Topics in Central Auditory Processing

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Start Off Each Day with a Smile

A few years ago I was working with a 10-year-old who is on the spectrum. He looked in my direction without any affect in his face or voice. In a slow, sound-by-sound manor he said, "D.o.c.t.o.r…..K.a.t.z……..y.o.u…..a.r.e……..s.i.l.l.y". [His mother did not jump in to apologize] I replied, "Thank you so much David. That is so nice of you to say!"

(We need a funny story for the next issue. Please send one of yours.)

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Auditory Processing as a Predictor of Reading

Wayne J. Wilson Ph.D.

It is not uncommon to find children with reading disorders who also perform poorly on auditory processing (AP) tasks. Two theories are offered to explain these findings. One is based on the premise that phonologic representations are essential for learning to read (Wagner & Torgesen, 1987). The other is based on the importance of underlying auditory processes that account for poor reading in some children (Ramus et al. 2003; Rosen 2003). While some AP tasks have been shown to be related to word and nonword reading, relationships between AP and spelling and passage reading are not as clear.

Sharma, Cupples and Purdy (2018) recently sought to investigate how measures of AP typically used by audiologists relate to measures of reading and spelling in school-aged children. These researchers sampled 90 children (7 to 13 years, 58 males) with normal hearing sensitivity who had been identified as having listening and/or reading concerns. The children were assessed for AP using frequency patterns (FP), dichotic digits, the random gap detection test, and masking level difference; and for reading using tests of word, nonword, and passage reading. The children were also assessed for phonologic processing, core language skills, nonverbal intelligence, memory, and attention.

To analyse the data, Sharma et al. first used simple correlations to identify potential relationships between the measured variables. They then decided which variables would be used in which order in a series of fixed-order multiple regression analyses. These analyses sought to determine if performances on the AP tests were associated with performances on the tests of regular and irregular word reading, nonword reading, nonword spelling, or passage reading accuracy and fluency.

The researchers found that performance on only one of the AP tests, FP, was uniquely associated with performances on word/nonword reading and nonword spelling. No other associations were found amongst the AP and other variables. This was interesting as while this unique association was weak, FP had not been associated with reading and spelling ability in other studies. On closer examination, the researchers concluded that this association was most likely due to the auditory aspects of FP and not to attention or memory.

The researchers also considered why FP might have been the only AP test to associate with reading and spelling in their study. While certainly not suggesting any cause and effect relationships, they postulated that it might have something to do with FP requiring skills in frequency discrimination and temporal sequencing. Both of these skills have been associated with reading disorders in previous research (Hamalainen et al., 2013).

Based on their findings, the researchers concluded that while more research is needed, audiologists should consider including FP in their APD test batteries when assessing children with word reading disorders.

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The Influence of Old Spondees on SSW Results and a Possible Fix

Jack Katz, Ph.D.

In recent years, I was unaware of concern about the effect of Old SSW spondees (that are not presently in common use). The current concern prompted me to study this complex issue.

1. I took 3 looks at the SSW items to see how many spondees are not now in common use. I identified 11 spondees that were probably in more common use when the norms were gathered (1996-8). I did not include 2 less familiar words (i.e., band saw, beach craft), because they were just as unfamiliar at the time of the norms, so they are already accounted for.
2. Files were studied for 40 children, 6-17 years of age, who were free of hearing loss and all were native speakers of American English.
3. The final choice of 11 old spondees (of the 80 spondees) is shown in Table 1 below.

