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THE SPEECH STRING BEAN

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How well does a child have to hear?

How well does a child with hearing loss have to hear? That depends on how well we want him/her to learn using audition. So much is possible with today's technology. We need to be sure we are providing what is possible.

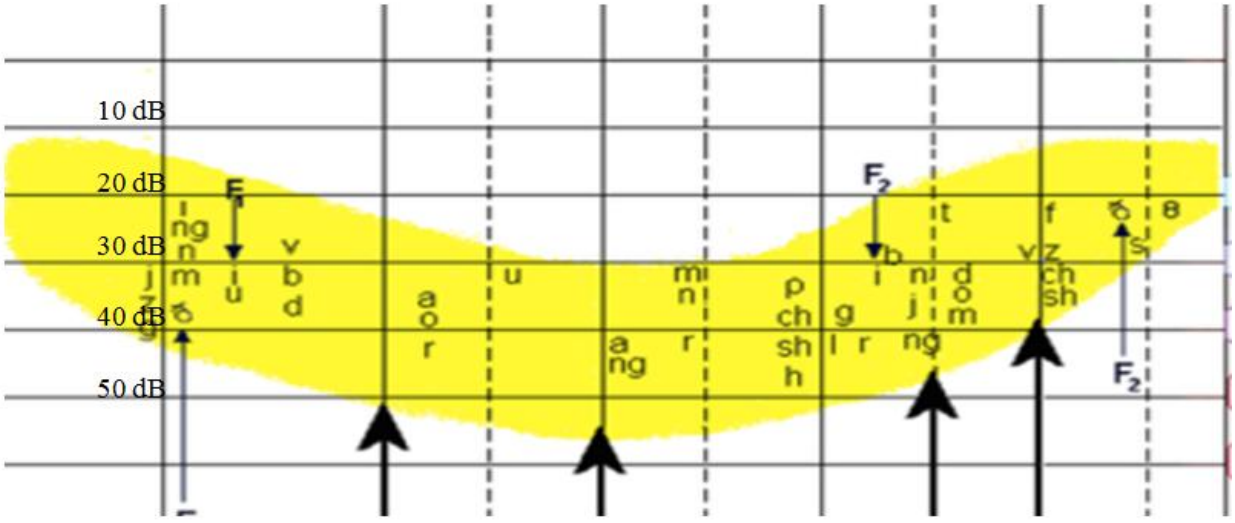
A reminder: we hear with the brain. The ears are the doorway to the brain for auditory information. Consequently, hearing loss is primarily a brain issue – not an ear issue (Cole & Flexer, 2019). Any time the word 'hearing' is used, think 'auditory brain development'. Acoustic accessibility of *intelligible* speech is essential for brain growth, because auditory brain development is a first-order event for the development of spoken communication and literacy skills.

If a family has chosen listening and spoken language as the outcome for their child with a hearing loss, the brain of their child needs to receive as much clear auditory information as possible, for 10 or more hours a day. Fortunately, with today's technology, children with hearing loss have the opportunity to use audition, build their auditory brains, learn language, develop literacy skills, and to do well in school. However, we cannot assume that because the child is wearing hearing aids or cochlear implants, his or her brain is receiving optimal auditory information. For a child to use hearing to learn, the brain needs to be able to hear both normal and soft conversational-level speech in quiet, and in competing noise. That is a tall order. How do we know if we have accomplished our goal?

The speech banana

Everyone working with children with hearing loss is familiar with the concept of the speech banana. The speech banana (Figure 1) was developed to help demonstrate at what frequencies different phonemes (speech sounds) are found. For example, by looking at the speech banana, we see that the phoneme /d/ has acoustic energy at around 300-400 Hz and 2500-3000 Hz, /f/ has acoustic energy at around 4000 Hz, and /s/ has acoustic energy at 5000 Hz. If we were to draw a child's unaided or aided thresholds onto the speech banana that has the phonemes printed on it, we would be able to determine which phonemes a child's brain will be able to receive, and which phonemes will be missing.

