Relationship of Auditory Processing Categories as Determined by the Staggered Spondaic Word Test (SSW) to Speech-Language and Other Auditory Processing Test Results

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In his Buffalo Model, Katz (1992) used primarily scores on the Staggered Spondaic Word test (SSW) to categorize children with auditory processing disorders. From this categorization, speech-language difficulties were predicted and management techniques were proposed within the Buffalo Model. This retrospective study of 159 files examined the relationship among test results on the SSW and other tests of speech-language and auditory processing. Results showed few significant correlations between speech-language and auditory processing measures and separate components of the SSW test. Most of the significant correlations had such low magnitude as to not be clinically significant. Descriptive analysis of reading skills and pitch pattern performance suggested results contrary to the Buffalo Model. The results indicate a lack of construct validity for the Buffalo Model, suggesting that a "cookbook" approach to management using this model should be approached with caution in managing children with auditory processing disorders.

Auditory processing disorders (APD) are an important area that requires further delineation of functional difficulties to provide effective management techniques. Various models have been proposed for classifying categories of APD. However, one of the earliest models for classification, developed by Katz (1992), is known as the Buffalo Model. In the Buffalo Model, categories of APD are based on patterns of errors suggested by the Staggered Spondaic Word (SSW) test (Katz, 1992). The SSW is a dichotic listening task where a different spondee word is presented to each ear with the second word of the first spondee being presented in one ear with the first half of the second spondee being presented simultaneously in the opposite ear. Over the last 40 years, the SSW has been shown to be a valid measure of site of dysfunction (Berrick, Shubow, Schultz, Freed, Fournier, & Hughes, 1984; Katz, 1968; Katz & Smith 1991). Berrick et al. (1984) also found that the SSW was instrumental in differentiating children with difficulty learning in the classroom from children with normal achievement. However, the use of the Buffalo Model in clinical practice warrants examination of whether the SSW alone is a valid tool for categorizing APD or if this test is best viewed, instead, as a dichotic speech task to be added to the overall central auditory test battery for the purpose of assessment of children suspected of APD.

The Buffalo Model described by Katz (1992; Katz & Ivey, 1994) classifies children into one of four categories: Decoding, Organization, Tolerance-Fading Memory, and Integration. Because these categories were based on site-of-lesion projections, expected difficulties for auditory processing as well as speech-language skills experienced by those in each category have been predicted. Management techniques have been developed to address these expected difficulties (Katz, Stecker, & Henderson, 1992). In summary, the Buffalo Model is used to categorize children with specific auditory processing test results and to help identify which management techniques they should receive.

The categories of the Buffalo Model are based primarily upon performance on the SSW test. The SSW is a dichotic listening task in which two spondee words are presented in an overlapping fashion. That is, the first spondee begins in one ear and then the second half of the spondee occurs at the same time as the first half of the next spondee in the opposite ear. Subjects are instructed to repeat both spondee words in the order they are heard. This arrangement allows for four scoring conditions: A right non-competing (RNC), a right (RC), left (LC) competing, and a left non-competing (LNC) condition. The order of Right Ear First (REF) and Left Ear First (LEF) is staggered so that the patient receives an equal number of each. Three response biases are also computed. Reversals are when the words are repeated out of order. An ear effect (EE) occurs when more errors are made when one ear is presented first versus the other. An order effect (OE) occurs when more errors are made on the first spondee versus the second spondee in both the REF and LEF presentation. Another method of analysis is the Type A pattern, which is determined by comparing the LC score from the left ear first and RC score from the right ear first and using the larger number of errors to calculate the score. The column with the next largest number of errors is subtracted from the previous number. This resulting Type A score is compared to normative data to determine if there are a significant number of errors in a particular competing condition. Normative data have been published in the "Number of Errors Classification Handbook" (Katz, 1996), which is available when purchasing the test. The number of errors allowed for each bias depends on the age of the child tested (Katz, 1996).

Proponents of the Buffalo Model assert that a relationship exists between the patterns of results on the SSW and expected results on speech-language and additional auditory processing tests. Much of the literature from the proponents of the model has been presented in book chapters and the SSW Reports, with little peer-reviewed literature to validate the method. The model uses the scores from the four response conditions (RNC; RC, LC, and, LNC) and four response biases (EE, OE, Reversals, and Type A pattern) to group children into categories. Literature in the field suggests mixed results on how well specific error patterns on the SSW correlate with other tests. For example, Welsh, Welsh, and Healy (1980) examined 22 children with dyslexia who had received testing using the SSW as well as Willeford's (1978) test battery. Four children exhibited normal right-ear scores and moderate to mildly abnormal scores in the left ear on the SSW. Four children exhibited moderately abnormal scores in both ears on the SSW, and one child exhibited severely abnormal scores in both ears on the SSW. The authors found that, the nine children with abnormal results on the SSW also exhibited abnormal scores on Willeford's filtered words and/or binaural fusion tests (Willeford, 1978). However, all but one of the 13 children with normal SSW scores still failed the filtered speech and binaural fusion tests (Welsh et al., 1980), suggesting that performance on the SSW correlated poorly with performance on other central auditory tests for these children.

