Topics in Central Auditory Processing

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This About That

*How are **Phonological Awareness** and **Hidden Hearing Loss** the same? They both avoid the term Auditory Processing Disorder or any connection to it. Noam Chomsky (1959) wrote that speech is really a mumble. The only way we know what was said is because of our intuitive skills (Duchan & Katz, 1982). When that turned out to be false, they gave in a little and said it's only necessary to have an awareness of speech sounds. As for **HHL**, based on the site-of-lesion how would you fit it into APD? I think that those brainstem nuclei are the same as those found in early recurrent otitis media. Coincidence, no? Please read Katz, Zalewski & Brenner chapter on O.M. & APD in the new Geffner and Swain (2018) book.*

In This Issue

Two Interesting Clinical Questions

Jack Katz, Ph.D.

Therapy or No Therapy for Those with Unilateral Speech-in-Noise Problems?

I know that some people question whether we should be doing therapy for speech-in-noise if it involves only one ear. I thought it would be interesting to see what could be learned from looking at the data that I used for columns in the first 2 issues of TiCAP.

There were 50 children (6-18 years of age), each had CAPD and received therapy. Table 1 shows a significant Noise score and/or Quiet-Noise Difference score, in just one ear. There were 3 cases for the RE and 3 cases for the LE (see below).

S#	Noise RE	Noise LE	Q-N Diff RE	Q-N Diff LE
1	ns	76	ns	20 ns
2	ns	76	ns	24
3	ns	52	ns	28
Mdn.	**% correct =**	**76%**	**% error =**	**24%**
4	80	ns	20	ns
5	64	ns	32	ns
6	76	ns	24	ns
Mdn.	**76%**	**= % correct**	**24%**	**= % error**

Table 1. 6 (of the 50 subjects) who had significant Noise score/s in just one ear.

Table 1 shows that the median noise scores for each ear were the same (76% correct). And it just so happens that the difference for Quiet - Noise scores (% error) for each ear were also the same (24%). With that kind of luck I should have stopped there. They suggest speech-in-noise issues (mostly TFM) and the Quiet - Noise Difference scores (corrected for DEC). The results were still very similar for both L & R positive cases. So, severity of the affected ears for noise was essentially the same.

Table 2 shows the initial and final error/delay scores in the Words-in-Noise (WINT) therapy. Therapy is usually given via loudspeaker to both ears.

Ear	1st # Errors	1st # *Delays*	Last # Errors	*Last # Delays*	Improve # Errors	*Improve # Delays*
Left	7	*8*	3	*2*	4	*6*
	9	*6*	1	*5*	8	*1*
	18	*5*	2	*0*	16	*5*
Mdn	**9**	***6***	**2**	***2***	**8**	***5***
Right	11	*7*	4	*1*	7	*6*
	15	*19*	5	*0*	10	*19*
	23	*12*	11	*2*	12	*10*
Mdn	**15**	***12***	**5**	***1***	**10**	***10***

Table 2. Initial and final WINT errors and delays for the two unilateral SN problem groups.

Table 2 also shows that each of the 3 children with significant right ear test scores had several more initial errors and delays on WINT (which was presented to both ears via loudspeaker) than the left ear group. Assuming that most of them were right-handed this could make sense, because of involvement of the 'dominant' ear. For this tiny sample, on the final day of this therapy both errors and delays for the right ear group improved a bit more. Medians for improvement (errors and delays) were similar for RE and LE cases, with maybe slightly more improved for the 3 RE cases.

The first thing that we see (and experience made me think) is that those with unilateral problems in noise did improve with WINT. So, if this is what you see in your patients it would suggest that you should work with those who have unilateral noise issues. But there is one step more. Table 3, importantly compares the 6 unilateral cases with the other 44 children. Note that the unilateral S-in-N group had similar improvement as the not-unilateral group on the first and last WINT session for errors and delays. This is additional support to provide therapy for children with unilateral noise problems.

n	Group	1st-err	1st-X	Lst-err	Lst-X	#Ses	impr err	Impr X
6	UniSig	14	8	4	2	12	10	6
44	NotUS	14	6	6	2	13	8	4

Table 3. The 6 children with one RE or LE significant (UniSig) on WINT and 44 (NotUS).

Do Cases with Unilateral Speech-in-Noise Issues Improve as Much as Bilaterals?

Figure 1 shows the results for all 50 children divided up by how many noise questions on BMQ-R were significant for those children. Most children had all 4 noise scores positive (n=27), the next largest group had 3 positive scores (n=11), for 2 positive signs n=9, with 1 positive n=1, and n=2 had no positive SN signs.