Item	Errors	Spondee	Item	Errors	Spondee
4	31	wash tub	***27***	20	corn starch
4	23	black board	***27***	33	soap flakes
10	3	black board	*33*	49	drug store
17	20	snow white	*37*	15	milk man
21	8	hair net	*39*	18	street car
23	6	ash tray			

Table 1. Eleven spondees not-in-common-use and number of errors for each.
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4. Fortunately, not all old spondees were on separate items. Two items (i.e., 4 & 27) involved both spondees and 7 other items had just one Old spondee each.
5. Did the Old spondees have lots of errors? Yes, with a mean of 25.9 errors. Interestingly, Old spondees a wide range of errors (3 to 49 errors,). So being an Old spondee may not fully explain the large number of errors. For example, the fewest Old errors were on ‘blackboard’, but the same spondee that was given before had 23 errors. The mean error for the 69-Regular (not Old) spondees was 12.5. The Regular spondee errors ranged from 0 to 50. So the range for the Old and Regular spondees was surprisingly similar.

Let’s see how the errors for each group were distributed. Figure 1 shows the 4 SSW Conditions for their Original 80 spondees. As expected there is a large LC peak, followed by a sizeable RC peak and then 2 minimal NC scores with the fewest errors for RNC. As expected the Regular-69 remaining spondees followed the same pattern. Of special interest, the errors for the 11 Old spondees also followed the same curve. These items seem more sensitive, but to the same dichotic challenges.

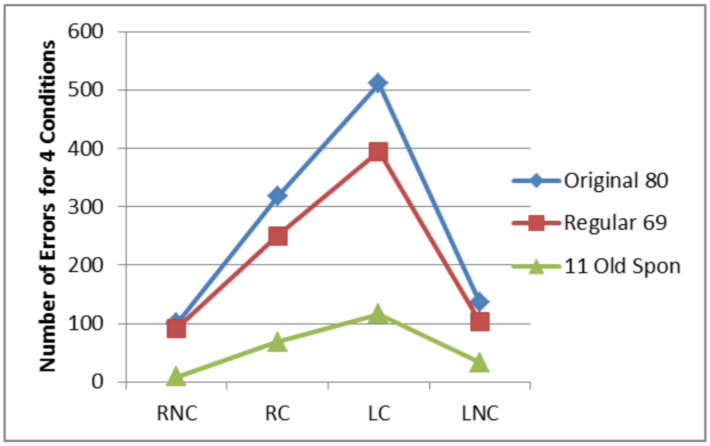

Figure 1 shows the Original errors for the 4 SSW Conditions. This is based on results for 40 children with APD. The third curve is the errors on the 11 Old spondees and the middle curve is for the Original errors minus the Old errors. If they had the same number of spondees the error patterns would be the same. It is encouraging that they seem not simply familiarity-errors, but importantly depend on the dichotic task.

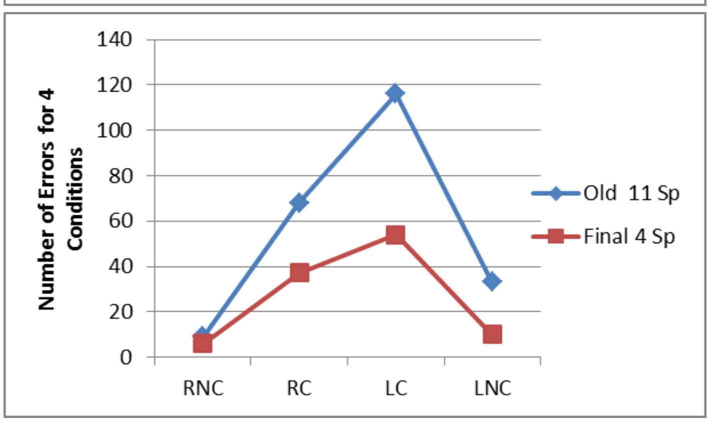

Figure 2 shows the Old 11 Spondee errors and the Final-4 Spondees (discussed below) that we removed from the Old 11. This curve generally follows the same curve in Figure 1. These will be discussed in the text below.

