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Measuring what matters: Effectively predicting language and literacy in children with cochlear implants

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Abstract

Objective—To evaluate how well various language measures typically used with very young children after they receive cochlear implants predict language and literacy skills as they enter school.

Methods—Subjects were 50 children who had just completed kindergarten and were 6 or 7 years of age. All had previously participated in a longitudinal study from 12 to 48 months of age. 27 children had severe-to-profound hearing loss and wore cochlear implants, 8 had moderate hearing loss and wore hearing aids, and 15 had normal hearing. A latent variable of language/literacy skill was constructed from scores on six kinds of measures: (1) language comprehension; (2) expressive vocabulary; (3) phonological awareness; (4) literacy; (5) narrative skill; and (6) processing speed. Five kinds of language measures obtained at six-month intervals from 12 to 48 months of age were used as predictor variables in correlational analyses: (1) language comprehension; (2) expressive vocabulary; (3) syntactic structure of productive speech; (4) form and (5) function of language used in language samples.

Results—Outcomes quantified how much variance in kindergarten language/literacy performance was explained by each predictor variable, at each earlier age of testing. Comprehension measures consistently predicted roughly 25 to 50 percent of the variance in kindergarten language/literacy performance, and were the only effective predictors before 24 months of age. Vocabulary and syntactic complexity were strong predictors after roughly 36 months of age. Amount of speech produced in language samples and number of answers to parental queries explained moderate amounts of variance in performance after 24 months of age. Number of manual gestures and nonspeech vocalizations produced in language samples explained little to no variance before 24 months of age, and after that were negatively correlated with kindergarten performance. The number of imitations produced in language samples at 24 months of age explained about 10 percent of variance in kindergarten performance, but was otherwise not correlated or negatively correlated with kindergarten outcomes.

Conclusions—Before 24 months of age, the best predictor of later language success is language comprehension. In general, measures that index a child's cognitive processing of language are the most sensitive predictors of school-age language abilities.

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Keywords

cochlear implants; language; literacy; diagnostics; early intervention

1. Introduction

Measuring language progress in deaf children who receive cochlear implants (CIs) is important for meeting both clinical and research goals. In clinical treatment, it is important to monitor progress regularly so that modifications to interventions can be applied with appropriate timing to have optimal effects on outcomes for individual children. Where research is concerned, language skills serve as critical dependent measures for gauging relative effectiveness of various treatments across children. For these reasons it is essential that language abilities be evaluated in deaf children at regular intervals after cochlear implantation. But how do we know if we are measuring the abilities that are most predictive of language success at later ages? Variability in language skills at young ages across groups of children with CIs (such as those implanted relatively early and those implanted later) or between children with CIs and appropriate control groups (such as those with normal hearing) does not necessarily predict later differences. It is important that we have a clear picture of how performance at young ages portends later behavior if we are going to achieve the clinical and research goals of assessment. The purpose of this study was to examine how individual language measures made in infancy through preschool predict language and literacy performance as children enter school, and what the directions of those predictions are.

Several kinds of language skills are typically measured in young deaf children with CIs in order to judge how effective treatment has been. *Comprehension* is evaluated using instruments such as the Preschool Language Scales [1] or the Reynell Developmental Language Scales [2]. The comprehension subtests of these scales assess how well children respond to speech and understand simple linguistic structures. *Vocabulary* also serves as a focus of many assessments done after an infant or toddler receives a CI. These assessments can quantify either receptive vocabulary, by asking children to point to pictures when they hear words, or expressive vocabulary, by asking children to produce words when they see pictures. An example of a receptive vocabulary measure is the Peabody Picture Vocabulary Test [3]; an example of an expressive measure is the Expressive One-Word Picture Vocabulary Test [4]. Instead of directly assessing children's vocabularies, some tools ask parents to report on their infants' or toddlers' receptive or expressive vocabularies by selecting from lists of early appearing words the ones that their children seem to understand or produce. These tools include the MacArthur-Bates Communicative Development Inventories [5] and the Language Development Survey [6].

Analyses of language samples obtained in naturalistic settings provide several measures that have been used to assess clinical effectiveness and inform research studies. Methods typically involve collecting audio-video samples of children interacting with adults, such as their parents, in quasi-structured settings, and then analyzing the recordings for linguistic *form* (e.g., gestures or speech) and/or *function* (e.g., inquiries or answers). These methods have been used to evaluate language delay in children with normal hearing [7, 8], as well as in children with hearing loss [9, 10]. In addition to quantifying the forms and functions of children's language, samples can be transcribed and analyzed for specific *syntactic* structures. Software utilities such as the Systematic Analysis of Language Transcripts [11] are commonly used to perform these tasks. These analyses provide information on how well children understand the purpose of communication and the structure of language.

The assortment of language skills described above emphasizes the fact that assessments done during the early years of life focus heavily on communicative competencies in a broad sense. The goal at those very young ages is primarily to evaluate how well children are functioning in their everyday lives as a result of the treatment(s) they have received for their hearing loss. That treatment can then be adjusted as needed in order to maximize language performance at that time, or in the near future. Although often implicit, the assumption generally is that better language abilities during the years from infancy through preschool portend better language and literacy abilities during the school years. In this current study we tested that assumption by explicitly asking how well each of the specific language measures made during the early years predicts that later language performance.

The question arises of how strongly language measures made between infancy and preschool predict language and literacy proficiency at later ages because language demands change as children enter school. Once children enter school, they need to be capable of rapidly acquiring and retaining the specific vocabulary of the content material they are learning. They also need to be able to follow long discussions in order to comprehend abstract ideas and recall complex instructions. And of course, children need to learn to read because much of the instructional material is presented in print format. In order to perform these sorts of academic tasks, children must develop language-related skills that may not have been assessed at earlier ages. In particular, sensitivity to phonological (especially phonemic) structure is important because sensitivity to linguistic structure at the level of the phoneme facilitates word learning and lexical access (e.g.,[12]), working memory (e.g., [13]), and of course, learning to read an alphabetic orthography (e.g., [14, 15]). Poor sensitivity to phonological structure in the speech signal has been linked to both language and reading deficits [16]. In addition, children need an understanding and proficiency with narrative devices once they reach school in order to appreciate and maintain continuity across long stretches of verbal material. Thus, measures of linguistic proficiency other than those used in the early years begin to be implemented for evaluation once children reach school age. Tests of phonological awareness assess children's sensitivity to the various levels of linguistic structure, such as syllables and phonemes. Discourse analysis examines children's knowledge of narrative structure and cross-sentence linguistic devices, such as grammatical reference and cohesive ties. Reading also starts being evaluated on a regular basis once children enter school.