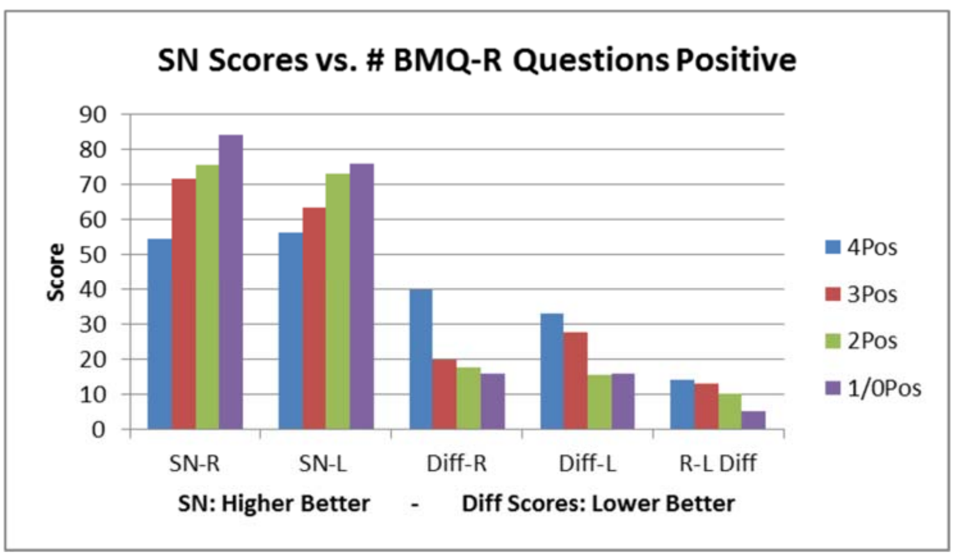

Figure 1

Figure 1 shows an impressive correspondence between the ratings of the of SN issues and the SN test performance for the children. Just about every one of the 20 means fell where it was predicted by the BMQ-R (Katz and Zalewski, 2013). This supports both the SN test findings and the predictability of the BMQ-R.

We just had 6 cases with one positive ear (UniSig) compared to the 44 of those not in the UniSig group (NotUS). The latter group had 42 children with both ears significant and 2 who had neither ear significant (but all had some therapy).

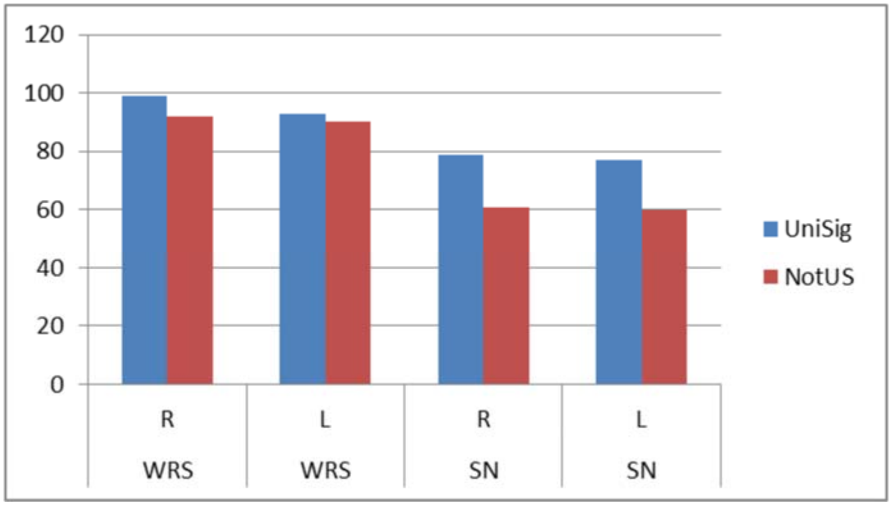

Figure 2. Percent correct for speech-in-quiet (WRS) and speech-in-noise (SN) for each ear for the unilateral group (UniSig) and those that were not NotUS.

The UniSig group appears to have performed a bit better than the NotUS. This may be a-given because half of UniSig subjects had at least 50% normal scores by definition. Another advantage was the UniSigs were four years older (13.2 vs 9.2 years).

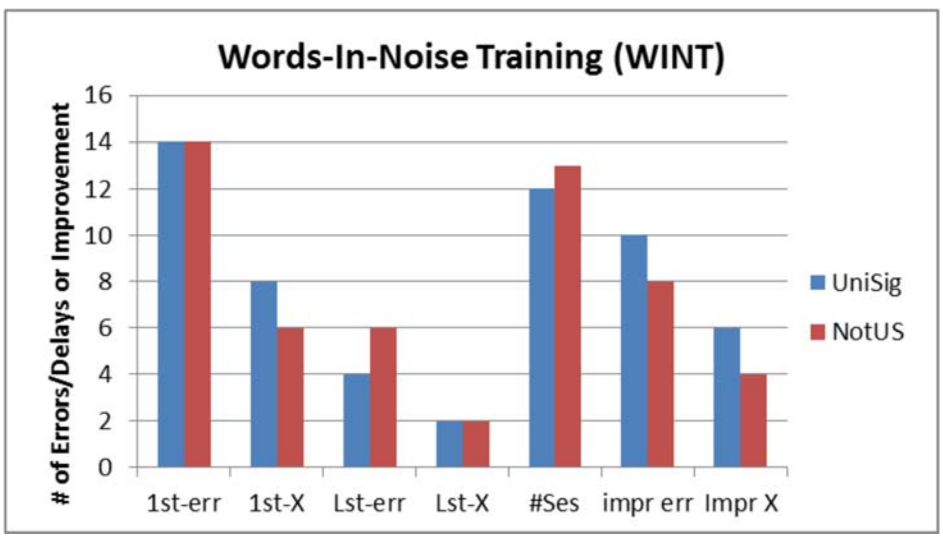

Figure 3. WINT scores for both groups showing number of errors and delays for first and last sessions. Also number of WINT sessions and improvement in errors/delays.

