Topics in Central Auditory Processing

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This about That

● Why are AP and APD so interesting, so helpful and so important? We have many professional choices, but choose to work intensively with AP. Was it because we were drawn by a personal connection with our patients, and the challenge to make life better for them? When we succeeded, this pushed us forward. ● Working with people who have this complex disorder gives us insights and more questions, so that pushes us to the next level: studying the problem, and answering our own questions (or asking IGAPS). ● Is APD work important? Yes, it saves people's lives in many ways. In addition, I have worked with several teens who wanted to die, and they are all alive today. Of course, there are many other ways to save lives.

In This Issue

Editors for this issue: Drs. Jay Lucker, Kim Tillery, Kavita Kaul and Jack Katz with the help of Drs. Tom Zalewski and Goldie Pappan.

All in a Day's Work

Kavita Kaul Au.D., M.S.,CCC-SLP/A

Before I met Jack, my idea of auditory processing services was limited to evaluations and assessments. I had no idea that therapy was so rewarding. After having put my heart and soul in APD for more than a decade, I have amassed much wealth of knowledge. I now know from experience that therapy improvements are most definitely based on neuroplasticity, I know that improving auditory skills improves many other areas. I thought it was only about listening. As I got more and more comfortable with therapy I started realizing that many other functions seemed to bloom such as visual processing, attention, eye contact, confidence, body posture, etc. However, the best part of my day is interacting with these precious children. They are just so full of innocence and sometimes they say the most endearing things spontaneously and inadvertently. Here are some such anecdotes.

- When AM was listening to the W-22 list he seemed very irritated with the carrier phrase "You will say…", he said that this man was just too rude and demanding. I tried to diffuse the moment and encouraged him to continue to listen. A little while later I started the SSW assessment, I suddenly saw a glitter in his eyes. He said, "I like this man much better, he is so polite." He says, "Are you ready instead of demanding me to say it."
- AM later started therapy. He started listening to the Phonemic Synthesis Therapy. Initially he felt a bit patronized listening to Jack's kind voice. He thought he was being treated like a child. As time went on he started to feel more comfortable with the recordings. One day he cracked me up and asked me who was speaking on the recordings. I told him that it was Jack and that he is a very kind man. He said Jack sounds like a very nice person, almost like Gandhi.
- LN had just started the Dichotic Offset Treatment (DOT). I was trying to ease her into the therapy because the task was just too difficult. On the second DOT session, she was procrastinating to get started. I asked her why she was delaying, she told me because when she hears the letters it feels like they are going into her head like in a blender and it all gets mushed up when it comes in to the brain.
- AE was listening to the phonemic synthesis program. He asked me whose voice it was. I told him that it is Jack's voice. I also told him that Jack is a wonderful person and he wants all children to do really well in school. He looked at me and asked very innocently, "Is that why he invented the recordings?"
- GB has been working on improving her auditory attention and endurance. Every session I see a small improvement in her stamina to stay on the listening tasks for longer periods of time. However, on this day she seemed very distracted and we had to work extra hard to keep her engaged so that she could finish her work. At the end of the session I asked her why she was having such a hard time. She said she was trying her best to stay focused but all these thoughts about her dog Rose kept coming in and bothering her, and even though she tried to keep them out, she just could not, they were crowding her brain too much.
- All of them seem so impressed that I know the man who is talking in the recordings. They ask me if I have met him. Their faces light up when I say that Jack is my friend.
- SC was a bit distracted one day, and I kept redirecting his attention. At one time I asked him, "Are you

ready?" He looked at me and said, "I was born to be ready!"

Over the years there have been many more funny incidents. I can't recall them all, but these moments are so rewarding and keep you wanting to come back for more.

My therapy experiences highlight the fact that these children are very aware of themselves. They can assess their strengths and weaknesses accurately. Without appropriate intervention they will never be able to overcome their shortcomings. Their weaknesses will always be their norms. They deserve better.

