Objective: To investigate the relationship between prelinguistic communication behaviors and subsequent language development after cochlear implantation in deaf children. Evaluative tools with predictive validity for language potential in very young deaf children remain elusive.

Setting: A tertiary care cochlear implant center and a preschool setting of spoken language immersion in which oral language development is emphasized through auditory and oral motor subskill practice.

Subjects: Eighteen prelingually deaf children who underwent unilateral implantation at an average age of 15 months also underwent testing with the Communication and Symbolic Behavior Scales (CSBS) before device activation and with the Reynell Developmental Language Scales (RDLS) at an average of 20 months after cochlear implantation.

Methods: A prospective study correlated preoperative communication behavior assessments of 18 children who were candidates for cochlear implantation. We examined the value of prelinguistic behavioral testing with the CSBS in predicting later language level after cochlear implantation as reflected in RDLS scores.

Results: We found positive, though weak, correlations between prelinguistic communication skills (CSBS scores) and language learning after cochlear implantation (RDLS scores). Linear correlation between test results failed to reach statistical significance (receptive comparisons, $P = .17$; expressive comparisons, $P = .13$).

Conclusions: Evaluating the quality of prelinguistic communication behaviors potentially adds important predictive information to profiles of children who are candidates for cochlear implantation. Correlative analysis suggests that early CSBS testing may provide useful clinical information. Poor CSBS scores may serve as a precaution: if children lack an appropriate prelinguistic behavioral repertoire, the emergence of age-appropriate formal language may be at risk. Observations suggest that symbolic prelinguistic behaviors are necessary, but not sufficient, for the development of strong linguistic skills. The variability of behavioral measures in very young deaf children poses challenges in designing objective measures with predictive value for later language level.
plant candidacy with little or no formal language, signed or spoken. Ideally, at least rudimentary communication patterns develop between the child and caregiver in naturally occurring situations such as mealtimes and in play. Observation of the child in a play interaction can lend considerable insight into communication skills. Prelinguistic communication behaviors, such as pointing, gesturing, object manipulation, affective signaling, turn-taking, and joint attention, can be assessed in play. Verbalizations and imitations may also be analyzed as approximations of true words. In a play environment, receptive and expressive language can be evaluated when the examiner gives directions, asks for labels, and encourages verbal interactions. Without access to sound, rudimentary means are used to establish a topic and to maintain an interaction, often with a physical object used to cue the interaction. For example, a child may request milk by holding a cup toward his or her mother or engage in a playful exchange when bubbles are blown by looking toward the bubbles and then giggling and looking at his or her mother. Both examples offer information about the child's ability to connect socially and to communicate basic needs and emotions. Data can be gleaned through observation of a child's variety of strategies and number of exchanges. For the very young child with hearing loss who lacks proficiency in sign or spoken language, play offers a practical and theoretically compelling vehicle with which to observe natural interactions. In the present study, we used the Communication and Symbolic Behavior Scales (CSBS) to assess constructs related to modeling communication behaviors reflecting communicative function, gestural means, vocalizations, and verbalizations. Later, when the child is a cochlear implant user, it is imperative to assess his or her skills in developing linguistic abilities. Activation of the cochlear implant should allow the child access to auditory information and provide benefit from verbal language models. Language therapy in the context of home or school experience can support receptive and expressive language growth of the new implant user. However, to gauge a child's progress, formal evaluations are needed. For example, a measure that indicates that a child is not making 6 months' progress in 6 months' time can prompt critical assessment of the environment in which the device is being used, as well as possible changes in device programming. Information gathered in subsequent testing after implantation can direct language intervention, particularly when baseline preintervention information is available.

The objective of the present study was to investigate the relationship between prelinguistic communication behaviors in implantation candidates and subsequent language development after cochlear implant use. We evaluated metrics that are amenable to early childhood stages, when candidacy evaluation for cochlear implantation in prelingual deafness is commonly performed, and later, with cochlear implant experience. We determined the predictive validity of prelinguistic communication behaviors in forecasting language outcomes after implantation.

The present study included 18 profoundly deaf children who underwent implantation at the average age of 14.2 months. All children received their implants at the Listening Center, The Johns Hopkins University, Baltimore, Md. The CSBS and the Reynell Developmental Language Scales (RDLS) were administered at the mean ages of 16 months (range, 10-22 months) and 36 months (range, 17-56 months), respectively. Each of the subjects received either a Clarion device (platinum series; Advanced Bionics Corp, Sylmar, Calif) or a Nucleus 24-channel device (Cochlear Corp, Englewood, Colo). All children were prelingually deaf and participated in a preimplantation trial period with binaural hearing aids. The children in the study presented without gross motor difficulties, and English was the primary language in all of the households. Cognitive levels were not assessed. Given the range of developmental levels of the subjects, speech recognition levels were classified for means of comparison.