In summary, the purpose of this current study was to evaluate how well separate language measures typically obtained from children with cochlear implants during the years from infancy through preschool predict performance on the kinds of language measures typically made once children reach school age. These data came from children participating in a longitudinal study of the early development of children with hearing loss [10]. The perspective adopted in this work was that children with hearing loss need to develop language and literacy skills commensurate to those of children with normal hearing in order to succeed in mainstream educational settings. Accordingly, the approach taken was to construct a latent variable reflecting the sorts of language skills important as children enter school using a variety of measures obtained from children with normal hearing. Then, measures obtained from children with and without hearing loss at six-month intervals from 12 to 48 months of age were used as predictor variables in correlational analyses in order to see how well each of those early measures predicts performance on that latent measure of linguistic performance at the start of school.

2. Methods

All procedures used in this study were approved by the Institutional Review Board of the Ohio State University.

2.1. Participants

Fifty children who participated in a longitudinal study from 12 to 48 months of age [10] and had just completed kindergarten came to The Ohio State University for further testing. Children typically start kindergarten at 5 years of age in the United States, so most children were 6 years old at the time the data were collected. Kindergarten commonly consists of half-day sessions and is meant to prepare children for the start of formal schooling.

To be in the original study, children had to have been full-term newborns and have no medical problems other than hearing loss that could possibly be expected to delay language acquisition. English had to be the only language spoken in the home, and parents had to have normal hearing.

Thirty-five children in the current study had permanent sensorineural hearing loss with 3-frequency pure-tone averages greater than 50 dB HL in the better ear. Twenty-seven of those children had severe-to-profound hearing loss and wore one or two cochlear implants (CIs). Eight children had moderate hearing loss and wore bilateral hearing aids (HAs). Another 15 children had normal hearing, and served as a control group. Pure-tone audiometric measurements made at the time of testing confirmed these designations. Including scores from these three groups of children meant that substantial richness in variability was available on all measures used in the correlational analyses, which helped to ensure that valid estimates of the magnitude of relationships among those measures would be obtained.

All children with hearing loss received intervention starting shortly after their hearing loss was identified at least once per week until they turned 36 months of age. Between 36 months of age and the start of kindergarten, all children with hearing loss attended preschool programs specifically designed for children with hearing loss for at least 16 hours per week. These programs all emphasized spoken language. Additionally, eight children with NH, four with HAs, and ten with CIs had some exposure to sign language during the years before starting kindergarten. Only one child continued to use any sign language at the time of kindergarten. All children participated in mainstream kindergarten programs during the year prior to testing.

Table 1 presents demographic and audiometric information for the three groups of children. Gender was well-balanced in all groups. Socio-economic status (SES) was indexed using a two-factor scale on which both the highest educational level and the occupational status of the primary income earner in the home is considered [17]. Scores for each of these factors range from 1 to 8, with 8 being high. Values for the two factors are multiplied together resulting in a range of possible scores from 1 to 64. A score of 30 represents a home in which the primary income earner has a four-year college degree and a job commensurate with that education. Although there appears to be some difference in mean SES across groups, it is not statistically significant.

Regarding types of CIs, 11 of the 27 children with CIs had Cochlear Freedom, three had Cochlear System 5, 12 had Advanced Bionics HiRes/Harmony, and one had MedEl Tempo. Thirteen children with CIs had worn a HA on the ear contralateral to the CI (i.e., had bimodal experience) for at least one year. Seven of those children later received a second implant. Five of the six children who had bimodal experience, but did not get a second implant stopped wearing their HAs on the unimplanted ear before kindergarten. In all, 18 children had bilateral CIs at the time of testing.

2.2. Equipment and Materials

2.2.1. Kindergarten testing—All testing took place in sound-attenuated rooms in the Otolaryngology department of the Ohio State University Medical Center. Five measures

were made with commercially available test materials: (1) comprehension; (2) vocabulary; (3) word reading; (4) reading comprehension; and (5) processing speed. Names of these materials are in the Procedures section below and in Appendix A. Stimuli for the three measures of phonological awareness were presented in audio-visual format using a 1500-kbps sampling rate and 24-bit digitization for video presentation. Audio signals were presented via a computer with a Creative Labs Soundblaster soundcard using a 44.1-kHz sampling rate and 16-bit digitization. A Roland MA-12C powered speaker presented the audio signal.

For audio-video recording, Sony HDR-XR550V video recorders were used. Children wore Sony FM transmitters that provided direct line input to the video cameras to ensure good sound quality for all recordings.

2.2.2. Infant – preschool testing—All testing took place in quiet rooms at facilities near the children's homes. Two tests of language comprehension and two tests of expressive vocabulary from these test sessions were used in the current analyses, and these four measures were obtained with commercially available materials. The measures of syntactic productivity, as well as of language form and function were obtained from 20-minute language samples. These samples made use of standard sets of toys, and were audio-video recorded using Sony model DCR-TRV19 cameras and the same FM transmitters as used at kindergarten testing.

2.3. Procedures

General procedures in this study involved constructing a latent variable of language/literacy ability from kindergarten data that represents the kind of skill set children need as they enter school. Included in this latent variable were some basic language skills typically evaluated before children enter school, such as comprehension and vocabulary. These basic skills had been evaluated throughout the longitudinal study. Also included in the latent variable were skills not evaluated earlier, such as children's abilities to recognize phonological structure and children's sensitivity to how language is combined across sentences to create narratives. These latter skills are important foundations for literacy development and success in academic settings where abstract concepts and complex instructions may be described orally [16, 18]. These latter skills are different in kind and higher in level than the sorts of skills evaluated between infancy and preschool.

Nine measures fitting into six broad categories were used in the construction of the latent language/literacy variable. These are listed below. Specific description of how each measure was obtained is provided in Appendix A.

(1) Comprehension: The ability to comprehend spoken language is obviously important in mainstream educational settings where most of the material is presented orally by the teacher. In addition, skill in comprehending oral language correlates strongly with skill in comprehending written language [19]. The auditory comprehension subscale of the Preschool Language Scales – 4 (PLS) [1] was used in this study to measure this ability.

(2) Vocabulary: As with auditory comprehension of language, vocabulary skills have been observed to correlate strongly with reading ability, both word reading and comprehension [19], and expressive vocabulary correlates more strongly than receptive vocabulary [20]. A measure of expressive vocabulary was obtained using the Expressive One-Word Picture Vocabulary Test (EOWPVT) [4].

(3) Narrative skills: The ability to comprehend and create narratives is essential for participating in mainstream instruction [21]. In this study, a narrative language sample was obtained and scored to provide a comprehensive measure of children's abilities to construct and combine sentence length material in order to tell a complex narrative. The rubric for scoring these narratives is provided in Appendix B.

(4) Literacy: Reading plays an important role in instruction. Two measures of emergent literacy were obtained. One evaluated how well children could read individual words, presented with no sentence context. For this purpose the word reading subtest of the Wide Range Achievement Test (WRAT) was used [22]. The other measure assessed how well children comprehend passages they read. For this purpose, the Qualitative Reading Inventory – 4 (QRI) was used [23].

