Auditory Processing Assessment in Children: Towards a Dual Approach

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The behaviors that are typically assessed in children referred for auditory processing concerns often do not relate directly to the to the behavioral problems that give rise to referral for evaluation. In order to bridge the gap between diagnostic results and classroom behaviors, the present paper advocates the use of instruments that measure both "auditory system mechanisms and processes" (ASHA, 1996) and communicative performance. Such an approach would be beneficial in the design of intervention for affected children.

Introduction

Many speech pathologists and audiologists continue to experience difficulty in providing effective management in the area of auditory processing. One possible reason for this difficulty is the leap that must be made from the types of behaviors typically assessed, such as auditory discrimination, auditory pattern recognition, temporal resolution and temporal ordering (ASHA, 1996) to the behavioral problems that give rise to referral for evaluation. Typical reasons for referral for auditory processing testing include: "difficulty hearing or understanding in background noise, difficulty understanding degraded speech, difficulty in following spoken instructions in the classroom, difficulty in discriminating and identifying speech sounds, inconsistent auditory attention" (Jerger & Musiek, 2000). It is often difficult to apply results from diagnostic auditory processing tests directly to these communicative problems.

A Familiar Problem

The difficulty in applying results of auditory processing tests (e.g. frequency/duration pattern and dichotic listening tasks) to complex behaviors (e.g. following multiple step directions) is reminiscent of problems that have been encountered historically in applying standard audiological test results (e.g. pure tone thresholds, single word recognition test results) to the complex communicative problems of people who have peripheral hearing impairment. It is accepted generally that " two individuals may have identical audiograms while differing greatly in development of speech, use of residual hearing, academic achievement, and language"(Schow & Nerbonne, 1996, p. 267). Similarly, single word recognition tests may be useful in identifying possible retrocochlear disorders, but these tests currently are not viewed as optimal assessments of communicative difficulty (Stach, 1998). With respect to auditory processing, tests that are sensitive to auditory system dysfunction (e.g. localization, dichotic tests, etc.) serve an important role in auditory processing assessment, but the results of such tests are difficult to apply to functional difficulties related to the disorder.

Audiology has attempted to bridge the gap between diagnostic tests and communicative performance by constructing models that relate test results to the site of dysfunction and to behavioral ramifications in terms of auditory processing. These models also extend to recommendation of specific remediation approaches for certain test findings. Examples of such models are the neurophysiological/ neuropsychological models described by Katz (1992) and by Bellis and Ferre (Bellis & Ferre, 1996; Bellis, 2001). In the Bellis and Ferre model, five subprofiles of auditory processing disorder are proposed: auditory decoding deficit, prosodic deficit, integration deficit, associative deficit, and output-organization deficit. Each subprofile includes diagnostic findings, postulated associated behavioral deficits, and management suggestions (Bellis, 2001). For example, diagnostic findings for the subprofile of prosodic deficit, include bilateral deficits on temporal patterning in both verbal report and humming conditions and left ear deficits in dichotic speech tasks. A right hemisphere dysfunction is proposed, and sequelae of such dysfunction (e.g. reading, spelling, and writing difficulty) are described along with management suggestions. It is important to recognize that these models await scientific scrutiny with respect to construct validity. The postulated behavioral deficits and management suggestions will require extensive and rigorous scientific investigation.

Although neurological research (e.g. Kimura, 1961 and Sparks & Geschwind, 1968) is provided as a basis for the development of auditory processing models (e.g. Katz, 1992), it is important to recognize that the results of neurological research must be interpreted with caution. Neurological damage is rarely confined to a specific neural system, and it can be argued that the reported behavioral deficits may not be purely auditory in nature (McFarland & Cacace, 1995). In addition, our current understanding of brain behavior relationships is very limited. It is very likely that current and future neurological models of auditory processing will be revised and refined significantly as new information becomes available.