Harris, Keith, and Novak (1983) found that 45 children with poor receptive language as measured by the Token Test for Children (DeRenzi & Vignolo, 1962) demonstrated significantly more difficulty on the competing conditions of the SSW. Keith (1983) examined the percentile ranks for the two competing conditions of the SSW and found that performance in the LC condition did not show a relationship with the Token Test for Children. Of the 57 children tested in this study, two exhibited a Type A pattern that, according to the Buffalo Model, would be indicative of severe reading and spelling problems (Keith, 1983). In fact, those two children did report such problems. However, 32 other children in the study also reported reading and spelling problems, but did not exhibit a Type A pattern. These findings cast doubt on the validity of using the Type A pattern to assign a child to a category of APD.

Keith, Rudy, Donahue, and Katbamna (1989) studied correlations of the SCAN Test for Auditory Processing Disorders in Children (Keith, 1986) with other auditory processing tests, one of which was the SSW (Katz, 1968). Results for 155 children indicated a significant correlation among all subtests of the SCAN as well as the composite score to the competing conditions of the SSW. The strongest correlation was found between the SSW and the Competing Words subtest of the SCAN. The Filtered Word and Auditory Figure-Ground subtests showed a lower significant correlation with the SSW. Although the correlations were statistically significant, the magnitude of the correlations suggested that the two tests were only somewhat related.

Sanger, Keith, De Shayes, and Stevens (1990) examined children who performed poorly on the SSW LC and RC in comparison to the results obtained on the several subtests of the Clinical Evaluation of Language Functions (CELF; Semel & Wiig, 1980), and subtests of the Goldman-Fristoe-Woodcock Test of Auditory Discrimination (Goldman, Fristoe,& Woodcock, 1970). There were no significant correlations found .

Riccio, Hynd, Cohen, and Molt (1996) studied 38 children from a pool of subjects who evidenced behaviors characteristic of auditory processing difficulties and poor performance on the SSW. The RC performance correlated significantly with performance on the Seashore Rhythm Test (Seashore, Lewis, & Saetvert, 1960), Performance IQ on the Weschler Intelligence Scale for Children (WISC; Wechsler, 1991), and the Recalling Sentences Subtest of the Clinical Evaluation of Language Fundamentals-Revised (CELF-R; Semel, Wiig, & Secord, 1980a). The LC condition correlated only with low-pass filtered speech for the right ear (Riccio et al., 1996). Alhough the correlations were statistically significant, the magnitude of the correlations were weak, suggesting that the findings should be interpreted with caution. Of note is that neither competing condition of the SSW correlated with behavioral features associated with attention deficit hyperactivity disorder (ADHD), including inattention, impulsivity, and hyperactivity. The authors hypothesized that children with ADHD (as diagnosed by checklists completed by the teachers and parents) would fall into the Tolerance Fading Memory category of APD as Katz and Smith (1991) suggested, but did not find that to be the case.

Finally, in a study of 20 subjects by Schmidt, Paschall, Sancibrian, Corwin, and Walker (2000), a significant relationship was found among raw scores on the SSW and performance on the Word Structure , Formulated Sentences, and Recalling Sentences expressive subtests of the CELF-R (Semel, Wiig, & Secord, 1980a), suggesting a relationship between scores on the SSW and some subtests of the CELF-R. As these are all expressive language measures, it was theorized that the SSW correlates positively with expressive language skills (Schmidt et al., 2000). The authors found no correlation between the SSW and the SCAN subtests and composite score (Keith, 1986; Schmidt et al., 2000). These results are in contrast to those of Keith, et al. (1989). The primary difference was in the data representation of the scores (i.e. raw scores versus percentile ranks).

SSW Results Categories

Katz (1992) reported the prevalence of the different Buffalo Model categories in a population of 94 children aged 6 to 12 years described as having "learning problems" for which concerns of auditory processing disorder were expressed. The distribution of the different categories in this population was reported as follows: 50% Decoding ; 20% Tolerance-Fading Memory; 17% Integration, and 4% Organization (Katz, 1992). Table 1 provides a description of the major and minor indicators that Katz (1992) used to define each category. Using this method, children can be ranked into primary, secondary, and tertiary categories with primary being based on the pattern with the greatest discrepancy from normal. If a clear category is not seen, rules were provided to look at the number of signs available (rather than one area of greatest discrepancy) to determine primary category (Katz et al., 1992).

Table 1. Summary of "major" and "minor" findings on the SSW which are characteristic of different Categories.

	"Major" indicators					"Minor" indicators
Category	4 response conditions	Order effect	Ear effect	Rever-sals	Type A	Other Indicators
Decoding	RC or LNC	L/H	H/L			Perseveration, Quiet Rehearsal, Delay responding
Tolerance-Fading Memory		H/L	L/H			[a]RNC without RC, LC, Quick response, answers are you ready, tongue twisters, "smush" responses
Integration					Yes	Sharp LC, extreme delay
Organization				Yes		

Abbreviation Key: RC – Right Competing condition; RNC – Right Non-competing condition; LC – Left Competing condition; LNC – Left Non-competing condition; L/H – Low/High; H/L – High/Low

Information from (Katz, Kurpita, Smith, & Bradner, 1992, p.3).
[a]Not in Katz, et al. (1992) suggested by Medwetsky (2002).