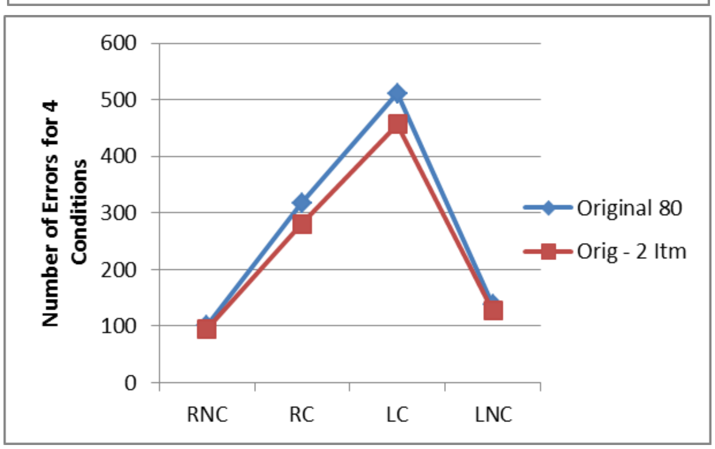

Figure 3 shows the Original errors and the strategic reduction when the errors for 4 spondees (2 items) are subtracted. The text will discuss the rationale and whether this will help or hurt the SSW.

The 4 spondees represent 107 errors compared to all 11 with 285 errors. So, omitting the 2 items reduced the Old spondees average errors by 40%. But, omitting 2 items also reduces the total items when using the norms based on 40 items!

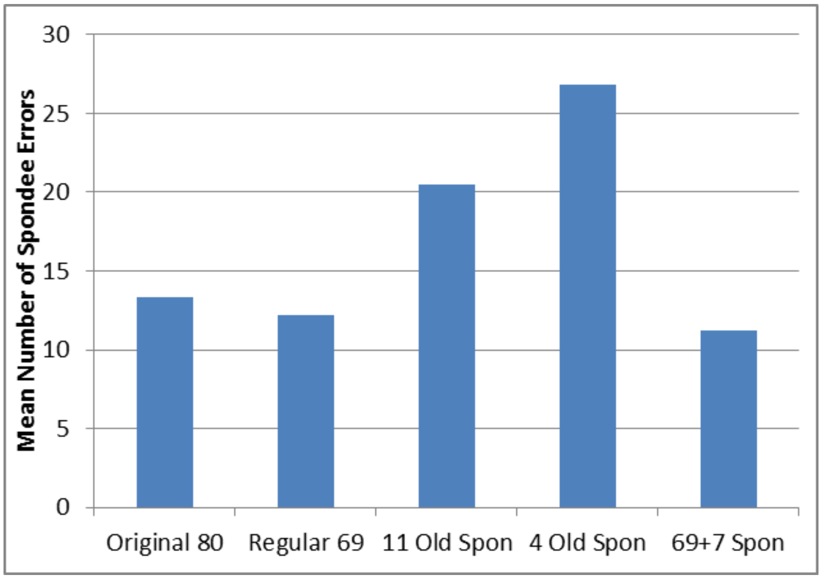

Figure 4. Mean errors per spondee for the 40 children. The Original 80 spondees had 13.2 errors that were somewhat colored by the 11 less familiar ones. The Regular-69 are likely more consistent with the originally normed 80 spondees. Their mean 11.1 has 2 fewer errors per spondee. The 11 Old ones had a mean of 25.9 errors. Fortunately, just the 4 spondees averaged 26.8 errors per spondee. When those 2 items were removed, the mean for the remaining 76 Spondees was 11.8 (slightly more than the target 11.1). That turns out to be very good.