Figure 3 (the same as Table 3) shows that the two groups were quite similar in number of errors (and delays) initially and for the last or most recent session. If anything the unilateral cases may have performed slightly better, but we need more unilateral cases to be more confident. The number of therapy sessions was about the same for both groups. The important thing to take away is that there is no reason not to provide therapy to those who show unilateral issues on our SN tests.

When people come to me for therapy, even if S-in-N is not significant, I do some WINT with them. (a) If they are coming for therapy and the S-in-N tests failed to show this problem, it can be picked up and treated. (b) If the S-in-N problem is not in either ear, but in them working together, we can work on that. (c) If there is no S-in-N issue, the few sessions will not hurt and may provide a bit of help.

Final Word

When I undertook this study I had no idea what to expect. Each step turned out to be both interesting and surprisingly good. I always found the BMQ-R noise items informative, but never suspected how strong they were despite different attitudes, intent and attention of those filling out the form.

If a person is referred to me, and indicates on the BMQ-R (or the case history) form that the person has speech-in-noise issues and if I find significant scores, on the tests, in one or both ears, it validates the need for help. If there is a speech-in-noise problem the person is not likely just to outgrow it. Fifty years ago I did not know that my son and daughter had speech-in-noise issues. Unlike DEC, that we addressed for fun, we did not address speech-in-noise and they are still with them today.

Reference

Katz, J & Zalewski, T. (2013). Buffalo Model Questionnaire Manual-Revised, Educational Audiology Association

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A Glimpse of APD in the Public Schools

Elizabeth D'souza, Au.D.

I am relatively new to evaluating and treating children with auditory processing disorders (APD), but it has become the most exciting part of my professional life. I am dual certified and work as a speech pathologist/ audiologist in the public schools. Since starting my work in APD, I feel like I have found the missing piece to the puzzle. Often, the APD diagnosis, helps me explain and offer a solution for a student's academic struggles. To my surprise, I have found APD to be more prevalent than I have known it to be. Many children whom I would have dismissed, in the past, as attention deficit, learning disabled in reading, or as pure behavior issues, I find have an underlying auditory processing disorder. The most fascinating revelation to me about APD, was the degree of improvement I saw in children who received my auditory therapy. I saw remarkable changes in their social, communication, and academics skills. I would like to share one of my current cases with you.

A 9.2 year (third grade) student, "RS," was referred to me in February 2017, by her teacher and her parent. The teacher's primary concern was, "work avoidance." The parent's concerns were related to RS's reading, writing and spelling skills, which had not shown growth, despite the extra support she had been receiving in school. RS was reported to avoid any kind of work in the classroom. She frequently complained of aches and pains, and would leave class to visit the nurse. The nurse reported that RS had complained, on a few occasions, that the classroom and indoor recess noises were too loud. She spoke in a faint voice, appeared to lack energy, and looked ill. However, when she was out on the playground, she was a different person. I observed her laughing, playing, speaking normally and seemingly having fun.

Initially, I administered the Fisher's Auditory Problems checklist as a screener. RS scored a 'fail' score of 48. She presented with a history of ear infections from 18 months to 3 years of age. She required directions to be repeated and her attention span was reported to be short. Day dreaming, tendency for distraction by noise, difficulty with phonics and sound discrimination, poor learning through the auditory channel, language problems (phonology), lack of motivation, slow and delayed response to verbal stimuli, and below average performance in one or more academic areas, all were some of the other concerns on the Fisher scale. To obtain a more comprehensive picture of APD, I had the teacher and the paraprofessional complete the Buffalo Model Questionnaire-Revised (BMQ-R). The ΣCAP score of 8 or greater warrants an auditory processing evaluation. RS had a score of 23 and was referred for an auditory processing evaluation.
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The educational team, including me, completed a comprehensive evaluation, which included speech and language, audiological, academic, social, medical, and psychoeducational assessments. The speech and language evaluation findings revealed average language skills on the CELF 5 and deficient phonological processing skills on CTOPP 2. Her auditory memory index on TAPS 3 was average. On the WISC 5 psychoeducational evaluation, her index scores were average on full scale IQ, verbal comprehension composite and visuospatial composite. On the BASC 3, Parent Rating Scale was average, except for attention. The Teacher Rating Scale was clinically significant for anxiety, depression, somatization, attention and learning. Her academic assessment scores on the KTEA 3 were average for reading composite, sound symbol, decoding composite, and deficient on reading fluency composite. On the Fountas and Pinnell, a benchmark assessment system to determine reading levels, RS performed at a beginning 2nd grade level, a year and a half behind where she needed to be. She had made no progress despite two rounds of intervention with the reading specialist in 18 months. The central auditory tests revealed auditory processing disorder of the Decoding and Integration categories (SCAN-C, SSW, PST and Pitch Pattern Sequence Test-PPST). The pre and post therapy scores are given in Tables 2-4. RS passed the Auditory Continuous Performance (ACPT) test revealing no concerns for auditory attention or auditory impulsivity. Peripheral hearing loss was ruled out prior to the auditory processing assessment.

