Central Auditory Processing Disorders: Neurobiology, Differential Diagnosis, and Intervention

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Definition and Nature of CAPD

To develop a definition of CAPD, we must first understand the nature of auditory processing and its disorders.

What does the science tell us about the nature of CAPD?

The evidence to guide our endeavors is drawn from many disciplines:
- Cognitive neuroscience
- Neuropsychology
- Cognitive psychology
- Auditory neuroscience
- Psycholinguistics
- Neurobiology/general neuroscience
- Others

Modality Specificity

- Modality specificity as a criterion for diagnosing CAPD (McFarland & Cacace, 1995; Cacace & McFarland, 1998)
- CAPD is a disorder that is specific to the auditory modality (Jerger & Musiek, 2000).
Are definitions of CAPD that require complete modality specificity as a diagnostic criterion ecologically valid?

Is the demonstration of complete modality specificity required for diagnosis of other disorders involving the auditory system?

Fundamentals of Brain Organization

- Few, if any, entirely compartmentalized areas of the brain responsible for a single sensory modality
- Evidence of convergent sensory “tracks,” multisensory neurons, and neural interfacing

Multimodality influences affect even the most basic neural encoding and manipulation of sensory stimuli

Processing of sensory data is interdependent and integrated, and supported by cognitive domains and language representations

Information Processing Theory: Applications to CAPD

- Bottom-up factors in auditory processing:
  - “Data-driven”
  - Acoustic properties of auditory stimulus
  - We cannot discount the influence of the auditory periphery on “central” auditory processing!

Top-down factors in auditory processing:
  - “Concept-driven”
  - Includes attention, language, cognition, executive function
  - Will affect the sensory percept – thus, we cannot discount the influence of higher-order factors on auditory processing, either!
Research is emerging to support the nonmodularity of central auditory dysfunction:
- Bellis et al. Use of visual analogs to central auditory tests; auditory and multimodal findings in interhemispheric dysfunction.
- Kraus et al. Impact of visual system, limbic system, and other factors on temporal processing at brainstem level.

Auditory processing is neither exclusively bottom-up nor top-down; it consists of interactive networks and multiple information sources that guide pattern identification and interpretation. The relative influence of top-down or bottom-up processing is influenced by changing listening demands.

Therefore:

Any definition of CAPD that specifies complete modality-specificity as a diagnostic criterion is neurophysiologically untenable.

Relationship of CAPD to Language, Learning, and Communication

Lack of association between basic auditory processes and language/learning outcomes (e.g., Bishop et al., 1999; Watson & Kidd, 2002)

Associations between auditory processing and language/learning outcomes depend upon the type of auditory deficit, type of language/learning difficulty, and unique confluence of the individual’s bottom-up and top-down abilities (e.g., Bellis & Ferre, 1999; Cestnick & Jerger, 2000; Heath et al, 1999)

Evidence of abnormal neurophysiologic representation of auditory (especially speech) signals in children with language-based learning and reading disorders (e.g., Abrams et al., 2006; Banai et al., 2005; Kraus et al., 1996; Warrier et al., 2004; Wible et al., 2004, 2005).
Therefore:

Heterogeneity of both CAPD and learning and related disorders precludes a simple one-to-one correlation between basic auditory processes and higher-order sequelae across large numbers of diverse subjects.

Brain Organization and Co-Morbidity

- Organization of the CNS underlies co-morbidity of disorders, e.g., CAPD and
  - ADHD
  - Learning or Language Disorder
  - Other

Resource Allocation

- Resource allocation occurs across systems and modalities

- Therefore, disproportionate allocation of resources to one system/task/skill (e.g., audition) may leave little left over for other tasks (e.g., comprehension, memory).

Toward an ecologically valid operational definition:

- CAPD (ASHA, 2005; AAA, 2010):
  - is a deficit in the perceptual processing of auditory stimuli, and the neurobiological activity underlying that processing

Evidence supporting a neurobiological basis to CAPD

- Abnormal neurophysiologic representation of both speech and nonspeech signals
- Atypical interhemispheric transfer
- Atypical timing in system
- Atypical hemispheric asymmetries
- Other

CAPD

- may lead to or be associated with difficulties in higher-order language, learning, and communication function; but the relationship is far from simple
- cannot be attributed to higher-order language, cognitive, or related confounds
- may co-exist with, but is not the result of, dysfunction in other modalities
Affects the perceptual and neural processes in CNS underlying:
- Localization/lateralization
- Discrimination
- Auditory pattern recognition
- Temporal processing
- Performance with competing/degraded acoustic signals

Abilities such as phonological awareness, attention to and memory for auditory information, auditory synthesis, comprehension and interpretation, and similar skills may be reliant upon or associated with intact central auditory function...