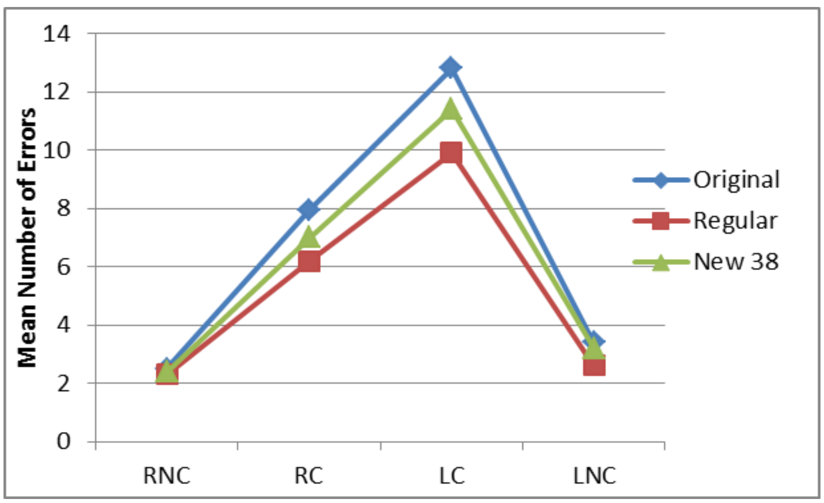

Figure 5. This shows the errors for the Original-80 spondee test (for the 40 children) and the errors for the Regular-69 spondees. The New 38 (76 spondees) items have more errors than the Regular 69, that we are aiming for. However, when we add the zero errors for the 8 words it reduces the actual effect on the norms, as you will see below.

To match the present test to the norms we would like to average about 11.1 errors for 40 items. We have a mean of 11.8, but for only 38 items (5% fewer than 40). So we have to subtract 5% (or 0.6) from 11.8 because of fewer test items are not as powerful. So that equals the amazing amount of 11.2! It's amazing that the most convenient 2 items (with old 4 spondees) just happen to have an almost identical effect as the desired correction. In addition, it is so balanced because each Condition has a similar correction as expected, and also Ear and Order Effects are equally corrected. I could not imagine that we would have such luck.

Conclusion

I think that omitting just 2 items (#s 4 and 27) from the calculation will provide a corrected score that is equivalent to the predicted 40 item normed SSW test. It appears that, by a stroke of luck there are 2 items that could be omitted and get the mean results and distributions that are about the same as desired. Please note: In the next TiCAP issue we should have data to show the effect of this correction on a new group of subjects. If it proves effective we will include the simple correction procedure.

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The SSW Repeatability Administered Twice in Six-weeks Apart

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A young girl (YG) was recommended for an APD evaluation by school professionals. Because the first evaluation was administered at the age of 5.11 years (and YG passed the 5-year norms) it was necessary to repeat the SSW test when YG was at 6 years of age. The SSW test was administered again at six weeks apart. The two test performances were identical with minimal variability, including the actual errored responses. YG displayed 3 smush responses and zero reversals at both sessions and a high/low Ear and Order error pattern.

Table 1 provides the total errors for the right competing (RC), right non-competing (RNC), left competing (LC) and left non-competing (LNC) scores at both sessions. Because she was so close to age 6 on the first test and her scores were so good, all 40 items were given. This was fortunate so the results for all 40 items could be compared. Table 2 shows the identical responses provided by YG at both sessions. The omissions were identical except for an additional omission in the RNC and RC conditions and 2 fewer omissions for the LC condition.

It was uncanny to see YG's identical word errors and similar test scores in both test performances. Although, using the SSW test for 29 years has shown this clinician that the SSW test is reliable and offers an abundant amount of information.

Table 1. Comparing the SSW test performance administered 6-weeks apart.

	RNC	**RC**	**LC**	**LNC**	**Total**	**Reversals**
Maximum Norm Age Errors (**1 SD) age 6:**	4	10	15	5	28	4
YG's errors at 5 year 11 months:	1	9	**25**	1	**36**	0
YG's errors at 6 years 2 weeks:	2	10	**23**	1	**36**	0
Maximum Norm Age Errors **20 items age 5:**	2	10	11	3	23	1
YG's errors 1st 20 items:	0	5	8	1	14	0
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Table 2. YG's identical response errors for test and retest

SSW Test **Stimuli**	**Response Provided at Both Sessions**
4. wash tub black board	wash **cloth** board
12. green bean home land	green bean **blend**
20. ice land sweet cream	ice **black** sweet cream
26. play ground bat boy	play ground **cat** boy
27. corn starch soap flakes	corn starch **plates**
34. wood work beach craft	wood **weach** craft
39. race horse street car	race horse **horse** car

Perhaps it would not be so surprising, on retest, to see a number of identical errors on speech in quiet, speech in noise or the Phonemic Synthesis test. However, the SSW is such a complex task that it presumably would require many factors to be consistent for the tests and retest.

