A (C)APD Screening Instrument For The Buffalo Model Diagnostic Test Battery

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The Buffalo Model Questionnaire (BMQ) is the screening tool developed for use in conjunction with the Buffalo Model diagnostic test battery. However, there is little empirical evidence of the relatedness of findings across these two measures. The purpose of this study was to explore whether such relatedness exists. A Chi Square Test for Independence showed significant relatedness between findings from the BMQ and the outcomes of the Buffalo Model diagnostic test battery. Findings support the use of the BMQ as a screening tool only when used in conjunction with the Buffalo Model diagnostic test battery.

Introduction

The definition of central auditory processing proposed by the American Speech-Language-Hearing Association (ASHA; ASHA, 2005a) broadly states that it is the efficiency and effectiveness with which the central nervous system (CNS) utilizes auditory information. A more narrow definition refers to central auditory processing as the perceptual processing of auditory information in the CNS and the neurobiologic activity that underlies the processing and gives rise to electrophysiologic auditory potentials (ASHA, 2005a). Central auditory processing includes the following mechanisms and processes responsible for the following skills: (a) sound localization and lateralization, (b) auditory discrimination, (c) auditory pattern recognition, (d) temporal aspects of audition, including temporal resolution, temporal masking, temporal integration, and temporal ordering, (e) auditory performance with competing acoustic signals (including dichotic listening), and (f) auditory performance with degraded acoustic signals (ASHA, 1996; ASHA, 2005a). Children exhibiting auditory problems in a school setting as a result of the skills listed above are usually referred to a speech-language pathologist to determine the need for services (DeBonis & Moncrieff, 2008). A speech-language pathologist uses language assessment tools to determine if there is an auditory deficit (DeBonis & Moncrieff, 2008). However, the use of a language assessment tool may result in the misdiagnosis of the auditory deficit. Therefore, the use of a screening tool specifically designed to identify a central auditory deficit would allow the speech-language pathologist to develop a more efficient and cost-effective diagnostic and intervention plan.

In 1996, ASHA identified the need to establish guidelines to screen children who may be at risk for a (central) auditory processing disorder ([C]APD). In response to ASHA's call for the development of effective (C)APD screening tools, Katz introduced the Buffalo Model Questionnaire (BMQ). The BMQ was developed by Katz based upon his experience with (C)APD (Katz, 2006, 2008). He incorporated the behavioral characteristics frequently exhibited by individuals diagnosed with (C)APD into the BMQ (Katz, 2006, 2008). Therefore, this screening tool is not a product of the Buffalo Model, rather, it is the result of the search for an effective screening tool for (C)APD that is based upon a seasoned clinician's/researcher's experience and knowledge (Katz, 2006, 2008). Currently, there is minimal empirical research documenting the relatedness of findings from the BMQ and the Buffalo Model diagnostic test battery, also developed by Katz (1992). This study was an examination of the relatedness of findings across these measures.

To better guide clinicians working with individuals with (C)APD, two models (Bellis/Ferre & Buffalo) have emerged based on academic and language difficulties, as well as audiological outcomes (Jutras et al., 2007). Although they are different, the Buffalo Model and the Bellis/Ferre Model utilize similar terminology and neuroanatomical correlates for the disorder (Jutras, et al., 2007). For instance, the Buffalo Model categorizes results of audiological (C)APD assessment data into four categories of deficit (decoding, tolerance fading memory, integration, and organization) to individualize a management plan (Katz, 1992). The Bellis/Ferre Model consists of three primary categories (auditory decoding deficit, prosodic deficit, and integration deficit) with two subcategories (associative deficit and output-organization deficit) to classify (C)APD (Jutras et al., 2007). It should be noted that neither model is based on peer-reviewed data (Jutras et al., 2007).

