Understanding a Child's Aided Hearing Characteristics

And How the Desired Sensation Level (DSL) Approach Can Help (Part 2)

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Part 1 of this article, published in the November/December 2010 issue of *Volta Voices,* described some of the limitations of using aided audiograms to prescribe hearing aids, and verifying that they provide the most appropriate amplification for each child. Most parents/caregivers and teachers are familiar with aided audiograms, which indicate hearing thresholds for the child while wearing the hearing aids. We are used to comparing aided hearing levels with unaided hearing levels, and describing this difference to teachers and others who need to understand how a child hears with his or her hearing aids. However, real ear measurement technology, in combination with a software program called the Desired Sensation Level (DSL) program, now allows audiologists to select, program, recommend and verify the characteristics of a child's hearing aids more quickly and accurately.

The Desired Sensation Level program (DSL), developed by Richard Seewald and colleagues at the University of Western Ontario in London, Ontario, specifically for children, provides a more accurate way of evaluating hearing aid characteristics and is widely used across North America and internationally (Seewald, et al., 1997).

The DSL program converts the hearing threshold data from the child's audiogram into a different kind of decibel, dB sound pressure level (or SPL). All hearing aid data is measured in this different kind of decibel and therefore comparing hearing testing information to hearing aid data compares apples to oranges. The DSL program plots the converted audiogram (in dB SPL) on an audiogram-like format, called the SPLogram. The SPLogram looks like an upside down audiogram. Frequency is still read from left to right; however, loudness values are now reversed – very soft sounds are at the bottom of the graph and loud sounds are at the top. Figure 1 shows the SPLogram for an audiogram with a 50 dB hearing loss at all frequencies.

The DSL program then calculates targets for both average conversational

speech level sounds and loud sounds for children. Figure 1 shows the child's hearing thresholds (as circles), targets for conversational speech (+) and targets for the maximum output of the hearing aid (*). The key to understanding the DSL printouts is to realize that the hearing aid targets have been calculated to ensure audibility of the speech sounds within that frequency range. By definition, the oft used audiological phrase "a good match to all DSL targets was obtained" implies that all speech sounds are audible (at least in quiet, which is all anyone can predict).

Once the targets are obtained, the audiologist can assess many hearing aids and settings to see which aid provides the best amplification. One of the advantages of the DSL program is that this process can occur without the child's presence. Once the Real Ear to Coupler Difference (RECD) is measured and incorporated into the DSL program, there is no need for the child to be physically present.

Figure 2 provides a sample hearing aid printout from the DSL program. The hearing aid response is the solid line; this example shows an excellent match to DSL targets since the response line touches all of the conversational speech targets (+) without going over or under them. This means that speech has been amplified to a level louder than the child's hearing thresholds (which it must be in order for the child to hear) without making it so loud that it is uncomfortable for the child.

The SPLogram shows what actually happens – that speech and other sounds are being made loud enough to be heard, *not* that we are improving the child's hearing levels. It is a subtle distinction, but one worth making. The traditional aided audiogram implies that we are changing the child's hearing levels, but the child's hearing levels cannot be changed. What *is* changing is the speech banana. The speech banana typically falls at a level of 50-60 dB and may be too soft for the child to hear, and therefore must be made louder to fall within the child's range of hearing (the range between the softest level that can be heard and the loudest level that can be tolerated). The SPLogram demonstrates how well the hearing aid is accomplishing this task. It also demonstrates another audiological truth – that sometimes this "range of hearing" can be very small. With sensorineural hearing loss, the individual's uncomfortable level for sounds (UCL) may be the same or

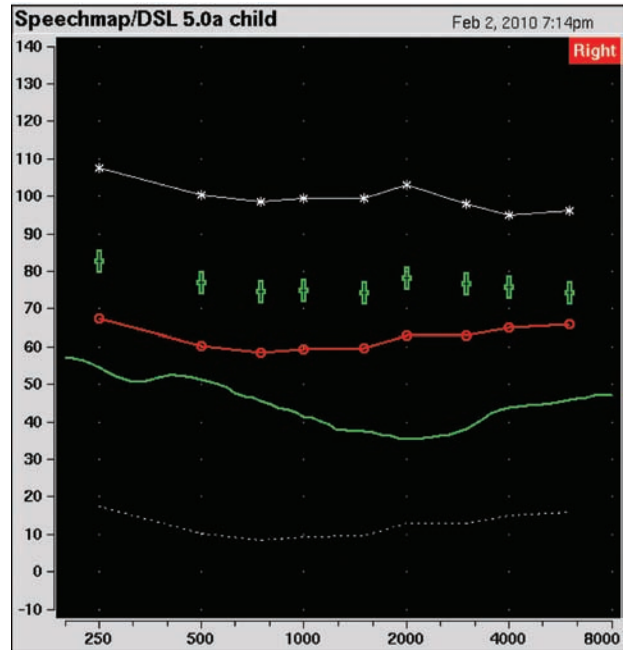

Figure 1. Unaided audiogram shown in SPLogram format from the DSL program of the AudioScan VeriFit real ear measurement system.