The team decided to develop a therapy plan based on the findings. The plan included instruction for reading skills by the Special Education teacher through the Wilson Reading Program and auditory therapy administered by me. I developed goals to work on: 1) phonemic synthesis using the Phonemic Synthesis Training program, and 2) binaural integration through dichotic listening tasks. I used two different dichotic listening programs based on availability. For the first 4 weeks, I used the Differential Processing Training Program-Acoustic Tasks, developed by Kerry Winget Au.D, CCC-SLP/A published by Linguisystem, followed by CAPDOTS by The Listening Academy, Inc., which is an online Dichotic Listening Program developed by Carol Lau (CASLPA). Therapy was scheduled for 30 minutes, 5 times a week. Each week, 2 of the 5 sessions were done by me while the other 3 were done by the paraprofessional.

The educational team also built in classroom accommodations to address the fatigue, behaviors, and academic challenges. RS was given breaks as needed, modified assignments, tests and quizzes, visual support of auditory information, extra time for work, small group instruction with paraprofessional support for reading and comprehension and alternate placement (a quiet environment) for testing. The teacher checked understanding of information. Compensatory strategies for RS's listening challenges were implemented through staff and student education. After 9 weeks of intervention, the teacher, parent and paraprofessional reported that RS had become a different child. She now seemed to be a happy and a confident student, who enjoys coming to school each day. She no longer keeps her head down on the desk, asks to see the nurse, or appears anxious, sad or withdrawn. Her parents also said they had noticed a change in her personality; she was happy and eager to be involved in activities at home and outside of school. She made good progress rapidly. As there were notable changes reported by the team, I asked the teachers to complete the BMQ-R again to correlate post therapy behavioral changes. See Table 1 for results. The ΣCAP indicators decreased significantly, from a total of 23 to 8. RS continued with auditory therapy and a re-evaluation was completed 9 months later. The pre and post therapy scores are given in Tables 2-4. Her reading scores on Fountas and Pinnell (F&P) progressed from level K (middle of 2nd grade level) to level N (middle of 3rd grade level). She has made 12 months of growth in 9 months and is behind by 12 months. Prior to intervention, reading comprehension was a concern, but now is reported to be at grade level. On a teacher questionnaire with a rating scale of great, moderate, mild, slight, or no improvement, teachers indicated "great improvement" in anxiety, behaviors, psychological issues and reading fluency. Her reading fluency which had lingered around 54 words per minute during intervention by the reading specialist prior to auditory training therapy, improved to 105 words per minute. Teachers indicated "moderate improvement" in processing what is heard, using, remembering and understanding language/verbal directions, understanding in noise, delays in responding, auditory-visual integration, sequencing and keeping things in order and learning problems. Teachers reported "mild improvement" in phonics, spelling, and reading accuracy.

Table 1. Pre-therapy and post-therapy BMQ-R

	DEC	TFM	INT	ORG	APD	ΣCAP	Gen
Pre therapy	7/9	6/14	4/6	2/3	4/7	23/39	4/9
Post therapy	5/9	1/14	1/6	0/3	1/7	8/39	0/9

Table 2. Pre-therapy and post-therapy SCAN-C

Subtests	Scaled Scores (pre/post)	Ear difference	Ear difference
AFG+8	10/12	Typical	Typical
FW	13/13	No LEA 15%	Typical
CW-DE total	5/10		
CW-DE Directed RE		No REA 2%	Typical
CW-DE Directed LE		No REA 2%	Typical
CS	5/10	No-REA 2%	Typical
CW-FR	5/12	No-REA 2%	Typical
TCS	10/12	No-REA 10%	15% REA

Table 3. Pre-therapy and post-therapy SSW results

Test Conditions	Normative Value	Score (Pre-Therapy)	Score (Post therapy)
Right non-competing	2 or lower	2	2
Right competing	4 or lower	8	6
Left competing	6 or lower	32	12
Left non-competing	1 or lower	2	2
Total	10 or lower	44	22
SIR	≤1.0	8.96	1.37

