes (MLUm) is a broad measure of morphosyntactic complexity that is sensitive to syntactic growth, even into adulthood (Nippold et al., 2005). Both MLUw and MLUm are frequently used in language development research, and the two measures are well correlated (Parker & Brorson, 2005). MLUm was used here because prior studies have shown it may be more sensitive in assessing and predicting the language development of adolescents with HL (Nittrouer, 2010; Nittrouer et al., 2012, 2014). Future references to MLU are understood to mean MLUm.

Pronouns index abilities related to morphology and agreement in utterances. Several categories of pronoun are counted in the SALT analysis, including personal, possessive, reflexive, relative, and demonstrative pronouns. They provide cohesion across narratives and are needed to maintain reference. Some types of pronouns are particularly sensitive to morphosyntactic knowledge due to properties such as case.

Adjectives may serve to lengthen clauses and contribute to morphosyntactic complexity (Beers & Nagy, 2011). Adjectives contribute to the formation of complex noun phrases, a morphosyntactic skill that continues to develop in writing through adolescence (Ravid & Berman, 2010). They also function as a measure of lexical sophistication that provides additional detail in narratives.

Conjunctions, like pronouns, can function as cohesive devices. Conjunctions lengthen utterances and provide opportunities for increased syntactic complexity. In the sixth-grade morphosyntactic analysis conducted by Nittrouer et al. (2018), number of conjunctions also correlated with MLU, a widely used measure of syntactic growth.

Adverbs index more sophisticated and descriptive lexical choices. They also mark greater syntactic complexity and clausal density through adverbial clauses, the most common type of subordinate clause in corpus research on writing samples conducted in Durrant et al. (2020).

Subordinators index subordinate clauses that greatly contribute to increased clausal density and are a common source of complex clauses in narratives (Berninger et al., 2011). Subordination, along with MLU, is commonly included in research measuring morphosyntactic complexity and development. Development of a writing voice for academic purposes would have to include a practiced use of subordinators.

Modal auxiliaries occur in passive constructions and syntactically express concepts important to academic writing, such as possibility and expectation, making them another potential measure of morphosyntactic complexity.

Predictor Variables

The Sentence Comprehension of Syntax, Grammaticality Judgment, Expressive Vocabulary, and Phonological Awareness tasks were all scored by the experimenter at the time of data collection. Subsequently, another laboratory staff member reviewed recordings of the data collection to assess the accuracy of the original experimenter's scoring. This staff member could review the audio/video recordings and correct any discrepancies between responses and scores. The Forward Digit Span task was scored by the computer program, so it required no review.

Global Narrative Features

In addition to analysis through SALT, oral and written narrative transcripts were scored by staff in 12 categories following the rubric used in Nittrouer et al. (2017), modified slightly to make allowances for increased age. Scoring categories reflected criteria for well-formed narratives, both for story elements (such as plot and characters) and structural considerations (such as tense and reference), collectively referred to as *global narrative features*. Although it might seem at first glance that some of these features reflect local structure—such as tense—that is not the case. For example, the global feature of tense refers to how well the participant could maintain tense across the entirety of the sample, changing it when appropriate.

Each of the 12 categories could receive 0–3 points, leading to a possible maximum score of 36. The same rubric was used for oral and written narratives. This allowed for a more qualitative comparison of higher order oral and written narrative abilities between adolescents with CIs and adolescents with NH. Details of the categories and scoring rubric are provided in Supplemental Material S1. Two staff members performed this rubric scoring independently, and scores were compared. If the total score across categories differed by more than 2 points, staff members reviewed the transcript together, resolving discrepancies. Otherwise the scores of Scorer 1 were used for analyses. Results for separate scoring categories and for the total score were analyzed.

Results

Analyses were conducted using SPSS Version 25. Data collected for all measures were first evaluated for normal distributions and homogeneity of variances; all measures met these assumptions. An alpha level of .05 was established, but p values are reported here when $p < .10$; when $p > .10$, results are reported as *not significant*. First, results of the morphosyntactic analysis are presented, followed by results for the predictor variables. Associations among those predictor variables and scores of morphosyntactic complexity are presented. These analyses allowed us to assess the extent to which standardized measures can evaluate morphosyntactic complexity in language generated by adolescents—either with NH or with CIs. Then, results for global narrative features are presented, and those scores are correlated with the measures of morphosyntactic complexity to see if both kinds of scores are assessing the same underlying constructs. Finally, demographic and audiometric factors are examined in relation to significant findings.

Samples of oral and written narratives are provided in Supplemental Material S2, one of each from an adolescent with NH and an adolescent with CIs. These adolescents received similar scores for their oral narratives, but the adolescent with NH received a higher score for the written narrative, whereas the adolescent with CIs received a poorer score. This was typical for these participants.