(5) Phonological awareness: More than any other skill, awareness of phonological structure is considered critical to reading acquisition (e.g., [14–16]). Three measures of phonological awareness, spanning a range of difficulty, were used: syllable counting, initial consonant same-different judgments, and final consonant choice tasks. These measures have been used and described previously [17, 24].

(6) Processing speed: Although not strictly a language measure, the speed at which individuals process sensory information contributes strongly to reading abilities and skill at following long and complex discourse [14, 15, 25]. For those reasons, processing speed is frequently measured in school-aged children. To do so, the time it takes children to name a sequence of objects is often measured. For this study, the object-naming subtest of the Comprehensive Test of Phonological Processing (CTOPP) was used [26].

All data were collected by laboratory staff trained to perform data collection in a consistent manner. With the exception of the phonological awareness measures, for which children's responses were recorded by computer software during testing, all test sessions were audio-video recorded, and scored at a later time by two staff members to ensure reliability.

2.3.1. Construction of Latent Language/Literacy Measure at Kindergarten—

Exploratory factor analysis (SAS software, version 9.2) was used to create a single latent score of language ability for children at kindergarten. Our assumption at the start of this exercise was that in order to succeed in mainstream academic settings, children with hearing loss need to have language and literacy skills comparable to those of children with normal hearing. In other words, performance of children with normal hearing was considered the standard against which the performance of children with hearing loss should be gauged. Therefore, only responses from the children with NH were used in the factor analysis. The factor analysis included the nine measures of kindergarten language ability described above. Fitting the factor analysis model using a principal components strategy, the first factor explained 50.8% of the total variation in scores while all subsequent factors explained less than 20% each. As a result, the first factor can be considered a reasonable summary measure of overall language ability. For this factor, all variables had approximately equal loadings, except for processing speed and the narrative score, each of which had a standardized loading approximately half the magnitude of the others. Standardized factor loadings are shown in Table 2. Using this single factor, scores on this latent variable were calculated for each child in the kindergarten sample separately, including children with hearing loss.

2.3.2. Scores Obtained from Earlier Ages—

Data for the earlier measures had been collected as part of a longitudinal study in which children with and without hearing loss were tested every six months from 12 to 48 months of age [10]. These data were collected in the child's home town by project staff. All project staff attended training sessions at a

central facility before testing started to ensure consistency in test procedures. Each staff member was required to provide videotapes of sample sessions where all measures were collected from one or more “practice” subjects. Only after it was clear that staff members were following standard test procedures did they begin testing participants.

Eleven measures fitting into five general categories were used as predictor measures. These measures are listed below. Description of methods for collecting these data is provided in more detail in the comprehensive report on that longitudinal study [10].

(1) Comprehension: Two measures of language comprehension were used. For the auditory comprehension subscale of the PLS [1], children are tested directly. In the language comprehension subtest of the Scales of Independent Behavior-Revised (SIB) [27], parents rate how likely their children are to perform certain behaviors. Both of these measures were collected at all seven test ages from 12 to 48 months of age.

(2) Vocabulary: For the current study, two tests of expressive vocabulary were used, at different test ages. From 12 to 30 months, the Language Development Survey (LDS) was used [6]. This is a parent-report instrument on which parents circle which words their children are able to produce from a pre-selected set. Parents can also add words their children produce that are not found in the prepared set. From 36 to 48 months, the EOWPVT was used [4]. This instrument directly measures children’s expressive vocabularies by requiring them to produce the words that name items pictured on separate pages of a test booklet.

Measures of the other three constructs were taken from 20-minute language samples, obtained from the parent and child playing together with a specific set of ten toys.

(3) Syntax: Syntactic knowledge and use is important to all aspects of receptive and expressive language. Two measures of productive syntax obtained from the first 50 utterances transcribed after the five-minute mark in the language sample were used in this study: First, mean length of utterance (MLU) was used, which is defined as the mean number of morphemes per utterance. The number of pronouns used correctly by the child in those 50 utterances was the other measure entered into analysis. To obtain these metrics, Systematic Analysis of Language Transcripts, Version 9 (SALT) was used [11].

(4) Form: The form, or modality, of early communication was included in these correlational analyses because it is often used as a metric of early communication ability with deaf children [9], although no predictions could be made for how effectively it predicts later language. The form of each communicative attempt made by a child during the 20-minute sample was coded by two independent laboratory staff members into one of three categories. *Speech* utterances were those that contained at least one recognizable real word. *Gestures* were communicative attempts that consisted entirely of manual gestures, whether formal signs or not. *Vocalizations* were attempts to communicate with vocal behavior, but no real words.

(5) Function: As with communicative form, the function, or intent of early communication is commonly regarded as a sensitive metric of language advancement [7, 8]. In this study, the function of each communicative attempt observed during the 20-minute language sample was coded by laboratory staff members. For the current study, only two kinds of functions were used because they were the only ones that varied in analyses of language proficiency during the preschool years [10]: answers to parental inquiries and imitations of parental speech. Answering a query requires that the child understands what the parent said, and generates a unique response. That means substantial psycholinguistic processing is involved.

Imitating something the parent said, on the other hand, requires only that the child repeats what the parent said. Thus the processing demands are less intensive.

2.3.3. Correlational analyses—In order to examine how well each of the preschool language measures predicted language/literacy skill at kindergarten, Pearson product-moment (i.e., zero-order) correlation coefficients were computed between each of the preschool measures at each age of testing and the latent language/literacy measure of kindergarten performance.

3. Results

3.1. Group differences at kindergarten

Although the primary goal of this study was to examine how well separate measures of language ability made during the years from infancy through preschool predict performance at the time children enter school, variability in kindergarten performance across groups of children was examined first to assess the magnitude of that variability. Table 3 shows mean scores and SDs for each group for each measure. For all scores there appears to be a gradual diminishment in means from children with NH to those with HAs to those with CIs. However, the first three columns of Table 4 show results of one-way analyses of variance (ANOVAs) performed on each of those scores and reveals that a significant effect of group was found for only five of the nine measures. The measures failing to show significant group effects were vocabulary, word reading, syllable counting, and processing speed.

Planned contrast analyses were also performed on scores from Table 3, comparing results for: (1) children with NH versus all children with hearing loss; and (2) children with HAs versus those with CIs. Results of these analyses are shown in the last two columns of Table 4. The first planned comparison (column 4) reveals that children with NH performed better than children with hearing loss on all but three measures: word reading, syllable counting and processing speed. The planned comparison for children with HAs and those with CIs (column 5) revealed no significant differences between these two groups.

In summary, these results for the one-way ANOVAs show that children with NH generally performed better than the children with hearing loss, but no significant differences could be detected between children with HAs and those with CIs.