The Buffalo Model diagnostic test battery consists of several tools to evaluate various components of auditory processing, including decoding, integration, organization, and memory. A weakness of the Buffalo test battery is the absence of a temporal measure. Although ASHA (2005a) includes temporal processing as a skill to be evaluated as part of a (C)APD evaluation, it does not require all skills to be evaluated during every (C)APD diagnostic battery. The use of a diagnostic model does not prevent clinicians from including additional tests outside the model of choice into the evaluation session. If a temporal processing disorder is suspected, clinicians can and should supplement the Buffalo Model diagnostic test battery with a tool that evaluates this skill. The Staggered Spondaic Word test (SSW) is the primary diagnostic procedure of the Buffalo Model (Katz & Tillery, 2005), and it is also the most sensitive test of the battery (Katz & Marasciulo, 2001). The other diagnostic tests are the Phonemic Synthesis Test (PST) and W-22 Speech-in-Noise test (S/N: Sparks, 2000). According to Katz (2007a), the three independent tests provide greater diagnostic power when used together. When all three tests are used in conjunction, the battery has a 96% sensitivity rate (Katz & Marasciulo, 2001). Independently, the sensitivity and specificity of the SSW has been found to be 85% (Katz, 2008). It should be noted, however, that when the tape-recorded version of the SSW was updated to a digital format, the background tape noise was removed. Yet, the background noise generated by the tape was determined to be an important factor in the sensitivity of the test and returned to the digital recording of the test (Katz, 1998a).

Katz (1968) suggested that the SSW differentiates individuals with and without central auditory processing disorders. Arnst (1981) found that the SSW was a fairly simple task for 86 normal-hearing adult listeners with no history of central auditory dysfunction. This group achieved a mean correct score of 98.4% on the SSW. This provides evidence that the SSW has strong specificity, as long as peripheral hearing loss has been ruled out (Katz, 1998a). Yet some research states the SSW is resistant to mild, and possibly moderate, peripheral distortions (Katz, Basil, & Smith, 1963). Arnst (1982) conducted a study wherein 50 male subjects with bilateral symmetrical sensorineural hearing loss were given the SSW. The mean pure-tone average (PTA) was 33.8 dBHL for the right ear and 34.2 dBHL for the left ear. Analyses showed that for those subjects with hearing better than 40 dBHL, the correlation was greater than 0.82; however, for those subjects with a hearing loss greater than 40 dBHL, the correlation was poorer than 0.82 (Arnst, 1982).

The linguistic load of the SSW test may influence the outcome of the test. However, a student with Spanish as his first language with two and a half years of enrollment in an English language learning school program was evaluated for (C)APD using the Spanish and English versions of the SSW, which resulted in the same outcome (Lucker, 2003). This indicates that the linguistic load of the SSW has minimal influence on the outcome of the test.

On the other hand, the PST is highly predictive of a person's ability to read words (Katz, 1998c), especially when the individual is required to read phonetically rather than using sight reading. Medwetsky (2002a) noted that an individual's phonemic synthesis ability is closely associated with articulation, spelling, and receptive language. Katz and Marasciulo (2001) reported that the PST has a hit rate of 54%, indicating it correctly identifies approximately half of the subjects with a decoding (C)APD. In the same study, the subjects were broken down into two groups; those above and below the age of 10 years. The sensitivity of the PST for individuals under 10 years of age was 54%, and the sensitivity was 55% for individuals aged 10 years old or older (Katz & Marasciulo, 2001). The PST is less sensitive (54% and 55%, versus 85% for the SSW) and the average number of significant findings (i.e., qualifiers) is less when compared to the SSW (Katz & Marasciulo, 2001). Qualifiers are noteworthy actions exhibited by the individuals during testing (Katz, 1998a). These important indicators will provide insight into the limitations, as well as the compensatory actions, of the individual (Katz, 1998a).

The S/N test is included as part of the Buffalo Model diagnostic battery to examine the tolerance aspect of the tolerance-fading memory category (Katz, 2007b). Research examining the S/N test found that 84% of 138 patients seen at Rochester Hearing and Speech Center had significant findings on this test (Medwetsky, 2002b). This may be due to lower order processing skills, while the other Buffalo Model categories represent higher order processing deficits. Katz (1998b) provided a rationale for the inclusion of the S/N test: (1) word recognition test results are normative so clinicians can determine the presence of significant variations; (2) poor performance might be a result of anxiety and/or distractibility, which may suggest the presence of a tolerance fading memory issue, and; (3) poor word recognition coupled with essentially normal hearing may indicate another underlying issue. Rationale number three supports the assumption that S/N testing assesses lower order processing deficits.