Table 4. Pre-therapy and post-therapy PST results

	Pre	Post	Normative value
Quantitative	13	21	18 or greater
Qualitative	10	20	16 or greater

Conclusion

These initial reports were exciting and encouraging. I have learned several things from this case regarding the evaluation and treatment of APD. This case illustrates:

1. Even a questionnaire, such as the BMQ-R, can provide good and comprehensive insight into a child's auditory processing deficits. This questionnaire is a reliable screening tool, for providers to use, when diagnostic testing by an APD audiologist is not readily available.
2. Improvement in social, emotional, and auditory behaviors can be observed and measured in as little as 9 weeks.
3. Individualized and detailed treatment plans, help the providers perform interventions appropriately, and appropriate interventions lead to the best outcomes.
4. Treatment for APD is life-changing. When APD is not treated, the student continues to struggle through school. The gap in the reading skills continue even with special education support.
5. A typical school-based speech pathologist, does not have a good understanding of APD and ways to treat it. Whenever a school aged child is diagnosed with APD, appropriate management of the disorder requires educating the team.

Case Benjamin

Merete Wolf, Child Neuropsychologist
Dorte Bisgaard, Speech and Hearing Therapist
Kjeld Johansen, PhD in Education

Introduction

Benjamin, a 5-year-old Danish boy, was very bothered by APD. He was given a Danish listening program, Johansen Individualized Auditory Stimulation (JIAS) therapy. The 15 months of treatment, he received, changed his life.

Clinical History and Description:

Benjamin had two sets of PE tubes because of recurrent otitis media. He was seen by an audiologist because of hypersensitive hearing. He could not cope with sudden, loud noises and often lived in his own world. To get his attention you would need to put your hand on his arm. Otherwise he did not seem to hear when he was spoken to. Benjamin was easily overload by background speech and could not concentrate. He is right-handed, left eye dominant, and right footed.

Description of Treatment

JIAS is an individualized frequency and hemisphere-specific auditory stimulation program. It uses specially-composed music that is recorded for each student on tape, CD or USB according to her/his audiogram. This is based on the results from binaural puretone thresholds, dichotic speech and testing of motor laterality.

Even though language and music in some aspects are “dealt with” in different networks of the brain, many neural networks are activated by music as well as by language. The general idea behind JIAS is careful testing (in Denmark usually including Danish SSW test) to find language processing problems and by adapting individual auditory stimulation by the JIAS program to improve auditory perception and to reduce APD.

Using especially composed music, recorded for each client, has proven beneficial. By selection of music tracks and the order in which the different frequency ranges are used, ideas from Volf were the inspiration. Adjustment of amplification and right/left differences, are mainly inspired by Tomatis. Selection of musical keys, rhythm and pulse follows suggestions from Steven Halpern.

The composer B.P. Holbech has written and recorded the music, skilled computer nerds have produced software algorithms to fulfill the JIAS individualization needs. More than five hundred therapists around the world in at least twenty five countries (from Europe, the U.S. to N.Z. and Australia) use JIAS with positive results to support students with learning and/or behavioral problems.

This case study is similar to case studies from many JIAS therapists “worldwide”. Unfortunately, many established language researchers are reluctant to accept the premise that neural stimulation, with special music, can improve language development.

The JIAS supervisor sees the test results and creates a CD with the music that the person needs to listen to for 10 minutes every day in the upcoming part of the therapy. The music is extracted from, 7 waves CDs and 4 undulations CDs, ranging from 100 to16000 Hz. The power of the music to each ear is adapted.

Right-handed persons are stimulated more in the right ear than the left. That worked for Benjamin. Had he been left-handed, the CD would need to be neutralized. The therapy was started February 2016 by letting Benjamin listen to the music 10-minutes every day for 15 weeks (instead of the recommended 8-weeks). In June 2016 a new therapy session was started. The music was adapted and Benjamin listened for 18-weeks (instead of the usual 12-weeks). In October 2016 a new therapy session was started. The music was adjusted and given 10 minutes every day for the 12 weeks that is usually recommended. In February 2017 the music was adjusted again. . It was used 10-minutes every day for 15- weeks (12 weeks recommended).

Clinical Testing:

WDS (Word Discrimination Scores and WDS in Noise)

Danish SSW contains a word discrimination test. See the results of the tests repeated 5 times during the treatment in Table 1. The table also shows the amount of gain from first testing to the last one in right and left ears without noise and with noise.

Table 1 WDS

Test	Date	WDS RE	WDS LE		Noise RE	Noise LE
1	2/27/2016	88%	92%		64%	48%
2	6/18/2016	88%	92%		88%	56%
3	10/22/2016	88%	96%		72%	72%
4	2/4/2017	96%	92%		76%	76%
5	5/20/2017	100%	96%		80%	88%
Difference #1 - #5		12	4		16	40

Conditions

We looked at the four conditions and the total number of errors on the Danish SSW on 5 occasions. The results are seen in Table 2.

