A Continuum Approach for Assessment of Auditory & Language Processing Disorders

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Speaker Disclosure

- Financial
  - Receive royalties from ProEd publications
  - The Source - Processing Disorders
  - The Language Processing Test
  - Language Processing Treatment Activities
  - Differential Screening Test for Processing Disorders
  - That’s Life Language Cards
    - Revenue share from MedBridge courses
    - Royalties from Dynamic Resources
    - Honorarium and travel reimbursement from ArkSHA
- Nonfinancial
  - Author of several book chapters and articles on processing

Historical Perspective

1954 – Myklebust – “auditory processing” in Auditory Disorders in Children

1962 – Vygotsky – “processing” in Thought and Language: relation between thought and words not a thing but a process - continuous back and forth movement from thought to word and word to thought

1978 – Weisenberg & Katz – “central auditory processing” in Neurological considerations in audiology: ability to receive and integrate auditory information

2005 – ASHA Working Group on Central Auditory Processing Disorders: perceptual processing of auditory information in the CNS and neural activity that underlies that processing

2007 – ASHA Ad Hoc Committee on Role of SLP in APD

2011 – LSHSS July Clinical Forum

Impact of Processing on Learning

- 1967 - Johnson & Myklebust: LD as disturbance in processing interfering with language comp. & verbal expression
- 1966 - Cruickshank: most LD result of processing deficits
- 1981 - Gerber & Bryen: processing difficulties result in school failure
- 2005 – ASHA Working Group: processing deficits may lead to or be associated with difficulties in learning

Major Points to Consider

- The problem is NOT in reception of signal
- Repeating the signal is minimally helpful
- Individuals process stimuli in different ways
  - Cues provide orientation, not the answer
  - Processing occurs “on top” of basic knowledge

Auditory Processing Defined

- Efficiency and effectiveness by which CNS utilizes auditory information (ASHA, 2005a) characterized by ...
- Poor performance in one or more of the following skills
  - Sound localization and lateralization
  - Auditory discrimination
  - Auditory pattern recognition
  - Temporal aspects of audition (e.g., temporal integration, discrimination, ordering, masking)
  - Auditory performance in competing acoustic signals (e.g., dichotic)
  - Auditory performance with degraded acoustic signals (ASHA, 2005b)

(Central auditory processing disorders: The role of the audiologist: a = Technical report; b = Position statement)
**Definition: Language Processing**
- Ability to abstract meaning from an acoustic stimulus (Massaro, 1983)
- Ability to interpret or attach meaning to auditorily received information to then formulate an expressive response (e.g., behavior, gesture, verbal, written) (Richard, 2017, 2001)

**Typical Problems Resulting from Processing**
- Reading
- Spelling
- Splintered Academics
- Written Language

**PROCESSING MODELS**

**Top - Down**
- Language info in mind of listener, not auditory signal
- Listener uses knowledge of language and world to interpret speaker’s message
- Process acoustic signal using lexical/semantic knowledge
  - familiar processed quicker
  - discriminate significant features

**Bottom - Up**
- Auditory processing is a “pre-linguistic” skill with acoustic info processed before linguistic
- Acoustic signal processed before being influenced by higher order knowledge
- Sound identification necessary prerequisite to speech-language development
- Tallal research: children with LD have deficits in rapid transition of both linguistic and non-linguistic signals

**Language Processing /Top Down**
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**Resolution**
- Processing is actually INTERACTIVE
- Type of processing depends on task
  - Times when focus on signal with minimal linguistic processing needed
  - Times when hear message but can’t understand message
- Most processing involves both signal processing & higher order processing
  - Continual fluctuation between signal (auditory) and cognitive (language)
- Different processing styles

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TOP DOWN
Language Processing
Knowledge of language & world to interpret
Semantic knowledge
Stress comprehension and intake

BOTTOM UP
Auditory Processing
Acoustic Information before linguistic interp
Acoustic knowledge
Stress production and output

The Neurology of Processing & Learning

“Language shapes culture, language shapes thinking – and language shapes brains. The verbal bath in which a society soaks its children arranges their synapses and their intellects; it helps them learn to reason, reflect, and respond to the world.”

