

Clinical Management of Children With Cochlear Implants

Second Edition

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Clinical Management of Children With Cochlear Implants

Second Edition

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Preface to the Second Edition

My career as an audiologist began in 1976 at the House Ear Institute in Los Angeles during the time when the single-channel cochlear implant was being developed by William F. House, DDS, MD. For 10 years I participated in the first cochlear implant clinical trials conducted on adults and children with profound hearing loss. I also had the opportunity to work with the first group of adult recipients of the auditory brainstem implant. During those early trials there were no resources to guide our team. My colleagues and I had to learn by experience and to develop our own materials and assessment tools. The primary objective for publishing the First Edition of *Clinical Management of Children with Cochlear Implants* in 2009 was to compile a series of chapters from experts in the field to guide students and clinicians. The Second Edition highlights the many ways in which the field is evolving with respect to patient demographics, expanding indications, technology, rehabilitation, and education. Although the clinical concepts and assessment tools described in the First Edition remain relevant today, new topics covered in the Second Edition offer fresh insights into this ever changing field.

The chapters in this book are as diverse as the disciplines that represent the specialty area of pediatric cochlear implantation. The authors come from a variety of professional backgrounds, including neurotology, otolaryngology, pediatric otolaryngology, developmental behavioral pedi-

rics, audiology, speech-language pathology, electrophysiology, auditory neuroscience, clinical and pediatric psychology, cognitive science, experimental methodology, epidemiology, and education.

Several chapters provide guidance for managing a pediatric implant program, encompassing candidacy, assessment, surgery, device programming, and post-implant follow-up. Other chapters address specialized areas of assessment such as electrophysiology, vestibular functioning, speech recognition, speech and language, neurocognitive and psychological functioning, and quality of life. The second edition also updates chapters oriented to the child, family, and intervention with emphasis on education, parental contributions, families of low socioeconomic status, and second language learners. Hearing aids, bilateral implants, and auditory brainstem implants are covered in individual chapters. Finally, special cases typically encountered in clinical practice are highlighted, such as those with auditory neuropathy, multiple disabilities, and/or developmental delays.

Preparation of the second edition follows my 2013 move from the House Ear Institute to the Keck School of Medicine (KSOM) of the University of Southern California (USC) along with a number of my research colleagues and pediatric clinical specialists. In particular, I wish to thank John K. Niparko, MD and the USC Tina and Rick Caruso Department of Otolaryngology–Head and Neck Surgery at KSOM for support of this book. I am most grateful to Kalie

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increases and becomes more sophisticated, de-contextualization increases. Academic learning incorporates more frequent usage of decontextualized talk. Recent studies highlight the importance of incorporating and teaching academic language in preschool programs (Bunch, 2013; Cummins, 2014; Gebhard, Chen, & Britton, 2014).

To develop proficiency, acquire content knowledge, and develop skills identified within the CCSS, a learner must demonstrate proficiency using academic talk and competency using decontextualized talk. Academic talk has been defined by van Kleeck (2014) as the broader pattern of language use incorporated into teaching and learning contexts. Academic talk is transferred from adults to children in turn, allowing children to develop and display academic knowledge. There is a growing body of research on the development of broad based formal register that incorporates the use of academic talk in school aged children. For children who are DHH there is compelling evidence of the need to incorporate the use of academic talk within the home environment and preschool learning contexts. Academic talk is embedded within the school curriculum, most often not taught explicitly. Comprehension and effective use of academic talk is essential to literacy skill attainment and overall school success. The CCSS contain embedded expectations for proficiency with the use of formal register and academic talk.

There is significant value in increasing the use of academic talk in inclusive preschool programs, specialized educational programs, and during listening and spoken language intervention and speech and language therapy sessions for preschool children who are DHH. Waiting for DHH children to naturally acquire the use of academic talk will place them substantially behind their peers. Children who are typi-

cally developing and whose parents possess higher levels of education often demonstrate greater proficiency with formal register and academic language by the time they are school age. Our early intervention efforts must focus on the development of formal register and academic language in children who are DHH as well. Timely introduction of the use of academic talk positively supports early school achievement levels which are directly related to reading comprehension skills. Geers, Tobey, Moog, and Brenner (2008) identified that 72% of the variance in reading outcomes in 181 students deafened by 3 years of age and implanted prior to 5.5 years of age was accounted for by child and family variables and speech and language use in the home. Further investigation of family variables and the quantity and quality of academic talk during the preschool years in children who are DHH is needed. Speech-language pathologists, early interventionists, listening and spoken language specialists, and parents who support children's early educational experiences must take advantage of every opportunity to use explicit teaching and academic talk during the preschool learning years.