Decoding Category. A person classified in this category would have difficulty using phonemic information. This category is characterized by significant errors in the Right Competing condition (RC; Katz & Smith, 1991) and Left Non-Competing (LNC) condition of the SSW with an order effect of more errors on the second word than on the first (low/high; Katz, 1992; Katz & Ivey, 1994; Medwetsky, 2002). In addition, children in this category demonstrate an ear effect for high/low errors (i.e. child made more errors in the right ear first versus left ear first presentation;Katz & Ivey, 1994; Medwetsky, 2002). Children with this pattern of results demonstrate difficulties in reading and spelling, which rely on phonics (e.g., sounding out a word; Katz, 1992; Katz & Ivey, 1994). Katz and Smith (1991) reported that children in this category also demonstrated, mild-to-moderate difficulty on speech-in-noise tasks; however, this characteristic was not repeated in later descriptions of the Decoding category. Medwetsky (2002) suggested that a child with decoding difficulties would show delayed response on the Competing Sentences Test (CST; Willeford & Burleigh, 1994), significantly more errors as compared to peers on the Auditory Numbers Forward subtest of the Test of Auditory Perceptual Skills Revised (TAPS-R; Gardner, 1996), and primarily inattention type errors on the Auditory Continuous Performance Test (ACPT; Keith, 1994a). Zoochi (1999) suggested that children within this category would have difficulty with auditory closure and subsequently do poorly on low-passed filtered speech testing. The projected site of dysfunction for this category has been projected as being the posterior temporal region (Katz, 1992).

Tolerance-Fading Memory (TFM) Category. TFM is represented by difficulty in two auditory processing areas including short-term memory and figure-ground (Katz, 1992; Katz & Ivey, 1994; Katz & Smith, 1991). Katz (1992) reported that both symptoms are present in 75% of TFM cases. Katz & Ivey (1994; p. 253) indicated, that when there are more errors on the first word as well as more errors in the left ear the child will have difficulty in both short-term memory and figure-ground. SSW results include an order high/low response (i.e. more errors on the first two words than the last two words) bias as well as a low/high (i.e. fewer errors in the REF than in the LEF) ear effect (Katz & Ivey, 1994; Medwetsky, 2002). Additionally, a child in this category may also perform outside normal limits for the Left Competing (LC) condition (Katz & Ivey, 1994; Medwetsky, 2002). Right Non-Competing (RNC) errors may be seen, but they are not as significant as the LC errors (Medwetsky, 2002). A significant RNC without significant RC scores is considered a soft indicator of TFM (Medwetsky, 2002). Expected reading and writing difficulties include poor written expressive skills and poor handwriting skills (Katz, 1992; Katz & Ivey, 1994; Katz & Smith, 1991). Reading comprehension difficulties may be evidenced as intact ability to sound out a word and knowledge of word meaning but difficulty remembering what was read (Katz, 1992; Katz & Smith, 1991). Speech-language results should show oral expressive language problems, as well (Katz, 1992; Katz & Ivey, 1994; Katz & Smith, 1991). Katz and Smith (1991) reported that these children have difficulty following directions characterized as inability to remember the instructions. The theoretic site of dysfunction for TFM is the anterior temporal region (Katz, 1992).

Organization Category. A person with an Organization difficulty is said to have problems maintaining the sequence of auditorily presented information and keeping it organized (Katz, 1992; Medwetsky, 2002). This category is characterized by significant reversals on the SSW (Katz, 1992). Characteristics include poor organization skills, reversals in spelling and reading, and poor handwriting (Katz, 1992). According to Katz (1992), data suggest that the site of dysfunction for this category should be anatomically close to the areas associated with TFM and Decoding; therefore, coexistence of Organization difficulties with these other two categories would be logical. Other test results reported to be associated with the Organization category are significant difficulties on the TAPS auditory number memory forward and reversed, with reversed possibly showing more difficulty (Medwetsky, 2002). Medwetsky (2002) also suggested that children in this category may have difficulty with the Pitch Patterns Sequence Test (PPST; Pinheiro & Ptacek, 1971).

Integration Category. The Integration category represents a person who has difficulty combining auditory and visual information (Katz, 1992; Katz & Ivey, 1994). A Type A pattern or a sharp LC condition (i.e. disproportionately large number of errors on the left competing condition, yet not enough to be a Type A bias) on the SSW characterizes this category (Katz, 1992; Katz & Ivey, 1994; Katz & Smith, 1991; Medwetsky, 2002). In a review of 90 learning-disabled children, Lucker (1980) found 23 children with a Type A pattern. Seventeen of those children were identified as having severe spelling and writing problems. The author advocated that a clinician could conclude from a Type A pattern that the child might have difficulty with sound-symbol association, which may affect spelling, reading, and writing. A child with Integration difficulty also might be expected to have difficulty with dichotic tests, competing sentences, and labeling the sequence for pitch/duration patterns tests (Medwetsky, 2002). For the dichotic and competing sentence tasks, a significant difference in between-ear performances would be expected (Medwetsky, 2002). The site of dysfunction for integration is thought to be at the tip of the Sylvian fissure near the Occipital lobe of the brain (Katz, 1992). Recently, Katz (2002) proposed dividing this category into four subtypes that are combinations of characteristics of Integration and indicators of the three other categories. He suggested that there could be four possible variations of the integration category: 1) Integration (Type A pattern) and Decoding characteristics, 2) Integration and Tolerance Fading Memory characteristics, 3) Integration plus characteristics of both Decoding and Tolerance Fading Memory, and 4) Integration characteristics only (Katz, 2002). Katz (2002) also suggested that any of these four could also include Organization characteristics.

