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Two Paths of Auditory Development for Children with Cochlear Implants

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Impressive levels of performance continue to be documented in young children receiving cochlear implants. Word recognition skills are now expected in virtually all young cochlear implant recipients. In addition, the new generation of cochlear implants use speech processing strategies that encode the entire speech waveform. This results in faster learning rates and higher performance than observed with previous-generation technology that only encoded specific speech features. Nevertheless, virtually all studies show that there is a wide range of performance in implanted children. Many factors might contribute to post-operative benefit, including age at implant, duration of deafness, and the condition of the cochlea. One potentially important factor that affects all children is the type of training they receive.

The Didactic vs. Generalization Models

Traditionally, auditory development in profoundly hearing-impaired children was viewed as a process of *auditory training*. This meant that the child needed to be didactically *trained* to achieve each of the listening skills along a hierarchy of auditory development. And there were virtually hundreds of these skills! The assumption was the child learned only what was directly taught to him. This was not an unreasonable assumption prior to the advent of multichannel cochlear implants, given that many profoundly deaf children had access to only minimal auditory cues through their hearing aids. Using this minimal information, children were able to recognize *patterns* of auditory information rather than to discriminate fine differences in speech sounds.

It was demonstrated that children who perceived only patterns of auditory information could still utilize sound to make a remarkable number of discriminations of the speech signal. However, these pattern perceivers did not hear enough of the auditory code to use listening as their primary source of language learning. In order for these children to learn spoken language, a direct, systematic approach to training was required. The children were, in large part, unable to make use of incidental learning as a means of acquiring language. This incidental language learning is the means by which normal-hearing children learn language. It is the most efficient, and perhaps the only way to truly master a spoken language code.

Incidental learning takes place when a child acquires knowledge or skills through naturally-occurring events. The ability to generalize is central to an incidental learning model because such a model assumes that the developing child's cognitive system is able to make use of similarities and differences within situations in order to generalize across them. For example, a child who is hurt by touching the burner on his mother's gas stove probably will not attempt to touch the burner on his grandmother's electric range. He has generalized information from one context to another. One of the reasons the child can make these generalizations is that his sensory system, in this case, his sense of touch, is intact. If in fact, the child did not feel pain normally it is unlikely that he would be able to generalize this information and would need to be shown every source of dangerous heat separately. This is analogous to the case of the profoundly deaf child with little residual hearing. Because his sensory input system, in this case hearing, is so limited, the chances of using incidental learning for generalization are substantially reduced (See Boothroyd, 1985).

Cochlear implants provide the potential for deaf children to make use of generalization and incidental learning to a degree that was not possible with conventional hearing aids. Still, the signal provided by the implant is not complete. Even implant recipients using state-of-the-art speech processing technology receive a degraded, not a normal auditory signal. In addition, children often receive a cochlear implant after several years of auditory deprivation. Even with the improved auditory signal provided by the cochlear implant, these youngsters will need a great deal of training to reach their auditory potential.

Have teaching methodologies in deaf education changed within the last ten years to accommodate the increased generalization ability of deaf children with cochlear implants? This change would be essential to successful auditory learning by pediatric cochlear implant users. If clinicians continue to assume that a child's learning is completely dependent upon didactic instruction, many opportunities for incidental learning will be lost. In addition, failure to adopt an emphasis on incidental learning lessens the effectiveness of parents to utilize "teachable moments" at home to foster their child's auditory progress.

Thus, given the improved auditory learning potential with cochlear implants, the goal is not to teach the child every skill he will ever need to know. Rather, in the generalization philosophy to training, the goal is to select teaching targets that will generalize to other targets that, in turn, will generalize to other targets, and so on (See Figure 1). This approach also promotes independent learning skills and helps the child become a "responsible" communicator.

Age at Implant is a Critical Factor

A child's potential for incidental learning and generalization is greatest in the early years and slowly decreases with age. All implanted children require a combination of didactic and incidental teaching. All things being equal, the younger the child at the time of implantation, the greater the influence of incidental learning and the less the need for didactic instruction. Conversely, the older the child at the time of implantation, the greater the need for didactic instruction to foster auditory development. Although children who are older at the time of implantation may still benefit from incidental learning, it is likely that their curriculum will need to be heavily weighted with didactic instruction if they are to acquire auditory skills (See Figure 2). This phenomenon, among others, argues for early implantation of children.