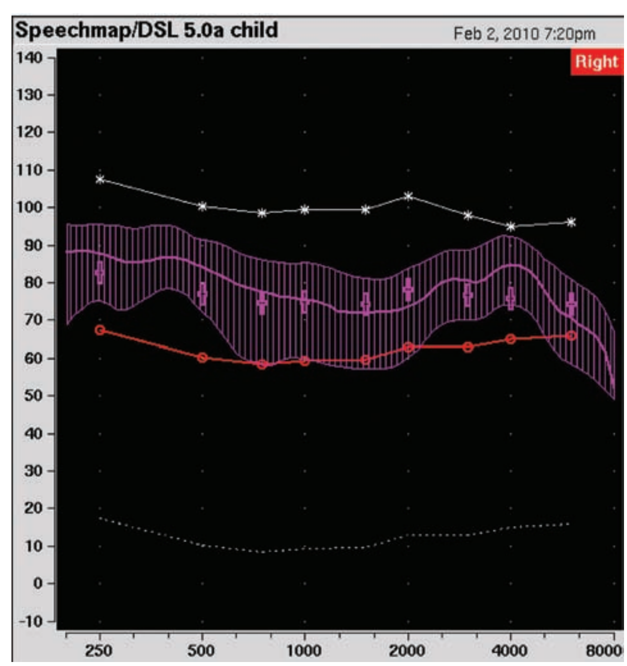

Figure 2. Printout of an appropriate hearing aid response.

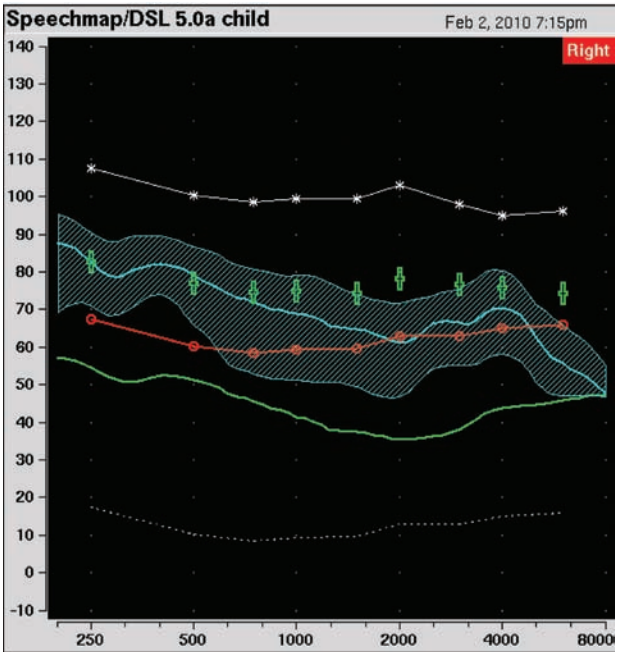

Figure 3. Printout of a poor hearing aid response.

lower than an individual with typical hearing, producing a small "dynamic range" of hearing. The SPLogram format provides a truer picture of audibility across the frequency range since it indicates predicted or measured uncomfortable levels as well as thresholds.

Figure 3 shows a poor hearing aid response. The hearing aid matches DSL targets up to 1000 Hz, but then the hearing aid response line falls below targets. If the hearing aid response line falls *below* the hearing thresholds, sounds in this frequency range are not audible at all with this hearing aid.

If the audiologist is prescribing new hearing aids, clearly this particular hearing aid is a poor choice as it does not provide appropriate amplification above 1000 Hz for this child's hearing loss. In behavioral terms, these results indicate that the child should be able to detect all speech sounds with formant information at 1000 Hz or lower, but probably cannot detect speech sounds above 1000 Hz. We can predict that this child should be able to hear most vowels but would confuse /u/ and /i/ and the words "cat" and "caught," would not hear the plural marker on most nouns, and would not hear the f, th or sh sounds. Remember that this is a prediction, as is the aided audiogram – it shows what sounds of the speech banana we *think* the child should be able to hear. However, the speech banana on an audiogram represents one person's voice at one point in time; there is no universal speech banana, and therefore comparing an aided audiogram to "the" speech banana is not an accurate reflection of hearing in the real world. The speech spectrum that we hear changes from second to second as distance, noise, reverberation and speaker characteristics change. The speech banana on audiograms is static, but speech in real life is dynamic. Therefore any predictions we make based on an aided audiogram or SPLogram apply only to ideal listening conditions. We must assess and observe the child's auditory performance in real life situations to know for certain how the child performs with his or her hearing aids.

