SSW Reports

• APD and Hearing Loss
• SSW Score Across Ages 5-96 Years

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Central Testing with the Hard-of-Hearing
Jack Katz

Most of us who evaluate for APD do not see many children who have a sensory-neural hearing loss. Of course, we do see children with a conductive loss, because of the close association between conductive loss and APD. In my practice quite a few cancel their appointment, because they have otitis media (OM) when they are to be seen for an evaluation or therapy.

We carried out some studies to find out if there were children with S-N losses of 30dB or more, at any frequency, in either ear. Each study came up with no hits (e.g., Katz and Armorim, 2001 in SSW Reports). However, there were significant numbers with conductive losses. Some of these losses were unbeknown to the parent and the child. In the 12 children who had evidence of OM at the time of testing; for 3 of them the parents had indicated that the child had never had OM. With air-bone gaps of as much as 40dB the children were not recognized as *ever* having had OM and certainly not identified for the weeks before the APD testing as having this middle ear disorder. We can only imagine how many more children have a significant history of OM but did not happen to have an ear/hearing evaluation at those times.

There is no doubt that middle ear problems are highly under reported. Therefore, when I see that the family has not checked off middle ear problems; I do not take that as a strong indictor. Indeed, some of these children now have PE tubes as teenagers but were thought until then to have been otitis free.

Recently, I saw a child whose parents indicated that he had only two bouts of OM. The mother pointed out that they never noticed any bouts but on 2 occasions when he was seen for a routine medical exam he had ear infections. Because of OM related test signs; I questioned how many other times he had OM that went undetected.

Hearing Loss Cases

There is something in the wind. I recently saw a child with a unilateral conductive loss and two others with a sensory-neural loss. All of a sudden they are coming out of the woodwork… well maybe that is an exaggeration. (By the way the parents of one child were told that central testing was not possible with a hearing loss). I would grant that it is more difficult to test and that these two influences may not be easy to separate on some measures. But, identifying APD as soon as possible is too important to be written off because of a hearing loss!

As stated in Katz (2009) it is likely that we do not get referrals for APD evaluations for those with permanent hearing loss because their auditory issues are assumed to be due to the hearing loss.

A (Unilateral) Conductive Case

We don't usually see a permanent conductive loss in one ear, but I did recently. Amy is 11-years-old. She had bilateral PE tubes starting at 9-months-of-age and a 50dB loss was noted in her left ear when she was 3 years old. Over the years her tympanograms in both ears varied from a Type As to B, but her hearing remained the same in the left ear and had minor variations in the right ear. OAEs were present in the right ear but were absent in the left ear. Surgery was attempted in the left ear but there was no change in the conductive loss. Amy was diagnosed with ADHD and is medicated for that. She has had 7 years of speech therapy at school. Amy now wears a hearing aid in her left ear. She is highly visual and tires easily (like many kids with APD). She is confused in noisy places, easily flustered, forgetful, has trouble maintaining sequence, trouble following directions, telling where sounds come from and in understanding TV. Thus she has many characteristics of those with APD.

Audiometric Results

Amy's puretone AC thresholds were:

AC	250	500	1k	2k	4k	8k
RE	10	10	10	5	10	DNT
LE	50	55	55	45	50	60
BC	DNT	5	5	20	10	---

	PTA	SRT	WRS	Aided
RE	8	15	100	Not
LE	52	50	100	Available

WRSs were 100% but they were obtained with PBKs and given live voice, so it was important to see how Amy would do with the standard WR test. She had 90% in the right ear and 88% in the left. Amy is quite pleased with her hearing aid.

Buffalo Model Tests

Step One:

To insure that we were not exclusively assessing the unilateral hearing loss, it was necessary to show that when compensated for the distortion of her hearing loss, it was likely that Amy had APD. For this we use the Traditional SSW Analysis and Speech in Noise tests which use WRSs to correct the scores. These SSW norms are also more lenient than the regular NOEs.

Measure	Significant
SSW	
Right Non Competing (0, NL=5)	NS
Right Competing (10, NL=7)	Significant
Left Competing (58, NL=17)	Significant
Left Non Competing (0, NL=7)	NS
Speech in Noise (SN)	
Right Ear Difference (26, NL=21)	Significant
Left Ear Difference (36, NL=22)	Significant

We studied 6 SSW and SN measures to determine the likelihood of APD. These measures represent basic DEC and TFM signs. Two SSW measures were significant even using 2 SDs limits and both SN scores provided further evidence of APD.