Morphosyntactic Complexity in Narratives

Appendix A provides means and standard deviations for all seven measures of morphosyntactic complexity, for both groups, across oral and written narratives. Potential group differences for the seven measures of morphosyntactic complexity were analyzed using t tests, and outcomes are presented in Table 2. The NH and CI groups patterned closely to each other for oral narratives, as seen in the left half of Table 2; no significant differences were found between groups. This outcome met our prediction for these children with CIs. Differences in scores between groups for both morphosyntactic complexity and global narrative features had been diminishing in magnitude across the elementary grades, so we had anticipated that the children with CIs would "catch up" to children with NH in their abilities to construct oral narratives. That is indeed what we found in these measures of morphosyntactic complexity.

Table 2. Statistical outcomes for measures of morphosyntactic complexity in oral and written narratives, comparing adolescents with normal hearing and those with cochlear implants.

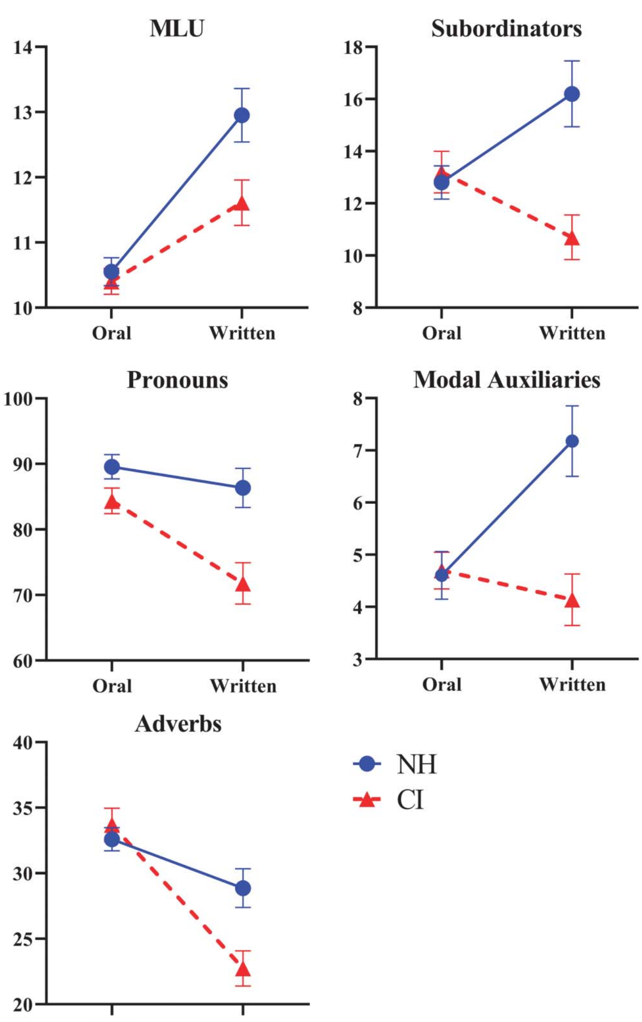
	Oral			Written		
Measure	***t***	***p***	**Cohen's *d***	***t***	***p***	**Cohen's *d***
MLU	NS	NS	—	2.454	.016	0.50
Pronouns	1.940	.055	—	3.360	.001	0.68
Adjectives	NS	NS	—	NS	NS	—
Conjunctions	1.967	.052	—	NS	NS	—
Adverbs	NS	NS	—	3.040	.003	0.62
Subordinators	NS	NS	—	3.525	.001	0.72
Modal auxiliaries	NS	NS	—	3.552	.001	0.73

Note. Degrees of freedom are 96 for all tests. Em dashes indicate that effect size was not calculated for nonsignificant p values. MLU = mean length of utterance; NS = not significant.

Differences between the two groups, however, were observed for the written narratives. The right half of Table 2 shows statistical results for the measures of morphosyntactic complexity for written narratives. Adolescents with NH had a longer mean MLU and used more pronouns, adverbs, subordinators, and modal auxiliaries than did the adolescents with CIs. The largest effect sizes were found for subordinators and modal auxiliaries. Only the measures of adjectives and conjunctions failed to show differences between these groups.

Figure 1 presents mean category counts for the five measures of morphosyntactic complexity that showed significant differences between adolescents with NH and CIs in written narratives, for both oral and written narratives: MLU, pronouns, adverbs, subordinators, and modal auxiliaries.

Figure 1. Mean counts with standard errors of the mean for the five measures of morphosyntactic complexity with significant group differences in the written modality. MLU = mean length of utterance in morphemes; NH = adolescents with normal hearing; CI = adolescents with cochlear implants.



