Assessing Auditory Processing Problems in the School Setting

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Recently, a consensus conference on auditory processing disorders (APDs) recommended a minimal APD test battery (Jerger & Musiek, 2000). These recommendations were made in the interest of defining a “gold standard” for APD assessment; however, they leave educational audiologists at a disadvantage since these professionals do not have ready access to certain clinical procedures. To meet the high volume of referrals for APD assessments in the school setting, it seems that another, second-tier type of test battery is needed; therefore, an alternative test battery is presented here for consideration. As a type of “silver standard” for assessment, it does not allow for a definitive APD diagnosis; however, it does provide sufficient information to identify a likely auditory processing problem. A two-dimensional model of auditory processing and an assessment matrix are described to provide an organizational framework for this alternative test battery.

Two questions consistently arise when educational audiologists talk about assessing auditory processing disorders (APD): how to manage the increasing number of referrals, and what kinds of assessments to use. Even when school programs have sufficient audiology and speech-language pathology (SLP) personnel, they typically lack the resources needed to comply with a recent report on APD assessment (Jerger & Musiek, 2000). This report recommended a minimal test battery comprised of behavioral tests, electrophysiological and electroacoustic testing, and neuroimaging studies. While certainly the clearest description of a “gold standard” for APD assessment to date, these recommendations create a dilemma for school-based personnel. Although expected to assess children experiencing listening difficulties, most school-based personnel do not have ready access to two of the three recommended procedures (i.e., electrophysiological/ electroacoustic testing and neuroimaging).

To address this “assessment dilemma,” the following alternative test battery is offered for consideration. As a kind of “silver standard,” this battery (comprised of behavioral tests only) will not provide a definitive diagnosis of a disorder, and therefore will not be useful to school systems requiring such a diagnosis. Some school systems, however, require only that an auditory processing problem be identified; for these environments, this test battery can provide the information needed to make informed programmatic decisions. This test battery can be administered by both audiologists and SLPS, thereby increasing the number of personnel available to respond to requests for assessments.

To provide an operational framework for this test battery, a two-dimensional model of auditory processing (AP) is presented. The two dimensions are then combined to create an assessment matrix, to be described in a subsequent section.

A “Horizontal” Dimension to Auditory Processing

All too often, the term “auditory processing disorder” is used to describe virtually every kind of listening difficulty, including inaccurately – receptive language problems (e.g., following directions or remembering verbally-given homework assignments). Figure 1 makes the distinction between auditory processing skills and receptive language skills by conveying the range of auditory input along a continuum, from simple pure tones to the highest levels of receptive language analysis. Auditory processing is placed at the beginning of this continuum to represent a foundational requirement for more advanced receptive language skills. The ability to process speech sounds and single words is more specifically called “phonological awareness” (Ball & Blachman, 1991; Wagner & Torgeson, 1987). Because phonological awareness does not entail language analysis per se, it is embedded within auditory processing skills.

When two or more words are combined, the listener uses receptive language skills, which must be assessed with instruments designed for that purpose. The brackets along the continuum are meant to demarcate where AP ends and where receptive language begins, and to plan assessment accordingly.

Although not noted on Figure 1, a “gray area” does exist on this continuum straddling both sections of AP and receptive language. It involves using auditory sequential memory with two words or more, such as a set of directions. For example, if a child can readily understand, “Read page 15,” or “Answer the odd-numbered questions,” he or she is demonstrating a command of simple receptive language. However, frequently a child can follow one direction, but becomes confused when a set of directions is strung together (“Read page 15, answer the odd-numbered questions, place the assignment on the right hand corner of my desk, and spend the remaining time in silent reading”). When this confusion occurs, he or she is not demonstrating a problem with receptive language per se, but rather an overload or breakdown in the use of auditory sequential memory. The same concept holds for the verbatim repetition of several digits or short sentences: although two or more words are used as a stimulus, auditory sequential memory skills are being tapped, not receptive language skills.
A "Vertical" Dimension to Auditory Processing

Each component of the AP continuum – pure tones, environmental sounds, speech sounds, and single words – can be evaluated at an increasingly complex cognitive level (American Speech-Language-Hearing Association, 1996a). Table 1 provides a list of different cognitive skills used to analyze auditory input. Note the quotation marks around the word "hierarchy," to caution against overgeneralization with regard to the developmental acquisition of these skills – that is, skills are not necessarily mastered in this sequential order. Temporal resolution has been placed at the end of the hierarchy because it is of relatively new interest (Pinheiro & Musiek, 1985; Tallal, Miller, & Fitch, 1993).