Development of the Buffalo Model

Stecker (1998) reported the clinical results of a study used to form the basis for the Buffalo Model. The initial data were obtained from 25 children who received both speech-language and auditory processing evaluations. The classification of auditory processing disorder was determined both from a battery performed by the speech-language pathologist and an audiology battery performed by the audiologist. Both the speech-language pathologist and the audiologist applied the Buffalo classification. Both batteries identified one child as having results within normal limits and 23 as having auditory processing disorders (APD). One child was found to have APD on the auditory tests but not on the speech-language battery (Stecker, 1998). The breakdown of speech-language versus audiology classification was 18 Decoding and 5 TFM for speech-language compared to 15 Decoding and 8 TFM for audiology (Stecker, 1998). The results show a unit-by-unit index of 86.9%, indicating variability in placing a child in a given category. The variance is large due to the small number of subjects used to develop this basis for the Buffalo Model.

The descriptions of children who perform poorly on the SSW indicate the possibility for some overlap in categorization. In fact, it is possible to have a child fall into more than one category. Katz, Kurpita, Smith, and Brandner (1992) recommended a method for assigning children to categories based on a rating of the severity of errors seen on the SSW test. They indicated that the errors in the four different conditions and the response biases should be considered “major” indicators whereas problems such as responding to the “Are you ready?” questions and blended responses should be considered “minor” signs (Katz, et al., 1992).

The four Buffalo Model categories appear to suggest that a relationship exists between these patterns and expected results on speech-language and additional auditory processing tests. However, the literature (Harris, et al., 1983; Keith, 1983; Keith, et al., 1989; Riccio, et al., 1996; Sanger, et al., 1990; Schmidt, et al. 2000; Welsh, et al., 1980) has revealed mixed results regarding how well the SSW correlates with other audiologic and speech-language measures. It is possible that the conflicting results are due to using a general population of children who score poorly on the SSW. Better correlation may have been found if children in a specific category were used for correlation as the Buffalo Model suggests.

Clinical observations suggest that speech-language pathologists and audiologists use the Buffalo Model categories to generate recommendations for remediation based upon on the categorization. In an era of evidence/outcome-based practice, the validity of making intervention recommendations based on classifications using the results from the SSW test needs to be supported empirically. The present study was undertaken to determine what relationship, if any, exists between the scores on the SSW and other speech-language or auditory processing tests.

Based on the above review of the literature, it was hypothesized that the following results would emerge if the Buffalo Model accurately predicted difficulties in speech-language, auditory, and related difficulties.

Decoding Category. Children in the Decoding category were expected to (1) perform poorly on tests of articulation and phonemic abilities; (2) exhibit more difficulty on receptive versus expressive portions of speech-language testing; (3) read below grade level; (4) have difficulty with auditory number memory forward and discrimination; and (5) show difficulty on figure-ground tests, tests of auditory closure, and dichotic tasks.

TFM Category. Children in the TFM category were expected to (1) exhibit difficulty with auditory figure-ground, as well as with memory and following directions, (2) exhibit poor reading comprehension; and (3) exhibit difficulty on expressive speech-language tests.

Organization Category. Children in the Organization category were expected to (1) exhibit difficulty on number memory forward and reversed, and (2) perform below the normal range on PPST testing.

Integration Category. Children in the Integration category were expected to (1) read below age level, and (2) perform poorly on dichotic tests and PPST testing.

Methods

Subjects

Data were collected retrospectively from files of 159 children between the ages of 5 and 17 years, who had been seen by clinicians at the Texas Tech University Health Sciences Center Speech-Language and Hearing Clinic for a joint speech and audiology auditory processing evaluation. Each had received the SSW as part of a joint speech-language and auditory processing evaluation. These children were referred by school diagnosticians, speech-language pathologists and educational psychologists for experiencing difficulty in school that had characteristics of auditory processing difficulties. Parents were instructed to administer any medications as specified by the child’s physician. Tests were scored using the child’s age at the time of evaluation. All testing was performed within a six month period of time. Patients ranged across socio-economic levels. The data were reviewed from children who all report English as his/her primary language. One hundred and fifty seven children had air-conduction screening results within normal limits bilaterally using a 25 dB HL criteria for 500, 1000, 2000 and 4000 Hz. Two clients had one threshold at 30 dB HL (one at 500 Hz and one at 4000 Hz). The clinical protocol called for any child with a recent history of middle ear disease to receive full audiometric hearing threshold testing and tympanometry. Any child with abnormal findings on either test was omitted from the protocol.