Case Example

An example of how a SPLogram can provide information about problems not evident from an aided audiogram may be helpful. Jamie is a 3 year old with a moderate hearing loss who has just been fitted with two new hearing aids. Everyone has been commenting favorably on how well Jamie seems to be hearing. He can hear all of the sounds in the Ling Six Sound Test and his aided audiogram shows responses at 20 dB from 250 Hz to 4000 Hz. However, his preschool teacher has noticed that he startles visibly and quickly covers his ears every time the school bell rings. She wonders if she should turn down the volume on his hearing aids, but she fears Jamie will then miss some speech sounds (and she would be correct). What is the source of the problem then? The SPLogram provides an immediate answer to this question. Figure 4 shows Jamie's SPLogram using targets from the DSL program.

It is evident that Jamie's hearing aid provides excellent amplification for conversational level sounds, such as speech, since the hearing aid response for average conversational speech touches all of the targets (+). The results for loud sounds, however, give the real answer to the problem. Targets for loud sounds for this child are shown by the (*) symbols. The hearing aid graph falls above these targets for all frequencies, indicating that this hearing aid is providing too much amplification for loud sounds. Behaviorally, the teacher observes that Jamie hears speech very well but loud sounds, such as the school bell, are not being "managed" by the hearing aid and are so loud that Jamie reacts by covering his ears. The solution to this problem is to adjust the control(s) on the hearing aid responsible for managing loud sounds, *not* to turn down the hearing aid volume or to in any way change the other amplification characteristics. The source of this problem is not identifiable from the aided audio-

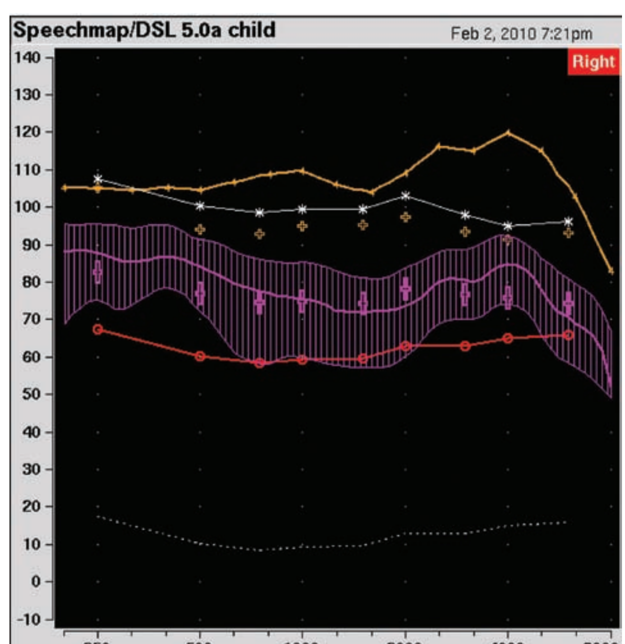

Figure 4. Jamie's hearing aid responses compared to DSL targets.

gram – the aided audiogram only tells us about hearing for soft sounds, not how the child hears moderate or loud sounds.

Conclusion

As hearing aids become more sophisticated and as we fit amplification for younger and younger children, we must use the most precise, accurate and comprehensive methods possible. SPLograms predict how well a child is expected to detect speech sounds, although it is not a perfect prediction. Aided audiograms, however, share the same weakness – they are also a *prediction* of how well the child will detect speech sounds in quiet only. It may be a leap of faith to trust that DSL targets are a more accurate, reliable and comprehensive way to select and evaluate hearing aids when they do not require any response from the child; however, after three decades of painstaking and exacting research, the clinical usefulness of the DSL program has been proven. The same information can be extrapolated from a SPLogram as from an aided audiogram; in fact, since the DSL aided results indicate how the hearing aid is performing for conversational level speech, it is a more accurate prediction. With a little practice, parents/caregivers and professionals can use DSL results as they have traditionally used aided audiograms to understand the benefits and limitations of hearing aids.

The DSL program is incorporated into many real ear measurement systems and hearing aid manufacturer software. Parents/caregivers and teachers would not be accessing or using this software themselves; however, they do need to understand how the results of the testing done using this technology relate to a child's ability to hear in every day life, at home and in school. Parents/caregivers can observe this testing being performed when they visit the audiologist for testing of the child's present hearing aids or prescription of new hearing aids, and should understand the test results. Teachers and other school staff may receive printouts of the testing performed using the DSL program instead of aided audiograms, and need to be able to interpret this information to understand implications for classroom listening. Of course, observation and assessment of a child's listening performance at home and school using measures (such as the Ling Six Sound Test), checklists (such as the Screening Instrument for Targeting Educational Risk [SIFTER] or Listening Inventory for Education [LIFE; available from www.karenandersonconsulting.com]) and individual assessment based on the listening skills hierarchy are also crucial in giving us the tools to provide children with hearing loss with the best opportunities to learn through listening.

Reference

Seewald, R., Cornelisse, L., Ramji, K., Sinclair, S., Moodie, K., & Jamieson, D. (1997). DSL v4.1 for Windows: A software implementation of the Desired Sensation Level (DSLi/o) method for fitting linear gain and wide-dynamic range compression hearing instruments. London, Ontario: Hearing Health Care Research Unit.