Step Two:

We have shown that Amy has APD so our next job was to find out what this entailed. For this purpose we used the usual NOE Analysis plus the other 2 Buffalo Model tests. See table below.

Measure	APD Category
SSW	
Total (NOE) Score (52, NL=9)	Various
Right Non Competing (4, NL=1)	Various
Right Competing (8, NL=2)	DEC
Left Competing (28NL=4)	TFM
Left Non Competing (12, NL=1)	DEC
Ear Effect (-7, NL= -2)	TFM
Delay (1, NL=0)	DEC
Perseveration (4, NL=0)	DEC

Phonemic Synthesis	
Quantitative Score (19, NL=21)	DEC
Qualitative Score (14, NL=20)	DEC
Delayed Response (2, NL=1)	DEC
O/L (2, NL=0)	DEC
Perseveration (1, NL=0)	DEC
Non-Fused (1, NL=0)	DEC
Quick Response (4, NL=1)	TFM
Speech in Noise	
Right Ear Difference (64, NL=78)	TFM
Left Ear Difference (52, NL=75)	TFM

Amy had 8 positive findings on the SSW test (using the usual 1 SD limits). She also had 7 positive signs on the PS test and 2 signs on the Speech in Noise test. These results indicate DEC and TFM.

Buffalo Model Questionnaire (BMQ)
Step Three

I find it most valuable to cross check the test results and interpretations with outside criteria. The criteria are the concerns of parents and teachers suggesting what communication and academic issues may apply. If they agree with the test results; that is most supportive, if not we try to figure out why.

In this case there were 4 out of 8 DEC factors that were indicated, 11 out of 14 TFM, 3 out of 3 ORG and 1 out of 6 INT. In addition, there were 3 out of 5 that are associated with APD more generally. Two test categories agree with the BMQ. There was also one INT sign (extreme delay) on the BMQ which is likely not significant. In addition, it is worth noting that some children with poor DEC who do not give up quickly have extreme delays as Amy did. I suspect that it was this behavior that was noted by her parents and not Integration Delays that are effortless. Where we differed was on ORG. It might be that the organization problems were more in the visual domain or that our tests did not do the job.

We needed to accommodate Amy's 50dB level in one ear. Did you know, if a person has an air-bone gap $\geq$ 20dB that the presentation level to that ear for the SSW should be 30dB SL (not 50dB SL)?
We erred on the side of caution to establish APD by employing the Traditional Analysis, but then to find out how to help Amy we used the sensitive NOE Analysis.

A Sensory-Neural Case
A 9-year-old boy was referred by a special educator for an APD evaluation because he found signs of processing difficulties. The boy had severe reading and spelling problems and his parents suspected Dyslexia. He wore hearing aids in each ear and was getting special help in reading and writing at school. Ben was also confused in noisy places, easily flustered, had difficulty maintaining proper sequence, mixed up speech sounds, had trouble following directions and in understanding TV. Such concerns as these may be compared to the hearing test results to see if the problems are likely a result of the peripheral hearing loss.

Audiometric Results
Ben's puretone AC thresholds were:

	250	500	1k	2k	4k	8k
RE	30	30	40	50	50	50
LE	25	25	45	40	50	45

	PTA	SRT	WRS	Aided
RE	40	35	92	PTA = 18
LE	37	35	88	WDS = 88

Ben has a mild-moderate SNHL with essentially normal word recognition. His two ears were similar in both threshold and clarity. Aided he had close to normal performance. Therefore, there was little reason to suspect that his learning difficulties were importantly associated with his hearing loss.

While Ben could have had difficulty in noise due to hearing loss, with good aided thresh-

olds bilaterally and good clarity it is somewhat less likely. However some of the other concerns were much less likely to be due to the loss (i.e., easily flustered, difficulty maintaining proper sequence, mixes up speech sounds, has trouble following directions and in understanding TV). Let's see what his APD test results reveal and whether we can distinguish between peripheral and central components.

Buffalo Model Tests

Step One:

The first job was to obtain confirmation that Ben has APD rather than just a hearing loss. For this purpose we used the Traditional SSW Analysis because it has a correction factor for WRS. Ordinarily we would use the 1 SD norms, but because we are looking at just a small number of scores I used 2 SD. See table below.