BUT

they are considered higher-order cognitive/communicative and/or language-related functions and, thus, are not included in the definition of CAPD

Definition/Nature of CAPD

Informs Diagnosis:

Because of the interactive nature of auditory processing, to document a (central) auditory deficit, you must use:

The terms auditory processing, phonological processing, language processing, and cognitive processing are NOT synonymous, although the skills may be inter-related and the behaviors may be similar.
Test tools that have documented sensitivity and specificity to known dysfunction of the CANS.

Tools developed/validated for other purposes (i.e., learning disability, language impairment) CANNOT be used for this purpose!

Because CAPD is an auditory disorder, the audiologist diagnoses CAPD.

Definition/Nature of CAPD

Informs Intervention:

Intervention for CAPD should:

- be a multidisciplinary endeavor, and should address both bottom-up and top-down skills
- be individualized and deficit-specific (the diagnosis drives the treatment)
- focus on improving access to auditory information, strengthening central resources, and remediating the auditory deficit

Definition of Terms

- **Diagnosis**: Determination of presence and nature of disorder
- **Assessment**: Data-gathering process to examine current levels of functioning and strengths and weaknesses

Auditory Processing Assessment and Diagnosis
All CAPDs do not lead to speech or language difficulties
All speech, language, and related difficulties are not due to or associated with CAPD

The Audiologist’s Role
- CAPD is an auditory disorder; therefore, the audiologist diagnoses CAPD
- The audiologist must have the necessary training and skills to do so

The SLP’s Role
- SLPs and other professionals collaborate in the assessment of individuals suspected of CAPD for both differential diagnostic and intervention purposes
- The SLP is uniquely qualified to delineate the cognitive/communicative and speech/language factors that may be associated with CAPD

Screening for CAPD
- Purpose:
  - To determine need for further testing
  - To reduce over-referrals
Screening for CAPD  
(Jerger & Musiek, 2000)

- Screening by questionnaire:
  - Difficulty hearing/understanding in noise
  - Difficulty following spoken directions
  - Difficulty discriminating/identifying speech sounds
  - Inconsistent responses to or awareness of auditory information

- Screening by Test:
  - Dichotic Digits Test
  - Gap Detection Test

- Under age 6-7: Use questionnaires

Does this really reduce over-referrals???

Screening for CAPD  
(Bellis, 2003)

- Review of “other systems” is a key component of screening
- Screening is focused on answering four primary questions:

1. Are the current evaluations sufficient in scope?
2. Is there a likelihood of CAPD?
3. Can the child participate in the evaluation?
4. Would results of assessment add information that would affect management?

Outcomes of Screening
- Referral for comprehensive assessment
- Referral for other testing/follow-up
- Interim Recommendations
- Other
Diagnosing CAPD

**Principles of CAPD Diagnosis**

- Purpose of Diagnostic Testing: To identify presence and delineate characteristics/nature of central auditory deficit
- Requires audiologist-administered diagnostic tests of central auditory function

- Provides information regarding integrity of left-hemisphere, right-hemisphere, interhemispheric, and brainstem auditory structures

- May include psychophysical and/or neuro(electro)physiologic tests of central auditory integrity
- Leads directly to development of deficit-specific treatment and management plans

**Diagnostic Tests for CAPD**

- Must employ a test battery approach that assesses various levels/loci within the CNS, as well as different perceptual processes
- The tests chosen should meet accepted psychophysical and scientific standards, should control for higher-order confounds, and should be appropriate to the individual being tested!

**Most importantly:**

The tests used should have been demonstrated to be sensitive, reliable, and efficient for identification of CANS dysfunction
Because of the interactive nature of auditory processing, to document a (central) auditory deficit, you must use:

- Test tools that have documented sensitivity and specificity to known dysfunction of the CANS
- Tools developed/validated for other purposes (i.e., learning disability, language impairment) CANNOT be used for this purpose!