Jane Healy, Endangered Minds (1990)

Neuropsychology:
Science of brain-behavior relationships
• All behavior mediated by CNS
• CNS composed of brain, brainstem, spinal cord
• Impairment in CNS will interfere with learning
• Brain dysfunction = interference in behavior
  o neurological model of diagnosis more objective
  o intervention only as effective as diagnosis
  o need to understand interference to remediate

A.R. LURIA
Functional Organization of the Brain
• Brain structures all play highly specific role & all under coordinated control
• Every mental activity affected through joint activity of discrete cortical systems
• When one system fails, behavior fails - but other parts secondarily resume that function
  o behavior returns in limited way
  o localization in diagnosis/remediation
  o individual differences as opposed to labels

FIRST FUNCTIONAL UNIT = RETICULAR FORMATION
• Neurological readiness to interact with environment
• Energy system for cortex
• Brainstem = midbrain, pons, medulla oblongata
• Maintain attentive state to incoming signals
• Awakens brain; keeps it alert; directs neural traffic
SECOND FUNCTIONAL UNIT = PARIETAL, OCCIPITAL, TEMPORAL LOBES

- Posterior two-thirds of cortex
- Isolate neural impulses into discrete areas for analysis, storage, coding, organization
  - Visual stimuli = Occipital
  - Tactile stimuli = Parietal
  - Auditory stimuli = Temporal
- Each cortical section further delineated into three zones

THIRD FUNCTIONAL UNIT = FRONTAL LOBES

- Anterior one-third of cortex, including frontal lobes, motor/pre-motor cortex
- Active response through motoric expression to stimuli processed in second functional unit
- Planning and execution, managing of person’s behavior in relation to perceptions and knowledge - through motor response

PRIMARY ZONE

- Reception of incoming neural impulses
  - Visual stimuli = Occipital
  - Tactile stimuli = Parietal
  - Auditory stimuli = Temporal
- NOT involved in interpretation of meaningfulness of stimuli; only sensory analysis/sensation
- Impairment = sensory/perceptual impairment; not deficit in higher order processing

SECONDARY ZONE

- Organize incoming information according to rules of language - attach meaning to input
  - Visual meaning = Occipital
  - Tactile meaning = Parietal
  - Auditory meaning = Temporal
- Interpretation through coding, organizing, associating, storing
- Integrate into meaningful experiences

TERTIARY ZONE

- Multisensory neural integration among sensory secondary zones
  - Integrate newly organized stimuli with stored information
  - Integrate discrete neural impulses between modality areas
- Coordinate higher level processing
  - Integrate information from all cortices
  - Transfer passive receptive input into active expressive output
Second Functional Unit – Left Temporal Lobe

<table>
<thead>
<tr>
<th>PRIMARY</th>
<th>SECONDARY</th>
<th>TERTIARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory/ acoustic perception</td>
<td>Attach Meaning</td>
<td>Integration/ synthesis</td>
</tr>
<tr>
<td>Auditory Integration</td>
<td>Language Integration</td>
<td>Cortical Integration</td>
</tr>
</tbody>
</table>

MODEL CONCLUSIONS

- Model supports hierarchical integration of processing following neuromaturational order of zones
  - zones develop maturationally in order - primary, secondary, tertiary
  - tertiary zone last to mature and most fragile
- Progressive attachment of meaning to stimuli supports contribution of each level in hierarchy
- Concept integrates entire nervous system in thinking process

Behavior Characteristics

Let's Meet Some Processing Disordered Students!!

- Most are male (75%)
- Normal pure tone hearing
- Trouble following directions
- Short attention span
- Poor memory
- Don’t seem to pay attention
- Poor listening in noisy environment
- Trouble locating sound
- Academic deficits
- Behavior problems
- Requests for repetition – “huh”
- Otitis media

CAP

LANGUAGE PROCESSING

- Word retrieval problems
- Neutral generic language
- Similar words
- Original creative words
- Response latency
- “I don’t know”
- Rehearsal
- Inconsistent learning
- Recognize but can’t fix errors
- Incomplete expressive language
- Pragmatic deficits; behavior problems
- Age commensurate ability
Characteristics of Processing Disorders

• Overlap / Similarity in observed behaviors
• Same behavioral symptom for different reasons
• Differential diagnosis important to determine appropriate intervention approach

Semantic Confusion

• Processing
• Auditory processing
• Central auditory processing
• Language processing

Depends on how you look at it!