Measure	Significant
SSW	
Right Non Competing (11, NL=4)	Significant
Right Competing (28, NL=9)	Significant
Left Competing (44, NL=16)	Significant
Left Non Competing (2, NL=2)	NS
Speech in Noise (SN)	
Right Ear Difference (64, NL=21)	Significant
Left Ear Difference (28, NL=22)	Significant

Three of the 4 SSW scores (@ 2 SD) and both SN scores were significant. This indicates that when the SSW and SN tests were corrected for the effects of hearing loss; the scores were generally well beyond normal limits. Once this has been established we can feel comfortable in studying APD in the usual way because it would be a bigger error to assume the problems are due to the loss than to assume they are due to APD.

Step Two:

The NOE Analysis is used to ferret out what Ben's APD issues are. See the next table.

Ben had 11 positive findings on the SSW test (using the usual 1 SD limits as we are now trying to establish what categories of APD he has). He also had 9 out of 11 positive signs on the PS test and all three

Measure	APD Category
SSW Test	
Total NOE Score (44, NL=10)	Various
Right Non Competing (6, NL=2)	Various
Right Competing (13, NL=4)	DEC
Left Competing (21, NL=6)	TFM
Left Non Competing (4, NL=1)	DEC
Ear Effect HL (+4, NL=+1)	DEC
Order Effect LH (-14, NL=-2)	DEC
Perseveration (10, NL=0)	DEC
Quick Response (3, NL=0)	TFM
Tongue Twister (3, NL=1)	TFM
Reversal (3, NL=1)	ORG
Phonemic Synthesis Test	
Quantitative Score (17, NL=18)	DEC
Qualitative Score (2, NL=16)	DEC
Delay (6, NL=2)	DEC
Extreme Delay (1, NL=0)	DEC
Perseveration (2, NL=0)	DEC
Non-Fused (2, NL=0)	DEC
O/L (1, NL=0)	DEC
Quick Response (4, NL=2)	TFM
Reversal (1, NL=0)	ORG
Speech in Noise Test	
Right Ear Difference (32, NL=75)	TFM
Left Ear Difference (64, NL=73)	TFM
Inter-aural Difference (+32, NL=+9)	TFM

signs on the Speech in Noise test. That is 23 out of 34 possible positive scores (actually once he had positive Ear and Order Effects it eliminated the chances of having the other 2 Ear and Order Effects so we can subtract 2 from the 34 possible).

We are able to see that DEC, TFM and ORG are the likely categories. With such severe scores we cannot rule out INT. Often with so many errors it is hard to see a Type-A pattern. But, Ben had 3 scores that were beyond 3 SDs poorer than the means (in fact a lot poorer!). To look for this potential INT sign I usually look at the Total NOE, the

poorer ear for SN and either the Quantitative or Qualitative PS score.

The PS and SN tests supported the SSW findings with DEC, TFM and ORG indicators.

Buffalo Model Questionnaire (BMQ)

Step Three:

Ben's mother filled out the BMQ. There were 25 signs of APD (out of 37) which is quite high. So this agrees with our first step that APD is present. She indicated 7 out of 9 DEC concerns, 7 out of 14 TFM, 3 out of 3 ORG and 4 out of 6 INT. In addition there were 4 out of 5 that are associated with APD in general. So there is agreement on 3 of the 4 categories. Although we did not find the Type A (the only solid sign of INT) we did see more than 2 signs on the three tests that were more than 3 SDs poorer than the means. Often when there are many SSW errors due to other aspects of APD it is less likely that the criterion will be met. But after a round of therapy we may see the Type A peek out when the number of errors are reduced.

Comments About Hearing Loss and APD

It seems that we are seeing more individuals with hearing loss for APD testing and perhaps for therapy. The ones we are seeing are generally those with rather mild losses, so it is hard to attribute a major APD to hearing alone. I suspect in time as we see more of these milder cases we will be called upon to work with those who have more hearing loss and greater clarity issues. This may be more challenging.

APD evaluations are not hugely different for evaluating hearing impaired individuals than working with normal hearers if the loss is fairly mild and the person has developed oral speech and language. It does require that you use the Traditional Analysis, at least in part. As you know I find combining the 2 methods as superior to using either one alone. To use just the Traditional greatly limits how much you can say about the type of problem, but it helps to insure that you are not confusing a peripheral loss for APD. On the other hand NOE would give you a good idea what processes are weak but you would not have confidence that it is APD unless it was too severe for the specific hearing loss.