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<kkaul@hotmail.com>

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A European Perspective on APD

Wayne J. Wilson Ph.D.

APD can certainly elicit vigorous discussion amongst clinicians and researchers alike. This can give the false impression that we lack consensus regarding APD, its definition and its management. To counter this, researchers from around Europe have recently joined forces to define "a baseline European APD consensus by experienced clinicians and researchers in this specific field of human auditory science" (Iliadou et al., 2017, p. 2).

These researchers define APD as "a specific deficit in the processing of auditory information along the central auditory nervous system, including bottom-up and top-down neural connectivity" (p. 3). They note that APD will impact on the auditory perception of speech and other complex auditory stimuli, and that detecting this impact requires testing beyond a simple audiogram. They also argue that in most cases, persons with APD will present with normal hearing sensitivity but few will present with macroscopic structural brain lesions. They also note that the presentation of APD can overlap with the presentations of other disorders including Hidden Hearing Loss and Auditory Neuropathy Spectrum Disorders (ANSD). Such statements can be seen to align with APD statements from the American Speech-Language-Hearing Association (ASHA, 2005) and the American Academy of Audiology (AAA, 2010), with the possible exception that the European consensus favours a greater involvement of top-down processes in APD than do the ASHA and AAA statements.
Perhaps the more interesting part of the baseline European APD consensus is their thoughts on the future of APD. They recommend research into APD continue to:

- focus not only on the brain but also on the interface between the ear and the brain. In this regard, they support the notion that APD may start at the level of the cochlea and that this should be reflected in our testing for APD.
- build on our scientifically valid, evidence-based understanding of how APD interacts with cognitive deficits. In this regard, they support large sample, longitudinal studies to evaluate cognitive skills in individuals diagnosed with APD, with these studies to include measures of brain activity including electroencephalography, magnetoencephalography, and functional magnetic resonance imaging.

They see this as a path to better differential diagnosis, prognosis and management outcomes for APD. They also acknowledge that APD will often co-exist with other disorders, but this should not prevent clinicians from directly addressing and managing the APD itself.
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Overall, the baseline European APD consensus reassures us that efforts to better understand and manage APD continue around the world. It also reminds us that these efforts are directed towards reaching consensus on APD for the benefit of the people who matter the most: the children and adults who have APD.

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<w.wilson@uq.edu.au>

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Turnabout Is Fair Play

Jack Katz, Ph.D.

They say, "Turnabout is Fair Play" (e.g., letting the patient give you therapy). Here's my 'evidence' that this is 'fair' and beneficial. Auditory training needs repetition over time, to fix the imprint on the patient's brain. But the person must be attending, and I'm quite sure, it is better if the person is in a good mood. That is, just repeating the same thing, again and again does not always hold the person's attention.

I play 'Turnabout' with patients for a variety of reasons; but instead of marking –time or wasting time, it turns out to be a very good training method. Turnabout is usually given during the Phonemic Training Program (PTP). When we finish the Review of the sounds from the previous lessons (usually given 4-at-a-time), we choose 4 phonemes that the person can reproduce pretty well. I tell them that, now they are the teacher and I am the kid. They are told/asked what to say for each of these sounds. The person says them, one at a time, and we make corrections in production as needed. Then the child gets the "hoop" to block your ability to see their mouth and they test you. Of course, you point to the card showing the sound the child produced.

That's all well and good, but why would you do this? I'm glad you asked. Here are some answers off the top of my head:

1. The child may be getting bored and this gets him/her back in the game.
2. It gives the child a sense of some control over the situation.
3. It is fun.
4. It gives the child a break when she or he doesn't want to do jumping-jacks.
5. It's generally easy to hear a sound and choose the appropriate card. But, Turnabout requires deciding on what sound they will say first, how to make the sound, actually produce it precisely, and after all that to see if the 'kid' pointed to the correct card.
6. Next, they must think of what they said before, and what should be next, and whether to give a foil (a sound that is not shown by the cards that can be used to help maintain attention), etc.
7. They might also get an appreciation that being the teacher might not be as easy as it looks.
8. You can check their speech production and see what confusions they might have (e.g., the sound saved
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for last, which they don't want to say because they don't remember what to say for that card).