When Benjamin was 5 years old the SSW results were based on 20 items, and when he was 6 years old they were based on 40 items. The norms for 5 and 6 years are inserted in the table with black numbers. At 5 years he had errors 2 standard deviations above the Normal Limits for each condition and the total score. There was a significant Order Effect L/H (The last two words of the items were most difficult). The second test was made June 18, 2016. Benjamin was 6 years old. The errors were still 2 SDs poorer than normal for the four conditions and total, and there was still a significant Order Effect L/H. There were also 2 perseverations. The third test was October 22, 2016. He had significant scores 2 SDs poorer than normal on RNC, RC, and LC as well as total. He had a significant LNC score, but only +1 SD. There was 1 perseveration. The fourth test was made February 4, 2017. The RNC, RC and total scores were still significant at +1 SD . At this point left ear, with and without competition, were not significant. Qualifiers were 3 perseverations. In the fifth test there were no significant scores, only 4 perseverations.

Table 2 Conditions

RNC, RC, LC, LNC and Total error means. Normal Limits (NL) for +1 & +2 SDs

Date and Norms	RNC	RC	LC	LNC		Total
2/27/2016 score	**5**	**12**	**15**	**9**		**41**
5 yrs (20 items) 1 SD NL 2 SD NL	3,5 4,8	6,7 8,8	8,6 10.5	5,2 6,8		21,9 26,6
6/18/2016 score	**14**	**22**	**21**	**13**		**70**
10/22/2016 score	**15**	**22**	**20**	**11**		**69**
2/4/2017 score	**4**	**13**	**12**	**6**		**35**
5/20/2017 score	**1**	**4**	**10**	**4**		**21**
6 yrs (40 items) 1 SD NL 2 SD NL	3,3 4,4	8,2 13,9	15,2 19,0	9,2 12,1		32,8 40,0

Table 3 Cardinal Numbers

Table 3 shows the improvement in number of errors for each cardinal number.

Date	A RNC	B RC	C LC	D LNC		E LNC	F LC	G RC	H RN
2/27/2016 (20 items)	**2**	**4**	**8**	**7**		**2**	**7**	**8**	**3**
6/18/2016 (40 items)	**2**	**8**	**14**	**11**		**2**	**7**	**14**	**12**
10/22/2016 (40 items)	**5**	**12**	**12**	**9**		**3**	**8**	**10**	**10**
2/4/2017 (40 items)	**1**	**7**	**6**	**3**		**3**	**6**	**6**	**3**
5/20/2017 (40 items)	**1**	**4**	**3**	**2**		**2**	**7**	**3**	**0**

Hearing

The hearing of frequencies were affected by therapy. See Benjamin's hearing at start February 2016 and end of the therapy May 2017 in Table 4.

Hz	125	250	500	750	1k	1.5k	2k	3k	4k	6k	8k
dB Left ear, 27 february 2016	25	15	15	15	10	15	20	15	10	15	25
dB Right ear, 27. february 2016	20	15	10	15	10	15	25	10	10	15	20
dB Left ear 20. may 2017	5	5	5	10	5	5	5	0	0	5	15
dB Right ear 20. may 2017	10	10	5	5	5	5	5	0	0	5	10
Improvement left ear	20	10	10	5	5	10	15	15	10	10	10
Improvement Right ear	10	5	5	10	5	10	20	10	10	10	10

Outcome:

Benjamin no longer needs to have things repeated. Suddenly he can synthesize all the sounds in the alphabet into syllables. In that activity he earlier took no interest at all. He can read short words. He appears calmer with his body movements. Finally he did better on all of the measurements (as is seen in the tables).

Suggested readings:

Diamond, M.C. (1988), Enriching Heredity: N.Y., The Free Press, Macmillan, Inc.

Halpern, S. & Savary, L. (1985), Sound Health: San Anselmo, CA, Sound Health Res. Inst.

Hugdahl, K., Davidson, R.J. eds. (2003), Asymmetrical Brain: Cambridge, Mass., MIT Press.

Johansen, K. (2011), Hearing and Learning, in E.M. Kulesza ed. Movement, Vision, Hearing –the Basis of Learning: Warsawa, Wydawnictwe Academi Pedagogiki Specjalnaj im. Marii Grzegorzewakiej.

Levitin, D.J. & Tirovolas, A.K. (2009), Music and Language, in The Year of Cognitive Neuroscience: N.Y., NYAS.

Merzenich, M. *et al* (1993), Neural Mechanisms, in Temporal Inform. Process.: N.Y., NYAS.

Tallal, P. (1993), Neurobiological Basis of Speech, in Temporal Inform. Process: N.Y., NYAS

Tomatis, A.A. (1991), The Concious Ear: N.Y., The Talman Company.

Wolf, M. & Bisgaard, D. (2005) How Denmark Obtained the Danish SSW Norms. SSW Reports, 37, 3.

SIR and 2B3: Are They Measuring the Same Thing?

Jay R. Lucker, Ph.D.