Developing Language and Early Literacy Abilities

Throughout the preschool years, a child's vocabulary increases at a rapid rate. Children typically use approximately 300 words by age 3 years; 1,500 words by age 4, and 2,500 words by age 5. This number rapidly increases between the ages of 5 and 7 years to approximately 12,000 to 13,000 words. (Gard, Gilman, & Gorman, 1980; Templin, 1967). Children should be acquiring between two and three words per day by the first grade year which equals an addi-

tional 800 words per year. Children who lag behind in vocabulary skills in the first grade have difficulty closing the word gap (Biemiller, 1999; Luckner & Cooke, 2010).

A child's understanding of vocabulary is a significant predictor of early reading success (Kim, Apel, & Al Otaiba, 2013). Children who are able to acquire rich extensive vocabularies are able to understand more of what they read; the "Matthew Effect" occurs. That is, those who know more words learn more words and as result become better readers (Stanovich, 2000). When children comprehend with ease as a result of knowing more words, they tend to read more. The more the children read and are read to during the preschool and early elementary years, the more competent children become in determining the meaning of unknown words.

Studies on vocabulary acquisition indicate that implantation in children younger than 2 years of age using CIs may achieve receptive vocabulary abilities equivalent to their typically developing peers (Connor, Craig, Radenbush, Heavner, & Zwolan, 2006; Fagan, 2015; Svirsky, Teoh, & Neuberger, 2004). The ability to overhear conversations and acquire linguistic information through incidental listening is crucial to building a strong understanding of vocabulary and a substantial lexicon. The contribution of incidental listening may be greater for children with CIs than in children who are DHH but who do not use CIs; however, even with a CI some children may not have sufficient hearing to adequately access language and other environmental information that supports incidental learning (Convertino, Borgna, Marschark, & Durkin, 2014).

As children progress through the grades, their ability to learn new words and increase their understanding of vocabulary is dependent upon their ability to add morphemes to the root word. Sixteen suffixes account for

87% of suffixed words. The suffixes *-s/-es*, *-ed*, and *-ing* account for 65% of word suffixes; the suffixes *-ly*, *-er/-or*, *-ion/-tion*, *-able/-ible*, *-al*, *-y*, *-ness*, *-ity*, *-ment* account for 22% of word suffixes (Stahl & Nagy, 2006; White, Stowell, & Yanagihara, 1989). A child's ability to use appropriate verb inflections and word endings correlates with a child's early reading and writing progress. A child who demonstrates the use of inflectional endings in spoken language should be able to incorporate the use of these cues in error correction strategies when learning to read. Conversely, the child with poor abilities to use inflectional endings may produce more reading errors and experience a greater degree of difficulty making self corrections. The acquisition of bound inflectional ending rules is a process that cannot be left to memorization. These rules continue to be acquired during the early schooling years, mandating the consistent need for auditory access, classroom acoustical enhancements, and the use of sound field and personal FM systems to ensure access to spoken language in children who are DHH listening with CIs and ABIs. In children who are typically developing, grammatical knowledge becomes a better predictor of reading comprehension than vocabulary skills by the second grade (Berninger, Abbott, Nagy, & Carlisle, 2010).

The level of reasoning required to support meeting the CCSS necessitates the use of inferential analysis abilities. Inferential uses of language require the child to think beyond literal meaning. Language use must support the development of a hypothesis and the abilities to predict, to generalize, to summarize, to evaluate, to analyze, and to create. For this reason, the authors suggest that interventionists, including speech-language pathologists, incorporate the use of the think-aloud strategies. By verbally stating their thoughts (i.e., using "think-aloud")

adults model what they are thinking, for example:

I am going to look at the picture on the front cover of the book. The picture might give me information about where the story is happening. Maybe the story will happen in the forest. I will need to read the story to find out.