9. After Turnabout the child is likely to be more attentive and responsive as I was when the child was the "teacher".

Sometimes, I use Turnabout for the "Focus" procedure, if the children are pretty good at saying the sounds. The other day one youngster even gave me the instructions that I had given him. He said, "I'm going to say the /w/ sound 3 times and then I will say the /r/ sound". Hey, I got them right!! "Yea for me! I got every one of them." Then he said, "Now, I will always say the /w/ first but won't tell you how many times". He must have been paying close attention to my instructions. Most kids don't do that. Some kids do say, "Please point to…" as I try to be polite to them. He returned the courtesy.

You could also use Turnabout for Itch Cards[1] or any other procedure that can be given live voice (perhaps some, "H-and-Friends" (HaF[2]), or "Just the Friends" (JtF[3]), if the person is older. I'd practice the syllables with them first. Then they need to block out the masking noise to read and say the 'words' to you, and listen through the noise to see if you said them correctly. Also try it with memory tasks. You'll get a lot for your investment.

I often play a Phonemic <u>Analysis</u> (PA) game, as well. We take turns testing each other for Phonemic Synthesis. I test them and they test me (auditory only). I have 4 sub-lists with 15 words each going from easy to hard (see below). To present a word sound-by-sound (as we do in Phonemic Synthesis) you need to think about how the word sounds and then break the word up into individual sounds (not letters, of course) and say them correctly. This PA task is good training to enable the patients to focus on the sounds of words (not the letters), separate them from the rest of the word, and to say them correctly one at a time. Years ago an article indicated that PA was especially helpful for spelling.

Table 1, next page, shows the 60 Words I use. They help the person to go from two to three sounds, etc., and gradually work up to harder and harder words. I start with group one and then moved up gradually over a few sessions depending how difficult the task is for the person. Without realizing how important PA and PS training could be, when my own children were very young we started playing this game, especially on car trips. It paid off big time.

The kids (and adults) usually like this, although it may be challenging for some at first. I don't know what techniques you use, but my guess is that you could find a way to play Turnabout.

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[1] Itch Cards – key words on cards, each emphasizing a particular phoneme in color.

[2] H-and-Friends – separate presentations of four phonemes (h,p,t,k), that are difficult in noise, are practiced as the initial consonants in a background of noise.

[3] Just the Friends – separate presentations of three phonemes (p,t,k), that are difficult in noise, are practiced in the final position.

60-Word Phonemic Analysis Contest

1) Say the word to yourself; 2) figure out how many sounds there are; 3) say them clearly one-by-one

	Group 1	Group 2	Group 3	Group 4
1	**go**	**five**	**clasp**	**Max**
2	**see**	**case**	**flat**	**judge**
3	**boy**	**bell**	**cream**	**jail**
4	**to**	**smile**	**dream**	**meant**
5	**up**	**slide**	**grain**	**false**
6	**no**	**knock**	**stale**	**frost**
7	**eat**	**class**	**rain**	**clocks**
8	**soap**	**blue**	**train**	**float**
9	**nice**	**grow**	**year**	**window**
10	**bike**	**fly**	**west**	**jokes**
11	**book**	**try**	**chin**	**blast**
12	**bake**	**crash**	**chain**	**chicken**
13	**lake**	**floor**	**close**	**robot**
14	**gray**	**press**	**cover**	**united**
15	**foot**	**news**	**blank**	**twisted**

This is a contest between you and your client. Have the person read down the first (easiest) list and help as needed to read/say. Both of you have copies. You alternate testing one another, using random selections, presenting the words as in the PS procedure. The person may try to say letters instead of sounds, may not leave pauses between sounds, or mispronounce the sounds. Provide the necessary help. The 'teacher' has to think of how the word sounds and then say each of them. after a brief pause. Try one or two columns per session.