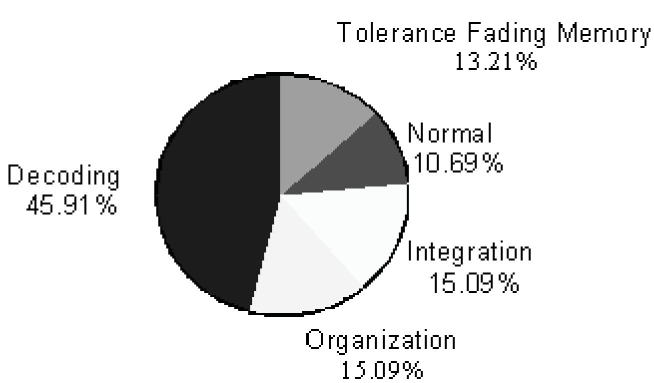
Materials

The SSW has been administered as part of a joint speech-language/auditory processing test battery at the Texas Tech University Health Sciences Center for several years. The auditory processing battery consisted of tests determined to be appropriate for the patient, based on case history, including the SSW, additional dichotic listening tests (SCAN & SCAN -A competing words and sentences), figure-ground tests [SCAN & SCAN-A figure-ground and Selective Auditory Attention Test (SAAT)], auditory closure tests (SCAN & SCAN-A filtered words), and tests of memory and sequencing of auditory information (TAPS, PPST). Speech-language measures include tests of articulation and phonemic skills (when case history suggests a need), expressive and receptive language (CELF-R and CELF-3), oral and written narrative skills, and reading [Independent Reading Inventory (IRI); Miller, 1978].

Procedures

Each subject was grouped into one of five categories (the four Buffalo Model categories plus a "normal" category). Of 159 data sets, 73 (45.91%) were classified in the Decoding category, 24 (15.09%) were classified in the Integration category, 24 (15.09%) were classified in the Organization category, 21 (13.21%) were classified in the Tolerance-Fading Memory category, and 17 (10.69%) had results within normal limits [defined as at or less than "1 normal limit" from the mean in all scores. This point is not precisely one standard deviation below the mean, instead it is rounded to the nearest whole number to facilitate analysis by number of errors (Katz, 1996).]

Figure 1. Demographics of categorization of subjects



Children were placed in a category, using the number of error (NOE) method of analysis established by Katz (1996). The NOE was examined by age to see if the results were greater than one normal limit below the mean as specified by Katz (1996). Any of the condition scores (RNC, RC, LC, or LNC) and response biases that were better than or equal to the one –normal-limit (1 NL) cutoff were classified in the normal range. The remaining sets of test results were examined to see which score in each data set was the furthest from the mean. If the poorest score within the data set was a major indicator, as previously defined, the child was placed into the category for which the score was an indicator based on Table 1. The Type A response bias was never the score furthest from the mean as it relies on extreme values in the RC and LC conditions and, therefore, the RC or LC conditions would be reflective of the greatest deviation from the mean. Therefore, all significant (> 1 NL) Type A responses were flagged. If the major indicator was LC or RC and a Type A pattern was present, the child was classified in the Integration category. The presence of a Type A response bias combined with any other major indicator was treated as if the Type A response bias was secondary and the subject was classified by the score that represented the greatest deviation from the mean (e.g., a case with a significant Type A response bias in which number of reversals was furthest from the mean was classified in the Organization category). Because the LC condition is considered only a "minor" indicator, when it was the score that was furthest from the mean and there was no Type A response bias present, the next greatest score that represented a "major" marker was used (e.g., high LC and RC without a Type A response bias were considered in the Decoding category). If the LC was the greatest from the mean and no other indicators were abnormal, the child was labeled in the Integration category. Further classification based on "minor" markers could not be performed since items such as "smush" responses, delay time, tongue-twisters, etc. are not recorded on the SSW test form and therefore were not available for this study.

Analysis

To examine the relationship between errors on a particular measure on the SSW and scores on additional speech-language and auditory processing tests, the different measures of the SSW were converted to percentile ranks. The means and standard deviations were used for each of the four scoring conditions and response biases for the SSW. Using this information, a z-score was obtained and a percentile rank assigned. The percentile ranks were used to allow for correlation statistics with the other standardized tests. Individual Pearson-Product-Moment Correlation Coefficients were examined at the $p < .05$ level for the different tests representative of the difficulties experienced in each of the categories. To examine the Decoding category, the RC, LNC, OE low/high, and EE high/low percentile ranks were compared. For the TFM category, percentiles from the OE high/low, EE low/high, LC, and RNC were used. A percentile for the number of reversals was used to examine the possible correlation that the Organization category exhibited in relation to other test results. For the Integration category, the Type A measure was used. If hypotheses were true, then a child with difficulty in a particular category should show a high numbers of errors on the other standardized test measures presumed to be associated with the given Buffalo Model category.

Once the subject scores were classified into the different categories, the results for the other measures were examined. These results included tests for which there was only a criteria cut-off (PPST) as well as some information available from clinician report. Clinician-reported results included information regarding articulation, oral reading, and comprehension, as well as oral and written narrative information.

Results

Correlation Analyses

Decoding Category. Results of correlation analyses for children classified in the Decoding category are presented in Table 2.

Table 2. Correlations between measures on the SSW that are characteristics of Decoding category and measures of speech-language and auditory processing.