I am sure that most of you have faced the problem of testing a child shortly before their birthday and wonder which norm to use, or actually doing what I did and retest. Statistically, the person is slightly closer to the actual age, but you could get some additional information by looking at the next age norm.

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What Do Non-Verbal Measures of Auditory Processing Tell Us?

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Many audiologists choose to use verbal and non-verbal measures of auditory processing. A question arises as to what information one obtains from measures of auditory processing, especially comparing verbal and non-verbal measures. For example, Katz (2007) presents his approach to evaluation of auditory processing using verbal measures only. In the Technical Report on auditory processing published by the American Speech-Language Hearing Association (ASHA) (2005a), and in their guidelines for the audiologist's role in the evaluation of auditory processing (2005b), and the guidelines from the American Academy of Audiology (AAA) (2010), these two organizations identified that verbal and non-verbal measures of auditory processing may be used in assessment of auditory processing disorders. These factors lead professionals to use whatever tests of auditory processing they choose which may be verbal measures or non-verbal measures.
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A major concern is if the audiologist uses some or all non-verbal measures, do these measures reveal information regarding a person's abilities to processing auditory-verbal information. The focus of auditory processing should be related to problems people have dealing successfully in processing verbal information (Hawkins and Lucker, 2016; Katz, 2007). Thus, it would be important to identify whether non-verbal measures of auditory processing are related to verbal measures.

As for non-verbal measures, various tests have been developed such as Frequency or Pitch Patterns and Duration Patterns tests (Musiek, 1994). More recently (2014a & b) Heath developed a battery of non-verbal measures into one test called the *Test of Auditory and Visual Skills* (TAVS). The TAVS bases its measures on previously developed non-verbal tests of auditory processing such as the two developed by Musiek. Additionally, in 2015, Heath presented a study in which he looked at outcomes from therapy using pre- and post- treatment findings based on the SCAN A (Keith 1994) and his TAVS test. He looked at improvements for each individual test and concluded, "Improvements in the SCAN A were mirrored by improvements in the TAVS auditory quick screen. This illustrates the validity of using TAVS as a measure of auditory processing difficulties." Interpreting what Heath states, it can be said that the SCAN A results are similar to the TAVS results, and that the TAVS quick screening test can be substituted for the SCAN A. Additionally, this statement by Heath could be interpreted to mean that results of the TAVS are related to results of the SCAN A which indicates that failure on measures of the TAVS would be reflected in a person's inability to process auditory-verbal information.

If it is true that TAVS results mirror the findings from the SCAN A, then results of the TAVS should correlate with results of measures from the SCAN A as well as from tests like the SSW and PST. Thus, it was decided to take a group of subjects and complete a battery of verbal measures (SCAN-3, SSW, and PST) and compare them with results from the five measures of the TAVS quick screen. The following discusses results of this research.

Methods

Participants

A group of 15 participants was used as subjects. Nine participants were young college students from Howard University. Each student was identified having normal hearing and no concerns regarding cognitive/ intellectual functioning. None of the students were identified having auditory processing disorders although two of the students met the AAA (2010) and ASHA (2005a & b) criterion for being diagnosed with an auditory processing disorder (APD). This criterion is failure on at least two measures of auditory processing below -2 standard deviations. The remaining participants were six students in elementary through high school identified with auditory processing deficits based on the same criteria. Thus, a total of 8 participants had APD problems and 7 did not. However, the group as a whole was used in the correlation analyses completed. The college students ranged in age from 19 to 24 with a mean age of 19.9 years (standard deviation (SD) of 1.83 years). The non-college students identified with APD problems ranged in age from 8 to 19 years with a mean age of 11.5 (SD of 3.83). Overall, the group had a range of age from 8 to 24 years with a mean age of 16.5 (SD of 5.03). There were 6 males and 9 females in the entire group.