Think-alouds support error free learning.⁵ It is also essential that service providers, care takers, and family members provide necessary wait time that allows young children who are DHH to process language rather than immediately scaffolding responses to support a child's comprehension.

Young children learning to read must acquire a metalinguistic understanding of language and conventions associated with printed texts such as comprehending what a word is, what a sound is, or what a letter is, and knowing the rules of directionality, including the use of left to right sweep and that we read from the top of the page to the bottom of the page. Print referencing techniques incorporated into shared reading experiences support greater gains in alphabetic knowledge, print concept knowledge, and early name writing skills (Justice, Kaderavek, Fan, Sofka, & Hunt, 2009). In addition to acquiring concepts of print and word knowledge, a child needs to develop an ability to produce most of the sounds of speech when attempting to read in order to link these skills to clusters of letters. The articulation of a word is linked to the sequence of sounds in a word (Zaporozhets, Zinchenk, & Elkonin, 1971). It has

been found that good articulation skills are associated with early progress in writing (Robinson, 2005). When articulation delays are evident at an early age in children who are DHH, strong consideration should be given to providing individualized instruction and intervention by knowledgeable service providers, including a certified and licensed speech-language pathologist.

As children develop increased proficiency in spoken language use and incorporate a greater degree of academic talk, typically developing children begin telling their own stories. Storytelling is a crucial step in learning to read and write. Children begin narrating their own stories; they soon develop the understanding that print can be turned into speech. A child develops the understanding that speech or the story's message can be recorded in writing. The picture accompanying the text serves as a guide to the written message. Children gain more experience with storytelling and come to the realization that some components of language begin recurring more frequently. As this understanding develops, a child comes to the realization that words often appear in a given order. Memory aids in the overall understanding of this process.

A child with a good memory for language may rely heavily on recalling what someone else has said. From the child's perspective, he is using his strengths. From an educational perspective, this comes with considerable risks if it interferes with the development of supporting visual strategies crucially bound to the reading and writing processes. It is vital during this early reading stage that young children develop the ability to search, to check, to formulate,

⁵Error free learning is an instructional design based on the work of B. F. Skinner that has been correlated with improved outcomes in individuals with impairments in memory. Individuals with sufficient memory function can recall their mistakes and learn from them. Those with reduced memory function may have difficulty recalling what supported learning most effectively. Error free repetition may be required to solidly link information (Thorne, 2006).

to recheck, and to self-correct in order to confirm accurate responses. A linguistically capable child will make errors in reading; however, these errors may be both grammatical and meaningful. Knowledge of language guides the child's responses and self-corrections.

Recent models for viewing the relationship between phonological awareness, spoken language, and reading development incorporate the role of working memory, executive function, and fluency in children who are typically developing (DeThorne, Petrill, Schatschneider, & Cutting, 2010). Children who are DHH may require explicit instruction in language development, phonological awareness training, and instructional support in attending to the development of executive function, Theory of Mind, and fluency during their primary years (Geers, Pisoni, & Brenner, 2013). Knowledgeable parents may contribute to the development of these skills in their children with the guidance of a literacy coach or highly qualified service provider. In this way parents have the opportunity to play a vital role in developing their child's language and literacy skills.

The functions and forms of literacy are equally important when developing reading and writing abilities. Young children learn the functions and forms of reading and writing concurrently through shared literacy experiences, such as writing a list before going to the grocery store. Families are essential to literacy development. Researchers have found repeatedly that the home literacy environment of toddlers and preschoolers has measurable effects on later literacy skills (Weinberger, 1996). Adult contributions provided during the

preschool language learning years through increased quality of talk and conversation with a child also play a significant role in top down phonological decoding and encoding necessary for the development of reading and writing skills (DeThorne et al., 2010). We believe that the quality of talk during conversational exchanges will support greater language and literacy outcomes in children who are DHH as well. Therefore, school placements for preschool children who are DHH and the provision of services under Part B of IDEA (2004) must be carefully considered. In addition to careful analysis of school placement, curricular methodologies selected that support early reading and writing processes in children who are DHH must be carefully analyzed, continuously evaluated, and reviewed for instructional fidelity by transdisciplinary team members. The authors believe that including balanced literacy instruction⁶ by providing children who are DHH with quality literature, explicit instruction in phonics, grammar skills, reading and comprehension, and writing instruction during the preschool and school aged years could provide significant educational benefit. While this evidence-based practice (balanced literacy) has been incorporated in general education classroom settings for decades, there is a need for investigation and research regarding the efficacy for use with children who are DHH using implantable technologies.