On-going controversies in assessment and intervention in APD

Problem

Assessing and/or Treating the multiple aspects of an auditory or language processing disorder is a challenge

Adjunct Problems

“Although abilities such as phonological awareness, attention to and memory for auditory information, auditory synthesis, comprehension and interpretation of auditorily presented information, and similar skills may be reliant on or associated with intact auditory function, they are considered higher order cognitive communicative and/or language related functions and, thus are not included in the definition of (C)APD” (ASHA 2005a)
**APD vs. CAPD?**

- Myklebust, 1954 – “auditory disorder” – very broad term
  - Intact peripheral hearing
  - Deficit – ability to listen and meaningfully respond to acoustic stimuli
  - “central deafness” – problem in higher neurological levels of auditory system
  - Auditory agnosia: can’t attend or comprehend auditory input
- Weisenberg & Katz, 1978 – “Central auditory processing”
  - Post-peripheral auditory deficit
  - Difficulty in ability to receive and integrate auditory information
- ASHA 2005 working group – (central) auditory processing disorder (C)APD – synonymous terms

**Consensus Definition of APD?**

- Multiple auditory skills encompassed within APD
  - Diagnose by specific deficit skill or global APD?
  - Battery of tasks/test for assessment of APD
    - Specific battery not specified
    - Variability among audiologists diagnosing APD
  - Lack definitive standard for interpretation of APD test
    - Combination of observed clinical impressions and performance outcomes on assessment tests
    - Recommendation: child perform 2 standard deviations below mean on two or more tests for APD diagnosis
- Issues with specificity and validity of APD assessments
- Need some guidelines for relationship between cognition, language skills, and performance on (C)AP tests (Friberg & McNamara, 2010)

**Relationship of APD and LD?**

- Premise – address auditory perceptual deficits before language
  - Challenged by Rees (1973) – futile effort to isolate specific auditory abilities as essential to language; artificial effort to make fit
  - Continue to question auditory deficits as significant risk factor for compromised language development (Kamhi, 2011; Watson & Kidd, 2009)
- Influence of auditory perceptual abilities on language development in pre-literacy skills (e.g., sound-symbol recognition, discrimination)
- Acknowledge dynamic interaction between perception of acoustic signal and linguistic decoding to interpret meaning

**Erroneous Diagnosis of APD?**

- Language developmental level influences performance on APD assessment tasks (e.g., directions of dichotic assessment task)
- Referrals from adjunct professional disciplines (e.g., teacher, school psychologist)
  - Observe deficits in listening, auditory comprehension, discrimination for spelling
  - Assessment tasks or screening checklists that resulted in APD
- Failure to recognize global profile of child (e.g., ADHD, ASD, EF)
- Early APD in conjunction with developmental delays resolved but diagnosis not changed
- Imperative that AUD and SLP work together to determine primary deficits negatively impacting academic and functional performance (McNamara & Richard, 2012)

**Adequate Processing Involves Continuum of Skills**

- Intact peripheral auditory system – perceive and receive acoustic stimulus
- Intact CANS – transmit through brainstem to upper cortex
- Phonemic knowledge to discriminate aspects of the acoustic stimulus
- Linguistic knowledge to decode message
- Executive function skills to attend, organize, execute behavioral response

**Continuum of Processing**

- Auditory Processing
  - audiologist
- Language Processing
  - speech-language pathologist
- Transition Area
  - Acoustic / Phonemic Processing
  - audiologist and speech-language pathologist

**Assessment**

**Continuum of Processing**
- Auditory Processing: audiologist
- Language Processing: speech-language pathologist
- Transition Area: Acoustic / Phonemic Processing: audiologist and speech-language pathologist

**AUD and SLP = Team Approach**
- Differentiate auditory versus language aspects of disorder
- Auditory aspects assessed by audiologist
- Language aspects assessed by speech-language pathologist
- Need to determine level of breakdown to program effective intervention

**Philosophy of CAP**
- CANS responsible for transferring auditory signal through brainstem to cortex
- Signal reaches brain intact = normal CAP
- Signal distorted or compromised when reaches brain = CAPD

**The geography of the auditory system**
- Peripheral system
  - Hearing sensitivity and acoustic reflexes
- Brainstem system
  - Acoustic reflexes
  - Binaural interaction
- Cortical system
  - Discrimination
  - Dichotic listening
  - Temporal processing

**Peripheral Auditory system**
- Outer ear
- Middle ear
- Inner ear
- 8th nerve
Peripheral auditory function

- Hearing sensitivity and reflex action
  - Signal collection – outer ear
  - Signal transmission – middle ear
  - Signal detection – inner ear
  - Signal transformation – 8th nerve

Central Auditory Nervous System (CANS)

- Transfer stimulus from inner ear to cortex
- Extremely complex system
  - Six different points to deal with auditory information
  - Four different pathways
  - Four cross-over points
  - One million cells
  - Eight different cellular responses
  - Six different cell types

