Auditory processing and the Common Core

Jeanane M. Ferre, PhD
Audiologist, CCC-A
Oak Park, IL

708.848.4363
Email: jmfphd@comcast.net
www.dr-ferre.com

PROCESSING
HAPPENS
ALL DAY
EVERYDAY
EVERYWHERE

Continuum of Processing

Central auditory processing

• neural processing of auditory stimuli
  – Auditory discrimination
  – Binaural processing
  – Temporal processing

• deficiency in skills subserved by CENTRAL auditory mechanism in brainstem/brain = CAPD

Subcortical/cortical auditory functions

• Auditory discrimination – ability to analyze fine acoustic differences in signal spectra
  - Occurs through the thalamic level AND primary auditory cortex (Heschl’s gyrus)
  - Perception of ACoustIC signal
**Binaural processing - interaction between the two sides**

- Dichotic listening – interaction between hemispheres
  - Integration – process multiple targets
  - Separation – process one and ignore another
  - Reflects cortical integrity
- Binaural fusion – interaction between ears
  - Reflects brainstem integrity
  - Assists listening in noise, localization, perception

**Temporal processing – ability to use timing aspects of signal**

- Temporal resolution - a left hemisphere skill involving ability to perceive “1” versus “2” targets
- Temporal patterning – a right hemisphere skill involving ability to perceive order/sequence
- BOTH skills important for perception of running speech

**Phonetic / Phonemic Processing**

- Preliteracy foundation
  - Sound-symbol correspondence
  - Spelling
  - Reading
  - Written Language
- Auditory Analysis/Synthesis
- Auditory Closure
- Auditory Figure Ground
- Auditory Memory
- Auditory Sequential Memory

**Linguistic Processing**

- Ability to interpret/attach meaning to signal
- Foundation for metalinguistic skills
- Conceptual basis for higher level, more complex language
  - includes
    - vocabulary
    - labeling, usage, association, categorization, similarities, differences, multiple meanings
    - integration with other information
    - attribution, memory, retrieval, comprehension

**Executive functions**

- Under control of frontal/pre-motor cortex
- Planning and execution of a response
- Includes
  - Attention, concentration, focus
  - Self-Regulation & impulse control
  - Goal Setting & Problem Solving
  - Working Memory
  - Abstract Reasoning

**Another way to “look” at process**

```
Executive functions
Language & learning
Sensory processing
```
**Development of Auditory Skills**

- Hearing sensitivity - adult-like for speech by 6 months, for pure tones by 12 months
- ABR response – adult-like by 2 years
- Localization – precision/accuracy improve until age 5
- Hearing in noise improves with age among children, decreases with aging among elderly
- Discrimination – by 12 months, restricted to constructs in native language; rapid improvement in vowel perception ages 4-7 yrs, adult-like by 8 years

- Dichotic listening – measurable by 5, adult-like by 12 years
- Temporal resolution - measurable by 6, mature by 10, decreases with aging > 40 yrs
- Temporal patterning - present at 5-6, adult-like by age 12
- Related “top-down” factors develop and change from birth throughout the life span

**Processing Disorders can co-exist with other disorders**

- Attention Deficit Disorder
  - distractible, inattentive, disorganization
- Executive Function Difficulties
  - poor working memory, strategy development
- Behavior Disorders
  - opposition, perseveration, noncompliance
- Asperger’s Syndrome
  - poor social language, impaired affect
- Nonverbal Learning Disability
  - impaired prosody, use of nonverbal cues
- Speech-Language Impairment
  - poor phonological awareness, pragmatic language

**Differential Diagnosis**

- Differentiates among disorders having similar symptoms/manifestations
- SLPs, psychologists, neuropsychologists & others provide insights re: listener’s auditory performance in various contexts
- Audiologists use well-controlled, norm-referenced tests that minimize influence of language, cognition & other sensory skills & maximize auditory system function
- Tests designed to tax CAP skills
- Patterns diagnose specific CAPD
- Test results help customize deficit-specific differential intervention