Table 1. The 60-word Phonemic Analysis Contest, between the tester and child as well as the 'tester' and 'child'.

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<jack.katz@buffalo.edu>

Diagnosis and Treatment of Spatial Processing Disorder

Harvey Dillon, Ph.D.
Sharon Cameron, Ph.D.

What is spatial processing disorder?

Spatial processing disorder (SPD) is a specific type of auditory processing disorder (APD). It is characterised by a markedly reduced ability to focus on a frontal talker while suppressing sounds coming from other directions. In order to understand speech in noise, people with SPD need a better signal-to-noise ratio (SNR) than those with fully developed auditory systems.

For people with SPD it is common that it is their only auditory deficit, as evidenced by their normal performance on other commonly used tests of auditory processing.1,2 Consequently, such people have normal ability to understand speech in noise if they are tested with speech and noise coming from the same direction. This includes testing in the free field using a single loudspeaker, and testing under headphones, with signal and noise mixed in a conventional manner. People with nor- mal auditory systems have greatly increased ability to understand the target signal once that signal and the interfering signals are spatially separated. This advantage is often called spatial release from masking. People with SPD, however, have less than normal spatial release from masking.

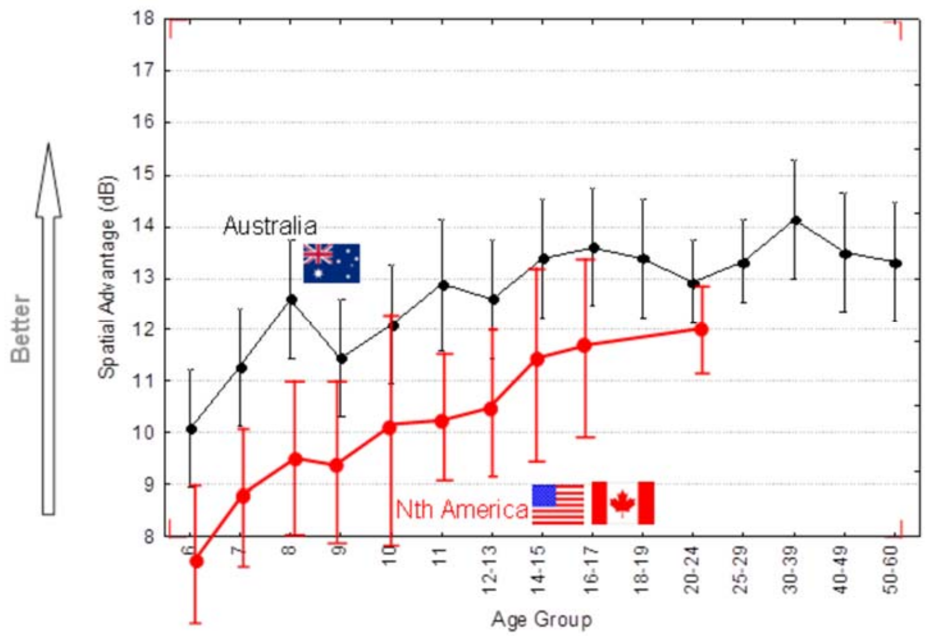

Figure 1: *Spatial advantage as a function of age, for both the Australian and North-American accented versions of the LiSN-S test. Data for North America (lower curve) are from Brown et al* [5]*, and data for Australia are from Cameron and Dillon*[4] *and Cameron et al.* [6]*.*

The degree of this spatial processing deficit is quantified by measuring how much the SNR can be made worse when competing sounds are moved from the front (i.e. co-located with the target signal) to the left and right (i.e. separated), while still understanding 50% of the words presented. To avoid creating a masked ear and an unmasked ear) two different equally intense competing discourses are used as maskers, so that one can be moved to the left of the person and one simultaneously moved to the right. Consequently, averaged across time, both ears remain equally masked. Despite both ears receiving equally intelligible signals, spatially separating the signal from the competing sounds, in this way, provides about 13 dB spatial release from masking in adults.