Professionals across disciplines use screening tools to determine the need for more extensive and comprehensive diagnostic evaluations. The Teacher's Report Form (TRF), for example, was designed to obtain a qualitative report of children's academic performance, adaptive functioning, and behavioral/

emotional problems (Achenbach, 2006). The TRF has relatively good sensitivity and specificity when used appropriately (Brown et al., 2001; Dunn & Lipkin, 2006). The Child Behavior Checklist (CBCL) is a screening instrument completed by the parents of children at risk for psychological morbidities, including externalizing problems (e.g., behavior problems) and internalizing problems (e.g., anxiety or depression). Nelson and colleagues (2001) found that the sensitivity of the CBCL's Obsessive Compulsive Subscale (OCS), for example, is between 75.3% and 84.9% and the specificity is between 82.2% and 92.5%.

Musiek and Guerkink (1980) stated that information provided by parents could help identify children who should be seen for more comprehensive diagnostic (C)APD evaluations. In addition, many researchers (Domitz & Schow, 2000; Jerger & Musiek, 2000; Katz et al., 2002) have encouraged the use of screening tools when establishing (C)APD evaluation guidelines. Today, hearing healthcare professionals regard screening tools as an essential part of the (C)APD test batteries (Bellis, 2003). The majority of (C)APD protocols use a screening method in the form of a questionnaire or checklist, similar to those of other disciplines. For example, the Willeford (1977) test battery implements the use of the Willeford and Burleigh Behavior Rating Scale to screen for central auditory disorders. This 41-item parent-completed checklist involves using a Likert-type scale to rate children's behaviors that are consistent with (C)APD (Willeford & Burleigh, 1985). Questions on the Willeford and Burleigh Behavior Rating Scale address the child's auditory, academic, and social behaviors (e.g., attention, daydreaming, speech/language therapy). This checklist was originally developed for use in a research project and has not been widely utilized, leaving its sensitivity, reliability, and validity unknown (Willeford & Burleigh, 1985). Therefore, researchers are focused on establishing a more contemporary behavioral checklist for (C)APD.

Bellis (2003) recommends the use of two behavioral checklists, which are known to be helpful in identifying compromised auditory function in children: Fisher's Auditory Problems Checklist (Fisher, 1985) and the Children's Auditory Performance Scale (C.H.A.P.S.) (Smoski, Brunt, & Tanahill, 1992). Fisher's Auditory Problems Checklist was developed to screen children, Kindergarten through sixth grade, in order to collect information about perceived auditory processing problems from various referring sources (i.e., classroom teachers, speech-language pathologists, parents, or other professionals) (Fisher, 1985). This 25-item checklist gathers information about observers' perceptions of children's auditory acuity, attention, attention span, discrimination, short-term memory, long-term memory, sequential memory, comprehension, speech and language problems, auditory-visual integration, motivation and performance. Unpublished data suggest that this checklist is effective in identifying children with auditory perceptual problems who are in need of further (C)APD diagnostic testing (Fisher, 1985). Furthermore, preliminary results support the clinical usefulness of Fisher's Auditory Problems Checklist as a screening tool when used with the Buffalo Model Diagnostic Test Battery (Strange, Zalewski & Duncan, 2009).