**Shared Symptomatology**

- Attention Deficit Disorder
  - distractible, inattentive, disorganization
- Executive Function Difficulties
  - poor working memory, strategy development
- Behavior Disorders
  - opposition, perseveration, noncompliance
- Asperger’s Syndrome
  - poor social language, impaired affect
- Nonverbal Learning Disability
  - impaired prosody, use of nonverbal cues
- Speech-Language Impairment
  - poor phonological awareness, pragmatic language

**Differential Intervention**

- Balance of treatment & management based upon neuroscientific principles & derived from assessment
- Customizes treatment and management plans to treat impaired skills & to minimize impact on listener’s life

Neuroscience foundations
**Continuum of Processing**

- Acoustic
  - Central Auditory Processing audiologist
  - Transition Area
    - Phonetic Processing
      - Phonemic Processing
      - Language Processing speech-language pathologist
- Linguistic

**Differential Screening Test of Processing - DSTP**

- Screen continuum
- 8 subtests delivered via CD
- 3 auditory processing
- 2 phonemic/phonics
- 3 language
- Identifies where to refer and/or spend more time in assessment
- Available from LinguiSystems

**Informal assessment of CAP skills**

- Spelling
- Memory for words vs. sentences
- Music
- Alphabet
- Wepman, ITPA
- Multisyllabic words

**Diagnostic CAPD Testing Battery**

- What?
  - Battery of tests to determine how efficiently CANS operates
- How?
  - Overloading or overworking it
- Who?
  - Children as young as 6-7 yrs
  - Results compared to age-matched peers
  - Performance profiles yield insights into nature of CAPD

**CAPD Test Assessment**

- *Minimize* influence of language, cognition & other sensory skills on performance
- Results examined re:
  - central auditory processes being taxed
    - Auditory discrimination, binaural processing, temporal processing
  - anatomical sites subserving those skills
    - Brainstem, right/left hemispheres, corpus callosum

**Considerations when testing**

- Hearing sensitivity
- Sufficient expressive speech skills
- Sufficient receptive language skills
- Intelligence test results
### Test Interpretation

**• NOT CAPD**
- Performance below normal on single test
- Performance below normal on **all** tests
- Contradictory findings

**• Evidence of CAPD**
- Poor scores on sets of tests tapping similar function
- Bellis/Ferre model describes 5 test profiles
  - Three primary
  - Two secondary

### Interpretation

**• Primary CAPDs**
- Decoding deficit – LH
- Integration deficit - CC
- Prosodic deficit – RH

- Represent true Central AUDITORY processing issues

### Auditory decoding deficit

**• Poor discrimination of fine acoustic differences in signal**
- Probable site: primary auditory cortex
- Signal distortion – poor neural representation
- Exhibit impaired discrimination, closure, & temporal resolution
- Poor scores on low redundancy tests, gap detection, and (possibly) binaural integration
- Behaviorally: they can’t “hear”
Integration Deficit

- Deficit in performing tasks requiring interhemispheric communication
  - Probable site: corpus callosum
  - Insufficient development of corpus callosum
  - Poor integration skills
  - Excessive LE suppression on dichotic tasks AND poor labelling with good mimicking of patterns
  - “it’s too much” – not synthesizing inputs

Prosodic deficit

- Deficiency in use of prosodic (timing) features of target
  - Probable site: right hemisphere
  - Inefficient RH pattern recognition
  - Trouble with acoustic contours
  - Exhibits poor temporal patterning
  - Poor scores both labelled AND mimicked on patterning tasks AND excessive LE suppression on dichotic tasks
  - Behaviorally: it’s all “blah, blah, blah”

Interpretation

- Secondary test patterns
  - Associative deficit
    - Likely reflects impaired language processing
  - Output-organization deficit
    - Likely reflects cognitive/executive function issues