An example of an ongoing research effort that has attempted

to link auditory processing assessment test results to higher level speech processing is a body of research that relates reading problems to deficits in temporal processing of rapid stimuli (e.g. Tallal, Miller, & Fitch, 1993). Results of one study, for example, suggest that children who have specific language impairment exhibit auditory perceptual deficits that could affect perception of the brief acoustic elements of speech (Wright, Lombardino, King, Puranik, Leonard, & Merzenich, 1997). The proposed relationships in this area are, at present, controversial (Nittrouer, 1999; Studdert-Kennedy & Mody, 1995; Cacace, McFarland, Ouimet, Schrieber, & Marro, 2000) and may involve deficits that are not specific to the auditory modality (Cacace & McFarland, 1998). Therefore, it is important to recognize that that the area of temporal processing is under active investigation (Phillips, 1999). In general, at present, it is important to be cognizant of the limitations of neuropsychological models and theories, to apply what has been revealed by research with caution, and to understand that more research is needed.

Current Recommended Auditory Processing Assessment

In a recent consensus conference report (Jerger & Musiek, 2000), the recommended minimal behavioral auditory processing test battery specifies pure tone audiometry, performance-intensity functions for word recognition, a dichotic task, a duration pattern sequence test, and a temporal gap detection test (Jerger & Musiek, 2000). Tests evaluating dichotic listening, temporal analysis, etc. have been found to be sensitive to lesions in the auditory system (e.g. Kimura, 1961; Sparks & Geschwind, 1968; Efron, 1963; Jerger & Jerger, 1974; Olsen, 1983; Jerger, Johnson, & Loiselle, 1988; Musiek, 1983; Musiek, Baran, & Pinheiro, 1990). Lesions of the auditory system in children are relatively rare (Musiek, Gollegly, & Ross, 1985), but use of sensitive behavioral, electroacoustic, and electrophysiological tests and neural imaging assessments of the auditory system also may be useful in the detection of delay in auditory system maturation, abnormal hemisphere dominance, etc. In addition, determination of physiological and behavioral correlates of auditory processing dysfunction in children may lead to a better understanding of associated communicative problems (e.g. Kraus, Koch, McGee, Nichol, & Cunningham, 1999; Kraus, Bradlow, Cheatham, Cunningham, King, Koch, Nichol, McGee, Stein, & Wright, 2000).

In addition to lesion-sensitive assessment, it is important to evaluate the child's communicative performance. Measures that relate directly to communicative problems such as difficulty understanding in background noise, difficulty following spoken directions, and difficulty understanding degraded speech can facilitate decision-making regarding intervention and can provide a basis for evaluating intervention effectiveness. There is precedent for this approach in the communicative performance assessment that audiology has used for many years in evaluating communicative problems related to peripheral hearing loss.

Communicative Performance Assessment

Traditionally, assessment of communicative performance related to hearing loss has included two approaches. Self-report questionnaires have been specifically designed to assess communicative function with and without amplification use (e.g. the Hearing Handicap Inventory for the Elderly (Newman & Weinstein, 1988), the Abbreviated Profile of Hearing Aid Benefit (Cox & Alexander, 1995), etc.). These questionnaires provide information that cannot simply be deduced from the audiometric results (Weinstein & Ventry, 1983). Responses on these questionnaires do not correlate highly with speech recognition scores and cannot be inferred from pure tone sensitivity (Weinstein & Ventry, 1983; Newman, Weinstein, Jacobson, & Hug, 1990).

In addition, tests that attempt to simulate or recreate communicative settings also have been used to evaluate communicative performance. These tests constitute an attempt to "capture the interaction" between the person and the environment in which the communication occurs (Borg, E., 1998). For example, the development of sentences to measure word recognition was an attempt to create more realistic stimuli (e.g. Silverman & Hirsch, 1955; Davis & Silverman, 1978). Similarly, speech testing under adverse conditions has been advocated because of its relevance for remediation:

"...once we have developed good methods for measuring a patient's capacity to understand speech under adverse listening conditions, we will possess the audiological tools for dealing much more insightfully with his everyday listening problems." (Carhart, 1968, p. 715).