Table 1.

"Hierarchy" of auditory processing skills

<table>
<thead>
<tr>
<th>Auditory Awareness, Localization</th>
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<tr>
<td>Auditory Discrimination</td>
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<td>Auditory Recognition</td>
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<td>Auditory Attention Span</td>
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<tr>
<td>Figure Ground (Discrimination in Noise)</td>
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<td>Auditory Sequential memory</td>
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<td>Temporal Resolution</td>
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attend to/repeat back two different (dichotic) stimuli, presented one to each ear (binaural integrator)? In other words, is the corpus callosum transferring auditory information across hemispheres (Belli, 1996)?

- Auditory memory and auditory sequential memory: can the child recall what was presented audition-only? Can the child recall auditory input (words, directions) in the order it was given?
- Temporal resolution: can the child do the above tasks at an age-appropriate speed? Does the auditory signal travel along the auditory pathway at the rate expected for one's age?

As mentioned earlier, these processing skills can be applied to pure tones, environmental sounds, speech sounds, and single words. The next section uses these horizontal and vertical components as axes for a matrix for behavioral assessment.

An AP Behavioral Assessment Matrix

The matrix found in Figure 2 merges the horizontal and vertical dimensions of AP to create an organizational framework to identify specific tests for specific AP problems. By no means is this an exhaustive list of all available tests; rather, it merely provides examples of tests that meet the following criteria:

1. They can be conveniently administered in the school setting, because they require at most only commonly available equipment (CD/tape player, headphones, a quiet room), and no specialized (i.e., audiologic) training.
2. They have little or no linguistic demands.
3. They have little or no memory demands.
4. They employ simple response modes (Jerger & Musiek, 2000).

If other tests are selected, they should meet the above criteria as well. The assessments included in this matrix are described below, in alphabetical order:

- Auditory Continuous Performance Test (Keith, 1994) measures auditory attention span of single words;
- Auditory Fusion Test-Revised (Screening Test) (McCroskey & Keith, 1996) measures gap detection or temporal resolution of pure tones;
- “Auditory Sequential Memory” (digit span) subtest of the Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk, McCarty, & Kirk, 1968) measures auditory sequential memory of single words (digits);
- Dichotic Digits, Double Pairs (Musiek, 1983) measures binaural separation and auditory memory of digits;
- Duration Pattern Test (Musiek, 1994) measures auditory discrimination and auditory short term memory of long and short pure tones;
- Lindamood Auditory Conceptualization (LAC) Test (Lindamood & Lindamood, 1979) measures auditory discrimination and auditory sequential memory of speech sounds;
- Pitch Pattern Sequence Test (Musiek, 1994) measures auditory discrimination and auditory short term memory of high and low pure tones;
- Subtest 1 of the SCAN-C: Test for Auditory Processing Disorders in Children, Revised (Keith, 2000) measures auditory closure of single words;
- SCAN-C, Subtest 2, measures perception of single words in background noise;
- SCAN-C, Subtest 3 measures binaural separation and auditory memory of single words;
- SCAN-C, Subtest 4 measures binaural separation of single sentences;
- “Sound Blending” supplemental subtest of the ITPA measures auditory synthesis skills of speech sounds (as in "b-oa-t") into single words,
- “Word Discrimination” subtest of the Test of Language Development-Primary (3rd ed.) (TOLD-P:3) (Newcomer & Hammill, 1997) measures the ability to discriminate between words that are the same (“work-work”) or different (“watch-wash”).

It is duly noted that the subtests of the SCAN-C are screening instruments only. However, they do provide normative data for auditory skills (e.g., figure ground and binaural separation) not readily found elsewhere, especially for age 5.

Tests such as the LAC Test and the Auditory Continuous Performance Test are included in this assessment matrix because they provide additional (and academically relevant) information regarding phonological awareness delays, attention problems, etc., to help advance the overall assessment process.