Preparing for Reading Instruction

Children with hearing loss bring to the task of reading language experiences that are

⁶Balanced literacy instruction is an evidenced based instructional approach that incorporates the use of whole language and phonics, balances teacher talk with child talk, and incorporates dialogic reading, read aloud, interactive read aloud, shared reading, guided reading, shared writing, interactive writing and guided writing.

both similar to and different from those of hearing children (Hanson, 1987). The National Reading Panel (2000) identifies five key components of reading instruction: phonological awareness/phonemic awareness, phonics, fluency, vocabulary instruction, and text comprehension. Lack of attention to teaching early foundational reading skills, such as phonemic awareness and phonics, may contribute to the reading difficulties experienced by students who are DHH and may contribute to the fourth-grade ceiling consistently documented for more than 90 years (Wang, Trezek, Luckner, & Paul, 2008).

Learning to read and write requires children to utilize four primary processing systems: an orthographic processor, a phonological processor, a meaning processor, and a context processor.

Children acquire the reading and writing processes during their preschool and early elementary years, increasing their competence with the use of the four primary reading processing systems, over time throughout the elementary years. Development of phonological awareness—the overall awareness of the sound of words—is deeply rooted in early conversational experiences that foster reading development and phonological awareness through interaction. Children develop this awareness through play with the sounds of spoken language incorporated in early rhyming activities, and also during early writing activities when they begin to explore the relationship of writing one's speech in print by identifying what is heard through recorded printed letters (Anderson & Briggs, 2011). A child's phonological and phonemic awareness is supported through early access to spoken language by full-time use of prescribed amplification. Children with CIs and ABIs may benefit from explicit intervention in

the development of phonological awareness skills applying research based instructional practices (Schuele & Boudreau, 2008). Avoiding prolonged use of electronic media that may distract the listener from attending to oral features of language is recommended. Clinicians must guide parents in allowing the young newly implanted listener to develop an internal schema necessary for organizing sound and its ultimate relationship to print. The contribution of phonological awareness to word learning and language learning in young CI users has been linked to building effective reading processors (Mayer & Trezek, 2014). Refer to Figure 17-1.

The four processing systems work jointly to assist with decoding and comprehension of printed text. The orthographic processor refers to the ability to use orthographic knowledge to read and spell words. This knowledge is critically bound to reading fluency and the spelling of words. Children rely on using their visual system to form, store, and recall words. Young readers learn to look at letters and words on a page and use their knowledge of sound/symbol relations to decode, or sound-out, the word. Eventually the child stores the memory of the word in the brain and retrieves the information at a later time. Words memorized in their entirety are defined as sight words. Children rely on orthographic processing to remember words and recall them later when reading and writing. Orthographic processing and phonological processing develop as parallel processing systems. Eventually children who are typically developing are able to store a significant number of words and no longer rely on sounding out the words. The meaning processing system involves incorporating the use of semantic relationships underlying meaning of words. Vocabulary knowledge plays a primary role