When examining Figure 1, it appears that adolescents with CIs fall behind their peers with NH in their ability to represent morphosyntactic complexity in writing. Both groups displayed similar use of morphosyntactic structures in oral narratives, but adolescents with NH produced longer utterances with more subordinators and modal auxiliaries in written narratives. Although adolescents with CIs showed increased MLU for written over oral narratives, they produced fewer subordinators and modal auxiliaries in their written narratives, compared with their oral narratives. Adverb use decreased from oral to written narratives for both groups, but this decrease was greater for adolescents with CIs. Where pronoun use was relatively unchanged for adolescents with NH across modalities, it decreased for written, compared with oral, narratives produced by adolescents with CIs.

To examine the effects of modality and group on these results, a two-way, repeated-measures analysis of variance (ANOVA) was performed for each of the measures of morphosyntactic complexity where there was a significant group difference for written narratives, with the modality (oral or written) serving as the repeated measure and group (NH or CI) serving as the between-groups factor. These results are presented in Table 3. The most significant finding of these analyses is that the interaction of Modality × Group was significant for every measure. This finding reinforces the observation that adolescents with CIs did not produce morphosyntactic complexity in a similar pattern as adolescents with NH in written narratives, even

Table 3. Outcomes of two-way, repeated-measures analyses of variance performed on measures of morphosyntactic complexity.

Effect	*F*	*p*	η_p^2
MLU			
Modality	44.845	< .001	.318
Group	4.645	.034	.046
Modality × Group	4.893	.029	.048
Pronouns			
Modality	12.138	.001	.112
Group	12.464	.001	.115
Modality × Group	4.260	.042	.042
Adverbs			
Modality	32.268	< .001	.274
Group	3.717	.057	—
Modality × Group	8.766	.004	.084
Subordinators			
Modality	NS	NS	—
Group	6.742	.011	.066
Modality × Group	11.452	.001	.107
Modal auxiliaries			
Modality	3.739	.056	—
Group	8.091	.005	.078
Modality × Group	9.035	.003	.086

Note. Degrees of freedom are 1, 96 for all effects. Em dashes indicate that effect size was not calculated for nonsignificant *p* values. MLU = mean length of utterance. NS = not significant.

Table 4. Statistical outcomes for measures of language and working memory comparing adolescents with normal hearing (n = 52) and those with cochlear implants (n = 46).

Measure	NH *M*	NH *SD*	CI *M*	CI *SD*	*t*	*p*	Cohen's *d*
Sentence Comprehension	106.9	12.6	101.5	16.2	1.832	.070	—
Grammaticality Judgment	100.5	10.9	88.3	16.5	4.356	< .001	0.87
Expressive Vocabulary	113.3	15.2	101.8	17.8	3.443	.001	0.69
Forward Digit Span	6.5	1.3	5.5	1.0	4.310	< .001	0.88
Phonological Awareness	82.5	11.5	67.5	20.5	4.540	< .001	0.90

Note. Standard scores are shown for Sentence Comprehension, Grammaticality Judgment, and Expressive Vocabulary. Span length is shown for Forward Digit Span. The mean percent correct score across the measures of Final Consonant Choice and Backwards Words is shown for Phonological Awareness. Degrees of freedom are 96 for all tests. Em dashes indicate that effect size was not calculated for non-significant *p* values.

though they show no significant differences in their presentations of oral narratives. Even when both groups increased or decreased their use of a morphosyntactic structure across modalities, as with MLU and adverbs, adolescents with CIs always produced fewer structures associated with morphosyntactic complexity than did adolescents with NH.

Potential Predictor Variables

Means, standard deviations, and statistical outcomes for both NH and CI groups on the five measures of language ability, working memory, and phonological awareness are shown in Table 4. Adolescents with NH outperformed adolescents with CIs in all measures, except for sentence comprehension. The smallest effect size was found for expressive vocabulary; effect sizes were similar for the other three predictor variables.

Pearson product–moment correlation coefficients were computed between these predictor variables and the measures of morphosyntactic complexity, for each group separately. These correlation coefficients are shown in Tables 5 (oral) and 6 (written). In each table, correlation coefficients for adolescents with NH are in the top row, and those for adolescents with CIs are in the bottom row. For both oral and written narratives, there were several correlations between the measures of morphosyntactic complexity and the standard measures of language ability, working memory, or phonological awareness, although none rose above .500, indicating only modest correlations.

In oral narratives (see Table 5), performance on the EOWPVT showed a significant correlation with four of the seven categories of morphosyntactic complexity for adolescents with NH; the composite measure of phonological awareness showed significant correlations with the same four categories for those adolescents with NH. For adolescents with CIs, however, no language measure correlated with more than one category of morphosyntactic complexity for these oral narratives. This finding means that it would be difficult to assess the abilities of these adolescents to use complex morphosyntax in the generation of oral narratives with these measures of basic

Table 5. Correlation coefficients for predictor measures and morphosyntactic measures from oral narratives.