Figure 1: Speech banana with phonemes



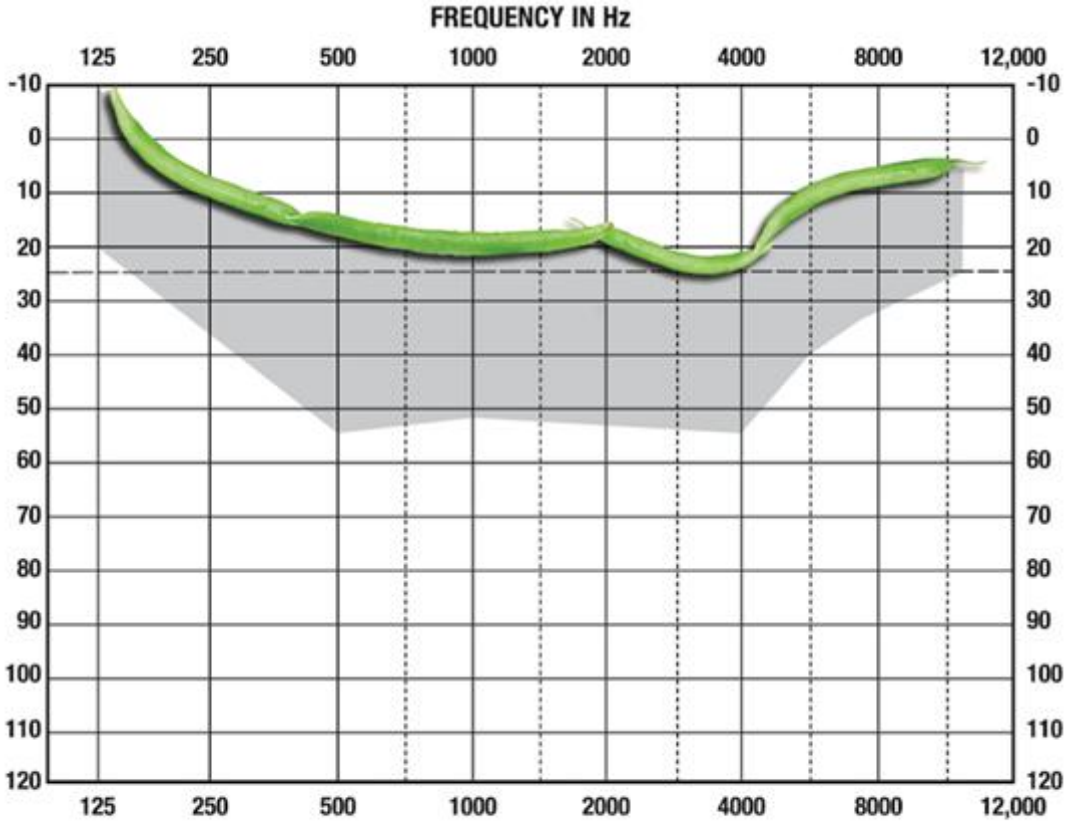
Is hearing anywhere in the speech banana sufficient?

Normal conversational-level speech has an intensity of about 45-50 dBHL. Soft conversational-level speech occurs at about 30-35 dBHL. If we want a child's brain to receive soft speech, we need to be sure that soft speech will be sufficiently loud. So, if a child has aided thresholds at about 35-40 dB HL they will definitely be hearing within the speech banana, but their brain will not be hearing soft speech and the child will not be able to hear all the formants of at least some phonemes. In addition, a child who cannot hear soft speech, will not be able to overhear conversation, to hear peers in the classroom, and will have difficulty hearing on the playground and in the lunchroom. *It is important to remember that 90% of what children learn they learn by overhearing*. So, if a child does not hear soft speech, they are not going to be overhearing and this will have a significant negative effect on developing language. A child who cannot hear soft speech will have difficult learning.

The Speech String Bean

Our goal is to have the brains of children with hearing loss have access to EVERY phoneme, not just a few, but every sound in whatever language they are learning. The way we do that, is by being certain that their technology is fitted so that their brains are detecting speech sounds at the top of the speech banana – at approximately 20 dBHL. Let's call it the Speech String Bean (Figure 2). That string bean at the top of the banana is the goal for aided thresholds. Only by being certain that a child is detecting speech sounds at the level of the string bean when wearing technology, can we be sure their brain has access to every phoneme.