The C.H.A.P.S. was developed to systematically collect and quantify the observed listening behaviors of children. This 36-item checklist gathers information about children's listening behaviors in a variety of listening conditions and functions: quiet, ideal, multiple inputs, noise, auditory memory/sequencing and auditory attention span (Smoski et al, 1992). The C.H.A.P.S. may be completed by a classroom teacher, special education teacher, or parent (Bellis, 2003). The individual completing the C.H.A.P.S. is asked to judge the amount of listening difficulty experienced by the child as compared to a "hypothetical reference population." The C.H.A.P.S. subdivides and quantifies listening performance, rendering it useful in prescribing and measuring the effects of therapeutic intervention. It also is useful for early and quick identification of children who should be referred for a diagnostic (C)APD evaluation (Smoski et al., 1992). Research suggests that there is a significant relationship between the six listening conditions as an individual subtest and the overall total score. Previous research also shows that teachers judge the listening characteristics of children diagnosed with (C)APD to be poorer than those of their age-related peers (Smoski et al., 1992).

The Buffalo Model Questionnaire (BMQ; see Appendix) is the only screening tool designed to complement the Buffalo Model diagnostic test battery. The screening measure consists of 48 questions concerning the individual's behaviors, as well as six mitigating factors (Katz, 2006). Typically, a parent reads each question and circles "yes" if the question describes that child's behaviors (Katz, 2004). Katz (2006) noted that the results of both the BMQ and the actual (C)APD diagnosis are relatively close. The questionnaire addresses issues associated with articulation, spelling, oral reading, speech understanding in noise, distraction, ADHD, coordination, sequencing, short-term memory, and other auditory-based tasks (Katz, 2006). The BMQ is an important factor in the (C)APD evaluation in that it gives pertinent information to the tester regarding the child's school and communication problems (Katz, 2004).

In a pilot study of the BMQ, the parents of children who were diagnosed with (C)APD reported a significantly higher number of concerns on the BMQ (M = 18.9; SD = 6.6) compared to children who were not diagnosed with (C)APD (M = 1.3; SD = 1.8) (Katz, 2004). A more in-depth study of the BMQ showed that there is little to no overlap in the number of questions marked "yes" when comparing the (C)APD group to the controls (Katz, 2004).

Katz (2006) also found that the seven most sensitive questions for identifying (C)APD on the BMQ never received affirmative responses from the parents of children without a diagnosis of (C)APD.

Jerger and Musiek (2000) recommend that no matter what diagnostic (C)APD protocol a professional chooses to use, a screening tool is to be used as well. Screening tools are useful in the determination of the need for a more comprehensive diagnostic (C)APD evaluation, which might include, but are not limited to, measures of receptive and expressive language skills, speech production skills, reading, and written language (including phonemic representation), cognition, psychoeducational abilities, medical status, and educational/developmental history (Bellis & Ferre, 1996).

The Buffalo Model Questionnaire (BMQ) is the screening tool developed for use in conjunction with the Buffalo Model diagnostic test battery. Jutras et al. (2007) found the Buffalo Model to be a clinically appropriate and applicable model for (C)APD. Therefore, the use of a valid screening tool that complements the model is important to identify. However, there is little empirical evidence of the relatedness of findings across these two measures. The purpose of the present study was to explore whether such relatedness exists between findings on the BMQ and conclusions based upon completion of the Buffalo Model diagnostic test battery. This study also examined the sensitivity and specificity of this screening tool when used only in conjunction with the Buffalo Model diagnostic test battery.

Method

The charts of all children between the ages of 6 and 13 years old who presented at the Bloomsburg University Speech, Hearing, and Language Clinic for a central auditory evaluation from January of 2006 to January of 2009 were reviewed. Fifty-nine children (Mean = 8.78 years old, SD = 1.99) were included in this study. The majority of study participants were boys (68%). The chart of each participant contained documented evidence of the following inclusion criteria: a complete Buffalo Model Questionnaire (BMQ), a complete Buffalo Model diagnostic test battery (i.e., SSW, PST, and S/N), hearing thresholds less than or equal to 20 dB HL from 500 to 4000 Hz (ASHA, 2005b), healthy and intact tympanic membranes, normal middle ear function as defined by peak static acoustic admittance from 0.25-1.05 mmho, a tympanometric width from 80-159 daPa, and an ear canal volume from 0.3-0.9 cm^3 (Margolis & Hunter, 2000). Children with myringotomy tubes were included since open myringotomy tubes usually indicate a healthy middle ear space. Children with identified learning or reading disorders or attention deficit hyperactivity disorder were included if they received a diagnosis of (C)APD following completion of the Buffalo Model test battery. Children with speech and/or language disorders were included, as well. A family history of hearing loss, chronic ear infections, learning difficulties, reading disabilities, or speech and language issues did not impact an individual's ability to participate in this project.