Central Auditory Processing

- Purpose
  - Assess brainstem and cortical function
  - Stress the system by eliminating redundancy or compromising the signal

- Premise
  - Brain looks for consistency in processing auditory signal
  - If confusing signal, abnormal behavioral response
  - Meaning derived from signal not dependent on receiving every formant
  - Acoustic info combines with linguistic context to attach meaning

CAPD Test Battery

- Minimize influence of language, cognition & other sensory skills on performance

- Maximize function of CANS

- Results examined re:
  - central auditory processes being taxed
  - anatomical sites subserving those skills
**Example Acoustic Skills**

- Binaural processing
- Auditory Localization
- Speech in Noise
- Temporal processing
  - Temporal pattern discrimination/recognition
  - Temporal recognition/manipulation of multiple targets
- Auditory Vigilance

**CAP Test Battery**

- Binaural interaction tasks
  - Tap brainstem level interaction between ears
    - Binaural fusion
    - Masking level difference
    - LISN
  - Monaural low redundancy tasks
    - Tap cortical auditory closure/discrimination
      - Low-pass filtered speech
      - Time-compressed speech

**CAPD Test Battery**

- Binaural Integration
  - Tap cortical level integration skills
    - Dichotic digits
    - Dichotic rhyme
    - Staggered spondaic words
    - Dichotic CVs
    - Competing words
- Binaural Separation
  - Tap cortical level separation skills
    - Provide information re neuromaturation
    - Competing sentence tests

**Continuum of Processing**

<table>
<thead>
<tr>
<th>Auditory Processing</th>
<th>Language Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>audiologist</strong></td>
<td><strong>speech-language pathologist</strong></td>
</tr>
<tr>
<td>Transition Area</td>
<td>Acoustic / Phonemic Processing</td>
</tr>
<tr>
<td>audiologist and speech-language pathologist</td>
<td></td>
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**SLP Assessment Concerns**

- Does child accurately receive signal?
- Does signal accurately transfer through the Central Auditory Nervous System to upper cortex?
- Can child retain signal long enough to analyze signal (e.g., identify sound segments)?
- Does child comprehend/understand what the signal means?

**SLP Assessment**

- Audiology has been neurological in assessment approach
- Speech-language pathology has been very behavioral in assessment approach
- SLP needs to become more neurological in approach; realize that brain mediates behavior
**Processing Assessment**

- Receptive Language Developmental Level
- Primary Zone - Functional Auditory Skills
- Secondary Zone - Hierarchy of Language Complexity
- Tertiary Zone - Integration of Language into Executive Functions
- Supplemental - Memory; Word Retrieval

**SLP Assessment**

- Auditory only; visual adds compensatory
- Begin in overlap area
  - If fail, refer for central auditory assessment
  - Assess phonemic awareness of signal
- Hierarchy of language complexity
  - Begin simple and discrete
  - Increase language demand
- Battery of tasks/tests

**Phonetic /Phonemic Processing**

- Preliteracy foundation
  - Sound-symbol correspondence
  - Spelling
  - Reading
  - Written Language
- Weak area for this generation
  - Visual learners
  - “Text speak”

**Phonemic Processing Skills**

- Auditory Analysis / Segmentation
- Auditory Attention
- Auditory Association
- Auditory Closure
- Auditory Discrimination
- Auditory Figure Ground
- Auditory Localization
- Auditory Memory
- Auditory Sequential Memory
- Auditory Synthesis / Sound Blending/Closure

**Example Assessment Instruments for Functional Auditory Skills**

- Illinois Test of Psycholinguistic Abilities (ITPA)
- SCAN Screening test for auditory processing
- Differential Screening Test for Processing (DSTP)
- Goldman-Fristoe-Woodcock
- Phonological Awareness Test (PAT)
- Comprehensive Test of Phonological Processing (CTOPP)
- Test of Auditory Processing Skills (TAPS)

**Linguistic Processing**

- Language Foundation for metalinguistic skills
- Ability to comprehend and express ideas through auditory to verbal modality
- Conceptual basis for higher level, more complex language
Language Processing Skills

• Labeling
• Stating Functions
• Association
• Categorization
• Antonyms
• Synonyms
• Idioms
• Analogies
• Multiple Meanings
• Stating Attributes

Sample Secondary Zone Hierarchy – Language Processing Test

• Labeling – nouns
• Functions – verbs
• Association
• Categorization
• Similarity
• Difference
• Multiple Meaning
• Attributes