Associative deficit

- NOT applying rules of language to acoustic signal
  - May be due to poor communication between primary and secondary (association) cortices
  - Poor scores for both ears on dichotic tests, good labelling/mimicking, adequate discrimination
  - Poor “translators”, “I don’t get it”
  - Show issues in manipulating multiple targets

Output-organization deficit

- Deficient ability to organize, sequence, plan appropriate response
  - May be due to deficient efferent, motor planning, or executive function
  - Exhibit difficulty with expression/execution
  - Poor scores multiple target tasks, in noise, sequencing errors
  - Can’t get it back out

Effective Intervention for Auditory Processing Disorders in line with the Common Core
CAP processes revisited

- **Auditory discrimination** - ability to analyze fine differences in acoustic spectra
- **Binaural processing** - ability to recognize and manipulate multiple acoustic targets
- **Temporal processing** - ability to use timing aspects of auditory signals, includes sequencing and patterning

Underlie ability to recognize/use speech

Necessary for active listening/learning

Educationally relevant to ALL Common Core standards, especially standard for Speaking and Listening

- Reading, Spelling, Written language, Math
- All aspects of language acquisition/usage
- Classroom listening, Note-taking, Test-taking

Management | Remediation
--- | ---
⚡ Modification of the communicative environment | ⚡ Formal and informal therapy to develop deficient skills AND
⚡ Use of compensatory strategies | ⚡ Teach compensatory strategies
⚡ Minimizes adverse effect of disorder of client’s life | ⚡ Designed to reduce or resolve deficit

Bottom-up - stimulus driven
- Therapy: adaptive/repetitive skills training
- Management: focus on access to signal

Top-down - concept driven
- Therapy: use of cognitive/linguistic strategies
- Management: focus on accommodations & communication

Direct Remediation for PDs

- Remediation based on research in neural plasticity.
  - Plasticity is brain’s ability to organize/reorganize in response to internal/external changes.
- When choosing treatment program, consider
  - Reported efficacy of program for specific populations – Does it work?
  - Program’s neuroscientific foundations – Should it work?
  - Appropriateness for type of deficit identified – Does it fit?

Remediation for CAPDs

- **Auditory training**
  - *bottom-up* therapy, plasticity-based
  - auditory, although not exclusively, stimuli
  - stimuli are repetitive
  - max number of responses elicited
  - feedback on accuracy provide
  - activities adaptive, systematic, and varied
  - nearly any CAP skill can be trained this way
## Remediation for CAPDs

- **Linguistic-Cognitive therapy**
  - *top-down* therapy
  - based on neurocognitive theory
  - concept-driven
  - teaches compensatory strategies
    - central resources training
    - use of visual cues
    - counseling

## Acoustic emphasis – bottom up

- Basic auditory skills training, including rhythm training
- *Phoneme Training Program* by Sloan
- *Fast ForWord, Sound Auditory Training*
- Dichotic listening training
- Temporal resolution
- Localization training
- LACE – Listening & Communication Enhancement

## Phonemic/phonetic emphasis- bottom up to top-down

- Earobics – both levels
- LIPS program
- Phonemic Synthesis Training
- Rhyming training
- Lipreading/speechreading training
- Diadochokinetics
- BrainTrain
- Hear Builder

## Linguistic emphasis – top down

- Lipreading / speechreading training
- Auditory closure (fill-in-the-blank)
  - Discourse cohesion devices, schema induction
  - Using context, predictability
- Meta-memory strategies
  - Reflexive strategies: verbal rehearsal, rote memory
  - Explicit Declarative Strategies: visual imagery, chunking, mnemonic s, rhymes
  - Episodic Strategies: “mark” learning with places, circumstances, field trips
  - Procedural Strategies: teach with movement, working models, songs

## Executive function - bottom-up/top down

- Auditory vigilance training
- Interhemispheric transfer training
- Noise tolerance training
- Prosody training
- Active listening Strategies
  - Self-monitoring
  - Assertiveness training and self-advocacy