The Risk of Greenhousing

The very nature of auditory therapy, in which one aspect of sound is focused on and intensely drilled, poses a risk of the development of a counterproductive pattern known as greenhousing. Robbins (1994) has used this term to describe therapy approaches that emphasize isolated, structured listening behaviors to the exclusion of other communication skills. This approach may lead to an asynchrony between auditory development and overall communicative competence. There are a number of "red flags" used to identify children whose auditory development may be following this counter-productive pattern. First, these children may be able to engage in many auditory tasks through listening alone, as long as they are not required to interpret what they hear in a meaningful way. This would include the child who can make fine distinctions between pairs of nonsense syllables ("mup" vs. "shup" for example) but who fails to make these distinctions when real words are used. Second, these children may be able to perform listening tasks for rehearsed material but are unsuccessful when the same information is presented in a novel situation. Third, children with greenhoused skills may rely heavily upon rote or elicited imitation during communication, even after considerable practice with the language structures used. Finally, these children's' successful auditory performance may be highly dependent on routinized tasks, suggesting that the skills have not generalized. For example, a school-aged child demonstrating this behavior might be able to answer the question "What is the weather outside today?" through listening alone, if asked during calendar time each morning by the teacher in a rehearsed format. If the same question occurred in the course of daily conversation, the child would be unable to process it.

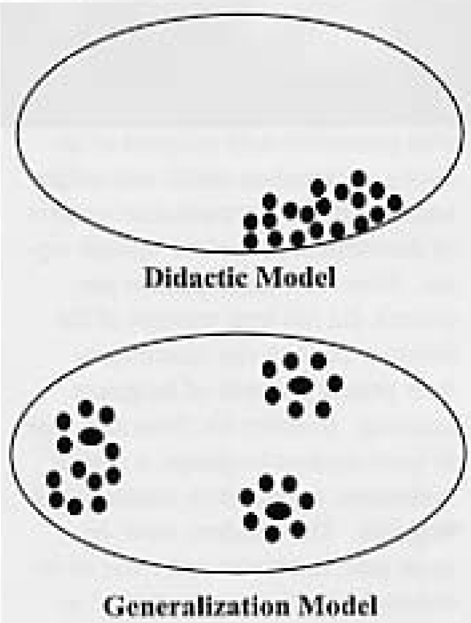

Figure 1. The ovals represent communicative competence. The didactic model attempts to fill the oval by teaching every skill needed. In the generalization model, selected goals generalize to other skills, gradually filling the oval.

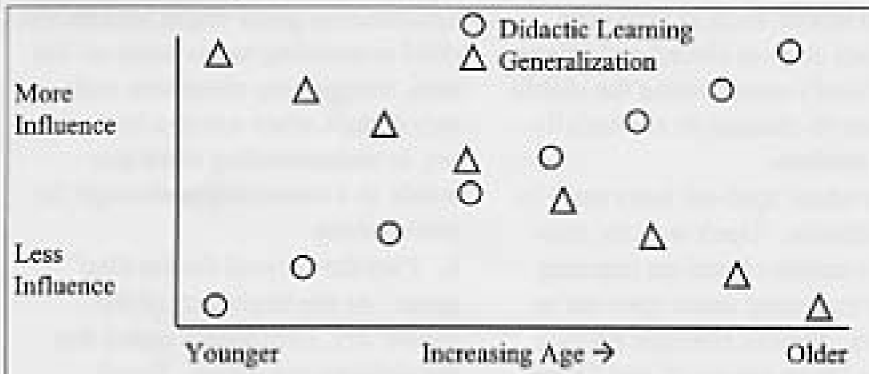

Figure 2. The relative influence of two auditory paths as a function of age.

Getting Started on the Right Foot

Most of us know from experience that getting started on the right foot is essential for accomplishing almost anything. How one approaches a task from the beginning, how the ground rules are set, and what expectations are conveyed initially, is critical. Starting out on the wrong foot and then having to radically readjust not only wastes time but requires an "unlearning" of bad habits.

Children receiving cochlear implants are no exception. The foundations for establishing generalization should be built from the earliest days of cochlear implant use, and embedded in the therapy program. The first weeks and months of implant use are critical in establishing either a pattern that encourages generalization or one that emphasizes isolated listening training that may lead to "greenhoused" auditory skills. Steps for building a foundation for generalization are outlined in Figure 3. Stage 1 involves consistent detection, clearly the first skill that the child must master. In most implanted children, this skill is acquired relatively quickly, often within days or weeks of initial stimulation. At stage 2, the clinician teaches the child to select what he has heard from a set of two alternatives. Following these two traditional steps, sabotage is introduced, in which stimuli not expected by the child are sometimes presented. The first stimulus used in sabotage is silence. At stage 3, the child's task is still to listen for one of two things; but once in a while, without warning, the clinician presents silence or "nothing." The goal is to teach the child that, although he or she is listening for one or two things, there might be a "trick," so that nothing would be heard at any time. This helps establish the child's ability to report hearing nothing, even when the expectation is to hear something. This is a fundamentally important skill because it aids in the accurate setting of threshold levels during device programming and in the child's knowing immediately when his or her implant is not functioning. In addition, this skill applies to the real world, where the presence of sound in unpredictable.