Test	n	RC	LNC	OE L/H	EE H/L
CELF RL	28	.66 *p*<.0001	.39 *p*=.0420	.08	.10
TAPS ANMF	108	.18	-.05	-.00	-.04
SCAN figure-ground	64	.20	.13	-.02	-.06
SAAT	58	.48 *p*=.0001	.22	.01	.24
SCAN DW	82	.38 *p*=.0004	.35 *p*=.0010	.10	.02
SCAN DS	14	-.00	.13	-.26	-.16
SCAN filtered speech	81	.40 *p*=.0002	.40 *p*=.0002	.15	-.24 *p*=.0307
TAPS discrimination	105	.14	.25 *p*=.0123	.14	-.00

Note. Significant correlations are shown on the table.

Correlations were examined for the CELF receptive language (CELF RL; n=28) compared to each of the following SSW characteristics: SSW RC, LNC, OE low/high, and EE high/low significant correlations were found between the RC condition of the SSW and the CELF RL(r = .66, p <.0001) and between the LNC condition and the CELF RL (r = .39, p = .0420). There were no significant correlations between the two response biases on the SSW and the receptive language measure. SSW test results also were compared to the Auditory Number Memory Forward subtest of the TAPS (n = 108). No significant correlations were found. Figure-ground was examined using the figure-ground test on the SCAN (n = 64), which showed no significant correlation, as well as the SAAT (n = 58), which indicated a significant correlation for the RC condition only (r = .48, p = .0001). Correlations were also performed between the Competing Words (CW; n=82) and Competing Sentences (CS; n=14) subtests of the SCAN and SCAN-A. Performance on the CW subtest correlated significantly with both the RC and the LNC conditions of the SSW (RC: r = .38, p = .0004; LNC: r = .35, p =.0010). No significant correlations were noted for competing sentences. Auditory closure was assessed by use of the SCAN filtered speech subtest (n = 81), which correlated significantly with both the RC (r = .40, p =.0002) and LNC (r = .40, p = .0002) conditions. A significant negative correlation was found between the EE H/L and the filtered speech subtest of the SCAN (r = -.24, p = .0307). Test results on the TAPS auditory discrimination (n = 105) also showed a significant correlation to the LNC condition (r = .24, p = .0123). In summary, for children in the Decoding category, several correlations were observed between SSW scores and measures of auditory processing and receptive language. However, although the correlations found were statistically significant, the magnitude of correlation was small for the majority of the characteristics (except for the RC to CELF RL, which had a moderate magnitude), and hence the results should be interpreted with caution. Tolerance-Fading Memory Category. Results of correlation analyses for children classified in the Tolerance-Fading Memory category are presented in Table 3.

Table 3. Correlations between measures on the SSW that are characteristics of Tolerance-Fading Memory category and measures of speech-language and auditory processing.

Test	N	OE H/L	EE L/H	LC	RNC
SCAN figure-ground	64	.02	.06	.13	.02
SAAT	58	-.01	-.24	.26 *p*=.0536	.22
TAPS ANMF	108	-.00	.04	.12	.19 *p*=.0444
TAPS SM	108	.01	-.09	.28 *p*=.0037	.20 *p*=.0371
TAPS WM	108	-.03	.04	.37 *p*<.0001	.22 *p*=.0240
TAPS ANMR	106	-.04	-.06	.32 *p*=.0008	.25 *p*=.0104
CELF EL	27	-.26	.05	.45 *p*=.0147	.35
TAPS ID	108	-.08	-.07	.25 *p*=.0094	.20 *p*=.0372

Note. Significant correlations are shown on the table.

Correlations were examined for the OE H/L, EE L/H, LC, and RNC conditions of the SSW and measures of auditory processing and receptive language. No significant correlations were seen for the two response biases (OE H/L and EE L/H) and any other measure. A borderline significant correlation was seen for the LC condition of the SSW and figure-ground abilities as measured by the SAAT (n=58, r = .26, p = .0536). There was no significant correlation between the SSW results and the figure-ground subtest of the SCAN (n=64). Results for all of the memory subtests on the TAPS (n =108) correlated significantly with the RNC condition, including auditory number memory forward (r = .19, p = .0444), auditory sentence memory (r = .20, p = .0371), auditory word memory (r = .22, p = .0240), auditory number memory reversed (n=106, r = .25, p =.0104), and auditory interpretation of directions (r = .20, p = .0372). For the LC condition, significant correlations were seen for auditory sentence memory (r = .28, p =.0037), auditory word memory (r = .37, p < .0001), auditory number memory reversed (r = .32, p = .0008), and auditory interpretation of directions (r = .25, p = .0094). The LC condition also correlated significantly with the CELF expressive language score (n=27, r = .45, p = .0147). In summary, children in the Tolerance Fading Memory Category indicated several correlations to the LC and the RNC conditions. Again, the magnitudes of correlation were weak and therefore should be viewed appropriately.

Organization Category. To examine Organization, correlation analyses were conducted between the reversals on the SSW and the TAPS memory forward and reversed. Results showed no significant correlations.

Integration Category. To examine Integration, correlations were examined between the SCAN CW and CS subtests and the SSW Type A response biases. Results showed no significant correlations.