## Managing CAPD effects

- **Bottom-Up**
  - Importance of Clear Speech
  - Using Assistive Listening Technology
  - Access to and use of visual cues
  - Noise abatement
Managing CAPD effects

- **Top-Down**
  - Importance of Clear Language
  - Using Technology
  - Visual aids
  - Educational accommodations

Common Core Standard: Speaking & Listening

Participate in collaborative conversations with diverse partners about grade appropriate topics

Auditory discrimination – inefficient analysis of acoustic cues

- **Impacts**
  - Phonological awareness
  - Spelling
  - Listening stamina
  - Direction following
  - Comprehension
  - Language skills
  - Foreign language acquisition

- **Treatment needs**
  - Sound discrimination
  - Auditory closure
  - Phonemic awareness
  - Recognition in noise
  - Use of visual cues

Sample goals for student with impaired auditory discrimination

- Student will discriminate speech presented under a variety of listening conditions
- Student will recognize speech under adverse listening conditions
- Student will use visual cues to improve speech recognition
- Student will recognize and use key elements in spoken targets

Sample benchmarks - discrimination

Discriminate minimally contrasted phoneme pairs presented auditorily only (i.e. no lipreading cues) in quiet with 90% accuracy.

Discriminate minimally contrasted phoneme pairs presented auditorily only (i.e. no lipreading cues) in background of multi-speaker babble that is of equal loudness (i.e., at a 0 signal-to-noise ratio) and emanates from the same location as the target signal with 90% accuracy.

Recognition in noise (noise tolerance)

- Student will recognize everyday sentences presented without visual cues in a background of equal loudness noise with 85% accuracy.
- Student will recognize everyday sentences presented with visual cues in a background of noise that is much louder than the target with 75% accuracy.
Using visual cues

Student will discriminate same-difference for target presented visually only with 90% accuracy.

Student will identify target compound word presented visually-only (i.e., no auditory input) from among a closed set of no more than 30 printed word or picture choices with 90% accuracy.

Listening comprehension

Given a sentence, student will state information conveyed by key (i.e., stressed) word with 90% accuracy (e.g., My sister baked two dozen chocolate chip cookies on TUESDAY. Key word: Tuesday. Information conveyed: when).

Given a sentence, student will state information conveyed by two (or more) key (i.e., stressed) words with 90% accuracy (e.g., My sister baked TWO DOZEN chocolate chip cookies on Tuesday. Key words: My, two dozen. Information conveyed: who, how many).

Binaural processing

• Impacts
  - Reading comprehension
  - Spelling
  - Listening comprehension
  - Direction following
  - Task completion
  - Note-taking

• Treatment needs
  - Dichotic listening
  - Interhemispheric communication
  - Synthesis of multiple auditory targets
  - Manipulation of auditory & non-auditory signals

Sample goals for student with binaural processing issues

• Student will recognize dichotically presented targets
• Student will increase communication between the two hemispheres.
• Student will synthesize and manipulate multiple auditory targets.
• Student will recognize & manipulate auditory, auditory-visual, and acoustic-linguistic targets.

Dichotic listening

• Repeat 2 digits presented simultaneously, 1 to each ear, with 90% accuracy (binaural integration )

• Repeat four words presented simultaneously, two to each ear, with 80% accuracy for each ear (binaural integration ) e.g., RE - house, car; LE - goat, dig; house & goat overlap and car & dig overlap

• Given two sentences, presented simultaneously, one to each ear, student will repeat sentence directed to right ear only (or to left ear only) with 90% accuracy (binaural separation).

Interhemispheric integration

• Given array of common objects, student will name object without looking with 90% accuracy.

• Given array of common objects, student will find named object without looking with 90% accuracy.

• Student will follow 2-part, 3-element verbal directions (e.g., point to large white square & small blue triangle), presented without visual cues in background of equal loudness noise with 90% accuracy.
**Sound blending/synthesis**

Given a word and using a “phoneme list”, student will create as many rhymes as possible within two minutes.