Measure	MLU	Pronouns	Adjectives	Conjunctions	Adverbs	Subordinators	Modal
Sentence Comprehension	**.315***	.252	.121	.168	.138	.269	−.024
	.281	.131	.093	−.134	.095	.235	.118
Grammaticality Judgment	.214	.181	.164	.155	.208	.240	.032
	.257	.235	.186	.027	.000	.142	**.299***
EOWPVT	**.386****	**.323***	**.281***	.035	.068	**.391****	.229
	.344*	.186	.110	.008	.180	.239	.281
Forward Digit Span	.103	.028	.260	−.036	.051	.103	−.115
	.111	.140	**.339***	.110	−.025	.093	.244
Phonological Awareness	**.294***	**.289***	**.313***	.176	.197	**.366****	.109
	.185	.084	.154	.011	−.075	.063	**.351***

Note. The top row shows data for adolescents with normal hearing, whereas the bottom row shows data for adolescents with cochlear implants. Significant correlations are indicated by bold text. MLU = mean length of utterance; EOWPVT = Expressive One-Word Picture Vocabulary Test.

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

Table 6. Correlation coefficients for predictor measures and morphosyntactic measures from written narratives.

Measure	MLU	Pronouns	Adjectives	Conjunctions	Adverbs	Subordinators	Modal auxiliaries
Sentence Comprehension	–.012 .137	.179 .179	–.113 –.072	–.094 –.042	.163 .126	.111 –.023	–.085 .162
Grammaticality Judgment	.175 .262	.175 **.493****	.073 .012	.036 –.052	**.279*** .140	.086 **.352***	–.208 **.456****
EOWPVT	.011 .162	.084 .246	–.036 .124	–.028 –.007	–.029 .002	.037 .170	**–.305*** **.321***
Forward Digit Span	.099 .115	.168 .175	–.064 –.171	–.055 –.080	.227 .153	–.090 .051	–.210 .227
Phonological Awareness	.180 .097	.206 **.294***	–.034 –.018	.009 –.117	**.335*** .183	.163 .109	–.123 **.361***

Note. The top row shows data for adolescents with normal hearing, whereas the bottom row shows data for adolescents with cochlear implants. Significant correlations are indicated by bold text. MLU = mean length of utterance; EOWPVT = Expressive One-Word Picture Vocabulary Test.

$^{*}p < .05$; $^{**}p < .01$.

language abilities, working memory, and phonological awareness.

In written narratives (see Table 6), significant correlations between these predictor variables and categories of morphosyntactic complexity were even sparser, for both adolescents with NH and those with CIs. None of the predictor variables appear to hold significant explanatory power for within-group variability in scores of morphosyntactic complexity.

Global Narrative Features

Means and standard deviations for all 12 global narrative features and their totals, for both groups and across oral and written modalities, are presented in Appendix B. As with the measures of morphosyntactic complexity, potential differences between groups were analyzed using *t* tests. Both groups patterned similarly to each other for oral narratives. Total scores did not display a group difference. In fact, the only global narrative feature that produced significantly different scores in oral narratives was the vocabulary feature ($t = 2.047$, $p = .043$). The finding of essentially no differences in oral narratives across groups reinforces the results of the analysis of morphosyntactic complexity: Adolescents with NH and with CIs produced similar oral narratives in terms of morphosyntactic complexity and global narrative features.

Global narrative features for written narratives, however, revealed some significant differences between groups. Table 7 shows detailed statistical results for any category with $p < .10$ for group differences, including effect sizes given as Cohen's *d*. Five results were significantly different between groups: total score, referencing, details, tense, and cohesion. Adolescents with CIs scored lower than adolescents with NH in all five significant results, and these patterns reinforce those seen in the analysis of morphosyntactic complexity.