Descriptive Analyses

Table 4. Descriptive Date: Number of subjects in each category who evidenced difficulty

	Normal n=17	Decoding n=73	Integration n=24	Organization n=24	TFM n=21
Articulation Difficulties	0 n=6	7 n=17	0 n=5	0 n=8	0 n=6
Oral reading difficulties	3 n=7	8 n=10	5 n=5	6 n=6	4 n=4
Poor reading comprehension	3 n=7	8 n-=10	3 n=4	5 n=6	4 n=4
Poor oral narrative	8 n=8	15 n=15	7 n=7	9 n=10	5 n=6
Poor written narratives	8 n=8	15 n=15	4 n=4	9 n=10	5 n=6
Pitch pattern difficulties	1 n=8	12 n=24	2 n=9	4 n=13	4 n=8

Articulation Measures. Clinician-reported results for articulation indicated that, of those children for whom articulation results were available, 7 out of 17 children in the Decoding category exhibited articulation difficulties. None of the children in the Organization category (n=8), Integration category (n=5), or TFM category (n=6) exhibited an articulation deficit. Finally, all six children with normal SSW results also exhibited normal articulation.

Reading Abilities. Oral reading and reading comprehension were evaluated using the Independent Reading Inventory (Miller, 1978). Of those children for whom these results were available, 8 of the 10 children in the Decoding category scored below age level for both oral reading and comprehension. All of the children for whom these results were available and who were classified as having Organization difficulties (n=6) were below age level for oral reading with five out of the six being below age level for comprehension as well. For children classified into the Integration category (n=5), none were described as having age appropriate skills for oral reading. Four were tested for reading comprehension with one of the four performing at age level. For the children in the TFM category, four were tested, with none of the children showing age appropriate oral reading skills and comprehension. For the children with normal SSW results, only four out of the seven tested indicated appropriate oral reading skills, as well as appropriate comprehension skills.

Narrative Skills. The speech-language pathologists assessed oral and written narrative skills. If these skills were tested in a category, they typically were poor for either oral or written skills or both for children in the majority of the Buffalo Model categories. One instance each of written and oral capabilities within normal limits was seen from the 6 reviewed in the TFM category and 1 out of 10 for the Organization category. There were no other instances in which the skills were assessed and found to be age-appropriate even for those children who had normal SSW results.

Pitch Pattern Recognition.

Results of the PPST indicated that, 12 of 24 children classified in the Decoding category who were administered the PPST exhibited results within normal limits. Nine of 13 children with Organization difficulties performed within normal limits on the PPST, as did 7 of 9 children in the Integration category. Of eight children classified in the TFM category who underwent PPST testing, four performed within normal limits, as did seven of eight children with normal SSW scores. In summary, descriptive statistics indicated few results consistent with predicted characteristics.

Discussion

The results indicated statistically significant correlations between some scores on the SSW and additional auditory processing and speech-language test results. This agrees with results reported by Keith et al. (1989) and Riccio et al. (1996). The majority of the significant correlations seen in this study occurred with the response conditions (RNC, RC, LC, LNC) rather than the response biases. This is in contrast to the previous literature in which relationships between the four response biases and measures of auditory processing and speech-language test results were reported, as well. Because this study was of a retrospective nature, there were limitations. The inability to control for some of the extraneous variables that have the potential to influence internal validity (e.g. variations as a result of different service providers administering the tests, length of and placement in the test battery, etc.) may have impacted the test results seen in the present study.

Nevertheless, the results of this study suggested that a clear relationship between categories of auditory processing as determined by SSW scores and other tests of auditory processing and speech-language skills is not evident. That is, the SSW and other tests of auditory processing do not appear to be measuring the same thing. This can be seen in the results of the correlations of the different scores for the SSW to additional tests. The findings indicate that, although significant correlations were found, the magnitude of the responses were so low in most cases as to indicate that they are not clinically meaningful. If the specified characteristics on the SSW were related closely enough to suggest that children with a particular pattern would have poor scores in additional auditory processing and speech-language tests, as suggested in the Buffalo Model, it would be expected that the magnitude of the correlation would be greater showing that as errors for a particular characteristic on the SSW increased so did errors on the other variables examined. Instead, the findings of the present study suggest that, although the SSW may serve as an individual test of dichotic auditory skills, it does not show a clear relationship to additional tests of auditory processing and speech-language skills as suggested by the Buffalo Model.

Another issue that questions the use of the SSW for categorization of APD relates to the fact that the majority of the significant findings were found when comparisons were made to the four response (RNC, RC, LC, and LNC) conditions. The lack of statistical significance for the response biases suggests that the SSW response biases do not correlate with other tests of speech-language and auditory processing. This suggests that creating categories based on the response biases, as is the case for Integration (Type A), Organization (Reversals), and to some degree TFM, is not appropriate.

It is possible that the type of data used for comparison may affect these correlations and that stronger correlations could be seen using the raw data as was performed in Schmidt et al. (2000). The use of percentile ranks is limited by the analysis of the test, which is performed on the actual number of errors. At times the published mean and standard deviation is small enough (e.g., mean = .2; standard deviation = .4) that one standard deviation below the mean (e.g., 1 S.D. below = .6) is less than a single error. Using the NOE analysis, an error of one would be considered abnormal as the scores for one normal limit below the mean. It is recognized that this may have affected the results of this study as well. However, a small mean and standard deviation are not typical of the response biases of ear effect, order effect, and Type A patterns, which tend to have a whole number standard deviation and a wider range of percentile rankings to use for correlation. Therefore, these scores were not as impacted by the methods used for calculation in the present study. Also, concerns regarding the use of raw scores for data analysis as seen in Schmidt et al. (2000) also exist in that this method would not take into account that it is normal for some ages to have significantly more errors in the LC condition. This large standard deviation may play a role in the lack of statistical significance, explaining why the SSW LC did not correlate well other measures, a finding that is consistent with a previous study relating the SCAN Left Competing Words score and the Token Test for Children (Keith, 1983).

