SSW Reports

• Screening Test for Auditory Processing (STAP)
[A Contribution from Mysore, India]

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Editorial Introduction by Jack Katz

I was most excited to read this STAP article and pleased to share the excellent work of Professor Yathiraj and Research Officer Maggu in SSW Reports. I think you will find it most interesting because they have developed an impressive screening test and because in the process of studying their test they have uncovered information pertinent to the Buffalo Model. In addition, I must admit I envy the sample sizes in their studies.

As you will see the authors came upon a relationship between auditory memory and speech-in-noise scores. But instead of working with data from children with APD, as we did 25 years ago when we developed the Buffalo Model, they studied an essentially normal group of children who were then screened for the purposes of checking their STAP. In studying correlational-type data they found that Speech-in-Noise and Auditory Working Memory were lumped together.

This work is particularly timely because recently an audiologist has indicated that the Tolerance-Fading Memory category should be divided into the speech-in-noise component and the memory component. Well just this week in the July-August, 2012 issue of JAAA there is an article by Brannstrom et al. that found the very same thing as our colleagues in India. The Brannstrom et al. study dealt with noise issues for the hard-of-hearing finding the very same relationship of speech-in-noise (i.e., background noise level) to load on the same characteristic as Working Memory in a group of essentially normal hearing adults.

When three different studies, in three different languages, all looking at different objectives with different populations and yet have the same improbable result; it adds considerable strength to the joint findings. I think I can speak for those who use and benefit from the Buffalo Model that we are grateful that you brought your work to our attention.

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Screening Test for Auditory Processing (STAP): Revelations from Principal Component Analysis

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In India, screening for the presence of auditory processing disorders (APD) is carried out by using a screening checklist. Muthuselvi and Yathiraj (2009), using their screening checklist on 3120 school-going children, found a sensitivity of 71% and specificity of 68%. It is believed that screening tests, which reflect the actual auditory processes have higher sensitivity and specificity compared to screening checklists (Schow & Seikel, 2007). In order to screen the children at school for APD, certain audiological screening tests such as SCAN-C (Keith, 2000) and Multiple Auditory Processing Assessment (MAPA) (Domitz and Schow, 2000) have been developed. These tests take approximately 20 minutes (Lampe, 2011) to 30 minutes (Schow & Chermak, 1999) to administer, which does not meet a reported economic time requirement of a screening test (Lessler, 1972).

Keeping these issues in mind, we have developed the STAP: A Screening Test for Auditory Processing as a part of an ongoing research project. This test incorporates the most frequently occurring auditory processing deficits mentioned in the earlier studies (Welsh, Welsh & Healy, 1980; Musiek, Guerkink & Kietel, 1982; Katz, Kurpita, Smith & Brandner, 1992; Muthuselvi & Yathiraj, 2009). The criteria for inclusion of a particular process in the screening test also depended upon the high prevalence of that deficient process in a particular study. According to the literature, the processes that are more frequently affected are auditory separation (Welsh, Welsh & Healy, 1980; Katz et al., 1992; Muthuselvi & Yathiraj, 2009), binaural integration (Musiek et al., 1982; Katz et al., 1992; Muthuselvi & Yathiraj, 2009), temporal resolution (Musiek et al., 1982; Muthuselvi & Yathiraj, 2009) and auditory memory (Muthuselvi & Yathiraj, 2009). Hence, our screening test consists of four sub-sections which tap the above processes. The sub-sections included are speech-in-noise, dichotic CV, gap detection (GD) and auditory memory (AM). Table 1 provides details regarding these sub-sections.

Table 1. Details of the sub-sections included in the screening test.

Sub-Sections	Number of Items	Mode	Processes Tested
Speech in Noise (SPIN)	10 words per ear	Monaural	Auditory Separation
Dichotic CV (DCV)	6 pairs (/pa/, ta/, /ka/, /ba/, /da/, /ga/)	Dichotic	Binaural Integration
Gap Detection (GD)	6 tokens for each ear	Monaural	Temporal Resolution
Auditory Memory (AM)	16 words	Binaural	Auditory Memory

Participants included 267 children from 8 years (grade III) to 13 years (grade VIII) who were screened in a public school by an audiologist. The screening was carried out using the compact disc (CD) version of the STAP. In addition to the test items, the CD also contained instructions for carrying out each sub-section. Prior to testing each child, it was ensured that he/she had no observable speech and hearing problems, based on the reports of the class-teacher and the child.

Procedure
The participants were asked to follow the recorded instructions and their verbal responses were noted down by the audiologist. Each correct response was awarded a score of one while an incorrect response was given a score of zero. The pass criteria of the various sub-sections were adapted from the earlier existing diagnostic tests. Details of the scoring are provided in Table 2.

Table 2: Maximum scores and pass criteria of the sub-sections STAP.