3.2. Latent language/literacy measur

Table 5 shows mean scores for each group on the latent variable of language/literacy performance at kindergarten. The mean score for children with NH was 0.00 with a SD of 1. That outcome was mandated by the construction of the variable, which was based on performance of children with NH. Children with HAs and CIs had mean derived scores more than 2 SDs below the mean of children with NH. A *t* test done on scores for children with hearing loss showed no significant difference between those with HAs and those with CIs. As with analyses performed in separate measures, this analysis on this latent variable indicates that children with HAs and CIs were performing similarly in terms of language and literacy skills at kindergarten, but far below children with NH.

3.3. Predicting performance

The primary goal of examining how well separate measures of language ability made during the years from infancy through preschool predict performance at the time children enter school was addressed next. Figure 1 displays zero-order correlation coefficients between each early measure made at each preschool age and the dependent variable of latent language/literacy performance at kindergarten. These correlation coefficients were

computed using data from all children in order to maximize variability on the measures used to compute those coefficients. However, analyses were also performed to examine whether these relationships (between the dependent latent measure and each early measure) differed between children with normal hearing and those with hearing loss. To accomplish that objective, a series of univariate ANOVAs were performed on the latent language/literacy scores using group (normal hearing or hearing loss) as a fixed factor, and a different early language measure as a covariate in each ANOVA. In this type of analysis, a significant Group × Covariate interaction indicates that the magnitude of relationship between that covariate and the dependent measure differs across groups. For this series of analyses, only four out of the 62 interactions were found to be significant. Because so few were significant and there were no consistent trends in those outcomes, the prudent interpretation is that those few significant interactions were obtained by chance. Consequently, it may be concluded that the relationships described between each early language measure and the latent language variable shown in Figure 1 are similar across groups of children.

Taking the square of these coefficients indexes the amount of variance in kindergarten language/literacy performance explained by each earlier measure at each age. The dotted lines show the points above and below which 10 percent of kindergarten performance is explained by a given early measure, by either a positive or negative correlation. Although somewhat arbitrary, 10 percent is the amount of variance established here as being sufficient to be of interest; that is, a threshold that makes a specific measure one worth using diagnostically during the early years of a child's life after cochlear implantation. Examination of these coefficients shows that the two measures of language comprehension predicted at least moderate amounts of variance in kindergarten performance at every age. In fact, these measures were the only ones that predicted to any reasonable extent before the age of 24 months how children would perform once they entered school. The comprehension measure obtained directly from the children (PLS) was a better predictor than the measure obtained by asking parents to rate their children's abilities to comprehend language (SIB). In fact, the PLS comprehension measure was one of the best predictors of kindergarten performance at every age tested between 12 and 48 months of age.

The measures of vocabulary explained at least moderate amounts of variance in kindergarten language/literacy performance once children reached 24 months of age, but not before. Again, the measure obtained directly from children (EOWPVT) was a better predictor than the measure that asked parents to report their children's vocabulary skills (LDS).

The two measures of syntactic productivity (MLU and pronouns) both explained at least moderate amounts of variance in kindergarten performance after 30 months of age. The measure of MLU was a particularly strong predictor from 36 to 48 months of age.

The measures of form and function in children's communicative attempts during the unstructured language sample varied greatly in their predictive power. The numbers of communicative attempts consisting of speech and the numbers of answers children provided were almost identical in predictive power across all ages examined. These two measures explained little variance in kindergarten performance before 24 months of age, but then moderate amounts through 48 months of age. However, these measures of form (speech) and function (answers) were never as strongly predictive as were the measures of comprehension, vocabulary, and syntactic productivity.

The measure of how often children imitated their parents had weak predictive power at 24 months of age (explaining just under 10 percent of the variance in kindergarten language/literacy performance), but otherwise was not a good predictor of how children would perform in kindergarten. In fact, for most ages examined, the number of times a child

imitated the parent was negatively correlated with language and literacy performance at kindergarten, although those negative correlations were weak.

The number of manual gestures used by children during the 20-minute language sample correlated negatively with language and literacy performance at kindergarten, although those correlations were also weak. On the other hand, the numbers of non-speech vocalizations a child produced during the language sample were negatively correlated with kindergarten performance, and these correlations were stronger. After 30 months of age, vocalizations explained more than 10 percent of the variance in kindergarten performance.

4. Discussion and Implications

The primary purpose of this study was to evaluate how well the kinds of language measures obtained at very young ages from children who receive cochlear implants predict the kinds of language abilities they will need as they enter school. To that end, correlational analyses were performed between a latent measure of language ability at school age and several language measures obtained at younger ages. In addition to meeting the primary goal of the study, insights were gained about differences in language abilities between children with normal hearing and those with hearing loss, regardless of whether they use hearing aids or cochlear implants.

4.1. Language and literacy skills in kindergarten

The children with hearing loss who participated in this longitudinal study all received appropriate treatment and intervention, according to current standards. They were identified early in life, were fit with auditory prostheses relatively early, and received intervention from trained professionals on a regular basis. Nonetheless, most of these children were about to begin formal schooling behind their peers with NH in terms of their abilities to handle the language requirements of school settings. This finding suggests that more research is needed to develop early intervention strategies that will be more effective in helping all children with hearing loss attain higher levels of language functioning.

The outcomes reported here also emphasize the need for comprehensive evaluation, because three of the measures made at kindergarten showed no differences in skill levels between children with NH and those with hearing loss: word reading, syllable counting, and processing speed. The three measures either did not strictly evaluate language performance (processing speed) or were ones that do not require substantial psycholinguistic processing: Reading individual words at the kindergarten level can be accomplished largely by memorizing those word forms, and the ability to count the number of syllables in a word is a low level phonological awareness skill. If one of these measures had been made at kindergarten and accepted as a valid representation of overall reading and/or language proficiency, the conclusion would have been drawn that children with hearing loss are just as prepared for the language and literacy demands of school as are their peers with NH. Using measures that tap into higher level psycholinguistic processes and sampling those skills more broadly leads to a different conclusion, one that indicates that children with hearing loss are starting school at a disadvantage in terms of their language foundation.

4.2. Predicting kindergarten performance at younger ages

The correlational analyses performed on these data revealed which specific measures routinely used with infants, toddlers, and preschoolers with hearing loss are most predictive of language abilities at kindergarten. In general, the measures that indexed higher level psycholinguistic processing were the best predictors of kindergarten language/literacy performance. In particular, the comprehension measure from the PLS that required children to respond to specific grammatical and syntactic devices was a consistently strong predictor

across ages from 12 to 48 months. Similarly, the mean length of children's utterances was a strong predictor of kindergarten performance, once children reached three years of age. On the other hand, the numbers of nonspeech vocalizations or simple imitations of parental speech produced by children during a 20-minute language sample were both negatively correlated with kindergarten language/literacy performance, for most of the early test ages. That trend means that the more vocalizations and imitations that were produced by a child, the poorer the language prognosis was. Both vocalizations and imitations require little psycholinguistic processing.