Materials

The verbal measures of auditory processing included subtests from the SCAN-3 C (Keith, 2009b) for children below 13 years and A (Keith, 2009a) for those 13 years and older. They were also administered the SSW Test (Katz, 1968, 1977) and the Phonemic Synthesis Test (PST) (Katz, 1983). For the SCAN-3, the subtests included Auditory Figure-Ground (AFG) +8 SNR for children and 0 for adolescents and adults, Filtered Words (FW), Competing Words–Free Recall (CWFR), Competing Words-Directed Ear (CWDE), Competing Sentences (CS), and Time Compressed Sentences (TCS). From the SSW Test, only the four condition scores were used. For the PST, only the total correct score was used.

For the non-verbal measures of auditory processing, the five subtests of the TAVS quick screen were used (Heath, 2014a & b). These measures include Temporal Order Thresholds (TO) (shortest time difference at which one identifies from which ear a sound was heard first and second), Auditory Fusion Threshold (AF) (number of milliseconds needed for a person to identify whether the sound heard is one or two sounds), Auditory Motor (AM) (shortest time in milliseconds needed for a person to identify the correct order (right-left or left-right) for a sequence of sounds, Pitch Discrimination (PD) (number of semitones needed for a person to identify that two tones are the same or different), Duration Pattern (DP) (number of milliseconds needed to determine the pattern of long and short tones being long-short or short-long).

Procedures

To ensure that there was not a significant effect of doing the verbal followed by the non-verbal tests, participants were presented with the verbal or non-verbal first in random order. Thus, some students completed the verbal measures followed by the non-verbal measures while some completed the testing in reverse order. However, the order for the tests remained the same: SCAN-3 AFG, FW, CWFR, CWDE, CW, TCS, SSW, PST and TO, AF, AM, PD, DP.

Correlations for Verbal and Non-Verbal Measures of Auditory Processing

To determine whether there were any significant correlations, Pearson correlational analyses were performed. Results of the Pearson correlations revealed that only relationship (Competing Words Directed Ear and Auditory Fusion was found to be significant ($r = -.540$, $p = .038$) with a negative correlation indicating that as performance on Competing Words increases in standard score, the Auditory Fusion threshold decreases. Thus, both improved. Therefore, for the total of 50 comparisons, only this one revealed a significant correlation. As such, it must be concluded that, overall, there is no significant correlation between verbal measures and non-verbal measures of auditory processing used since only one finding was significant.

Conclusions

Results of the present investigation indicates that there is no evidence to support Heath's conclusion that we can use his TAVS quick screen test instead of verbal measures of auditory processing to obtain information about how people are processing auditory-verbal information which is the usual focus of auditory processing testing. The findings from the present study indicate that these non-verbal measures of auditory processing did not relate to performance on verbal auditory processing tasks. In the present investigation, only one comparison was found to be significant which does not support a conclusion that non-verbal and verbal measures of auditory processing relate to each other.

Although AAA (2010) and ASHA (2005a & b) state that one may use both verbal and non-verbal measures of auditory processing, this should not be taken to mean that one type of measure can substitute for the other. The present investigation supports a conclusion that verbal measures and non-verbal measures do not correlate so that there is no significant relationship between them.

When we consider the findings and conclusions drawn, it is important for professionals and researchers to understand that the measures they choose to evaluate auditory processing can involve very different processes. Thus, generalizations should not be made identifying that non-verbal measures provide indications of how a person will process verbal information, and vice versa. Since auditory-verbal processing problems are the usual reason for a person being evaluated for APD (AAA, 2010; ASHA 2005a; British Society of Audiology, 2011), it is felt that verbal measures of auditory processing are most important in the evaluation of a person's auditory processing abilities. Further research is needed to support such a conclusion.

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