At stage 4, two alternatives are still presented to the child, but sabotage now may be employed either with silence or by saying the child's name in place of one of the stimuli. This stage teaches spontaneous name recognition, which has far-reaching safety and social implications and is one of the most common reasons given by parents for seeking an implant for their child. Again, the child must recognize his or her name when it is not expected. This skill is needed in the real world, where children do not know when their names might be called. Teaching the child to respond with "That's me" when hearing his own name allows adults to distinguish name recognition from simple auditory detection. Once the child has clearly mastered name recognition, this response may be extinguished.

At stage 5, additional names are added to the list of sabotage stimuli. This skill is also important because the child must not only be able to recognize when his or her name is called, but also to distinguish it from other names. Only after the child resists sabotage at stage 5 does the clinician begin to expand the set of stimulus choices. This strategy differs from the traditional approach to auditory training, where identification of an increasing number of closed-set items is a primary goal. As the child is able to handle more complex listening tasks, sabotage becomes more subtle but should continue to be used as a check of the stability of skills.

In the method described here, a great deal of time is invested in the early stages of implant use to establish skills that will generalize into real-world listening. Building a foundation for generalization is only the beginning of a long process of meaningful auditory learning.

Teaching Suggestions to Promote Generalization

1. Alternate global and discrete listening activities in therapy. Global listening tasks rely upon suprasegmental cues and the "gestalt" of the message, whereas discrete listening tasks require an analytic approach to recognizing fine details in the message. Both are important, but a balance is required. Traditional auditory training relied too heavily upon many repetitions of discrete listening tasks, such as minimally-different word pairs. Make certain that structured, discrete listening tasks account for no more than half of a child's auditory activities during therapy. For global tasks, use motivating stimuli such as music, nursery rhymes, recognition of emotion in the voice, and listening walks.

2. Establish listening routines, then break them. Young children need routines in their schedule, and teachers of the hearing-impaired have made good use of routines. However, over-using routines can mask our ability to judge the child's auditory understanding. By "sabotaging" a child's routine, we are able to separate situational from auditory comprehension. If a teacher greets the implanted child every morning with "Go hang up your coat," and the child hangs up his coat, it is impossible to judge whether or not the child understands the command or simply predicts it from the context. The teacher should alternate this command with several others, such as "Put your book bag on your chair," and "Hang up a friend's coat," noting the child's response to changes in auditorially-based routines.

3. Introduce open-set tasks early in rehabilitation. Don't wait for children to master closed-set listening before expecting some open-set responses. Present common phrases, such as "How are you?" and "Time for lunch" through listening alone. Even if the child doesn't understand, clarify with speechreading and try again later. You're conveying the message that you expect the child to listen and comprehend.

4. Make closed-set listening tasks less predictable. For example, if Sally is picking an object out of a field of four objects through listening alone, try these variations: (a) ask for one of the objects several times; (b) ask for an object that is not one of the choices; (c) fail to ask for one object; (d) call the child's name in place of an object; (e) present silence and observe the child's response.

5. Set spontaneous listening goals just as you set structured ones. Spontaneous goals might include the child responding to his name on his own, recognizing classroom auditory signals when not in a listening set, or understanding some key words in a conversation through listening alone.

6. Play the "Sound for the Day" game. At the beginning of the school day, introduce a sound that the children can detect. Small noisemakers that fit into a pocket work well. Then, move on to other activities. Without warning, present the sound throughout the day, providing no visual cues. The child who recognizes it first as the "Sound for the Day" receives a point. The child with the most points wins a prize.

7. Document instances where the child repeats something he has overheard in conversation, uses a new word without being directly taught it, or re-auditorizes by "thinking aloud" with language to problem-solve. All of these suggest that the forces of generalization and incidental learning are alive and working in the child with a cochlear implant.

A Foundation for Generalization

	Child's Task		Sabotage	
Stage 1	Detection			
Stage 2	a or b			
Stage 3	a or b	+	(Nothing)	
Stage 4	a or b	+	(Nothing) or Christy	
Stage 5	a or b	+	(Nothing) or Christy or Allyson	or Mom or Amy
Stage 6	a or b or c or d	+	(Nothing) or Christy or Allyson	or Mom or Amy

Figure 3. A model for enhancing generalization of auditory skills in the early stages of cochlear implant training. The open squares represent stimuli presented to the child. The shaded squares represent stimuli used to sabotage at various stages. From Robbins & Kirk (1996).

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