The outcomes of the correlational analyses reported here inform us about which diagnostic measures should be used to monitor language development in very young children with CIs. The kinds of measures that are obtained by direct measurement are generally more sensitive to language development than are measures that ask parents to rate their children's language behavior. Children's abilities to comprehend language turn out to be good indicators of future success, as are measures of syntactic competence. Expressive vocabulary can serve as a good index of children's language development, especially when children are being asked to retrieve lexical labels themselves, in real time. Again, parent report was not as strong in predictive power. This study did not use any measure of receptive vocabulary, so the predictive power of that particular vocabulary skill could not be determined.

Looking across ages for the best predictor variables, it is seen that up until 24 months of age the only measures that provided any kind of predictive power were those looking at infants' abilities to comprehend language in the environment. Of course, at those young ages the items on both the PLS and SIB comprehension subscales are rather simple, restricted to questions such as whether children respond to their own names. Nonetheless, these sorts of items appear to be the best predictors that are available at ages so young.

In the third year of life (24 and 30 months of age), children's productive capacities begin to show some power to predict later language skill. In particular, the amount of real speech the child produces, the child's ability to answer simple questions, and the child's expressive vocabulary all provide information about whether or not the child is progressing towards the kinds of language abilities needed for school.

From 36 to 48 months of age, a stronger separation among early language measures emerges in terms of how well they predict kindergarten language/literacy performance. At these preschool ages, the most predictive measures are those of comprehension of specific linguistic devices, as measured by the PLS, expressive vocabulary skills elicited from the child by a clinician, and measures of productive syntax.

The finding that vocalizations for all of the early years and imitations for most of those early years are negatively correlated with kindergarten language/literacy performance is informative. It means that these measures should not be used as indices of language proficiency in young children with hearing loss, unless they are used as red flags, so to speak.

Finding that the number of manual gestures produced during the 20-minute language sample was weakly and negatively correlated with language and literacy skill in kindergarten was not necessarily expected. Several investigators have demonstrated that the use of gestures at roughly one year of age predicts the size of children's vocabularies later, at roughly 42 months of age (e.g., [28, 29]), leading to the expectation that the productive use of gesture at early ages might predict language and literacy skills at kindergarten. However, the latent language/literacy variable constructed from kindergarten measures in this current study was purposefully designed to incorporate indicators of complex psycholinguistic functions, such as sensitivity to phonemic structure in the acoustic speech signal and an appreciation of how

continuity is maintained across several sentences. Gesture has been found only to predict vocabulary acquisition, not syntactic productivity [30], which can be considered a higher function than vocabulary. Thus, it should not be surprising that the amount of gesturing children did was a poor predictor of the kind of language used as the dependent measure in this study.

4.3. Implications for intervention

The outcomes of this study extend our understanding of the sorts of language skills that should be measured during the early years of a child's life in order to most effectively monitor language development. However, the findings also speak to the sorts of language skills that need to be fostered during intervention, if language acquisition is to be promoted most effectively. Language processes that require higher level psycholinguistic processing seem most important to helping children who receive CIs early in life develop the kinds of language skills they will need when they reach school age. Having young children simply imitate adult language models apparently does little to promote the sophisticated language skills that are needed once children reach school age. Finally, manual gestures were not found to encourage complex spoken language abilities.

5. Summary

The purpose of this study was to evaluate how well various language measures typically used with infants, toddlers, and preschoolers after they receive cochlear implants predict language and literacy skills as they enter school. Here it was found that the more complex the skill being indexed by a language measure, the stronger the predictive power of that measure. Also, measures that require the direct observation of child behavior were found to be more sensitive than those using parental report. These findings should have implications for diagnoses and treatment of childhood hearing loss, as well as future research.

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References

1. Zimmerman, IL.; Steiner, VG.; Pond, RE. Preschool Language Scale. 4. San Antonio, TX: The Psychological Corporation; 2002.
2. Reynell, J.; Gruber, C. Reynell Developmental Language Scales. Western Psychological Services; 1990.
3. Dunn, L.; Dunn, D. Peabody Picture Vocabulary Test. 4. Bloomington: Pearson Education Inc; 2007.
4. Brownell, R. Expressive One-Word Picture Vocabulary Test. 3. Novato, CA: Academic Therapy; 2000.
5. Fenson, L.; Marchman, VA.; Dale, PS.; Reznick, JS.; Thal, D.; Bates, E. MacArthur-Bates Communicative Development Inventories (CDIs). 2. Paul H. Brookes Publishing Company; 2007.
6. Achenbach, TM.; Rescorla, LA. Manual for the ASEBA preschool forms and profiles. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families; 2001.
7. Coggins TE, Olswang LB, Guthrie J. Assessing communicative intents in young children: Low structured observation or elicitation tasks? J Speech Hear Dis. 1987; 52:44–49.
8. Wetherby AM, Cain DH, Yonclas DG, Walker VG. Analysis of intentional communication of normal children from the prelinguistic to the multiword stage. J Speech Hear Res. 1988; 31:240–252. [PubMed: 3398497]