Student will smoothly blend three nonsense syllables (e.g., puh-tuh-kuh, spruh-struh-skruh) using equal stress on each phoneme (or varying stress across phonemes, e.g., SPRUH-struh-skruh).

**Temporal processing**

- Impacts
  - Listening comprehension
  - Memory
  - Reading comprehension
  - Social & pragmatic language
  - Direction-following

- Treatment needs
  - Pattern recognition
  - Use of prosody
  - Listening comprehension
  - Use of visual cues
  - Working memory
  - Sequencing

**Sample goals for student with temporal processing**

- Student will recognize auditory patterns.
- Student will discriminate, recognize, and interpret stress in speech.
- Student will recognize/use key elements within a spoken target.
- Student will use visual cues to assist message comprehension.
- Student will recognize/use patterns within linguistic signals.

**Temporal pattern discrimination/recognition**

Determine same-difference for 2-, 3, or 4-tone sequences composed of soft/loud (e.g., loud-soft), high/low (e.g., high-low-high), short/long (e.g., short-short-long-short) tones with 90% accuracy.

Imitate two-, three-, or four-tone patterns, presented with equal stress with 95% accuracy.

Attach verbal label to 2-, 3-, or 4-tone sequences varying in pitch, loudness, or duration with 90% accuracy.

**Use of prosody**

Identify three-phoneme sequence from among a closed set of three choices, with 90% accuracy.

Imitate three-phoneme sequences with 85% accuracy.

Judge intent of statements with 85% accuracy, including sincerity/insincerity and emotion (e.g., anger, happiness, fear, sadness).

**Recognize /manipulate multisensory targets**

Given a “deck” of 50 word cards, student will generate single rhyming word for printed target within two minutes with 90% accuracy.

Given a list of 50 words, student will generate two rhymes for each word within 3 minutes with 90% accuracy.
Listening comprehension

When given a sentence, student will identify stressed word in sentence with 90% accuracy.

When given a sentence, student will identify two stressed words with 90% accuracy.

Use of visual cues

Given picture choices, student will match emotion word/phrase, e.g., They are frightened, with corresponding picture with 90% accuracy.

Given printed sentences, student will identify and imitate the “prosodic” marker in the sentence with 90% accuracy (e.g., identify the ? in a sentence to denote questioning/rising intonation and imitate same)

Using linguistic patterns (working memory)

Given no more than three clues, student will recognize word with 90% accuracy (e.g., given white, fluffy, falls student would respond snow)

When given a sentence, student will state what information is conveyed by two (or more) key (i.e., stressed) words with 90% accuracy (e.g., MY sister baked TWO DOZEN chocolate chip cookies on Tuesday. Key words: My, two dozen. Information conveyed: who, how many).

Sequencing – using verbally mediated strategies to sequence/organize auditory information

Given a single word target, student will create as many rhyming words as possible in 2 minutes and in alphabetical order with 90% accuracy.

Student will execute 3-step sequential directions, in which each direction has 1- or 2-critical elements, with 90% accuracy when presented in a quiet environment (e.g., 1st, draw a straight line, then draw a circle below the line, & then draw a red star above line).

For all students

- Student will demonstrate ability to use active listening strategies
  - Active listening - taking responsibility for one’s listening success or failure by understanding impact of auditory impairment in one’s life, recognizing aspects of communication under listener’s control, displaying effortful listening behaviors, taking overt steps to avoid or correct potential communication mishaps.

- Student will maintain auditory vigilance

Active listening

Student will state two difficult listening situations that he/she has encountered.