I would not recommend that those who are new at APD testing evaluate those with significant hearing loss. But, with some experience and some confidence working with people who have mild losses should prove successful.

SSW Results Across Age Groups
Jack Katz

It is interesting to think about young children developing auditory processing as well as many other skills and continue to refine their skills as they get older. On the SSW we have found that at about 12 years-of-age children perform pretty much as adults until approximately 59 years based on our early studies of normal control subjects. We also found that a number of the subjects in their 60s begin to have a little trouble with the SSW; here and there, but in the 70's having several more errors is the rule and in the 80s performance is poor or very poor for all subjects. Generally in the 90s it's not any better.

I came across RSSW and CSSW data for 379 controls; 5 to 96 years of age. Subjects were native born speakers of English from across the U.S. and Canada. No significant neurological or otological histories were reported for these individuals. Data are shown (Figure 1) for single years from 5 to 11 yrs (n=183) because their scores improved rapidly during these years. For ages 12 through 49 labeled "Ad" for *adults* (n=104) single scores are given because the mean performance does not differ significantly

across this span. Between 60 to 79 years (n=83) 5-year groupings are used designated by the age mid-points and our sparse (n=8) group for ages 80 through 96 years is labeled 87. There were approximately equal numbers of males and females in the sample.

Total NOE scores that we use with APD cases are best represented by the Raw-SSW (RSSW) scores (% error). To obtain the NOE you would need to divide RSSW by .625. RSSW includes both hearing & APD errors. The Corrected-SSW (CSSW) score neutralizes the influence of hearing loss (subtract % error for WRS from the RSSW). CSSW is the central score. By comparing the two curves we also learn the mean WRS for each subgroup.

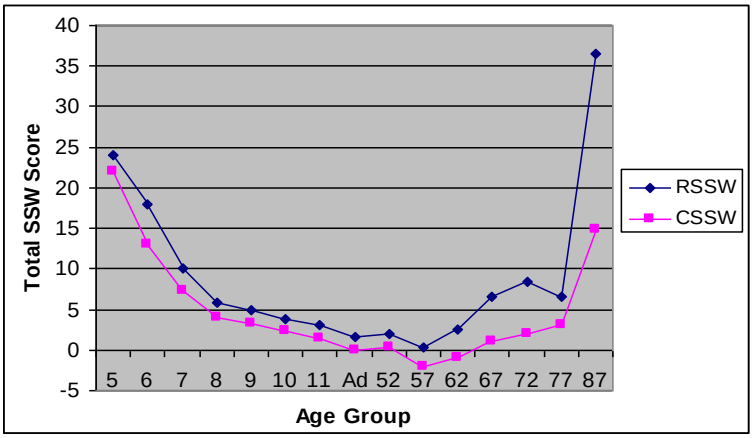

Figure 1. Total SSW results for 379 control cases from 5 to 96 years. "Ad" stands for adults (12 to 49 years in this figure).

Figure 1 shows RSSW and CSSW data for control subjects. The RSSW and CSSW curves run parallel to one another until the upper 50s because these subjects have no hearing loss and do not have central aging effects. The CSSW curve rises gently over the next 20 years suggesting the increase in central changes (see Rawool, 2007). During this time the peripheral losses increase (at least as expressed by the WRS errors). We have relatively few subjects in the oldest groups so these may not be reliable values; however the trend is clear that in the 80s and 90s both peripheral and central performance show a great deal of deterioration.

On the left side of the figure we see a sharp improvement from 5 to 8 years of age and then the curve shows gradual improvement into the 50s. However, when we studied the results statistically we found those 12 years of age did not differ significantly until the 6th decade.

This figure gives us some insight into our test norms. The norms for the early ages are not as tight as for those 9 years through the 60s. This may be, in part, because of the improved scores for these latter age groups. In the earlier years maturation appears to be more uneven. This increases the SDs and consequently gives us less sensitive norms for those ages.

On the older end we have data, but do not have Traditional or NOE norms for those 70 and above because I don't believe that there is a 'norm'. The aging effect on the auditory system appears to be too idiosyncratic to see a consistent picture. This also makes it harder to determine what is normal aging and what is a CANS lesion superimposed on normal aging in older patients.

Reference

Rawool, V.W. (2007). The aging auditory system, Part 2: Slower processing and speech recognition. *Hearing Rev.*, 14: 36-42.

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