Children with an IQ of 70 or lower, autism, and/or Fragile X were excluded from the study. Children with histories of traumatic head injury were excluded due to possible damage to auditory structures. Children who had received therapy (e.g., aural rehabilitation or speech therapy) were excluded as therapy has been shown to influence testing outcomes (Katz, 2006).

Given the nominal scales of measurement upon which data were recorded, a Chi Square Test for Independence was conducted to determine whether parents' reports of children's central auditory processing, as measured by the BMQ, were significantly related to findings from a more objective and comprehensive diagnostic test for (C)APD, the Buffalo Model diagnostic test battery. In addition, descriptive analyses determined the sensitivity and specificity of the BMQ.

Results

Descriptive analyses showed that the parents of 77% of participants reported more than eight concerns on the BMQ, suggesting the need for a formal central auditory processing evaluation. Descriptive statistics also showed that 76% of the participants received diagnoses of (C)APD following the completion of the more objective and comprehensive Buffalo Model diagnostic test battery. More specifically, 75% of participants achieved abnormal scores on the SSW, 58% of participants achieved abnormal scores on the PST, and 39% of participants achieved abnormal scores on the speech in noise test.

A Chi Square Test for Independence showed the majority of participants (n = 40) obtained abnormal scores on the BMQ and received a diagnosis of (C)APD based on the Buffalo Model (C)APD test battery (i.e., 68% true positive rate). Furthermore, the analysis showed that six participants obtained normal scores on both the BMQ and received no diagnosis of (C)APD based on the Buffalo Model test battery (i.e., 10% true negative rate). In addition, eight participants obtained abnormal scores on the BMQ, but did not receive a diagnosis of (C)APD based on the Buffalo Model test battery (i.e., 13.5% false positive rate). Finally, five participants obtained normal scores on the BMQ and received a diagnosis of (C)APD based on the Buffalo Model test battery (i.e., 8.5% false negative rate). The Chi Square test (see Table 1) achieved significance (X^2 [1, N = 59] = 7.10, $p < .01$) suggesting that findings from the BMQ are significantly related to findings from the comprehensive Buffalo Model diagnostic test battery.

Descriptive statistics showed a sensitivity rate for the BMQ of 89% (i.e., 40 of the 45 children who received a diagnosis of (C)APD received scores above eight on the BMQ). Descriptive statistics also showed a specificity rate for the BMQ of 43% (i.e., 6 of the 14 children who did not receive a diagnosis of (C)APD received scores of eight or lower on the BMQ).

Chi Square Tests for Independence also were conducted on findings from the BMQ and each of the three tests that constitute the Buffalo Model test battery (i.e., SSW, PST, and S/N). With respect to the SSW, analyses showed significant relatedness with the BMQ [X^2 (1, N=59) = 6.05, $p < .05$]. With respect to the PST, analyses showed significant relatedness with the BMQ [X^2 (1, N=59) = 5.10, $p < .05$]. In contrast, analyses did not show significant relatedness between the BMQ and the S/N test [X^2 (1, N=59) = 1.42, $p > .05$].

Discussion

Previous research on central auditory processing screening tools (i.e., Willeford and Burleigh Behavior Rating Scale, Children's Auditory Performance Scale (C.H.A.P.S.), and Fisher's Auditory Problems Checklist) has shown that the use of behavioral checklists are an efficient and effective way to determine if a child is in need of a more in-depth evaluation for central auditory processing problems (Bellis, 2003; Smoski et al., 1992). The present study attempted to expand the existent literature on the clinical usefulness of (C)APD screening tools by examining the relatedness of the parent-completed Buffalo Model Questionnaire and its companion Buffalo Model diagnostic test battery. A Chi Square Test for Independence performed on data gathered through a retrospective chart review shows that there is significant relatedness between the BMQ screening tool and the diagnosis of (C)APD based on the Buffalo Model test battery. This finding suggests the BMQ is a useful screening tool when paired with the Buffalo Model diagnostic test battery.