9. Nicholas JG, Geers AE. Communication of oral deaf and normally hearing children at 36 months of age. J Speech Lang Hear Res. 1997; 40:1314–1327. [PubMed: 9430751]
10. Nittrouer, S. Early development of children with hearing loss. San Diego: Plural Publishing; 2010.
11. Miller, J.; Chapman, R. Systematic Analysis of Language Transcripts (SALT): Version 9. Madison, WI: University of Wisconsin-Madison, Language Analysis Laboratory; 2006.
12. Ramachandra V, Hewitt LE, Brackenbury T. The relationship between phonological memory, phonological sensitivity, and incidental word learning. J Psycholinguist Res. 2011; 40:93–109. [PubMed: 20872250]
13. Brady S. Short-term memory, phonological processing, and reading ability. Ann Dyslexia. 1986; 36:138–152.
14. Catts HW, Gillispie M, Leonard LB, Kail RV, Miller CA. The role of speed of processing, rapid naming, and phonological awareness in reading achievement. J Learn Disabil. 2002; 35:509–524. [PubMed: 15493249]
15. Torgesen JK, Wagner RK, Rashotte CA, Burgess S, Hecht S. Contributions of phonological awareness and rapid automatic naming ability to the growth of word-reading skills in second- to fifth-grade children. Sci Stud Read. 1997; 1:161–185.
16. Pennington BF, Bishop DVM. Relations among speech, language, and reading disorders. Annu Rev Psychol. 2009; 60:283–306. [PubMed: 18652545]
17. Nittrouer S, Burton LT. The role of early language experience in the development of speech perception and phonological processing abilities: Evidence from 5-year-olds with histories of otitis media with effusion and low socioeconomic status. J Commun Disord. 2005; 38:29–63. [PubMed: 15475013]
18. Snyder LS, Downey DM. The language-reading relationship in normal and reading-disabled children. J Speech Hear Res. 1991; 34:129–140. [PubMed: 2008067]
19. Wise JC, Sevcik RA, Morris RD, Lovett MW, Wolf M. The relationship among receptive and expressive vocabulary, listening comprehension, pre-reading skills, word identification skills, and reading comprehension by children with reading disabilities. J Speech Lang Hear Res. 2007; 50:1093–1109. [PubMed: 17675607]
20. Chiappe P, Chiappe DL, Siegel LS. Speech perception, lexicality, and reading skill. J Exp Child Psy. 2001; 80:58–74.
21. Gillam RB, Pena ED, Miller L. Dynamic assessment of narrative and expository discourse. Top Lang Disord. 1999; 20:33–47.
22. Wilkinson, GS.; Robertson, GJ. The Wide Range Achievement Test (WRAT). 4. Lutz, FL: Psychological Assessment Resources; 2006.
23. Leslie, L.; Caldwell, J. Qualitative Reading Inventory - 4. New York: Pearson; 2006.
24. Nittrouer S, Shune S, Lowenstein JH. What is the deficit in phonological processing deficits: Auditory sensitivity, masking, or category formation? J Exp Child Psy. 2011; 108:762–785.
25. Phan AV, Fine JG, Semrud-Clikeman M. The influence of inattention and rapid automatized naming on reading performance. Arch Clin Neuropsychol. 2011; 26:214–224. [PubMed: 21422009]
26. Wagner, RK.; Torgesen, JK.; Rashotte, CA. The Comprehensive Test of Phonological Processing (CTOPP). Austin, TX: Pro-Ed; 1999.
27. Bruininks, RH.; Woodcock, RW.; Weatherman, RF.; Hill, BK. Scales of Independent Behavior-Revised. Itasca, IL: Riverside Publishing; 1996.
28. Iverson JM, Goldin-Meadow S. Gesture paves the way for language development. Psychol Sci. 2005; 16:367–371. [PubMed: 15869695]
29. Rowe ML, Ozcaliskan S, Goldin-Meadow S. Learning words by hand: Gesture's role in predicting vocabulary development. First Lang. 2008; 28:182–199. [PubMed: 19763249]
30. Rowe ML, Goldin-Meadow S. Early gesture selectively predicts later language learning. Dev Sci. 2009; 12:182–187. [PubMed: 19120426]
31. Heilmann J, Miller JF, Nockerts A, Dunaway C. Properties of the narrative scoring scheme using narrative retells in young school-age children. Am J Speech Lang Pathol. 2010; 19:154–166. [PubMed: 20008470]

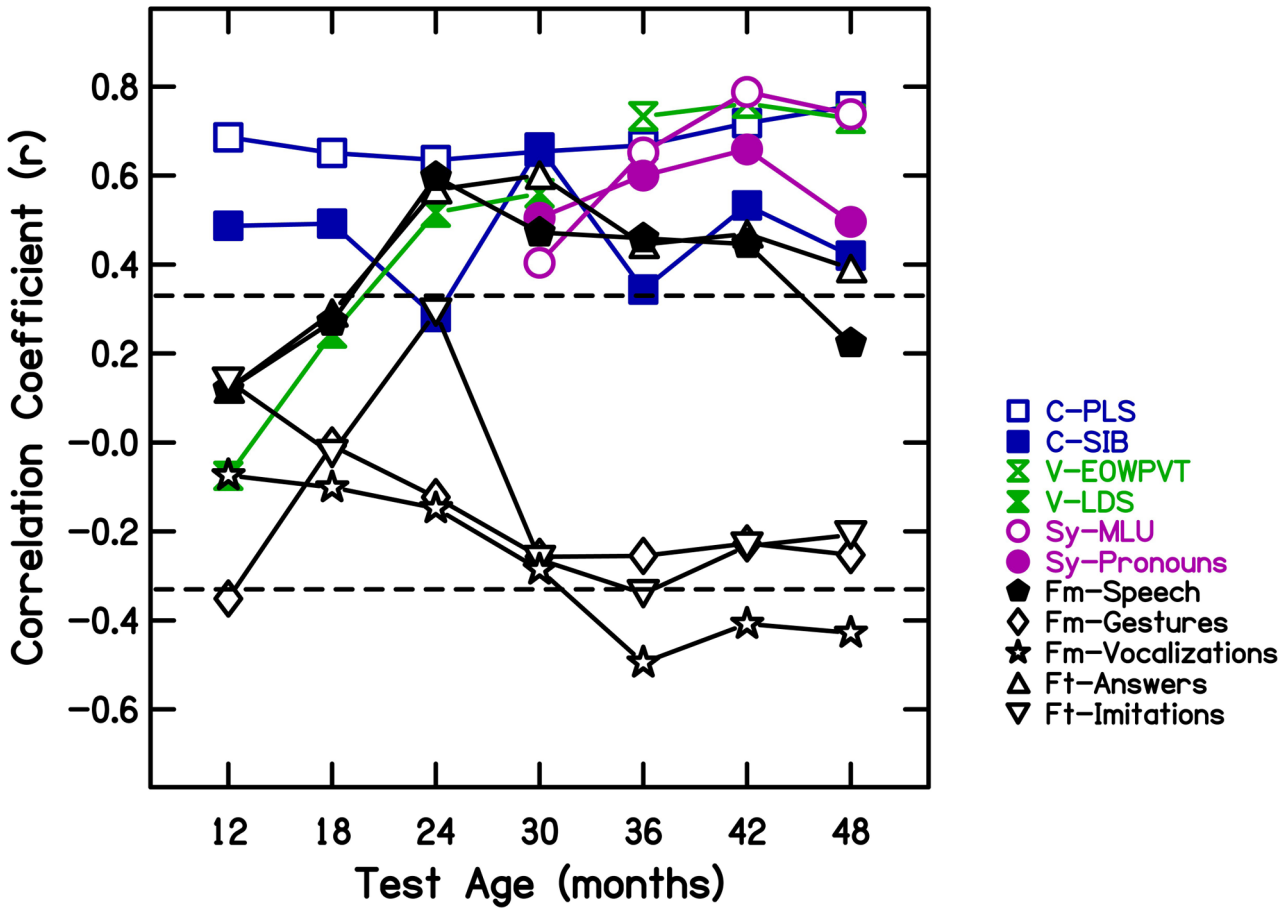

FIGURE 1.

Zero-order correlation coefficients between each of 11 early language measures collected at six-month intervals from 12 to 48 months of age and a latent language measure constructed from nine separate measures collected at kindergarten for 50 children with normal hearing and hearing loss. C = *Comprehension* measures; V = *Vocabulary* measures; Sy = *Syntax* measures for 50 transcribed utterances from the 20-minute language sample; Fm = numbers of utterances with a specific *Form* during the 20-minute language sample; Ft = number of utterances with the specified *Function* during the 20-minute language sample.

Table 1

Means and SDs for demographic and audiometric measures for the three groups of children.