Subsections	Maximum scores			Pass scores		
	Right Ear	Left Ear	Double Correct	Right Ear	Left Ear	Double correct
SPIN[a]	10	10	----	6	6	----
DCV[b]	6	6	6	4	4	2
GD[c]	6	6	----	4	4	----
AM[d]	16		-----	12		----
SPIN: Speech-in-Noise; DCV: Dichotic Consonant Vowel; GD: Gap Detection; AM: Auditory Memory Pass criteria adapted from: a, Kalikow et al. 1977; b, Yathiraj (1999); c, Shinn, Chermak & Musiek (2009); d,Yathiraj & Vijayalakshmi (2005)						

Statistical Analysis
Since our aim was to check the independence of the four auditory processes from each other as well as to determine their interaction with each other, Principal Component Analysis (PCA) was chosen for data reduction. The analysis was carried out using SPSS 16.0 software.

Results
As a part of the PCA procedure, correlational values among the sub-sections were obtained. Overall, it was found that the within sub-sections correlations were greater than the between sub-sections. For instance, the left ear speech-in-noise scores had a higher correlation with the right ear scores than with any other sub-section. This reflected the independence of auditory separation from the other processes. Likewise, the binaural integration and temporal resolution were independent from the other processes. This can be observed in Table 3.

From the PCA, 8 different components emerged. However, there were only 3 components which had Eigen values greater than 1 (Figure 1).

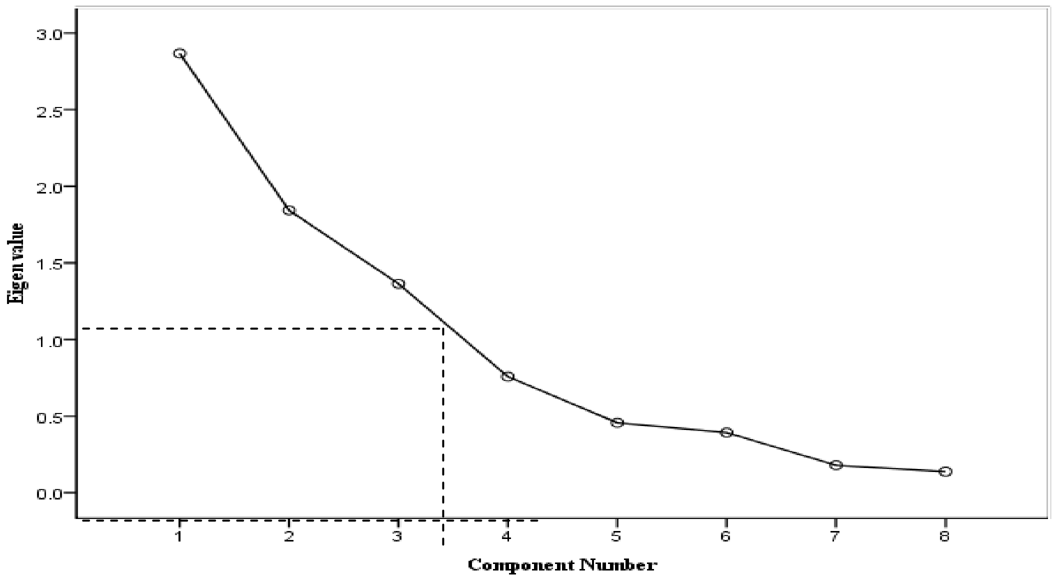

Figure 1. Scree plot showing the various components with their Eigen values.

Orthogonal rotation of these components led to a better representation in space and it was found that the variables within the dichotic CV sub-section were maximally loaded on component 1, gap detection sub-section had most loading on component 2 while the component 3 was shared by both speech-in-noise sub-section and auditory memory sub-section. (See Table 3.) We found that the three components which emerged in our study accounted for a total variance of 75.9%.

Table 3. Depicting the rotated component loadings of the various sub-sections.

Sub-sections	**Components**		
	1	**2**	**3**
SPIN Rt	-0.114	0.076	**0.871**
SPIN Lt	0.144	0.070	**0.853**
DCV Rt	**0.824**	0.047	0.114
DCV Lt	**0.879**	0.098	0.012
DCV DC	**0.942**	0.011	0.091
GD Rt	0.049	**0.947**	0.102
GD Lt	0.084	**0.937**	0.125
AM	0.333	0.153	**0.478**

Rt, Right ear; Lt:, Left ear; DC, Double correct; SPIN, Speech-in-Noise; DCV, Dichotic Consonant Vowel; GD, gap detection; AM, auditory memory

Discussion

There are some important points that emerged in this study that are worth discussing here. First, we were concerned about the time taken by the screening procedure. We found that STAP took a total of 12 minutes per child. This included the time taken from seating, placement of headphones, instructions to the child, administration of the test to tabulation of the responses. The total duration taken by STAP is markedly less than the time reported to be taken by other available tests such as SCAN which takes approximately 20 minutes (Lampe, 2011) and MAPA which takes approximately 30 minutes (Domitz & Schow, 2000). Second, our analysis of 267 subjects revealed that the three major components which accounted for variance of 75.9%, was higher than the already existing tests such as SCAN which could account for a variance of 61.9% (Schow & Chermak, 1999).