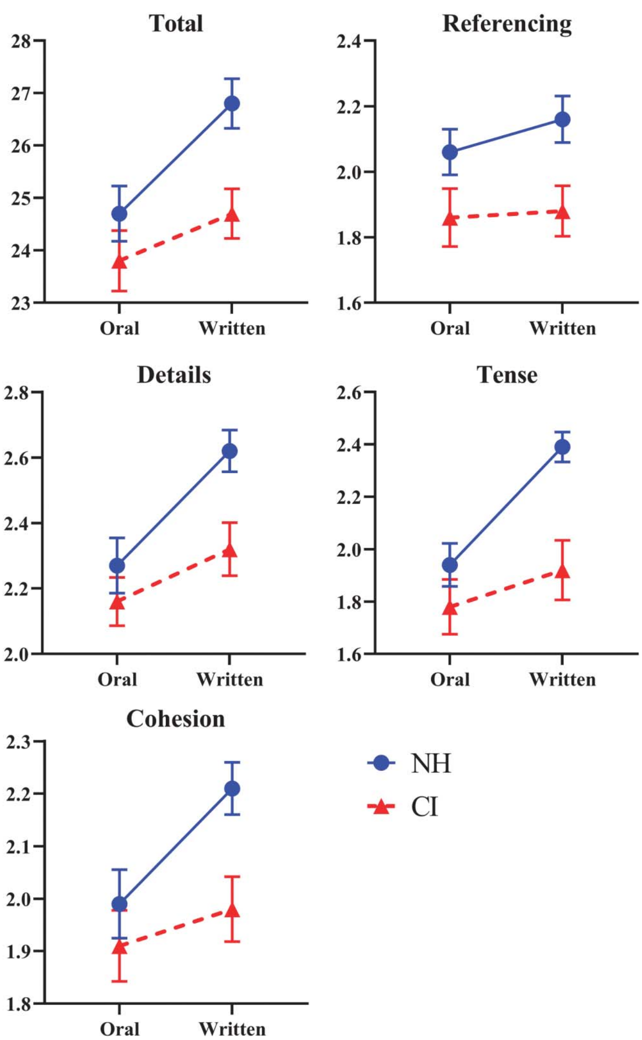
Figure 2 displays group means for these four global narrative features and the total scores, for each group and across oral and written narratives. Table 8 shows outcomes of a two-way, repeated-measures ANOVA performed on these scores, using modality as the repeated measure and group as the between-subjects measure. Figure 2 reveals a pattern that differs from that seen in Figure 1: Whereas for the measures of morphosyntactic complexity, adolescents with CIs showed different outcomes across modality than

Table 7. Statistical outcomes for global narrative features that were significantly different between groups for written narratives.

	NH		CI				
Measure	*M*	*SD*	*M*	*SD*	*t*	*p*	Cohen's *d*
Total score	26.8	3.4	24.7	3.2	3.199	.002	.65
Referencing	2.16	0.51	1.88	0.52	2.716	.008	.55
Details	2.62	0.46	2.32	0.55	2.936	.004	.59
Tense	2.39	0.41	1.92	0.77	3.813	< .001	.76
Cohesion	2.21	0.36	1.98	0.42	2.950	.004	.60

Note. NH = adolescents with normal hearing ($n = 52$); CI = adolescents with cochlear implants ($n = 46$). Degrees of freedom are 96 for all tests.

Figure 2. Mean counts with standard errors of the mean for total score and the four global narrative features with significant group differences in the written modality. NH = adolescents with normal hearing; CI = adolescents with cochlear implants.



peers with NH (i.e., significant interactions), for these global narrative features, the adolescents with CIs patterned similarly to adolescents with NH, but consistently received lower scores. This trend manifested as significant group effects, but a lack of significant interaction terms in the ANOVA outcomes.

Pearson product–moment correlation coefficients were computed between the global narrative features and the morphosyntactic complexity categories that showed group differences in the written narratives for each group separately. This was done to see if global features in the written language of these adolescents are related to style at the more local or sentence level. Correlation coefficients are presented in Table 9 for adolescents with CIs. Correlation coefficients are not shown for the adolescents with NH, because only one was significant: the referencing

Table 8. Outcomes of two-way, repeated-measures analyses of variance performed on measures of global narrative features.

Effect	*F*	*p*	η_p^2
Total			
Modality	12.177	.001	.113
Group	6.713	.011	.065
Modality × Group	NS	NS	—
Referencing			
Modality	NS	NS	—
Group	9.138	.003	.087
Modality × Group	NS	NS	—
Details			
Modality	16.072	< .001	.143
Group	5.353	.023	.053
Modality × Group	NS	NS	—
Tense			
Modality	19.889	< .001	.172
Group	8.368	.005	.080
Modality × Group	5.453	.022	.054
Cohesion			
Modality	6.624	.012	.065
Group	5.372	.023	.053
Modality × Group	NS	NS	—

Note. Degrees of freedom are 1, 96 for all effects. Em dashes indicate that effect size was not calculated for nonsignificant p values. NS = not significant.

feature and adverbs, $r = .326$, $p = 0.018$. Table 9 shows that, for adolescents with CIs, there were several significant correlations between individual measures of morphosyntactic complexity and global narrative features in written narratives, but no correlation coefficients reached .500. Pronouns showed the greatest number of significant correlations with global narrative features (four out of five). Pronouns not only maintain reference throughout narratives, they also act as cohesive devices, and they may relate to the maintenance of narrative tense because the use of some pronouns is especially sensitive to morphosyntactic knowledge, such as case. Modal auxiliaries correlated with three categories of global narrative features. The highest correlation coefficient was with tense, and this may be explained by the fact that achieving the highest tense score required at least one change of narrative tense, which could be accomplished through conditional or other tenses that employ modal auxiliaries.