	Group					
	NH		HA		CI	
	15		8		27	
	M	(SD)	M	(SD)	M	(SD)
Age at time of testing (months)	79	(4)	78	(4)	81	(5)
Proportion of males	.50	---	.50	---	.46	---
Socio-economic status	37	(15)	25	(11)	33	(12)
Age at identification (months)			9	(11)	7	(8)
Pre-implant (CIs)/current (HAs) PTA			65	(11)	99	(18)
Age at 1st implant (months)					20	(13)
Age at 2nd implant (months)					36	(15)
Mean length of 1st implant use (months)					61	(13)

Note: Socio-economic status is a two-factor index based on the occupation and education of the primary income earner in the household. Pure-tone averages (PTAs) are given in dB HL and are for the three speech frequencies of 500, 1,000, and 2,000 Hz. PTAs shown here are for the better ear. Eighteen children received a second implant. Range of age at 1st implant was 8 to 66 months, and range of length of 1st implant use was 14 to 66 months.

Table 2

Standardized factor loadings of the nine kindergarten language measures used in the construction of the latent language measure.

Measure	Loading
Comprehension	0.178
Vocabulary	0.186
Narrative skills	0.079
Literacy	
Word reading	0.156
Reading comprehension	0.182
Phonological Awareness	
Syllable counting	0.180
Initial consonant task	0.167
Final consonant task	0.144
Processing speed	−0.086

Table 3

Means and SDs for scores obtained at testing after kindergarten.

	Group					
	NH		HA		CI	
	15		8		27	
	M	(SD)	M	(SD)	M	(SD)
Comprehension	61.20	(1.21)	57.50	(6.89)	54.78	(7.61)
Vocabulary	75.53	(10.78)	63.00	(19.81)	58.26	(16.44)
Narrative skills	23.70	(3.84)	13.56	(6.08)	13.69	(8.74)
Literacy						
WRAT word reading	25.40	(7.01)	25.25	(8.12)	21.37	(6.92)
QRI comprehension score	17.20	(5.12)	11.25	(9.29)	8.07	(7.84)
Phonological Awareness						
Syllable counting	60.14	(38.86)	59.64	(23.44)	46.17	(30.28)
Initial consonant task	93.06	(10.26)	70.05	(32.94)	64.42	(21.10)
Final consonant task	58.75	(23.04)	23.70	(24.32)	13.67	(14.63)
Processing Speed	96.33	(29.34)	109.13	(23.41)	127.84	(59.85)

Note: Raw scores are given for the first four categories of scores, percent correct for phonological awareness scores, and time in seconds for processing speed.

Table 4

One-way ANOVAs for each kindergarten measure.

	F	p	η^2	C1 p	C2 p
Comprehension	5.04	.010	.177	.018	NS
Vocabulary	2.04	NS	.087	.005	NS
Narrative skills	10.15	<.001	.302	<.001	NS
Literacy					
WRAT word reading	1.30	NS	.076	NS	NS
QRI comprehension score	7.35	.002	.238	.003	NS
Phonological Awareness					
Syllable counting	1.09	NS	.046	NS	NS
Initial consonant task	8.96	.001	.285	.001	NS
Final consonant task	26.08	<.001	.537	<.001	NS
Processing Speed	2.04	NS	.087	NS	NS

Note: C1=planned comparison between children with NH and all children with hearing loss; C2=planned comparison between children with HAs and those with CIs. NS = $p > .10$.

Table 5

Summary statistics for latent language/literacy measure at kindergarten.

	Mean	SD	Minimum	Maximum
Group				
Normal Hearing	0.00	1.00	−2.46	1.33
Hearing Aid	−2.43	2.72	−6.22	0.14
Cochlear Implant	−2.69	1.76	−5.27	0.54

Appendix A

Summary of language measures obtained at kindergarten, and used to construct the latent measure of language and literacy.

Language Measure	Description
Comprehension	The auditory comprehension subtest of the Preschool Language Scales-4 [1] was used to measure children's understanding of spoken language, usually involving specific syntactic or grammatical forms. The task requires children to demonstrate their understanding by performing specific commands given by an examiner. Raw scores were used in analysis.
Vocabulary	The Expressive One-Word Picture Vocabulary Test [4] was used to assess expressive vocabulary. For this task, children are asked to provide the words that label a series of pictured items shown one at a time on separate pages. Raw scores were used in analysis.
Narrative skills	A 20-minute narrative sample based on five related themes was elicited from each child. Each narrative sample was scored by three independent viewers. All narrative segments were used to score narrative abilities based on 12 different assessment points similar to many other rubrics [31]. For each assessment, the observer gave a score between 0 and 3, so the final narrative score could vary between 0 and 36. The average score from all three observers was used in analysis. The rubric is presented in Appendix B.
Word reading	Word reading was assessed using the word reading subtest of the Wide Range Achievement Test – 4 (WRAT) [22]. Children are asked to read 55 words aloud. As they progress through the list, the words get harder. If a child makes 10 consecutive mistakes by either pronouncing a word incorrectly or skipping a word the task is stopped. The total raw number of words read correctly was used in analysis.
Reading Comprehension	The Qualitative Reading Inventory (QRI) – 4 [23] was used to assess reading comprehension. Each child read three passages – one narrative written one level below kindergarten (pre-primer), one narrative written at the kindergarten level (primer), and one expository written at the kindergarten level. The child would read each story, retell the story to the examiner, and then answer questions about the story. The raw sum of correct answers (out of 30) to the comprehension questions across all three stories was used in analysis.
Syllable Counting	Syllable counting assesses sensitivity to syllable structure within words. Children saw and heard a man on a computer monitor say a word and were asked to count the number of syllables in the word by tapping them on the table. The percentage of correct answers (out of 48) was used in analysis [17].
Initial Consonant Task	For the Initial Consonant Same –Different task, children saw and heard a male speaker produce two words. The child's task was to judge whether both words started with the same sound. The percentage of correct answers (out of 48) was used in analysis [17, 24].
Final Consonant Task	In the Final Consonant Choice task, children saw and heard a male speaker produce a target word which the child was to repeat correctly. Three more words were then presented in a similar fashion. The child's task was to select the word out of the three that had the same ending sound as the target word. The percentage of correct answers (out of 48) was used in analysis [24].
Processing Speed	The object naming subtest of the Comprehensive Test of Phonological Processing [26] was used to examine processing speed. The test consists of two pages, each with four rows of nine pictures of simple objects. Children had to name the objects in order as quickly as possible. Both trials were timed and the time in minutes across both trials was used in analysis.

Appendix B

Scoring rubric for narrative language sample.