Secondary Zone Assessment

• Language Processing Test
• WORD
• Comprehensive Assessment of Spoken Language
• Bracken Basic Concept Scale

Caution: Be sure you are assessing temporal lobe/auditory skills; monitor influence of other modalities (e.g., visual, motor)

Tertiary Zone Assessment

• Test of Problem Solving
• CELF
• Listening Test
• Detroit Test of Learning Aptitude

Executive Functions

• Ability to plan, organize, manage, execute response
• Coordinate and integrate the foundation skills from the temporal lobe
• Under frontal lobe, pre-motor, motor cortex control
• Orchestra analogy
• Computer isn’t spooling to the printer

Third functional unit
**Executive Functions Skills**
- Attention
- Inhibition
- Planning and Organizing
- Initiation and Persistence
- Flexibility Self-Regulation
- Goal Selection
- Problem Solving
- Working Memory
- Impulsivity
- Abstract Reasoning

**Example Assessments for Executive Functions**
- Behavioral Rating Inventory of Executive Functions (BRIEF)
- Behavioral Assessment of Dysexecutive Syndrome in Children (BADS-C)
- Functional Assessment of Verbal Reasoning and Executive Strategies (FAVRES)
- Stroop Color and Word Test – children
- Diagnostic Analysis of Nonverbal Accuracy 2 (DANVA 2)

**Adjacent Areas of Assessment**
- Auditory Memory-related/unrelated
  - ITPA: Auditory Sequential Memory
  - ACLC
  - TOLD, CELF – Sentence
    - Imitation/Repetition
- Word retrieval
  - Test of Word Finding
  - Northwestern Word Latency Test
  - Informal

**Types of LP Procedures**
- Auditory input
- Subtest complexity
- Discrete language skills
- Increase processing demand
- Multimodality tertiary integration skills

**CAP Assessment Summary**
- Auditory/acoustic processing occurs before you “know” the target
- Auditory processing is “adult-like” by early teens
- Auditory processing can affect and be affected by language, learning, social-emotional health, neurocognitive skills
- Differential diagnosis MUST be used to find the level of breakdown
- Audiologists DIAGNOSE specific CAPD using controlled, norm-referenced BATTERY of tests
- Assess all skill sets - auditory discrimination, temporal processing and binaural processing – get multiple “looks”
- Consider effects of age/test construction on reliability
- Look for patterns to make diagnosis

**LP Assessment Summary**
- Language develops in hierarchy of cognitive complexity
- Language progresses from concrete functional to more abstract
- Language processing is imposed ‘on top of’ basic language foundation
- Language processing continues to develop and refine throughout life
- Language processing can affect and be affected by sensory processing and executive skills
Differential Screening Test of Processing
• Screens continuum
• 8 subtests delivered via CD rom
• 3 auditory processing
• 2 phonemic/phonic
• 3 language
• Identifies where to refer and/or spend more time in assessment
• Available from www.proedinc.com

Listen carefully!
• Did you hear that?
• Can you repeat it?
• Can you tell me the first sound you heard?
• Can you tell me another sound you heard in the phrase?
• Can you tell me what the phrase meant?
• Will repeating it multiple times help?
• Will amplifying the phrase help?
• Will saying it slower help?

If yes...
If no...

Neurological Continuum of Processing

<table>
<thead>
<tr>
<th>Anatomic Structure/Site</th>
<th>Type of Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral Auditory System</td>
<td>Auditory Acuity; Reception of Signal</td>
</tr>
<tr>
<td>Central Auditory Processing</td>
<td>Neurological Transfer of signal; Discrimination of acoustic characteristics of signal</td>
</tr>
<tr>
<td>Phonemic Processing</td>
<td>Discrimination of phonemic characteristics of signal</td>
</tr>
<tr>
<td>Language Processing</td>
<td>Use linguistic characteristics of signal; attach meaning using code</td>
</tr>
<tr>
<td>Executive Functions</td>
<td>Planning and executing response</td>
</tr>
</tbody>
</table>

Confluence of Processing Disorders
A. CAPD only
B. PPD only
C. LPD only
D. CAPD & PPD
E. CAPD & LPD
F. PPD & LPD
G. CAPD, PPD, & LPD

The practical importance of making a correct diagnosis is that children having different types of problems vary significantly in their needs and unless a differential diagnosis is made, their potentialities are lost.

-H. Myklebust, 1954

Selected References