Although uniquely prepared to identify and respond to the needs of children who are unable to benefit from traditional formal classroom instruction, teachers are relatively unprepared to identify children with central auditory processing problems (Ortiz, 1992). (C)APD is a disorder not well-understood by mainstream educators (Grant, 2009). Teachers often comment that children who ultimately are diagnosed with (C)APD "hear but do not listen" (Grant, 2009). Given the similar behavioral manifestations of ADHD and (C)APD (Tillery, Katz, & Keller, 2000), teachers may mistakenly refer a child with (C)APD for ADHD testing because of their greater familiarity with and understanding of the chronic neuro-developmental disorder (Boeree, 1999; Jerome, Gordon, & Hustler, 1994; Sasso, et al., 1992; Snyder, Busch, & Arrowood, 2003; Wolraich, Hannah, Pinnock, Baumgaertel & Brown, 1996). Similarly, teachers' prior training and experience with behavior disorders, autism, speech/language disorders, and reading deficiencies may lead to other errant referrals of children with (C)APD (Boeree, 1999), inappropriate treatments, and limited improvement in affected children's academic and social functioning. A (C)APD screening tool, such as the Buffalo Model Questionnaire, may assist educators and other school-based professionals make appropriate referrals for more comprehensive diagnostic testing for (C)APD.

When the referral is made to the appropriate professional initially, across any discipline, there is a greater amount of monetary savings for the parents and schools (Teska & Stoneburner, 1980). Glascoe, Foster, and Wolraich (1997) encouraged the use of parent and teacher reports to screen for (C)APD, in order to maximize the opportunity for a timely, fiscally responsible, and productive response to children's central auditory processing problems. According to Glascoe (2004), approximately 30 to 50 percent of children who are referred for screenings, in general, ultimately receive a true diagnosis of the disorder (approximately one out of every two or three children). This value can vary depending upon the screening tool and diagnostic battery employed. Data from the present study showing the relatedness of findings from the BMQ screening tool and Buffalo Model diagnostic test battery suggested that the BMQ is a useful instrument that can enhance school professionals' ability to make appropriate referrals for (C)APD testing if the Buffalo Model is the battery of choice.

Table 1. Chi Square Test for Independence of the BMQ and Buffalo Model Test Battery

		Buffalo Model Test Battery		
		CAPD Diagnosis	No CAPD Diagnosis	TOTAL
BMQ	Abnormal	**40** (37)	**8** (11)	**48**
	Normal	**5** (8)	**6** (3)	**11**
	TOTAL	**45**	**14**	**59**

Note: Observed frequencies are reported in bold type. Expected frequencies are reported in parentheses.

Average screening costs are significantly lower than the monies needed to compensate for a missed diagnosis (Mehl & Thomson, 1998). Even if various screening tools are completed, the cost of administering screening tools is far more economical than undergoing comprehensive test batteries for all of the possible disorders.

When each of the core tests of the Buffalo Model diagnostic battery were independently analyzed, results of the Chi Square Test for Independence show that the SSW and the PST are significantly related to the BMQ, whereas the S/N test was not. Because the SSW and the PST are tests that are multi-dimensional in their tasks (Katz, 1998a; Katz & Fletcher, 1998) more behaviors addressed on the BMQ will also be seen throughout the diagnostic testing. The S/N test is important in that it establishes a child's ability to discern speech in noise (Heckendorf, Wiley, & Wilson, 1997). However, the S/N test is used to identify a tolerance-fading memory issue, which is one of the four Buffalo Model processing disorder categories. This will result in fewer behaviors on the BMQ that concerns the tolerance-fading memory category. Therefore, the professional should keep in mind that the BMQ will address a multitude of behaviors displayed by the child, and the diagnosis should not depend on the results of only one of the core tests.