Large test-retest variability and practice effects can complicate the development of "realistic" test materials (Jerger, Malmquist, & Speaks, 1966), and performance is affected by the acoustic-phonetic and linguistic characteristics of the stimuli (e.g. Hutcherson, Dirks, & Morgan, 1979). Communicative performance assessment also may be complicated by non-auditory disorders and by variables such as attention, motivation, etc. Despite such difficulties with developing realistic tests of communicative performance, this approach continues to be useful, and several instruments of this type (e.g., the CUNY Sentence Test (Boothroyd, Hnath-Chisolm, & Hanin, 1988), the Hearing in Noise Test (Nilsson, Soli, & Sullivan, 1994)) have been used successfully particularly for the purpose of remediation planning and determination of hearing aid benefit.

In auditory processing evaluation, there has been insufficient attention given to the development and use of valid and reliable instruments that assess functional difficulty in pertinent listening situations. Questionnaires that assess functional auditory processing skills currently are recommended for the purpose of screening for auditory processing deficits (Jerger & Musiek, 2000). The Children's Auditory Performance Scale (C.H.A.P.S.) (Smoski, Brunt, & Tannahill, 1992) is one such questionnaire that could be used for communicative performance assessment. The C.H.A.P.S. relates directly to the communicative problems a child may exhibit in different listening situations in the classroom. In addition, the Listening Inventory For Education (L.I.F.E.) (Anderson & Smaldino, 1998) surveys the level of listening difficulty in a variety of situations that can be challenging for a child who has auditory processing disorder. The preschool and school-age versions of the Screening Instrument for Targeting Educational Risk (S.I.F.T.E.R.) (Anderson, 1989; Anderson & Matkin, 1996) also have been used to assess functional classroom behavior of children with auditory processing disorder. Such instruments could provide a useful starting point for future

psychometric research regarding measurement of auditory processing-related functional challenges to student success.

Although not recommended as part of the minimal test battery (Jerger & Musiek, 2000), several existing behavioral tests relate to the communicative problems associated with auditory processing disorder. Two of the SCAN-C subtests (i.e. filtered speech and auditory figure ground) (Keith, 2000) relate directly to reported difficulty hearing in non-optimal listening environments. Similarly, the auditory continuous performance test (ACPT) relates to auditory vigilance problems (Riccio, Cohen, Hynd, & Keith, 1996). Speech and language diagnostic protocols also include instruments that are directly relevant to areas of difficulty typically related to auditory processing disorder (e.g. the Test of Auditory Perceptual Skills (TAPS) (Gardner, 1985)). Two older tests, the Goldman-Fristoe-Woodcock (Woodcock, 1976), and the Flowers-Costello Test of Central Auditory Abilities (Flowers, Costello, & Small, 1973) might be useful if re-recorded, reinvestigated, and re-normed. Other similar tests could be developed. Such assessments could be very useful in decision-making regarding management of auditory processing disorders and in the assessment of treatment efficacy. More and better communicative performance auditory processing assessment instruments are needed.

It is conceivable for a child with auditory processing difficulty to show considerable improvement on communicative performance measures while continuing to perform poorly on behavioral auditory system diagnostic measures such as gap detection and pattern perception or other measures such as electrophysiological assessment, neural imaging, etc. Accordingly, in auditory processing evaluation, there is clearly a need for the inclusion of functional auditory processing assessments that evaluate the interactions between the communicating child and his school environment and define the level of adverse effect on classroom performance that the child may be experiencing.

Summary

At present, a theoretical leap must be made from the results of auditory processing diagnostic tests to decisions regarding management of auditory processing disorder. The present paper advocates assessment of functional auditory processing in conjunction with the recommended lesion/dysfunction sensitive test battery (Jerger & Musiek, 2000). This approach extends audiology's long history of assessing both degree of impairment and also communicative difficulty associated with peripheral hearing loss to the area of auditory processing disorders assessment. The present paper advocates for: 1) a change in the recommended function of questionnaires such as the C.H.A.P.S. from screening instruments to instruments of functional performance assessment, and 2) increased psychometric research and development of questionnaires and behavioral measures of communicative performance.

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References

American Speech-Language-Hearing Association (1996) Central auditory processing: Current status of research and implications for clinical practice. Task force on central auditory processing consensus development. American *Journal of Audiology, 5*, 41-64.

Anderson, K. (1989) *S.I.F.T.E.R. Screening Instrument for Targeting Educational Risk.* Tampa, FL: Educational Audiology Association.