**Behavioral Tests**

(Categories)

- Dichotic Speech Tests
- Temporal Patterning Tests
- Tests of Other Temporal Processes
- Monaural Low-Redundancy Speech Tests
- Auditory Discrimination Tests
- Tests of Localization/Lateralization

**Electrophysiologic Tests**

(Categories)

- Standard ABR, MLR, Corticals, P300
- Multi-channel MLR and Corticals to speech and nonspeech signals (electrode and ear effects and hemispheric asymmetries)
- Other (e.g., MMN, etc.)
- Brainstem responses to speech and other complex signals

Electrophysiologic and related measures may play an important role in the objective demonstration of neural deficits in the auditory system in many cases, as well as in the documentation of treatment efficacy. They may also indicate which patients might benefit from training (e.g., speech-evoked ABR!)

**Test Battery Interpretation**

- Norm-referenced criteria
- Using the patient as his/her own control (pattern analysis using neurophysiologic tenets):

Intra-test analysis (including ear differences)

Inter-test analysis

Cross-discipline analysis
A diagnosis of CAPD is enabled only when performance on ≥ 2 tests is abnormal AND the pattern of findings is consistent with underlying neuroscience tenets (ASHA, 2005).

Lack of a pattern (e.g., poor performance on all measures) argues for more global or motivational deficit, not CAPD.

Levels of Interpretation

- Site-of-dysfunction-based interpretation
- Process-based interpretation
- Functional deficit profiling

Purpose

- To identify the auditory deficits using results of behavioral central auditory testing and other data to determine specific areas of auditory dysfunction that need to be targeted

Process-Based Interpretation

- Auditory performance with competing acoustic signals
  
  Binaural Separation – assessed by dichotic tests involving directed attention (e.g., Competing Sentences)

- Auditory performance with competing acoustic signals
  
  Binaural Integration – assessed by dichotic tests involving report of both ears (e.g., Dichotic Digits)
Auditory performance with competing acoustic signals

- Binaural Fusion (e.g., Dichotic Rhyme)

Auditory performance with degraded acoustic signals

- Auditory Closure – assessed by tests of monaural low-redundancy speech and those involving ipsilateral competition (e.g., Filtered Speech, Time-Compressed Speech)

Auditory Pattern Recognition

- Auditory Patterning/Temporal Ordering – assessed by temporal patterning tests (e.g., Frequency and Duration Patterns)
  - Includes aspects of nonspeech discrimination, interhemispheric transfer, sequencing, and specific temporal processes

Auditory Discrimination

- Complex auditory skill
- Element of virtually all central tests
  - Can be directly assessed through difference limens for nonspeech stimuli, speech-sound discrimination tasks, etc.

Temporal Aspects of Audition

- Critical for discrimination, localization/lateralization, prosody perception, etc.
  - Can be assessed through direct measures of temporal resolution (e.g., gap detection), temporal masking, temporal integration/summation, etc.

- Discrimination and temporal processing also can be assessed indirectly through electrophysiologic indicators of neural representation and discrimination (e.g., MLR, Cortical Responses, MMN, speech-evoked ABR)
**Remember: TIMING IS EVERYTHING!**

ALL CAPDs LIKELY HAVE SOME DEFICIT IN TEMPORAL PROCESSING!

Sound Localization/Lateralization
- Critical for speech-in-noise skills and other auditory functions
- Tapped by tests such as MLD, binaural interaction tests, LISN
- Additional research needed

Functional Deficit Profiling
- Involves examination of auditory and cross-discipline data for patterns that conform to well-established neurophysiologic and neuropsychologic tenets
- Not intended to be a “catch-all,” cookie-cutter approach to interpretation and programming treatment

Key to interpretation, diagnosis, and effective treatment: Presence of patterns that make sense based on scientific foundations and principles

Functional deficit profiling serves as a guide for clinicians to assist them in understanding these patterns

ONE Subprofiling Method: The Bellis/Ferre Model
- Involves integration and pattern analysis of auditory and multidisciplinary findings
- Three primary profiles:
Auditory Decoding Deficit
- Auditory deficits indicate left-hemisphere (primary auditory cortex) pattern:
  - Bilateral or right-ear deficit on dichotic speech tasks
  - Poor performance on auditory closure tasks
  - Poor phoneme discrimination
  - Reduced LH electrophysiologic responses (MLR, cortical)
  - Poor temporal resolution abilities

Associated difficulties in left-hemisphere functions:
- Phonological decoding (word attack) difficulties
- Speech-in-noise problems
- Better performance with visual/multimodality cues
- Other phonological and language-based concerns
- Better Performance than Verbal IQ

Prosodic Deficit
- Auditory deficits indicate right-hemisphere pattern:
  - Left-ear deficit on dichotic speech tasks
  - Poor temporal patterning performance (BOTH humming and labeling)
  - Reduced RH electrophysiologic responses (MLR, cortical)
  - Elevated frequency, intensity, duration difference limens