The degree of spatial advantage achieved depends on the stimuli used to illicit the response, and hence the degree of informational masking. For example, an average of 20 dB spatial release from masking has been achieved by adults using consonant-vowel syllables as both the target and distracter stimuli.3 Regardless of the stimuli, the auditory skills needed to achieve spatial release from masking develop gradually with age. For Australian-accented sentence material, Cameron and Dillon 4 found that, on average, the spatial release from masking increased from 9 dB at age 5 to 13 dB at age 16. For USA-accented material, Brown et al 5 found a similar increase (see Figure 1), but the overall spatial advantage was smaller, probably reflecting the availability of other non-spatial cues in the speech material.

When the spatial advantage for an individual is less than average for people of that age by more than two standard deviations of the population, we refer to the deficit as a disorder. Of course, this line beyond which a deficit becomes a disorder is somewhat arbitrary.

What Spatial Processing Disorder Is Not!

Although SPD certainly involves binaural processing, and hence the brain combining the sounds received by each ear, the binaural processing involved is different from the binaural processing involved in each of the following.

- Localization (i.e. identifying the direction of arrival of sounds);
- Dichotic perception (i.e. where different stimuli are presented simultaneously to each ear); and
- Masking level difference (where perception of a target is enhanced by reversing the phase of the target, or simultaneous noise in one ear relative to the other ear)

Thus it is possible (or even likely) for a person with SPD to have normal performance in each of those abilties [1,2.]

What Causes It?

Numerous studies have shown that SPD is *many* times more common in people who previously had repeated or protracted middle ear disease during their early childhood. This occurs even though when tested for SPD the middle ear problems have long since resolved. Graydon et al [6] contacted primary-school aged children whose medical records indicated that they had repeated otitis media during their first five years of life. Of those children, 18% had a spatial processing deficit large enough to be classified as a disorder. Furthermore, analysis of the same medical records indicated that the spatial advantage deficit is larger:

- the greater the elevation in pure tone hearing thresholds during the infection [5];
- the earlier the onset of otitis media [6]; and
- the longer its duration [6].

In populations known to have a high prevalence of otitis media in early childhood, SPD in later childhood is much more common than in the general population. In three Australian Aboriginal populations with very high otitis media prevalence, for example, the prevalence of SPD in primary school-aged children was 10% [7], 7% [8], and 17% [9]. There was no conductive hearing loss in the children at the time of evaluation for SPD.

Our interpretation is that hearing loss caused by the otitis media disrupts inter-aural level differences between the ears. This disruption makes it harder for the brain to develop the binaural processing strategies needed to focus on a talker in one direction and suppress sounds from other directions.

Our investigations into how adults with normal auditory systems perform this task show that it is primarily the inter-aural level differences caused by the acoustic head shadow that facilitate the processing, rather than the inter-aural time differences [10]. It appears that, even when, on average, the two ears are equally masked by competing sounds arriving from each side, if at any instant one ear has less masking than the other, the brain can rapidly latch onto the signal being picked up by the ear that momentarily has the better SNR. This mechanism has been referred to as "better-ear glimpsing".[11,12]

While one might expect that the brain would develop the necessary binaural processing once the middle ear infections resolved, the studies referred to above show that this does not always occur. Indeed, people who had protracted otitis media in early childhood on average have reduced spatial advantage even when adolescents, despite having normal ability to perceive speech in noise when there is no spatial separation. [13]

How common is SPD?

In keeping with APD more generally, the prevalence in the general population is actually unknown, as no large-scale prevalence study has been performed. However, based on the chance finding of a few children with SPD when various studies of size 80 to 150 children have been performed to obtain normative data, we get the impression that prevalence in the general population of primary school-aged children is in the range 0.5% to 2%.

How is it diagnosed?