Therapeutic intervention varied. All children participated in weekly postimplantation therapy with an oral (re)habilitation specialist for at least 12 months. Some children continued therapy for longer periods. Family involvement and support crossed a wide range. Therefore, the variation in the intensity of both formal rehabilitative and informal family-based communication training was considerable, as is representative of all cases involving children who receive implant services in our center and educational training in our school. However, all children received school-based support of their spoken language learning. The central research question we pursued related to within-subject baseline vs posttreatment scores using age-appropriate tests. Thus, we believe that this analysis withstands potential intersubject variability in experience and environmental factors related to oral language learning.

All subjects were evaluated using the CSBS and the RDLS. The CSBS assesses communicative, social-affective, and symbolic abilities of children whose functional communication age is between 8 months and 2 years. Prelinguistic communication is rated in 22 scales measuring parameters of communicative competence and aspects of symbolic development. A structured play session is videotaped, and the child's behaviors are analyzed to assess communicative function, noting gestural means, vocalizations, verbalizations, reciprocity, social-affective signaling, and symbolic expression in play. Standard scores are compared to norms for hearing children based on chronological age or language stage. Six months after activation (and at subsequent 6-month intervals), each child was tested using the RDLS.

The RDLS measures verbal comprehension and expressive language abilities in children between the ages of 12 months and 5 years. Pictures, objects, and observations are used to assess each child's understanding of verbal preconcepts, attributes, and verbal reasoning. Expressively, each child's responses are analyzed with respect to the structure, vocabulary, and content of the message. Results report standard scores, percentile rank, and developmental levels. The RDLS has been used successfully in this population to track language development after implantation. Robbins et al and Swirsky et al applied the RDLS to populations of deaf children, with and without cochlear implants, and found that the rate of language development in children with implants exceeded that expected from children without implants. We hypothesized that there would be correlations between early communication behaviors (CSBS) and later language (RDLS) scores. That is, performance on the CSBS would likely correlate with both receptive and expressive standard scores on the RDLS. Specifically, we postulated that the CSBS...
The present study assessed the feasibility and accuracy of an early characterization of communication behaviors in predicting later language level. In general, we observed positive correlations between baseline, postinterventional measures and later, postinterventional outcomes; ie, age-normed early CSBS scores and later RDLS scores showed positive linear correlations. The variability in test results, both before and after intervention, was substantial. Clearly, such variance is to be expected in testing highly integrated functions, such as receptive and expressive language, in young listeners. Investigators have observed high variability in assessing other inventories of early childhood development. The high variance that has been observed with some metrics of language level is thought to accurately represent individual differences in early language development rather than measurement deficiencies.7

High variability in testing communication capabilities is particularly likely when early childhood subjects exhibit severe-to-profound sensorineural hearing loss, as these capabilities normally rely on a sense that is variably impaired across subjects. Furthermore, the study design could not exclude variables related to differences in cognition and different stages of development assessed before and after intervention, although age-norming of scores ameliorates the latter concern. Thus, we believe that the positive correlations that were observed in our study provide grounds for the continued assessment of the CSBS metric of early communication behaviors in young implantation candidates.

Pragmatic skills enable dynamic communication exchanges and thus would seem to be a key predictor of succeeding language learning potential. By 8 or 9 months of age, based on a foundation of phonological awareness, children enter the stage of development when they intentionally perform specific behaviors to accomplish desired social functions.2,8,9 Nonverbal means are used by children to communicate intention (eg, looking at a ball, reaching out, and then looking again toward the parent), joint attention (eg, smiling while looking at the face of a parent and then looking at a shared toy/action), and protest (eg, showing dissatisfaction through facial expressions and vocalizations). Formal interactive speech and language skills begin to replace prelinguistic behaviors. In normal development, competence with prelinguistic communication appears to be both a precursor and a prerequisite to appropriate speech and language use.10,11 In the present study, we assessed constructs related to pragmatics of
communication, including reciprocity, social-affective signaling, and symbolic expressions in play, as integrated into the CSBS battery of tests. We therefore tested the hypothesis that preimplantation pragmatics, as tested with the CSBS battery of tests, would predict oral language learning after implantation.