For a self-reported difficult listening situation, student will state (and practice) one strategy to minimize the listening difficulty.
Auditory vigilance
Given a string of random words (or phonemes), student will indicate through hand signal each occurrence of pre-determined “target” word

Student will indicate through hand signal “rare” or different target from within a string of common targets (e.g., buh-buh-dee-buh-buh-buh-buh-dee)

SUMMARY COMMENTS
• Auditory/acoustic processing occurs before you “know” the target
• Auditory processing is “adult-like” by early teens
• Impaired auditory processing can affect language
• Language develops in hierarchy of complexity & progresses from concrete functional to abstract
• Language processing is imposed ‘on top of’ basic language foundation & continues to develop and refine throughout life
• Impaired processing can affect learning & social-emotional health
• Differential diagnosis MUST be used to find the level of breakdown

Assessment Summary
• Auditory/acoustic processing occurs before you “know” the target
• Impaired auditory processing affects ability to meet ALL Common Core Standards
• Phonologic, linguistic, and executive processing are “above” basic acoustic processing
• Differential diagnosis is used to find the level of breakdown

INTERVENTION SUMMARY
Effective Intervention MUST be deficit-specific AND include modifications, compensation, remediation

Bottom-Up management
• Noise abatement
• Clear Speech
• Visual cues
• Seating
• Assistive Listening Technology

Top-Down management
• Clear Language
• Familiarity & redundancy
• Curricular changes
• Technology

Use your ABCs
• A = activities & all day processing
  – CAP: starts auditory only, bottom-up- TRAINING
  – LP: starts multi-modality, top-down-TEACHING

• B = behavioral benchmarks
  – Use the hierarchy of skills
  – yes! CAP Tx does fit into the Common Core

• C = creating effective communication
  – CAPD – emphasis on acoustic signal
  – LPD – emphasis on comprehension

Great games to enhance auditory processing and related skills

<table>
<thead>
<tr>
<th>Game</th>
<th>Processing skill taxed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battleship</td>
<td>listening, patterning, integration</td>
</tr>
<tr>
<td>Boggle</td>
<td>pattern recognition, integration</td>
</tr>
<tr>
<td>Bopit,</td>
<td>integration, vigilance</td>
</tr>
<tr>
<td>Catch Phrase</td>
<td>integration, vocabulary, output</td>
</tr>
<tr>
<td>Clever Endeavour</td>
<td>metalinguistic strategies, critical</td>
</tr>
<tr>
<td>Feely Bag</td>
<td>interhemispheric communication</td>
</tr>
<tr>
<td>Ending sound game</td>
<td>auditory discrimination</td>
</tr>
<tr>
<td>Mad Gab</td>
<td>temporal patterning, language</td>
</tr>
<tr>
<td>Marco Polo</td>
<td>localization, binaural interaction</td>
</tr>
<tr>
<td>Musical Chairs</td>
<td>vigilance</td>
</tr>
<tr>
<td>Name that tune</td>
<td>interhemispheric integration</td>
</tr>
<tr>
<td>Game</td>
<td>processing skills taxed</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Password</td>
<td>vocabulary, linguistic skills</td>
</tr>
<tr>
<td>Plexers</td>
<td>metalinguistic strategies</td>
</tr>
<tr>
<td>Rags to Riches</td>
<td>metalinguistic skills (idioms)</td>
</tr>
<tr>
<td>Read My Lips</td>
<td>lipreading/speechreading</td>
</tr>
<tr>
<td>Scattergories</td>
<td>vocabulary, linguistic strategies</td>
</tr>
<tr>
<td>Simon</td>
<td>auditory-visual patterning</td>
</tr>
<tr>
<td>Simon Says</td>
<td>vigilance, active listening</td>
</tr>
<tr>
<td>Taboo</td>
<td>vocabulary, linguistic strategies</td>
</tr>
<tr>
<td>Twister</td>
<td>integration, critical listening</td>
</tr>
<tr>
<td>UpWords</td>
<td>integration, visual patterning</td>
</tr>
<tr>
<td>Wheel of Fortune</td>
<td>auditory closure</td>
</tr>
</tbody>
</table>

Resources for therapy

- Differential Processing Training Program (www.linguisticsystems.com)
- Processing Power (contact presenter)
- For more information about AP therapy in line with the Common Core, contact author at jmfphd@comcast.net