Because there are many potential causes of a speech-in-noise deficit, SPD can be diagnosed only by measuring the difference between perception in spatially separated noise relative to perception in co-located noise. Most conveniently, testing can be performed under headphones by presenting sounds that have had inter-aural time differences and inter-aural level differences applied so that they appear to come from different directions. (This processing is achieved technically by applying the head-related transfer functions appropriate to frontal or ±90° sounds, to create separate signals for the left and right ears).

The Listening in Spatialized Noise - Sentences test (LiSN-S)[4,14] has been created using the above principles. In addition to having spatially separated and co-located conditions, the test includes conditions where the target and competing messages are spoken by the same talker, and conditions where they are spoken by different talkers. The resulting four conditions, each a sub-test that takes about 5 minutes to administer, are shown in Figure 2 along with the difference measures that are derived from them. Within each subtest, the client's task is to repeat back each target sentence. Depending on whether the client correctly repeats more or less than 50% of the words in each sentence (as keyed in by the clinician), the test software automatically decreases, or increases, respectively, the level of the target sentence and hence the SNR. Testing stops when the standard error of measurement drops below 1.0 dB, or 30 sentences are presented, whichever comes first. The result of each subtest is the speech reception threshold in noise, SRTn, which is the SNR at which 50% of words are correctly perceived. Equations describing the normative data (i.e., mean performance as a function of age, and spread around the age-dependent mean) are built into the software. Consequently, the result of each subtest is presented both as the SRTn and the corresponding z score (i.e., deviation from the mean score achieved by people of the same age with no known auditory processing problems, expressed in population standard deviations). The software also derives the difference scores shown in Figure 2, and presents them as both dB change in SNR and as age-corrected z scores.

The two most revealing measures are the high-cue SRTn and the spatial advantage measure. The high-cue z-score gives an overall indication of the client's ability to understand speech in noise relative to same-age peers. The spatial advantage measure is the difference between the same voice 0° (SV0) and same voice 90° (SV90) conditions and so shows the ability to benefit from spatial separation. Note that it is also possible to derive a second measure of spatial separation by subtracting the DV90 score from the DV0 score (see Figure 2). This spatial advantage is not as large as the one derived from the SV90 and SV0 scores, because when there are no voice differences, the person is extremely reliant on spatial cues to separate the target from the distracting sounds. However, the different voice conditions provide a useful reliability check, and the software uses all four scores to identify SPD when present.

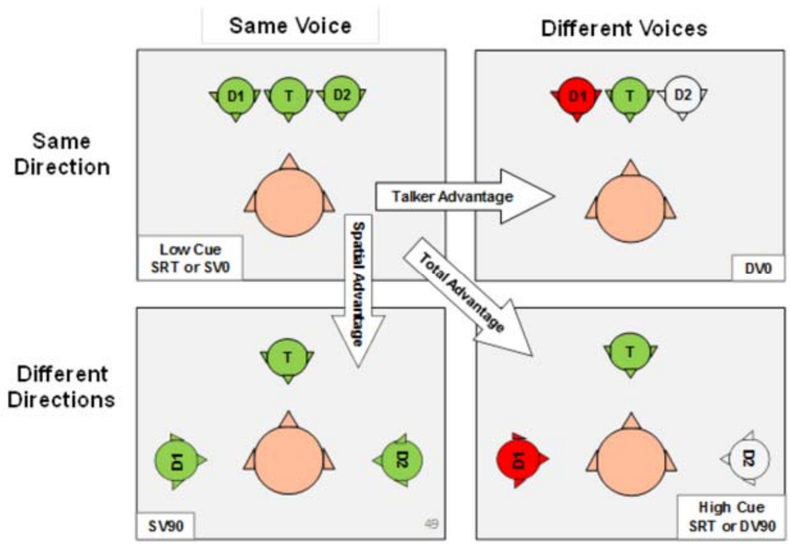

Figure 2 (left)***:*** *The structure of the LiSN-S test showing the four base measures: Same voice 0° (SV0, also called Low cue), Same voice 90° (SV90), Different voice 0°*