Later, skills were assessed with the RDLS through observation and documentation of formal language skills. The examiner used miniature figurines to enact familiar scenes (eg, a mother comforting her baby, a parent serving dinner, or a farmer caring for animals), and the child was expected to answer questions or to describe the scenes depicted. Basic understanding of social norms is needed to perform these tasks. Engagement with the examiner is also required to complete the RDLS. The test is lengthy, as props are presented. Without appropriate eye contact, eye gaze, and interest in the examiner, the child will have difficulty following the standardized guidelines. Therefore, the CSBS and the RDLS assess corollary behaviors that, in the context of normal developmental practice and learning, contribute to verbal communication competence.

We hypothesized that the children who performed well on the CSBS would demonstrate accelerated language learning after cochlear implantation. Pragmastic communication skills would seem to serve as a foundation for formal language to be learned and used effectively. As new vocabulary replaced gestures, a more sophisticated, rule-based language could be acquired. Support for this hypothesis can be considered weak based on the present data, and further investigation is needed. As overall correlations of CSBS and RDLS scores did not reach statistical significance (P = .13), linear correlation does not appear to be a good measure of the association between the CSBS and the RDLS within the context of the present study.

Poor performance on the CSBS may serve as a precaution. Very low CSBS scores tended strongly toward low RDLS scores. These preliminary observations suggest that if children lack appropriate prelinguistic behaviors, the emergence of age-appropriate formal language may be at risk. Low scores on the CSBS may reflect limitations in symbolic representations and a need for significant therapeutic support of behaviors that facilitate communication. Postimplantation habilitation should address prelinguistic skills to foster pragmatic as well as auditory and linguistic development. Multidisciplinary evaluations are recommended to assess cognitive, physical, and other sensory delays on an individual basis.

The converse was not true, however. High performance on the CSBS showed poor predictive value for subsequent RDLS scores. One possible explanation for this observation is that CSBS and RDLS measures reflect capabilities that, though age-appropriate, represent different receptive and expressive capabilities. For example, approximately 15 of the 22 subtests on the CSBS reflect visual abilities, while performance on the RDLS depends more heavily on auditory abilities. Adding other measures of auditory performance to the assessment protocol after implantation may lend further insight into factors that contribute to postimplantation language growth. Future assessments of the CSBS should better account for developmental variables related to cognition and environment. For example, it would be helpful to identify characteristics that contrast the subgroup scores with high CSBS, low RDLS scores, thus enabling stronger conclusions about conditions in which performance on the CSBS predicts RDLS scores.

The present study investigated the prelinguistic behaviors that predict later communicative competence. Behaviors, including joint attention, positive affect, and gestures, should be considered in cochlear implantation candidacy evaluations. However, such behaviors are often subtle and compose a challenging set of measures for formal, quantitative assessment. The analysis of functional communication through emergent play and social-interactive skills appears to be an informative alternative, particularly in the assessment of children with severe-to-profound sensorineural hearing loss. Use of a standardized measure to quantify pragmastic skills allows examiners to formally assess very young children. The information provided by the CSBS results reflected the importance of symbolic prelinguistic behaviors in the development of strong linguistic skills after implantation. Preliminary data indicate that poor performance on the CSBS is a “red flag” to members of the implantation team regarding later language acquisition.

Tools for measuring pragmastic communication behaviors may lend insight into strategies of therapeutic intervention. Pragmastic assessments potentially guide the intensity of therapeutic intervention and can help to set parental expectations by identifying deficits in integrative or psychosocial functioning at an early stage. Early assessment may also implement parent-based interventions that are designed to bolster pragmastic

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Figure 2. Bivariate analysis of overall scores on the Communication and Symbolic Behavior Scales (CSBS) and the expressive Reynell Developmental Language Scales (RDLS) showing the calculated line of regression and 95% confidence limits (curvilinear lines). These measures demonstrated a correlation coefficient of 0.36 (P = .13).
behaviors in young children. Facilitating prelinguistic communication skills in children with developmental disabilities has been found to have a positive impact on later language acquisition. Improvements in prelinguistic behaviors were found to have reciprocal effects with teachers and other communication partners, resulting in improved communicative competence. Investigators have also observed positive relationships between prelinguistic vocalization and later expressive vocabulary and between parental responsiveness and the effectiveness of prelinguistic communication intervention in exerting measurable effects on language. These findings suggest that the facilitation of prelinguistic skills in the context of the parent-child relationship is likely to carry a positive longitudinal benefit of later communicative competence.

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