Anderson, K. & Matkin, N. (1996). *Preschool S.I.F.T.E.R. Screening Instrument for Targeting Educational Risk in Preschool Children (age 3-Kindergarten).* Tampa, FL: Educational Audiology Association.

Anderson, K. & Smaldino, J. (1998). *L.I.F.E. Listening Inventory for Education An Efficacy Tool.* Tampa, FL: Educational Audiology Association

Bellis, T. (2001) *Auditory Processing Disorders: Current perspectives.* Presented at the Educational Audiology Association summer conference, Portland, WA.

Bellis, T. & Ferre, J. (1996). Assessment and management of central auditory processing disorders in children. *Educational Audiology Monograph, 4*, 23-27.

Boothroyd, A., Hnath-Chisolm, T., Hanin, L., & Kishon-Rabin, L. (1988). Voice fundamental frequency as an auditory supplement to the speechreading of sentences. *Ear and Hearing, 9*, 306-312.

Borg, E. (1998). Audiology in an ecological perspective-Development of a conceptual framework. *Scandinavian Audiology, 27*, 132-139.

Cacace, A. & McFarland, D. (1998). Central auditory processing disorder in school-aged children: A critical review. *Journal of Speech, Language and Hearing Research, 41*, 353-373.

Cacace, A., McFarland, D., Ouimet, J., Schrieber, E., & Marro,P. (2000). Temporal processing deficits in remediation-resistant reading-impaired children. *Audiology and Neuro-otology, 5*, 83-97.

Carhart, R. (1968). Future horizons in audiological diagnosis. *Annals of Otology Rhinology, & Laryngology, 77*, 706-716.

Cox, R. & Alexander, D. (1995). The Abbreviated Profile of Hearing Aid Benefit. *Ear and Hearing, 16*, 176-186.

Davis, H., & Silverman, R. (1978). *Hearing and Deafness.* 4th Ed. Holt, New York: Holt, Rinehart, & Winston.

Efron, R. (1963). Temporal perception, aphasia, and deja vu. *Brain, 86*, 403-424.

Flowers, A., Costello, M., & Small, N. (1973). *Flowers-Costello tests of central auditory abilities.* Dearborn: Perceptual Learning Systems.

Gardner, M. (1985). Test of auditory-perceptual skills. Burlingame,CA: Psychological & Educational Publications. Hutcherson, R., Dirks, D., & Morgan, D. (1979). Evaluation of the speech perception in noise (SPIN) test. *Otolaryngology Head and Neck Surgery, 87*, 239-245.

Jerger, J. & Jerger, S. (1974). Auditory findings in brainstem disorders. *Archives of Otolaryngology, 99*, 342-349.

Jerger, S., Johnson, K., & Loiselle, L. (1988). Pediatric central auditory dysfunction: Comparison of children with confirmed lesions versus suspected auditory processing disorders. *American Journal of Otology, 9*, 63-71.

Jerger, J., Malmquist, C., & Speaks, S. (1966). Comparisons of some speech intelligibility tests in the evaluation of hearing and performance. *Journal of Speech and Hearing Research, 9*, 136-149.

Jerger, J, & Musiek, F. (2000). Report of the Consensus Conference on the Diagnosis of Auditory Processing Disorders in School-Aged Children. *Journal of the American Academy of Audiology, 11*, 467-474.

Katz, J. (1992). Classification of auditory processing disorders. In J. Katz, N. Stecker, & D. Henderson (Eds.) *Central auditory processing: A transdisciplinary view* (pp.81-91). St. Louis, MO: Mosby Year Book.

Keith, R., (2000). *SCAN C Test for Auditory Processing Disorders in Children - Revised.* San Antonio: The Psychological Corporation

Kimura, D. (1961). Some effects of temporal-lobe damage on auditory perception. *Canadian Journal of Psychology, 15*, 156-165.

Kraus, N. Bradlow, A., Cheatham, M., Cunningham, J., King, C., Koch, D., Nichol, T., McGee, T., Stein, L., & Wright, B. (2000). Consequences of neural asynchrony: A case of auditory neuropathy. *Journal of the Academy for Research in Otolaryngology, 1*, 33-45.