A test result typical of a child with SPD is shown in Figure 3. The graph shows the results of each test score in z-score (i.e., standard deviation) units. The green region shows (somewhat arbitrarily) the normal range as $\pm$2 SDs. For this child, results for the low-cue SRT and talker advantage conditions (DV0), and Different Voice 90° (DV90, also called High cue as both talker and spatial cues help differentiate the target from the competition). From these base measures, three difference scores are derived: Spatial advantage, Talker advantage and Total advantage. Signals shown in the same color are spoken by the same talker (i.e., ability to use vocal cues to separate the target from competition) are both very close to average. However, for the three scores that require spatial segregations skills (high-cue, spatial advantage and total advantage), scores are well outside the normal range.

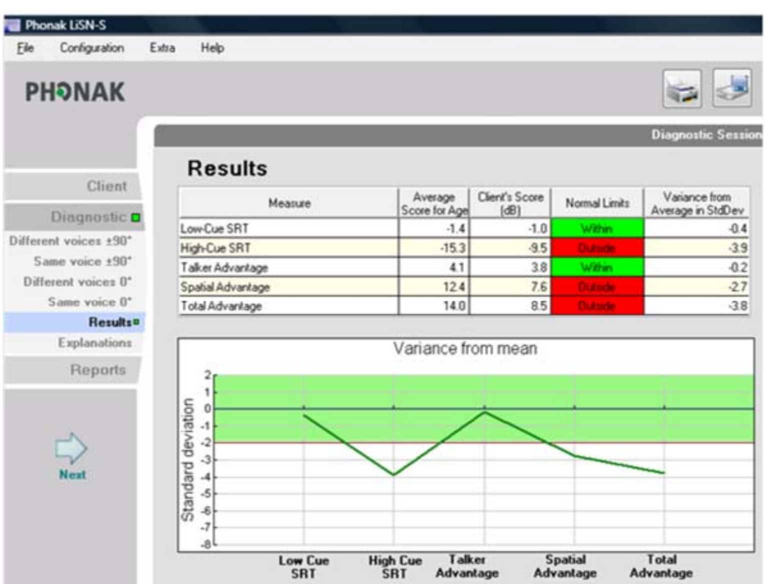

Figure 3 *(left)**:** Results of the LiSN-S test for a child with spatial processing disorder.*

Using difference measures to diagnose a condition has other advantages. It is well known that deficits in attention, memory or language can adversely affect speech recognition. However, these deficits will similarly affect scores in the co-located and the separated conditions. Consequently, these complicating deficits will have little or no effect on the difference scores, including spatial advantage.

Difference measures are only useful, however, when the base scores from which they are derived are very reliable, or else the difference measures become very unreliable. In LiSN-S, good reliability was achieved during test development by individually adjusting the difficulty of every sentence so that they have equal intelligibility when administered at the same SNR[4].

The four subtests are administered in a specified order (and the normative data assumes that this order is followed), with the high-cue condition presented first. This has a strong practical advantage: If the high-cue score obtained is no poorer than one standard deviation below average (i.e., the z-score is better than -1), then there is virtually no chance that the person has SPD, so there is no point in administering the remaining three subtests. If the high-cue condition does indicate the speech perception is poor (i.e. z-score more negative than -1), the remaining tests may or may not show that the cause is SPD. Either way, however, the high-cue test score gives a useful quantification of the person's speech-in-noise ability.

In part II, we will show how SPD can be treated, the impact of hearing loss on measurement of spatial processing, and indicate when it is most appropriate to include the LiSN-S test within a clinical assessment battery.

Disclosure: The National Acoustic Laboratories (but not the authors) derives some income from sale of LiSN-S (via its distributor, Phonak) and of Sound Storm (via the Apple App store).

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<Harvey.Dillon@nal.gov.au>

<Sharon.Cameron@nal.gov.au>