Overall, however, these measures of global narrative features—a metric of macrostructure—showed little relationship to the measures of morphosyntactic complexity—a metric of microstructure. This outcome suggests that each kind of analysis assesses a separate aspect of narrative ability. Thus, both kinds of analysis need to be performed when evaluating students' writing so that a thorough understanding of their strengths and weaknesses can be obtained.

Demographic and Audiometric Factors

Finally, measures of morphosyntactic complexity and global narrative features showing significant group

Table 9. Correlation coefficients for morphosyntactic measures and global narrative features that were significantly different between groups. Data from written narratives of adolescents with cochlear implants only.

Measure	Total score	Referencing	Details	Tense	Cohesion
MLU	.274	.046	.190	.274	**.291***
Pronouns	**.475****	.084	**.440****	**.342***	**.483****
Adverbs	.200	.053	.036	.258	.127
Subordinators	**.339***	.199	.149	.122	**.357***
Modal auxiliaries	**.425****	.108	.258	**.455****	**.405****

Note. Significant correlations are indicated by bold text. MLU = mean length of utterance.
$^{*}p < .05$. $^{**}p < .01$.

differences (in written narratives) were analyzed for potential relationships with demographic or audiometric factors, for each group separately. These factors included SES, brief IQ, gender, age of first implant, and whether a child had one or two CIs. The factors of SES, brief IQ, and age of first implant were examined as continuous variables using Pearson product–moment correlation analyses. The factors of gender and number of CIs were examined as categorical variables using *t* tests. Scores from neither group showed any significant relationship to SES, brief IQ, or gender, but it is noteworthy that extreme variability did not exist for either SES or brief IQ. For the adolescents with CIs, no significant correlation was found for age of first CI, and *t* tests for number of CIs showed no significant differences as a function of adolescents having one or two CIs.

Discussion

The goal of this study was to examine the written language abilities of adolescents with CIs, compare those abilities to their oral language abilities, and determine if their written language is developing a distinct style, as happens for children with NH. A distinct written language style would take the form of more complex morphosyntactic structures at the single utterance level and more sophisticated and comprehensive features being maintained across the entirety of the narrative. These enhancements in writing style begin to be necessary in adolescence in order to effectively engage in the increasingly academic environment of school. However, writing development, particularly as it relates to complex language development, has been scarcely studied in children with CIs. Moreover, children and adolescents with HL continue to perform below their peers academically, despite gains in oral language development brought about by the availability of CIs. The analyses reported here addressed research questions related to differences between groups in the production of morphosyntactic complexity and global narrative features in oral and written narratives and how differences might be attributable to hearing status; to modality (oral or written); or to general language abilities, working memory, or phonological awareness.

Morphosyntactic Complexity

Analyses of the oral narratives showed similar morphosyntactic structures for samples from adolescents with NH and those with CIs, but analyses of written samples revealed significant differences. Adolescents with NH adjusted their written narratives to contain longer C-units with more subordinators and modal auxiliaries, whereas adolescents with CIs showed a smaller increase in MLU in the written narratives and actually produced fewer pronouns, adverbs, and subordinators compared with their oral narratives. Thus, both groups produced written narratives that were unlike their oral narratives in terms of these morphosyntactic markers, but each group did so in a different manner. The written narratives of the adolescents with CIs unambiguously contained fewer markers of morphosyntactic complexity, whereas those of the adolescents with NH contained more of such markers, compared with their oral narratives.

We had predicted that the oral narratives of the adolescents with CIs might resemble those of their peers with NH at this age, reflecting gains in oral narrative abilities for adolescents with CIs from younger ages. And that is what was found. The children with CIs in this study had continued to lag behind their peers with NH in morphosyntactic complexity in oral narratives at sixth grade (Nittrouer et al., 2018), but those differences evaporated by the end of eighth grade, as measured in this study. It was less clear what we might expect concerning written narrative abilities of adolescents with CIs, given that these abilities have been so sparsely studied. Based on their findings, Spencer et al. (2003) had suggested that differences in writing between children with NH and those with CIs stem from a separation of oral and written language abilities on the part of children with NH, but not children with CIs. This kind of separation is a normal part of the development of writing under the framework of linguistic literacy from Ravid and Tolchinsky (2002). Indeed, the adolescents with NH in our study produced written narratives that differed from their oral narratives in a way that was compatible with this interpretation: They did not increase their use of morphosyntactic complexity indiscriminately but selectively showing increases for MLU, subordinators, and modal auxiliaries.