If a person has integration problems (INT), various measures can be used to evaluate this e.g., Standard Integration Ratio (SIR) (Katz & Medwetsky, 2015) and Two-By-Three (2B3) (Katz, 2015). SIR compares only right competing (RC) and left competing (LC) measures, while 2B3 adds other factors including speech in noise (SIN) and Phonemic Synthesis Test (PST). In what ways do SIR and 2B3 relate to SSW features right and left noncompeting (RNC and LNC), Type A and Total SSW, as well as to measures of SIN (RE and LE separately) and PST. Thus, looking at relationships between SIR and 2B3 is important to determine whether they are evaluating same or different things. Further, it was questioned whether people who have significant SIR also have significant 2B3. The following is a summary of the findings.

Methods

Participants

This research is based on review of clinic files of the last 50 children seen for APD testing, aged 6 to 18 years (mean age 10.4; standard deviation of 3.39). There were 31 males and 19 females. All children were identified with APD based on failing at least 2 measures at -2 standard deviations (criterion used by ASHA, 2005 and AAA, 2010).

Results

Correlation between SIR and 2B3

Because the absolute values for SIR and 2B3 differ, it was decided to state Yes (1) or No (0) if the child was found to have a significant SIR or 2B3 finding. Spearman Rank Order Correlation was then calculated. If the correlation was not statistically significant ($r = .250$, $p = .080$), but reveals a trend towards significance there may be factors in both SIR and 2B3 which are the similar, but the two measures are likely looking at different things. Since both use RC and LC, it was suspected that these measures led to the trend found. However, the extra factors used for 2B3 may indicate they are measuring different factors.

When we consider different aspects of INT, the author identifies three types (Hawkins & Lucker, 2017): phonological, lexical, and sound-symbol association. Phonological INT relates to problems mentally manipulating phonemes for analyzing sounds in words for blending (such as on the PST), segmentation, and analysis (such as evaluated on the CTOPP-2 and the phonological measures of the TAPS-3). Since SIR only looks at RC and LC, it is questioned whether SIR is involved with phonological INT at all. Lexical INT is the integration of words so that the brain figures out the meaning of the whole from its parts. This is more likely the primary measure for SIR since it only uses the dichotic measures of RC and LC. Sound-symbol association is measured via the Type A pattern (Lucker, 1979, 1980, 1982). SIR does not use the Type A in its analyses. Since 2B3 uses RC and LC as well, but also uses other measures, it would include in its analysis lexical INT which may be why we observe the trend towards a significant correlation between SIR and 2B3. Thus, it was decided to look at correlations between other measures used in the Buffalo Model, SIR and 2B3 findings.

SIR and 2B3 versus Type A

One INT is the Type A pattern. The question arises whether there is a significant difference in predicting Type A/sound-symbol association problems using SIR versus 2B3. If there is a significant difference, then SIR and 2B3 may be measuring different factors related to sound-symbol/Type A INT. To compare the findings between the SIR and 2B3 with Type A, a non-parametric, Chi-Square analysis was completed using Yes/No decisions for SIR and 2B3.

For the Type A pattern, children were identified having or not having a Type A using the standard method for identification. Of the 50 children, 15 were found to have significant Type A while 35 did not. A Cross Tabulation (Cross Tab) table was developed in which the Rows are Yes (a rating of 1) meaning the two measures agree, and No (a rating of 0) means that one measure was positive and the other negative.

Table 1. Cross Tab table comparing SIR/Type A (Rows) versus 2B3/Type A (Columns)

	Yes (2B3 & Type A)	No (2B3 & Type A)	Total
Yes (SIR & Type A)	12	6	18
No (SIR & Type A)	13	19	32
Total	25	25	50

Findings of 31 children's data agreed on the relationship between SIR and 2B3 with Type A, while 19 did not agree. Results of the Chi-Square analysis revealed no significant difference, but a trend occurred (Chi-Square = 3.125, df = 1, p = .077). Thus, there is a trend for a significant difference between SIR and 2B3 in their relationship to Type A. As such, this supports a conclusion that SIR and 2B3 may be related to different things comparing them with Type A, but there is a trend towards them being related to the same things. This trend likely occurs because SIR, 2B3, and Type A depend on LC value which may be a strong factor in identifying INT. That is, Type A and INT problems may be associated with LC more so than RC. But the fact that they are found to be different may be that 2B3 adds additional factors.

Because this trend was found, it was decided to look at the correlation between Type A and SIR as well as Type A and 2B3 by using Spearman Rank Order Correlations.

Table 2. Results of Spearman Rank Order Correlations Comparing Type A with SIR and 2B3.

Factor	R	p
SIR	.351	.012*
2B3	.306	.031*

*significant finding p<.05

It was not surprising that SIR would be correlated because RC and LC values are used. However, the surprise was that the 2B3 correlation analysis was significantly related to Type A. 2B3 does use RC and LC along with other factors. Since 2B3 and SIR were both found to correlate significantly with Type A, we might have problems differentiating between Type A and other INT problems. As discussed above, the 2B3 may be better in identifying lexical extraction problems, while the SIR seems to identify general lexical INT problems while Type A is associated with sound-symbol association INT difficulties.