Kraus, N., Koch, D., McGee, T., Nichol, T., & Cunningham, J. (1999). Speech-sound discrimination in school-age children: Psychophysical and neurophysiologic measures. *Journal of Speech Language and Hearing Research, 42*, 1042-1060.

McFarland, D., & Cacace, A. (1995) Modality specificity as a criterion for diagnosing central auditory processing disorders. *American Journal of Audiology, 4*, 36-48.

Musiek, F. (1983). Assessment of central auditory dysfunction: The Dichotic Digit Test revisited. *Ear and Hearing, 4*, 79-83.

Musiek, F, Baran, J, & Pinheiro, M. (1990). Duration pattern recognition in normal subjects and patients with cerebral and cochlear lesions. *Audiology, 29*, 304-313.

Musiek, F., Gollegly, K., & Ross, M. (1985). Profiles of types of central auditory processing disorders in children with learning disabilities. *Journal of Childhood Communication Disorders, 9*, 43-63.

Newman, C., & Weinstein, B. (1988). The Hearing Handicap Inventory for the Elderly as a measure of hearing aid benefit. *Ear and Hearing, 9*, 81-85.

Newman, C., Weinstein, B., Jacobson, G., & Hug, G. (1990). The hearing handicap inventory for adults: Psychometric adequacy and audiometric correlates. *Ear and Hearing, 11*, 430-433.

Nilsson, M., Soli, S., & Sullivan, J. (1994). Development of the hearing in noise test for the measurement of speech reception thresholds in quiet and in noise. *Journal of the Acoustical Society of America, 95*, 1085-1099.

Nittrouer, S. (1999). Do temporal processing deficits cause phonological processing problems? *Journal of Speech Language and Hearing Research, 42*, 925-942.

Olsen, W. (1983). Dichotic test results for normal subjects and for temporal lobectomy patients. *Ear and Hearing, 4*, 324-330.

Phillips, D. (1999). Auditory gap detection, perceptual channels, and temporal resolution in speech perception. *Journal of the American Academy of Audiology, 10*, 343-354.

Riccio, C., Cohen, M., Hynd, G., & Keith, R. (1996). Validity of the auditory continuous performance test in differentiating central processing auditory disorders with and without ADHD. *Journal of Learning Disabilities, 29*, 561-566.

Schow, R., & Nerbonne, M. (1996) *Introduction to Audiologic Rehabilitation.* Boston: Simon & Schuster.

Silverman, S., & Hirsh, I. (1955). Problems related to the use of speech in clinical audiometry. *Annals of Otology Rhinology and Otolaryngology, 64*, 1234-1244.

Smoski, W., Brunt, M., & Tannahill, J. (1992). Listening characteristics of children with central auditory processing disorders. *Language, Speech, and Hearing Services in Schools, 23*, 145-152.

Sparks, R. & Geschwind, N. (1968). Dichotic listening in man after section of neo-cortical commissures. *Cortex, 4*, 3-16.

Stach, B. (1998). Word-recognition testing: Why not do it well? *The Hearing Journal, 51*, 10-16.

Studdert-Kennedy, M., & Mody, M. (1995). Auditory temporal perception in the reading impaired: A critical review of the evidence. *Psychonomic Bulletin & Review, 2*, 508-514.

Tallal, P., Miller, S. & Fitch, R. (1993). Neurobiological basis of speech: A case for preeminence of temporal processing. *Annals of the New York Academy of Sciences, 682*, 27-47.

Weinstein, B., & Ventry, I. (1983). Audiometric correlates of the Hearing Handicap for the Elderly. *Journal of Speech and Hearing Disorders, 48*, 379-384.

Woodcock, R. (1976). *Goldman-Fristoe-Woodcock Auditory Skills Test Battery - Technical Manual.* Circle Pines, MN: American Guidance Service.

Wright, B., Lombardino, L., King, W., Puranik, C., Leonard, C., & Merzenich, M. (1997). Deficits in auditory temporal and spectral resolution in language-impaired children. *Nature, 387*, 176-178.