Jennifer Mertes, AuD, is the director of Related Services and campus audiologist at the Maryland School for the Deaf. She has worked in The Listening Center; the cochlear implant center at Johns Hopkins Hospital in Baltimore, Maryland; and The River School, an inclusion program for students who are deaf or hard of hearing in Washington, D.C. She welcomes questions and comments about this article at *jenniferdavismertes@gmail.com*.

Auditory Technology

AND ITS IMPACT ON BILINGUAL DEAF EDUCATION

By Jennifer Mertes

Brain imaging studies suggest that children can simultaneously develop, learn, and use two languages. Bilingualism is common throughout the world, and children who are raised bilingually experience linguistic and educational benefits. For children who are deaf or hard of hearing and who have access to language through listening, these studies have special importance. They show that keeping expectations high may mean taking advantage of a natural bilingual opportunity; deaf and hard of hearing children can be fluent in both a visual language and spoken language.

A visual language, such as American Sign Language (ASL), facilitates development at the earliest possible moments in a child's life. Spoken language development can be delayed due to diagnostic evaluations, device fittings, and auditory skill development. While the auditory pieces are coming together, visual language should be used to support a child's cognitive development and social-emotional well-being. Once auditory access is established and auditory skills are developing, the two languages can be used to support education and bilingual approaches are available as teaching tools.

Research does not indicate that any single methodology is 100 percent successful when instructing children who are deaf or hard of hearing. Proponents of all methodologies boast of star students and admit to struggling students. A bilingual approach to deaf education ensures the best of methodological worlds: language development and literacy are the primary focus. Fostering development of a visual language and spoken language at the same time safeguards language acquisition and allows deaf and hard of hearing children to achieve their full potential.

Technology: Impact on Auditory Access

New auditory technologies—from cochlear implants, to hearing aids, to devices that allow sound to be carried to the brain through bone conduction—provide many deaf and hard of hearing children with improved access to spoken language. These devices

Photos courtesy of Jennifer Mertes

have become increasingly sophisticated; more deaf and hard of hearing children than ever before access spoken language so extensively they can learn through listening.

HEARING AIDS

Hearing aids are now "smart" in that they use digital processing to analyze the listening environments and optimize reception of speech. Even in adverse listening situations, where surrounding noise is loud and persistent, hearing aids allow some deaf and hard of hearing people to identify and understand the conversational signal.

Further, today's hearing aids allow improved amplification and processing of high frequency speech sounds. This has proven to be a powerful advance as these sounds—such as consonants *k*, *t*, *s*, and *f*—can influence the content of the message and are necessary for following the important grammatical structures that underpin comprehension. Spoken language contains sounds that vary in volume, pitch, and frequency. If a person can hear low frequency sounds but not high frequency sounds, he or she can hear someone talking but not understand what is being said. Children with this hearing configuration develop speech production skills that are intelligible, but their reception of spoken language and novel vocabulary is degraded.

Previous hearing aid technology provided limited access to these high pitched sounds due to limitations of microphones and sound processing; today, expanded bandwidths and the advent of frequency transposition and non-linear frequency compression allow sound to be shifted from high frequencies to a lower frequency, therefore making it more audible for the hearing aid user.

COCHLEAR IMPLANTS

Cochlear implant (CI) candidacy was previously restricted to those who were deaf and had minimal access to spoken information with hearing aids. Candidacy has now expanded to include individuals who are hard of hearing and have partial access to spoken language when wearing hearing aids. Previously, recipients were implanted in one ear only. Today CIs in both ears are recognized as the standard of care; and most children receive bilateral CIs or use a CI for one ear and a hearing aid in the other ear.

Right: The simplest approach to defining a child's auditory access is to complete a Ling 6 listening check. The Ling 6 sounds (*mm*, *oo*, *ah*, ee, *sh*, *ss*) can be used as a guide of which grammatical features a child can hear.

Recently the Federal Drug Administration (FDA) approved the use of a "hybrid CI," which takes advantage of residual low frequency hearing through an acoustical component connected to a CI sound processor. While the acoustic component allows the reception of natural sound, an internal component electrically stimulates the high frequency region of the cochlea. Today only adults have access to this technology, but the FDA is anticipated to approve expansion of its use for children soon.

So complete has auditory access become for some deaf and hard of hearing students that they can learn to read through auditorally based literacy strategies used with hearing children. These strategies may be modified on an individual basis to take into account the child's hearing levels. An auditory access profile developed for each child specifies what the child can hear and what parts of English are missed through listening alone. A multidisciplinary team can use this data to guide implementation of teaching strategies and monitor student progress. Instructional strategies, based on visual and spoken language, shift depending on the area of need. Through tracking language development data, teachers and specialists ensure concepts are understood and use each language to support the other.