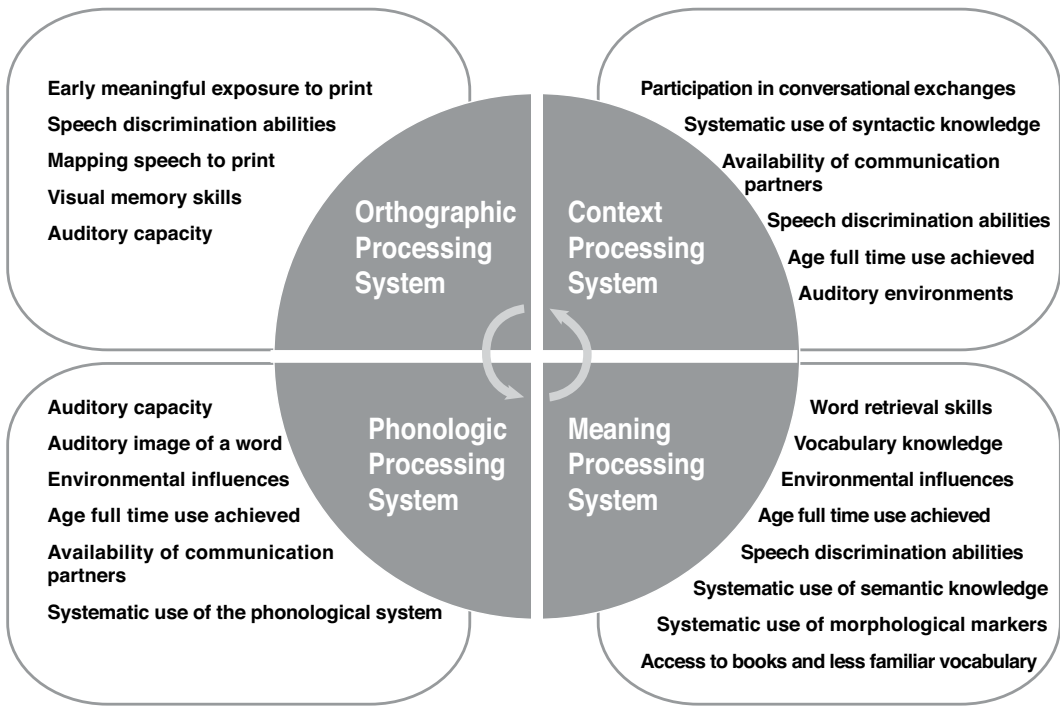


Figure 17-1. Relationships between listening and spoken language development to the use of the four processing systems.

in the application of the meaning processing system when reading. Young children begin to systematically apply their knowledge of word meanings to interpret text that they are decoding. The final processing system, the context processing system, involves the order and arrangement of words bound to printed text, (e.g., the use of syntax to support decoding and comprehending printed text). As children develop coordination and proficiency using all four processing systems, they reduce the amount of effort required to read. Reading becomes automatic; when automaticity is achieved, cognitive efforts decrease. This frees cognitive resources that can be allocated to support higher levels of achievement through increased comprehension and engagement

with the text. If one of the processing systems is weak, reading outcomes may be constricted.

The use of each of the processing systems may be highly effective or ineffective in an individual implanted child. Given the complexity of the acquisition of the reading and writing processes, education and intervention practices must not further contribute to reading difficulties of children who are DHH by allowing them to continue to use ineffective processes for literacy learning. Success in school historically has been highly correlated with reading and writing abilities (Taylor & Pearson, 2002). Traditional viewpoints toward slow progress in young readers often suggest that a child needs more time to develop phonological

awareness skills. These viewpoints may be incorrect; slow progress may be the result of developing ineffective processing systems. Allowing a child to continue operating on a haphazard system with no means for efficiently monitoring or checking his accuracy may perpetuate poor progress (Clay, 1991). Service providers during the preschool and primary years must possess the necessary expertise to implement and monitor the overall development of the reading and writing processes to avoid allowing children to continue to use ineffective processes, thus delaying reading and writing skill development (Katz & Fallon, 2015). Similarly, the authors believe that children who are DHH and continue to use ineffective processes as young readers are at great educational risk for reaching the well documented fourth grade reading ceiling levels. Children can be prompted and guided by mainstream preschool teachers, teachers of the deaf and hard of hearing, listening and spoken language specialists, and their parents to the acquisition of these early reading processes.

It is essential that young children who are DHH using spoken language develop listening and speaking skills that parallel reading and writing processes. Sharing books with infants provides visual stimuli and auditory pleasure. Long before a child understands what a book is, learning is taking place. The child who looks at books as early as 2 years of age will scan pictures for meaningful messages (Clay, 1979). An unfamiliar book will take the brain longer to scan pictures; comprehending and labeling images will require additional processing time. Young children need time to analyze two dimensional spaces.