Figure 2: The Speech String Bean

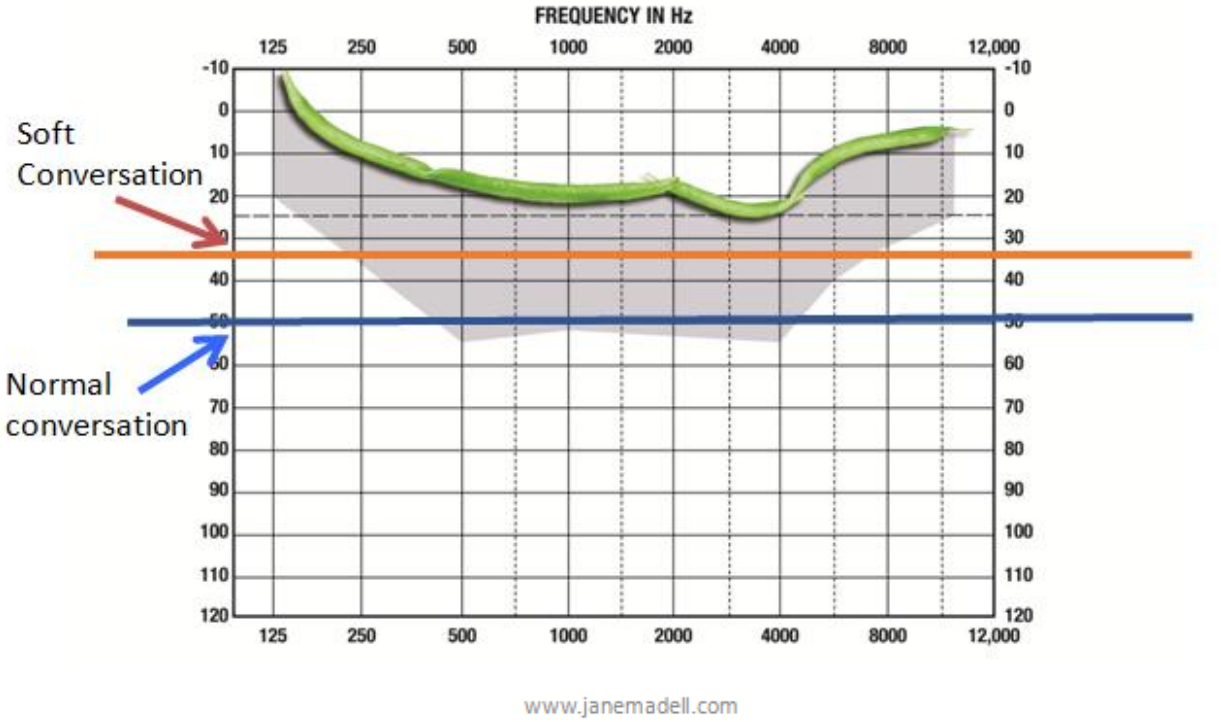


How do we know if a child is hearing at the level of the string bean?

We cannot assume that a child is hearing well enough to hear all the phonemes. We can only know if a child's brain is receiving speech information at the level of the String Bean if we obtain thresholds with the child's technology in sound field. Real Ear measures do not tell us what a child hears. While Real Ear

testing is critical, it is not sufficient. Real Ear tests measure only the sound that is reaching the eardrum, but nothing further up the auditory pathway. Real Ear tests cannot tell us what sound is actually reaching the auditory brain. To know that all phonemes that are reaching the child's brain, it is necessary to obtain aided thresholds for each ear, separately. By obtaining aided sound field thresholds, we will be able to verify that the brain of a child with hearing loss is receiving all the phonemes at a sufficiently soft level – about 20 dBHL. Figure 3 shows the Speech String Bean with the levels for normal and soft conversational levels. When evaluating aided thresholds, we should keep in mind where normal and soft conversation levels are to determine if a child's aided thresholds will permit the child to hear normal and soft conversation. If testing indicates that the brain of a child with hearing loss is not hearing all the phonemes, it is the responsibility of the audiologist to modify the child's technology settings. Adjustments in technology may be accomplished by modifying the hearing aids or cochlear implant settings. With hearing aids it may be necessary to test hearing aids with more power or a different frequency response, trying acoustically-tuned earmolds, or, if it is not possible to enable a child to hear well enough with hearing aids, moving to a cochlear implant.

Figure 3: The Speech String Bean with normal and soft conversation



Are aided thresholds enough?

Aided thresholds, while important, do not give the whole picture. It is also critical to test speech perception. The only goal of technology is to deliver auditory information to the brain. Aided thresholds are the first step in determining how effective the technology is in delivering specific speech information to the brain, and with infants, aided thresholds may be all we have. But as children get older, we can, and we must test speech perception (Madell, 2007, 2012, 2015, 2019). As soon as children understand some words, we can begin to test their speech perception. As they get older, testing becomes more complicated. Testing needs to be accomplished using words that are at a child's vocabulary levels, and at the vocabulary at the level we expect them to need for school. We should be testing a nine-year-old with nine-year-old's vocabulary, not a five-year-old's words, if we want to know how well he will manage academic information in his nine-year-old's class.

Aided speech perception should be tested at normal conversational levels in quiet (50 dBHL) to help us understand what the brain of a child with hearing loss will receive when standing about 3 feet from the talker, and at soft conversational levels (35 dBHL) to help understand how they will comprehend speech when they are about 10 feet from the talker. In addition, testing in the presence of competing noise will help us understand how the brain of a child with hearing loss might manage in the many difficult listening situations that children experience at home and at school.

Conclusion

The concept of the Speech String Bean is useful in understanding how much detailed speech information the brain of a child with hearing loss is receiving, and can also assist in predicting the child's speech perception skills. The Speech String Bean is a useful construct in discussing audiological test results with families as well as with teachers and other clinicians. As children get older, the Speech String Bean can be useful in helping children understand how much specific speech information their brain is receiving. The Speech String Bean is also helpful in planning therapy by helping to identify what sounds a child is and is not hearing well, and in planning education by helping to understand what a child is hearing in school. Having access to this information is often of assistance in helping 11 - 17 year olds accept the needs for technology as social issues begin to pressure them to try and fit in, and not to be different.

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