Descriptive data also did not support that the Buffalo Model categories showed unique characteristics other than the possibility of articulation deficits for children in the Decoding category. With regard to reading abilities, the literature (Katz, 1992; Katz & Ivey, 1994; Katz & Smith, 1991) suggested that a child in the Decoding category would have more difficulty with reading skills, whereas a child with a TFM deficit would have more difficulty with reading comprehension. In contrast, results of the present study indicated that children in these two categories tended to exhibit similar difficulty with both reading skills and reading comprehension.

The descriptive results for the PPST indicated results in direct opposition to what was suggested in the literature. The literature suggested that children in the Organization and Integration categories would perform poorly on pitch patterns (Medwetsky, 2002). The percent of children in these two categories who experienced difficulty with the PPST was 31% and 22%, respectively. This is in direct contrast to 50% for children in the Decoding and TFM categories.

One reason the descriptive data did not show adequate differences could be related to the methods used to place a subject into a specific category. The demographics for this study indicated more subjects being placed in the Organization category as compared to the prevalence of this category estimated by Katz (1992). This could be related to the decision of which major indicator to use to place a child into a category. Using the score with the greatest number of errors from the mean may not always classify a child in the category that best describes the child’s difficulties. This is supported by Katz (1992), who indicated that a child with enough “minor” indicators in another category could be reclassified or placed into more than one category. Twelve of the subjects in this study with the greatest score in reversals (i.e., Organization category) also had significant minor indicators. If these 12 were removed from the Organization category, the prevalence of Organization difficulties in the present study would have been 7.55%, a number that is more similar to that reported by Katz (1992).

Grouping these children into categories based on the SSW may require more information. This is suggested by Katz et al. (1992), who advocated phonemic synthesis results as a “major” indicator for Decoding as well as figure-ground tests for an indicator of TFM. This raises the question of whether it is necessary to add a figure-ground test as a criterion for classifying children into the TFM category.

In addition, grouping children into categories (as defined by Katz et al, 1992) also relies on “minor” characteristics (e.g. “smush” responses and response time) to solve difficulties in placement such as were seen in this study. These indicators have not been defined operationally (e.g., number of sounds needing to be combined for the two words to be “smushed” or length of time that constitutes a long response time). Using these qualitative measures to identify category placement is very subjective and relies on the observations and judgment of the clinicians.

This difficulty in placement into categories is reinforced by the unit-by-unit index of 86.9% noted by Stecker (1998). It would be logical that persons involved in the author’s study would be trained in placing children into these categories. Nevertheless, variability in category placement exits. It is possible that the

Buffalo Model relies more on the use of critical thinking skills, opinions, or bias of the clinician rather than on specific quantitative measures.

The differences between the distribution of this study and Katz (1992) may be more fundamental in nature. Katz's (1992) clinical population was recruited from children with learning disabilities who exhibited characteristics of auditory processing disorder rather than from a general population of children having difficulty in school, which was examined in the present study. In Katz (1992), the children were described as, "referred because of concern about CAP disorder, usually associated with learning problems" (p. 89). At another point in the text, the children were described as "94 learning-disabled children" (Katz, 1992, figure 6-8, p. 89). If the population was restricted to children who qualify as learning-disabled, the expected distribution cannot be generalized to children for whom auditory processing is the primary or only diagnosis.

This study shows some support for the Decoding category. This can be seen by the significant correlation between the RC and the CELF receptive language scores. This suggests that, for the RC condition, there is a significant relationship between the SSW and receptive language skills as measured by the CELF, and a moderate amount of the relationship can be explained by these two tests. This finding should be expected in light of the fact that a right dichotic task should assess left-hemispheric function, and receptive language is a left-hemispheric function as well.

Management of auditory processing disorders is a focus in many fields related to child development and education. A quick way of categorizing what might be expected of a given child has an alluring appeal. To be able to make some assumptions of a child's possible performance by using a "cookbook" approach to management would allow for reduction of the test battery, resulting in a saving of time and cost to families. Although this allure is attractive, the concept of efficacy and evidence-based care suggests that audiologists should not be too hasty in making these classifications without addressing whether the categories can be defined as having unique quantifiable characteristics that can set them apart from the others. Research and evidence-based literature is needed to support or refute such methods. This study supports that unique test characteristics for each category cannot be easily identified. Using the SSW alone to categorize children has little or no construct validity. This study also indicates that categorizing children on the basis of the SSW is not straightforward. Future research into the application of different strategies for rehabilitation developed based on this program is warranted. If these categories do not show a clear pattern of characteristics and skills, using management techniques based on these categories may not provide optimum rehabilitation for the child. The lack of construct validity to the Buffalo Method of categorization suggests that this "cookbook" approach may not meet the clinical needs of many children with auditory processing difficulties and should be approached with caution in the clinical management of these children.

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