By increasing early experiences with picture books, children who are DHH gain experience scanning visual information while developing necessary visual control. Young children whose musculature is not

well developed (e.g., children who do not have good control of hand-eye movements) may encounter later difficulties in acquiring necessary directionality when learning to read if early literacy experiences are infrequent. When a child develops inappropriate scanning abilities at an early age, the eyes do not support what the head and body are trying to achieve when responding to pictures and to text. The relationship of eye movements to more advanced reading is essential when developing left to right, top to bottom directionality, discriminating and identifying individual letters, and identifying clusters of letters. The inflexible use of directionality is often difficult for typically developing 5-year-old children; we must not underestimate the importance of attending to and providing appropriate intervention which monitors the development of these processes in young CI and ABI users.

The years before a child enters school are prime years for nurturing reading behaviors that will carry them into becoming readers. Talking about books allows parents the opportunity to encourage an interest in books, expand vocabulary, and spend quality time with their children, thus building fundamental literacy abilities (Davidse, de Jong, Bus, Huijbregts, & Swaab, 2011; Taylor & Pearson, 2002). In addition to the importance of talking to and with the child as discussed earlier in the chapter, the value of reading aloud to children of all ages has been studied for years as well (Mol & Bus, 2011). Reading aloud has been determined to be the most important factor in raising a child to be a reader (Trelease, 2001). Bus and van Ijzendoorn (1988) and Wasik (2004) emphasized the importance of reading to children prior to their sixth birthday; this exposure corresponded to higher outcomes in the areas of language growth, emergent literacy, and reading achievement. Their research supported the concept that read-

ing development starts before the preverbal stage of linguistic development. Early shared book reading through read-alouds also offers an opportunity to support the acquisition of decontextualized language and vocabulary (Justice, Pence, & Beckman, 2005).

Children listening with CIs and ABIs will need more linguistic input, more opportunities to acquire and use decontextualized language, increased exposure to different genres, and a greater number of background experiences than their peers who are typically developing. Schirmer (2000) suggests reading aloud to a child who is DHH before the child can understand every word and every concept. Parents and service providers are encouraged to consider the level of difficulty of story books selected for early read aloud experiences. Considerations should be given to the overall complexity of the language and story structure, the quantity and type of inference found within the text, and abstract concepts introduced, the length of the book, and the child's experiential familiarity (Schwarz et al., 2015).

When children begin to read, they incorporate simultaneous use of visual, auditory, and tactile kinesthetic senses (Clay, 1979). Support for integration of these senses begins at birth. Familiarity with early books triggers a brain response. Research indicates that between the ages of 3 and 9 years the young child fully comprehends that the two sides of the body are different from one another (McManus, et al., 1988). Sensory postural awareness develops during this period of time. Dominant hand awareness likewise is developing. Children double their frequency of eye movements between ages 4 to 6 years relative to the age of 3 years

(Clay, 1991). The child who has had a greater number of early literacy experiences incorporating the use of all sensory systems most likely will demonstrate a greater degree of readiness for formal literacy instruction.

Formal Literacy Instructional Practices

Balanced literacy, based on the research of Marie Clay, Irene Fountas, Gay Su Pinnell and others, is a comprehensive model of language acquisition that incorporates fundamentals of listening, speaking, reading, writing, and word study into daily instruction (Clay, 1991; Fountas & Pinnell, 2006; Pinnell & Fountas, 2007). It is also a curricular methodology which includes the use of modeled, shared, guided, and independent practice when teaching effective reading and writing skills. Balanced literacy instruction offers equal time for teacher talk and child talk during teacher-directed and child-directed learning activities (determined through the ongoing administration of formal and informal assessments) supporting multiple opportunities for engagement, expression, and inquiry. The authors believe that children who are DHH using listening and spoken language may benefit from a balanced literacy approach rooted in highly individualized instruction that moves learners from high dependency on teacher support to learner independence. This model of literacy instruction is frequently incorporated in the Reader's and Writer's Workshop model⁷ of instruction in general education classrooms.

⁷A result of a mandate to improve instructional practices in the New York City Public Schools, the Columbia Teacher's College Reading and Writing Project, was pedagogical work (e.g., Reader's and Writer's Workshop) that supported daily instruction in reading as well as writing. The workshop approach to teaching literacy, rooted in the work of Lucy Calkins, provides explicit instruction in comprehending text (Calkins & Bellino, 1997).