Research Limitations

There are several limitations to the current study. First, this study did not use a random sample. The 59 participants included in this study represent all of the children whose adult guardians completed the BMQ upon arrival at the clinic and whose charts included documentation of results from the SSW, PST, and S/N tests. A relatively more random sample could have been generated by randomly and independently selecting 30 participants from the available 59 participants. However, such an approach, which limits the number of study participants, would have decreased the power of the statistical analyses.

Another limitation of this study was the broad age range of participants in the sample. Between the ages of 6 and 13 years, there are numerous developmental differences, including auditory attention and handwriting development (Vuontela et al., 2003). Barnes, Kaplan, and Vaidya (2007) noted a definitive difference in cognitive control in early childhood versus middle childhood, which can affect spatial attention, or attention directed toward a particular location within the visual field (Martinez, Ramanathan, Foxe, Javitt, & Hillyard, 2007). If spatial attention is affected, then auditory attention displayed by a child can also be affected (Andersen, Tiippana, Laarni, Kojo, & Sams, 2009). This was shown by an increased auditory perception in subjects exposed to direct visual attention cues. Ultimately, a deficit in auditory and spatial attention could affect the child's score on the BMQ, as some of the questions refer to the child's attentive behaviors reported by the parent or caregiver. Parents with younger children who are answering the BMQ may indicate more attention issues than parents with older children, which may be a developmental issue rather than (C)APD.

According to Feder and Majnemer (2007), poor handwriting can be an indication of negative academic success and poor self-esteem. Handwriting is a complex occupational task that has various underlying component skills (Feder & Majnemer, 2007), and although it is not addressed extensively on the BMQ, handwriting issues are steadfast indications of integration and organizational issues (Medwetsky, Riddle, & Katz, 2009). Some of the component skills identified in Feder and Majnemar's (2007) study are, but not limited to, fine-motor control, bilateral integration, visual-motor integration, motor planning, in-hand manipulation, proprioception, visual perception, sustained attention, and sensory awareness of the fingers. These component skills are developed sufficiently by age 6 years to complete writing, dressing, and feeding tasks, but they will continue to be refined as the child ages into teenage years (Tervo, 2003). Therefore, there will be developmental differences in handwriting and its component skills in 6 year-old children versus 13 year-old children. As a note, some of the component skills of handwriting are listed as areas of concern on the BMQ (i.e., visual perception, visual integration, and attention). Therefore, some of the overt behavioral symptoms exhibited may be a function of age rather than a processing deficit. It must also be stated, the neurological development of the areas mentioned above may also have an impact on the processing ability.

Another limitation to this study is the inclusion of children reported to have co-morbid disorders. Disorders such as Attention Deficit Disorder (ADD), Attention Deficit Hyperactive Disorder (ADHD), learning disabilities, and even depression can manifest in such a way that mimic signs of (C)APD (e.g., ask for repeated directions, listening difficulty in background noise) (Morlet, 2007; Tillery, Katz, & Keller, 2000). Accordingly, parents of children with ADHD are likely to report more than eight concerns on the BMQ (i.e., a finding that suggests the presence of central auditory processing problem). Given the pervasiveness of ADHD (i.e., three to five percent of school-aged children [Low, 2008]), it is reasonable to assume that one or more of the false positive outcomes in the current study could have been a function of an inappropriate referral of a child with ADHD to the Bloomsburg University Speech, Hearing, and Language Clinic. However, upon reviewing the data, the expected frequency of false positives was more than the observed frequency in this study. Therefore, the chances of this occurring were not likely. The inclusion of participants with co-existing disorders may have resulted in a higher number of parental concerns, which would not have occurred if individuals with co-morbid conditions were not included.

Finally, the relatively small sample size is a limitation of this study. The larger the sample size studied, the more likely the measured findings are representative of the population parameters (Lunsford & Lunsford, 1995). If the current project utilized a larger sample size, the outcomes might be more representative of the (C)APD general population. Because the study was limited to charts available at the Bloomsburg University's Speech, Hearing, and Language Clinic, the overall representation of the general population may have been confounded, due to the given demographics of the rural area. In the future, a sample size drawn from a more global population would be ideal to account for racial, cultural, and socioeconomic differences among groups, as well as for various assessment styles.