Assessment Points for Narrative Scoring	0 Points--Way Below Expectations	1 Point--Below Expectations	2 Points--Age Expected	3 Points--Above Expectations
Introduction/Focus of Narrative	• No introduction to narrative or How To (no main idea given) • No focus on one particular narrative or How To (ex. Speaker combines two different narratives or How Tos in one) • Listener must ask questions to understand and even when asked, child still doesn't explain what the topic is	• Partial introduction of narrative or How To is made but listener is still not clear on the actual topic • Speaker keeps some focus on one particular narrative or How To, but still wanders to other topics • Listener has to ask several questions to understand topic, confusing to a new listener	• Introduction of narrative or How To, clear what the speaker is talking about • Speaker remains focused on narrative or How To with little or no wandering to other topics • Becomes apparent early on what speaker is talking about, stays on topic, no tangents • If prompted, reiterates topic	• Clear and concise introduction to the narrative or How To (main idea is clearly stated about topic, elaborates on introduction statement) • Speaker stays clearly focused on the narrative or How To topic - listener does not have to ask any questions, no prompts needed, clearly states what they are going to talk about • New listener follows easily at any point in the conversation
Mental States of Characters (Thoughts and Feelings)	• Overall, no feelings or thoughts are conveyed for any of the characters involved in the narrative • If feelings are addressed, they're used incorrectly	• States some feelings and thoughts during the narrative but uses the same describing words over and over	• States feelings and thoughts for most of the characters in the narrative and uses more than one description word • The descriptive words are usually correct and fit appropriately	• Clearly states the feelings and thoughts of all characters involved in the narrative, including self • Uses correct description words to explain feelings and thoughts
Referencing	• No clear referencing to any of the characters in narrative or How To • Ex: Speaker may use an excessive number of pronouns, or use pronouns inappropriately when nouns are not known • Listener does not know who/what the speaker is referring to at any point during the narrative or How To.	• Speaker uses some referencing, but may be unclear • Listener may be confused at some points about who/what the speaker is referring to	• Speaker uses adequate pronouns and referencing but doesn't always check for listener comprehension	• Uses adequate and correct referencing for all character in narrative or all parts in How To • Easy for listener to follow and understand who/what the speaker is referring to • Above and beyond what a typical child of this age would say – speaker makes sure the listener knows exactly what they're talking about

Assessment Points for Narrative Scoring	0 Points--Way Below Expectations	1 Point--Below Expectations	2 Points--Age Expected	3 Points--Above Expectations
Materials/Players in the Narrative	• No mention or description of who the characters are or how many there are in the narrative • No referencing made to any of the materials/ players needed for the How To	• Mentions and describes only one character in the narrative, no reference to other characters • States some materials/ players that are needed for the How To	• Mentions and describes more than one character in the narrative • States most of the materials/ players needed for the How To	• Mentions and describes all characters involved in the narrative • States all materials/players that are needed for the How To • Provides extensive list of items needed or states extra items needed
Order of the Narrative (logical steps to narrative or How To)	• No order or logical progression to the narrative or How To • Listener has to ask questions about when things happened throughout entire narrative or How To	• States some of the narrative or How To in order • Listener still had to ask several questions to completely understand the progression	• States most of the narrative or How To in order • Listener only had to ask a few questions to understand the progression	• States all of the narrative or How To in correct order • Listener doesn't have to ask any questions to understand the progression
Details	• Narrative/How To clearly lacks any supporting details • Very short • Uninteresting	• Narrative or How To contains a few details to make it somewhat interesting	• Narrative/How To has adequate details and the listener is engaged in the narrative the entire time	• Narrative or How To is filled with explicit details, making it much more enjoyable for the listener
Style (elements of voice used during narrative)	• Narrative or How To is presented with no intonation, modulations or use of creative flare Ex: speakers voice is monotone with no excitement or flare	• Narrative or How To is presented with minimal inflection/creative flare Ex. uses inflection in few spots and even then may not be correct	• Narrative or How To is presented with some inflection/creative flare Ex. Uses creative wording in a few spots and is correct; uses correct inflection to create excitement or interest in a few spots of the narrative or How To	• Telling of narrative or How To is presented with correct and appropriate inflection, volume and use of creative flare, speaker creates an enjoyable story
Vocabulary – Verb Tense	• Little use of bound morphemes • Almost always uses wrong verb tense • No descriptive words used to describe things in the narrative or How To	• The speaker varies the amount of different words only by a few • Frequently uses wrong verb tense • Mostly uses the same words over and over again; occasionally changes the descriptive words	• Uses bound morphemes appropriately; Inappropriate use is a result of overgeneralizations such as "ed" • Uses range of age appropriate words, adjectives, and adverbs • Varied use of descriptor words in the narrative	• Good use of descriptive words; changes the words often in the narrative • Uses colorful language and idioms appropriately • Uses correct verb tense

Assessment Points for Narrative Scoring	0 Points--Way Below Expectations	1 Point--Below Expectations	2 Points--Age Expected	3 Points--Above Expectations
	• Uses the same words over and over again; narrative is said in as few words as possible	• Inappropriate use of idioms	• Small amount of colorful words are used appropriately • Does not use the same word too many times during the narrative • Occasionally uses wrong verb tense • Somewhat successful use of idioms	
Cohesion – from Liles (1985)	• No clear ties/segues from one sentence to the next/one thought to the next • Listener is very confused as to what the narrative or How To is even about	• Some clear ties exist between sentences/ thoughts • Some ambiguity remains over subject of conversation	• Almost a complete tie in that there is little confusion throughout most of the narrative • Occasionally speaker might stray from the subject but find his/her way back • Majority of the time the listener is clearly understanding the line of thinking	• Speaker clearly ties all thoughts and sentences together to form a very coherent narrative/How-to • Absolutely no confusion on the part of the listener as to the subject of conversation • Speaker never strays off topic
Conclusion to narrative or How To	• No clear ending to the narrative or How To • Listener has to ask if there is any more or if that is the end of the narrative/How To	• Narrative/How To concluded, but no clear, general concluding statement is used	• Narrative/How To concluded, but only a partial general concluding statement is used	• Ending to narrative/How To is clear and easily understood • Clear, complete general concluding statement
Theory of Mind	• Tells narrative/How To without regarding listener's ability to follow along, never clarifies or checks whether the listener is understanding	• Occasionally checks in with the listener to make sure they are following along • Rarely clarifies statements	• Often checks in with the listener to make sure they are following along • Occasionally clarifies statements if they suspect the listener is confused	• Does a great job of double checking with the listener to make sure they fully understand the narrative or How To • Usually clarifies statements if they suspect the listener is confused
Replicability (ability to reproduce narrative or How To accurately)	• Listener unable to repeat the narrative/ How To to another person	• Listener would be able to repeat some of the narrative/How To, however, clarifying questions would need to be asked of the original	• Listener would be able to repeat some of the narrative/How To but might have to ask just a couple of clarifying questions of the original storyteller	• Listener would be able to repeat most of the narrative/ repeat the entire narrative/ How To without any help from the original storyteller

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Assessment Points for Narrative Scoring	**0 Points--Way Below Expectations**	**1 Point--Below Expectations**	**2 Points--Age Expected**	**3 Points--Above Expectations**
		storyteller to give a complete recap		