Third, based on the rotated component loadings, two auditory processes i.e., binaural integration and temporal resolution were identified as component 1 and component 2, respectively. Fourth, and an important finding of the study was that the component 3 was shared by speech-in-noise and the auditory memory sub-sections. This indicates that there is some relationship between these two areas. Such findings may be obtained when fewer subjects are studied. However, this was not the case in the present study. We looked at the literature and found that our findings were in consonance with the findings of Katz (1992). The Buffalo Model proposed by Katz (1992) has a sub-type of deficits in which one is known as the Tolerance Fading Memory (TFM) deficit. According to Katz (1992), this is the second most common sub-type in the general population. In this deficit, a person has problems in speech perception in noise along with reduced short-term memory. According to Katz and Smith (1991), there is a close association between frontal and anterior temporal lobe and if there is a lesion in this association, there is a possibility the person will exhibit a TFM deficit. We believe that existence of TFM sub-type accounts for component 3 of our results, which was shared by speech-in-noise and auditory memory sub-section.

The developed screening test, STAP, seems to be a promising tool because it accounts for a large proportion of the variance. Currently, its sensitivity and specificity are being determined on a larger sample.

References

Domitz, D, M., & Schow, R. L. (2000). A new CAPD test battery - multiple auditory processing assessment factor analysis and comparison with SCAN, *American Journal of Audiology*, 9, 101-111.

Kalikow, D. N., Stevens, K. N., & Elliott, L. L. (1977). Development of a test of speech intelligibility in noise using sentence materials with controlled word predictability. *Journal of the Acoustic Society of America, 61*, 1337-1351.

Katz, J. (1992). Classification of auditory processing disorders. In: Katz, J., Stecker, N and Henderson, D (eds). *Central auditory processing: A Transdisciplinary View.* pp. 81-92. Chicago: Mosby Yearbook.

Katz, J. & Smith, P. (1991). The Staggered Spondaic Word test: a ten minute look at the central nervous system through the ears. *Annals of the New York Academy of Sciences, 620*, 233-251.

Katz, J., Kurpitha, B., Smith, P. S. & Brandner, S. (1992). CAP evaluation of 120 children. *SSW reports, 14* (1), 1-7.

Keith, R. (2000). Development and standardization of SCAN-C Test for Auditory Processing Disorders in Children. *Journal of the American Academy of Audiology, 11*(8), 438-445.

Lampe, B. (2011). Critical review: Are currently available pre-packaged behavioral test batteries (SCAN and MAPA) effective for use in the assessment and/or diagnosis of auditory processing disorder (APD) in children assuming the American Speech-Language Hearing Association (ASHA) definition of APD? Retrieved from: http://www.uwo.ca/fhs/csd/ebp/reviews/2010-11/Lampe.pdf

Lessler (1972). Health and educational screening of school-age children: Definition and Objectives. *American Journal of Public Health, 62*, 191-198.

Musiek, F., Guerkink, N., & Kietel, S. (1982). Test battery assessment of auditory perceptual dysfunction in children .*Laryngoscope*, 92, 251-257.

Muthuselvi, T., & Yathiraj, A., (2009). Utility of the screening checklist for auditory processing (SCAP) in detecting (C)APD in children. *Student Research at A. I. I. S. H. Mysore (Articles based on dissertation done at AIISH). 7*, 159-175.

Schow, R. L., & Chermak, G.D. (1999). Implications from factor analysis for central auditory processing disorder. *American Journal of Audiology, 8 (2)*, 137-142.

Schow , R. L., & Seikel, J. A (2007). *Screening for (central) auditory processing disorder.* In: Chermak, G. D., Musiek, F. E. (2007). *Handbook of central auditory processing disorder, auditory neuroscience and Diagnosis.vol:1*. San Diego: Plural Publishing Group.

Shinn, J. B., Chermak, G. D., & Musiek, F. E. (2009). GIN (Gap-in-Noise) performance in pediatric population. *Journal of the American Academy of Audiology, 20* (4), 229-238.

Welsh, L. W., Welsh, J. J., & Healy, M. P. (1980). Central auditory testing and dyslexia. *Laryngoscope, 90*, 972-984.

Yathiraj, A. (1999). The Dichotic CV test. Unpublished material developed at the Department of Audiology, All India Institute of Speech and Hearing, Mysore.

Yathiraj, A., & Vijayalakshmi, C. S. (2006). Kannada auditory memory and sequencing test. Unpublished departmental project at the Department of Audiology, All India Institute of Speech and Hearing, Mysore.