Monitoring and Tailoring Teaching as the Child Develops

Teachers and professionals must continually:

- ***Assess linguistic competence in English and American Sign Language.*** A multidisciplinary team should continually assess the child's language development. Assessment can show how a child is developing language and help in setting goals to ensure that progress continues.
- ***Assess auditory skills.*** Auditory skills are a precursor to spoken language development. Areas to consider in auditory skill development include sound awareness, discrimination, identification, and comprehension.
- ***Build on the child's skills.*** For children with emerging listening skills, structured listening opportunities provide important support. Exposure and scaffolding are essential in this area.
- ***Alert to lack of progress.*** If progress is not forthcoming and if the child is unable to benefit from the equipment for whatever reason, use of a visual language for instruction should be considered.

A bilingual approach with children who wear amplification and who have auditory access to English is a vital consideration for many deaf and hard of hearing children. These children can be encouraged to develop both languages—visual and spoken—at the same time. This preserves the individual learning experience and results in improved literacy. Bilingual competence provides expanded opportunities for direct and accessible communication with family members, peers, professionals, and Deaf community members plus increased options for academic learning.

Deaf and hard of hearing children deserve language acquisition at the earliest possible age, and this is accomplished most surely through the children's accessible visual pathways. With children enrolled in bilingual programs that equally respect ASL and spoken English and facilitate development of both languages, parents and professionals can feel confident that children are receiving services designed with language and educational development in mind. No time is lost waiting for one language to develop. Both languages are utilized and facilitated in a systematic way to ensure each child's success.

TOOLS for SCHOOLS

THE SOUNDS of Speech

English Consonants

Adapted from Ling, Daniel (1976) Speech and the Hearing Impaired Child: Theory and Practice

Consonant	1st Formant	2nd Formant	3rd Formant	4th Formant
/p/			1,500–2,000	
/t/			2,500–3,000	
/k/	300–400		2,000–2,500	
/d/	300–400		2,500–3,000	
/b/	300–400		2,000–2,500	
/g/	200–300		1,500–2,500	
/m/	250–350	1,000–1,500	2,500–3,500	
/n/	250–350	1,000–1,500	2,000–3,000	
/ng/ (wing)	250–350			4,500–6,000
/f/				4,000–5,000
/s/				5,000–6,000
/sh/			1,500–2,000	4,500–5,500
/th/ (thin)				6,000
/h/			1,500–2,000	
/v/	300–400			3,500–4,500
/z/	200–300			4,000–5,000
/TH/ (that)	250–400	1000-1,500	2,000-3,000	
/ch/	200–300		1,500–2,000	4,000–5,000
/dg/ (jot)	200–300		2,000–3,000	
/l/	250–400		2,000–3,000	
/r/ (err)	600–800	1,000–1,500	1,800–2,400	

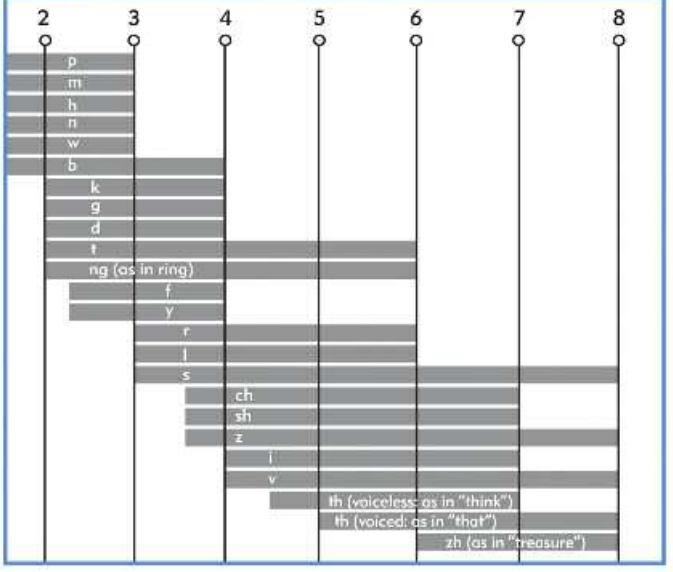
Vowels

Adapted from Ling, Daniel (1976) Speech and the Hearing Impaired Child: Theory and Practice

Vowel	Example	1st Formant	2nd Formant
/i/	bee	370	3,200
/I/	bit	530	2,730
/ɛ/	bet	690	2,610
/æ/	bat	1,010	2,320
/ɑ/	box	1,020	1,750
/ə/	bail	600	1,680
/U/	book	540	1,410
/u/	boot	430	1,170
/^/	but	850	1,590
/ɜ/	bird	560	1,820

English Consonants—Age of Acquisition

Adapted from Sanders 1972 and Templin 1957



Tips for using The Sounds of Speech charts and tables

1. These charts and tables with vowel and consonant formant information are designed to assist you during therapy.
2. If the child doesn't have access to the sound(s) auditorily, he/she can not be expected to produce and/or imitate them. Review the child's audiogram to determine what sounds he/she is able to detect.
3. Remember to review the English Consonants—Age of Acquisition table before planning therapy goals for a young child.
4. It is important to note not only the first formant of the target sounds during therapy, but also the subsequent formants as well.