The adolescents with CIs demonstrated a different pattern of modality-specific outcomes. The most important outcome where these adolescents are concerned might be that they were not simply transcribing their oral language into written form. If these adolescents were still strictly reliant on their oral language scripts, we would have expected to see written narratives that echoed their use of morphosyntax in their oral narratives, but this was not the case in our results. In terms of morphosyntactic structure, adolescents with CIs produced written narratives that were not only less complex than the written narratives produced by adolescents with NH but also less complex in several dimensions than their own oral narratives. This finding suggests a distinct written language deficit. Also, although narratives served as the only genre examined in this study, deficits in written morphosyntactic complexity might exist in all academic language for these adolescents with CIs, including genres such as expository essays. Writing development requires improvement in the command of written language, which is largely reflected by the increasing use of more complex and varied morphosyntactic forms. A study by Beers and Nagy (2011), however, emphasizes the need for understanding which specific forms are appropriate for each discourse genre, including academic genres.

This study sought to examine whether standardized language measures can predict morphosyntactic complexity in written language for the adolescents with either NH or CIs. The two groups differed in their performance on standard predictor measures, where the adolescents with CIs performed below those with NH in the Grammaticality Judgment subtest of CASL, Expressive Vocabulary, Forward Digit Span, and a composite Phonological Awareness measure. As with Spencer et al. (2003), the morphosyntactic structures produced by adolescents with NH in their written narratives did not display any pattern of correlation with these standard general language measures, once again pointing to a separation of their written language from their oral language. For adolescents with CIs, moderate correlations were found between scores on the Grammaticality Judgment subtest and three measures of morphosyntactic complexity: pronouns, subordinators, and modal auxiliaries. Furthermore, the measure of phonological awareness mildly correlated with pronouns and modal auxiliaries for the participants with CIs. Although these significant associations are more than was observed for adolescents with NH, a strong, interpretable pattern is not apparent. In fact, no single measure of general language ability acted as a strong predictor of morphosyntactic complexity in writing, which differs from the findings of Spencer et al. Adolescents with CIs may have a clear deficit in developing a writing voice, but this deficit is not indexed by standard measures of general language. This fact demonstrates a need for writing-focused assessments. Importantly, natural language samples are integral to understanding the writing abilities of students, so analysis of writing samples should be a central fixture of assessments and interventions intended to address writing development in children with CIs.

Global Narrative Features

Nittrouer et al. (2017) reported overall (total) scores of oral narratives for the subjects in this study at fourth grade, using the same story prompts. At that time, a significant difference in these total scores was found for fourth graders with NH and with CIs, when the narratives were scored using a grade-appropriate version of the same rubric used in this study. Quite clearly, these children with CIs were able to "catch up" with their peers with NH in their development of appropriate global narrative features in their oral language by eighth grade, as evidenced by the lack of difference in almost all features for oral narratives in this study. The scores of global narrative features for these eighth-grade oral narratives revealed a significant difference between groups only in the use of vocabulary. Again, this outcome supports the suggestion that adolescents with CIs have developed oral language abilities commensurate with adolescents with NH.

A different outcome was observed for written narratives, where adolescents with CIs scored lower than their peers with NH on the total score, referencing, details, tense, and cohesion. Apart from total scores, these particular global narrative features are related to abilities to maintain cohesion throughout the entire text to produce a well-formed narrative. Categories directly related to story elements—such as plot, setting, or characters—did not differ between the two groups. It is possible that control over these elements is acquired early, as narratives are a genre familiar even to very young children (Ravid & Tolchinsky, 2002). The results presented in this study indicate that adolescents with CIs are not demonstrating writing abilities on the same level as adolescents with NH, and this clearly impacts their ability to appropriately produce some global narrative features.

An examination of correlation coefficients between measures of morphosyntactic complexity and global narrative features for written narratives revealed only one significant relationship for adolescents with NH of moderate strength. Several significant correlation coefficients were obtained for the written narratives of these adolescents with CIs, but none rose above a level of .500, which is a reasonable threshold for defining a strong relationship.

Nonetheless, the use of pronouns correlated with four of the five global narrative features that differed between groups in writing. This finding may reflect the fact that pronouns are associated with fundamental understanding of morphology and case agreement. Overall, however, strong correlations between measures of morphosyntactic complexity and global narrative features in written language were not obtained, indicating that both kinds of assessments should be performed on narrative samples from children with CIs in order to evaluate their writing abilities.