SIR and 2B3 Versus Other Measures

To help answer the question whether SIR and 2B3 are measuring the same or different things, Spearman Rank Order Correlations were conducted looking at the relationships between these factors and other measures.

Table 3A. Results of Spearman Rank Order Correlations for Measures Associated with The Buffalo Model Test Battery and SIR.

Factor	r	p
RNC	.179	.214
RC	.483	.000*
LC	.518	.000*
LNC	.233	.103
Total SSW	.089	.541
SIN-RE	.008	.965
SIN-LE	.063	.662
PST	.183	.203

*significant finding p<.05

These correlations reveal that the ONLY significant relationships found were with SIR and RC and LC. This is not surprising since SIR is calculated based on these two SSW values. Thus, a significant SIR seems to be related to lexical processing rather than phonological processing problems.

Table 3B. Spearman Rank Order Correlations for Measures of Buffalo Model Test Battery and 2B3.

Factor	R	P
RNC	.464	.001*
RC	.479	.000*
LC	.385	.006*
LNC	.330	.000*
Total SSW	.510	.000*
SIN-RE	.123	.396
SIN-LE	.095	.512
PST	.125	.386

*significant finding p<.05

These correlations show that all SSW values correlate with 2B3. However, 2B3 is not related to SIN or PST findings. Thus, SIR and 2B3 are measuring different things. But, 2B3 measures **all** factors of SSW. In Lucker's model (Hawkins & Lucker, 2017), problems with RC and LC only are lexical INT problems, but problems with RNC, RC, LC, and LNC are due to lexical extraction problems. Extraction is associated with ability to pull out the important verbal information from what is heard (e.g., if someone said, "I went to the store and bought some milk and bread," the key words are "I went - store – bought – milk, bread."). Then, we integrate the key words and the situation to figure out the meaning of the message. Lucker's LMSIA model states that we must first extract the appropriate key words to integrate the message to comprehend the whole (put it all together).

Type A and Other Measures of Auditory Processing

Lastly, what other factors correlate with Type A. Type A was assessed for presence (1) versus no significant (0) Type A.

Table 4. Spearman Rho Correlations Analyses: Type A and Buffalo Model Battery

Factor	R	P
RNC	.144	.319
RC	.371	.008*
LC	.396	.004*
LNC	.274	.054**
Total SSW	.449	.001*
SIN-RE	.109	.451
SIN-LE	.046	.752
PST	.111	.451

*significant finding p<.05; **trend because p>.05 but <.10

Not surprisingly the Type A is correlated with LC as it's used to identify the Type A. What is surprising is that Type A is correlated with RC. However, when LC is abnormal, often RC is abnormal. It's not surprising the Total SSW correlates with the Type A as it uses RC and LC values. What was a surprise is that LNC revealed a trend. It has been the author's clinical experiences that when LC is very poor, LNC is often abnormal.

Conclusions

We found SIR, 2B3 and Type A measure different things, but they overlap. SIR looks at lexical INT while 2B3 is looks at word extraction (also known as decoding). Lucker's LMSIA model sees the sound-symbol (Type A), lexical INT (SIR), and lexical extraction (2B3) as three totally different, but associated, problems. This article provides an initial step in differentiating these three types of APD problems. Further research is needed looking at these factors to support the conclusions presented.

References

American Academy of Audiology (AAA) (2010). Clinical Practice Guidelines: Diagnosis, Treatment and Management of Children and Adults with Central Auditory Processing Disorder. https://audiology-web.s3.amazonaws.com/migrated/CAPD%20Guidelines%208-2010.pdf_539952af956c79.73897613.pdf

American Speech-Language-Hearing Association (ASHA) (2005). [Technical Report]. Retrieved January 31, 2018 from www.asha.org/policy

Hawkins J, Lucker JR (2017). Looking at auditory processing from a multisystem perspective. *Topics in Central Auditory Processing, 2* (1), 4+.

Katz J (2015). INT and the challenge in identifying it. *SSW Reports, 37* (2), 1-2.

Katz J, Medwetsky L (2015). Standard Integration Ratio (SIR). *SSW Reports, 37* (2), 2-6.

Lucker JR (1979). Diagnostic significance of the Type A pattern. *SSW Newsletter,1* (4), 4-5.

Lucker JR (1980). Diagnostic significance of the Type A pattern on the Staggered Spondaic Word Test. *Audiology and Hearing Education, 6* (2), 21-23.

Lucker JR (1982). Diagnostic significance of the Type A pattern on the Staggered Spondaic Word (SSW) Test. In D. Arnst & J. Katz (eds). *Central Auditory Assessment: The SSW Test: Development and Clinical Use* (pp. 350 – 355). San Diego, CA: College-Hill Press.