Future Research

In addition to providing information about the usefulness of the BMQ, the current research also allows insight into directions for future research. Future research could determine if a relationship exists between the BMQ and the (C)APD categories, as defined by the Buffalo Model (Katz, 1998a). This could guide the clinician in choosing a more efficient and effective test battery. For example, the Phonemic Synthesis Test (PST) is associated with the patient's ability to decode phonemically (Medwetsky, 2002a). If the BMQ reveals that decoding is an issue for the individual, then the PST should be a part of the (C)APD test battery.

The BMQ may also provide information that would suggest completion of testing that is outside the central three diagnostic tests in the Buffalo Model (SSW, PST, and S/N) (Katz, 2007a). Although the Competing Environmental Sounds Test (CES) was part of the original Buffalo Model test battery, more recent literature primarily discusses the use of the SSW, PST, and S/N as the current test battery (Katz, 2007a; Medwetsky, 2002a). The CES is a non-linguistic test that examines binaural integration skills of the listener (Chermak, 2001). If the BMQ indicates an expressive language issue, or if an expressive language deficit is observed by the audiologist, the CES would be an appropriate test to administer in addition to the core test battery. The CES removes the expressive language component of a (C)APD evaluation by having the child point to pictures heard under headphones, rather than verbally stating the sounds heard. However, the use of pictures and pointing adds a visual-motor component to the test, which must be taken into consideration. This test is said to be sensitive to cortical lesions (McKay, Headlam, & Copolov, 2000) and examines specifically the auditory areas of the brain. Future research may include examining how the CES and the BMQ are related.

Future research may focus on more discrete age groups (i.e., 6 to 8 year olds, 9 to 10 year olds, and 11 to 13 year olds). This would control for extraneous developmental differences among the current sample. Vuontela and colleagues (2003) found that children in the 9 to 10 year range perform auditory tasks more accurately than 6 to 8 year olds, which indicates that the older age group has improved executive function and memory capacity. This also indicates that auditory processing is related to the neuro-development of the individual. Furthermore, younger children may be behaviorally more impulsive, due to immature cognitive control systems (Vuontela et al., 2003). These children may display aberrant behaviors, such as quick responses, delays, and repetitions, which are important qualitative findings (Katz & Tillery, 2004). In general, qualitative indicators can be used by the examiner to clarify the nature of the deficit. The qualitative scores obtained on the SSW test can be an effective means of validating the parent/caregiver answers on the BMQ. That is, if a reliable parent/caregiver indicates a child exhibits frequent delays on the BMQ, quick responses would less likely be expected on the SSW test.

Another area of future research could determine if the overall number of affirmative responses on the BMQ is important or if a score of eight or greater warrants further testing (Katz, 2006). The cut-off value of eight was determined during initial studies of the BMQ (Katz, 2004). This value has not been studied extensively and would warrant further testing to validate the normative data based on age, gender, and the presence of co-morbid disorders (i.e., ADHD). As a final note, the total score is not always what is most important when analyzing the BMQ. It is imperative to look at responses to each question (Katz, 2004) and to remember that (C)APD is an individualized disorder that must be assessed on a case-by-case basis.

Conclusion

Jerger and Musiek (2000) recommended that audiologists use screening tools to complement (C)APD diagnostic protocols. Currently, there is no universal, empirically-tested screening tool that corresponds to any diagnostic battery. Katz (2006) suggested that findings from the BMQ and Buffalo Model (C)APD diagnostic test battery are related; however, there is limited research available to support this assertion. The purpose of this study was to determine if such relatedness exists. A Chi Square Test for Independence performed on data that were collected through a retrospective chart review showed that findings from the parent-completed BMQ screening tool were significantly related to the diagnosis of (C)APD as determined by the Buffalo Model diagnostic test battery. Data from the present study support the use of the BMQ as an appropriate screening tool only as a complement to the Buffalo Model diagnostic test battery.

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