Clinical Implications

One of the main clinical implications of this study is that as children with CIs get older, standard assessments of language ability may be inadequate for identifying areas of weakness that could impact academic achievement. Individualized educational plans focused on developing goals that can support academic achievement should assess writing proficiency directly, and these assessments should include natural language samples. In addition to standardized assessments that evaluate writing and language abilities, educators and clinicians can benefit from the use of language analysis tools such as SALT or holistic assessments such as rubrics when evaluating written language samples from children and adolescents with CIs. When it comes to intervention, it is apparent that standard classroom instruction is not adequate for these children. Intervention focused on developing morphosyntactic complexity and structure across passages should be provided. For the first of these goals, sentence-combining activities would be most helpful. In these activities, students are explicitly shown how to combine two or more sentences, which necessitates the enhancement of morphosyntactic complexity of the sentences created by that combination. For the second of these goals, story boards can serve to help students learn to organize their writing across the entirety of the passage.

Limitations

One limitation of this study was that participants were not administered a standardized writing assessment that explicitly measured writing productivity or writing complexity. The results of this study make it clear that standardized language instruments not targeting writing skill are inadequate for capturing deficits in writing achievement. It would have been good to assess whether standardized instruments of written language can provide the specificity in identifying relevant weaknesses required to design effective interventions.

A measure of clausal density might have been informative, as well. These measures provide a metric of the number of clauses comprising one C-unit. Such a measure would have provided another general indication of syntactic complexity and growth (Nippold et al., 2005).

Finally, narratives as language samples were collected in this study, but it would be valuable to assess differences in other written genres, as well, especially ones such as exposition that are increasingly represented in school as adolescents advance.

Summary

Children with HL who receive CIs and appropriate early intervention are making great strides in language development compared with their predecessors, but academic achievement is not necessarily keeping pace. In this study, we examined the hypothesis that at least one source of that continued achievement gap might be challenges faced by children with CIs, specifically in developing skill with written language. Accordingly, oral and written narratives from adolescents with NH and CIs were evaluated for morphosyntactic complexity and global narrative features. Adolescents across groups performed similarly on oral narratives, but significant differences were found between groups on written narratives. Scores on standardized language instruments were unable to account for the weaknesses in written language found in samples from adolescents with CIs. Overall, the development of a writing voice suited for the linguistic demands of advanced academic settings appears to be delayed or limited for adolescents with CIs. These findings contribute to a gap in knowledge regarding the continued deficits in academic performance observed for children with CIs that seem incongruent with the remarkable improvements afforded them by currently available treatments.

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Appendix A

Means and Standard Deviations for Morphosyntactic Complexity Measures

	Oral				Written			
	NH		CI		NH		CI	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
MLU	10.6	1.5	10.4	1.3	13.0	3.0	11.6	2.4
Pronouns	89.6	13.3	84.4	13.2	86.3	21.5	71.8	21.4
Adjectives	17.6	4.8	18.5	6.3	19.9	11.1	19.2	8.8
Conjunctions	58.3	10.6	53.9	11.2	42.7	16.5	38.5	13.1
Adverbs	32.6	6.4	33.7	8.7	28.9	10.7	22.7	9.1
Subordinators	12.8	4.6	13.2	5.4	16.2	9.1	10.7	5.8
Modal auxiliaries	4.6	3.3	4.7	2.4	7.2	4.9	4.1	3.4

Note. NH = adolescents with normal hearing (*N* = 52); CI = adolescents with cochlear implants (*N* = 46); MLU = mean length of utterance in morphemes.

Appendix B

Means and Standard Deviations for Global Narrative Features

	Oral				Written			
	NH		CI		NH		CI	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total score	24.73	3.82	23.79	3.88	26.79	3.37	24.65	3.23
Introduction/setting	1.91	0.51	1.89	0.55	2.21	0.53	2.05	0.49
Plot	2.32	0.69	2.27	0.70	2.35	0.73	2.19	0.61
Character descriptions	2.02	0.45	1.98	0.51	2.12	0.49	1.98	0.53
Mental states	2.01	0.40	1.95	0.54	2.10	0.41	2.03	0.43
Referencing	2.06	0.50	1.86	0.60	2.16	0.51	1.88	0.52
Focus	2.18	0.56	2.17	0.50	2.21	0.60	2.09	0.46
Order	2.14	0.54	2.10	0.50	2.21	0.52	2.09	0.44
Details	2.27	0.61	2.16	0.50	2.62	0.46	2.32	0.55
Tense	1.94	0.59	1.78	0.71	2.39	0.41	1.92	0.77
Vocabulary	2.05	0.42	1.88	0.38	2.25	0.36	2.12	0.49
Ending	1.85	0.44	1.84	0.48	1.96	0.39	2.01	0.40
Cohesion	1.99	0.47	1.91	0.47	2.21	0.36	1.98	0.42

Note. NH = adolescents with normal hearing (*N* = 52); CI = adolescents with cochlear implants (*N* = 46).