An Assessment Battery for the School Setting

After reviewing the tests organized in this matrix, the following minimal test battery was developed at a university clinic with the goal of obtaining the most information possible in about one hour. Prior to an appointment, screening information is collected via two teacher questionnaires (Fisher, 1980; Smoski, Brunt, & Tannahill, 1998). At the appointment, pure tone and middle ear screenings (American Speech-Language-Hearing Association, 1996b) are administered, as well as the following tests (for age 6 and older):

1. ITPA “Auditory Sequential Memory” (digit span) subtest
2. Lindamood Test of Auditory Conceptualization
3. Auditory Fusion Test, Revised* (Screening Test)
5. “Word Discrimination” subtest, TOLD-P:3
6. Duration Pattern Test* (for ages 7 and up)

In addition to the three behavioral tests recommended by Jerger & Musiek (2000) (identified above by asterisks), three other assessments were added with the following rationales:

1. Since poor performance on the Dichotic Digits Test (Double Pairs) could suggest problems with dichotic listening skills, auditory memory, or both, the digit span subtest of the ITPA provides a means either to rule out or confirm problems with auditory memory problems alone. (Note: the latest version of the ITPA [ITPA-3, Hammill, Mather, & Roberts, 2001] does not include an auditory memory subtest.)
2. The LAC Test provides additional information about an
### Figure 2. APD behavioral assessment matrix.

<table>
<thead>
<tr>
<th></th>
<th>Pure Tones</th>
<th>Environmental Sounds</th>
<th>Speech Sounds</th>
<th>Single Words</th>
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</tr>
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<tbody>
<tr>
<td>Aud. Awareness, Localizing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
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<tr>
<td>Auditory Discrimination</td>
<td>Pitch Pattern *Dur. Pattn</td>
<td>LindamoodAud Concept. (LAC)</td>
<td>TOLD-P:3, Word Discrim</td>
<td></td>
<td>n/a</td>
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<tr>
<td>Auditory Recognition</td>
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<tr>
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<td>Pitch Pattern *Dur.Pattn</td>
<td>*DDs, Double Pairs *SCAN-C #3</td>
<td>*DD, Double Pairs</td>
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<td>n/a</td>
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<tr>
<td>Temporal Resolution</td>
<td>*AFT-R</td>
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Academically relevant skill (phonological awareness) that is not addressed in the APD consensus conference minimal test battery. The ability to discriminate speech sounds (from LAC results) can be compared to discrimination of pure tones (in the Duration Pattern Test), and sequential ordering of speech sounds (from LAC results) can be compared to sequential ordering of single words (ITPA digit recall).

3. Results from the Word Discrimination test can be used to compare discrimination problems with pure tone stimuli to results obtained with pure tone stimuli as measured by the Duration Pattern Test. The Duration Pattern Test is often too long or too abstract for young children; if these scores are low but scores from the Word Discrimination test are within normal limits, a tester may decide not to put too much weight on the Duration Pattern Test.

These six tests evaluate a cross-section of auditory inputs at different processing levels. Figure 3 compresses the assessment matrix to describe specific outcomes:

1. Auditory discrimination is tested with pure tones (Duration Pattern Test), with speech sounds (LAC), and with single words (Word Discrimination Test).
2. Binaural integration is tested with single words (Dichotic Digits).
3. Auditory memory is tested with single words (Dichotic Digits).
4. Auditory sequential memory is tested with speech sounds (LAC) and words (ITPA Digit Span).
5. Temporal resolution is tested with pure tones (AFT-R).
Figure 3. Auditory skills tested with a variety of auditory inputs

<table>
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These tests were selected to allow for reliability checks (described above). Other tests in the assessment matrix can be selected to meet the particular needs of a student or school system; the main consideration is to test multiple auditory inputs at multiple processing levels.

**Conclusion**

The "gold standard" of APD assessment is usually not achievable in typical school settings; therefore, an alternative minimal test battery is presented here. It can be implemented by audiologists and SLPs alike, thereby increasing the number of personnel available for AP assessment. It does not definitively confirm a diagnosis of APD but it does provide enough information to decide whether significant auditory processing problems exist, and whether services should be initiated (for instance, using a pre-set criteria of at least two scores falling two standard deviations below average).

This proposed test battery is offered as a jumping-off point for discussion; for example, yet to be considered is criteria for referral for electrophysiological assessments and/or neuroimaging. Feedback regarding both the two-dimensional AP model and the concept of a "silver standard" for AP assessment is welcomed (english@duq.edu).

**References**