Associated difficulties in right-hemisphere functions:
- Sight word reading and other Gestalt patterning difficulties
- Problems with prosody perception
- Poor pragmatic skills
- Sequencing difficulties
- Other RH difficulties (e.g., visual-spatial skills, math calculation, better verbal than performance IQ)

Integration Deficit
- Auditory deficits indicate inefficient interhemispheric transfer:
  - Left-ear deficit on dichotic speech tasks (opposite for nonspeech)
  - Poor temporal patterning performance (labeling ONLY)
  - Traditional electrophysiologic responses (MLR, cortical) often normal; may see reduced hemispheric asymmetry to speech stimuli

Associated interhemispheric difficulties:
- Poorer performance with multimodality or visual cues
- Sound-symbol association difficulties
- Speech-in-noise and localization difficulties
- May have subtle difficulties in other interhemispheric tasks (bimanual/bipedal activites, etc.) but not "true" sensory integration dysfunction
A Fourth Subprofile

- Brainstem timing deficit
- Abnormal performance on speech-evoked ABR, associated with speech-in-noise complaints, reading deficits, and other symptoms
- Indicates potential for success with auditory training

Summary

- Accurate assessment and diagnosis of CAPD requires:
  - Ecologically valid definitions of CAPD
  - Evaluation of a variety of processes and CANS sites
  - Multidisciplinary input

The key to interpretation and differential diagnosis:

- Analysis of findings for neurophysiologically tenable PATTERNS consistent with CANS dysfunction

Comprehensive Intervention for CAPD

Basic Principles of CAPD Intervention

- Should arise logically from specific auditory deficits and functional/behavioral sequelae
- Results of diagnostic testing, along with other information, provide the framework

The key to effective treatment is accurate diagnosis!
Four-Step Process for Programming Deficit-Specific Intervention for CAPD

STEP ONE
- Identify the auditory deficits using results of behavioral central auditory testing and other data to determine specific areas of auditory dysfunction that need to be targeted.

STEP TWO
- Relate auditory deficits to language, learning, communication, and related sequelae for development of ecologically valid treatment plan.
- Functional Deficit Profiling

STEP THREE
- Select appropriate treatment and management strategies based on auditory deficits and related functional sequelae identified.
- Should be individualized and ecologically valid.

Components of Intervention Programs for CAPD

- Intervention should employ “bottom-up” (e.g., auditory training, signal enhancement) and “top-down” (e.g., compensatory strategies, central resources training, instructional modifications) approaches.
- Should include three components:
1. Environmental Modifications (bottom-up and top-down)
   To enhance access to and acoustic clarity of auditory information
   To increase opportunity for effective listening/learning

2. Compensatory Strategies/Central Resources Training (top-down)
   To strengthen higher-order top-down processing skills (metacognition, metamemory, metalinguistic)
   To overcome secondary/associated motivational and related deficits

3. Direct Remediation Techniques (bottom-up)
   To improve auditory performance by altering the way the brain processes sound
   Involve targeted activities that maximize neuroplasticity

Auditory Neuroplasticity and Auditory Training

- Auditory training can lead to functional AND structural alterations in neural and perceptual processing of auditory information
- Stimulation should be
  - Frequent
  - Intense
  - Challenging

Maximizing Neuroplasticity

- Stimulation activities also should:
  - Involve active participation on the part of the listener
  - Provide salient reinforcement to maximize long-term potentiation

Computer-Assisted Therapies

- Allow for multisensory stimulation, sustained interest, reinforcement, and intense/frequent stimulation
- BUT
- Use should be individualized and deficit-specific!
STEP FOUR

- Data collection re: individual efficacy of management/intervention components
- Group efficacy data collection and analysis

Focus on BOTH pre- vs post-test scores/physiologic data AND functional improvements in daily listening, learning, communication behavior

Electrophysiologic measures may play an important role in the objective demonstration of treatment efficacy and may be useful in indicating candidacy for treatment in some cases.

PROGRAMMING DEFICIT-SPECIFIC INTERVENTION: CASE STUDIES

Case Studies

- NOTE: The following treatment and management suggestions are NOT intended to be cookie-cutter approaches, but rather serve as examples of the types of activities that may be chosen for individuals presenting with different functional profiles of CAPD

CASE #1
Case #1:

- Age 8 years, 9 months
- Normal peripheral hearing sensitivity
- Primary complaint: Difficulty hearing in noisy environments; word-attack (phonics) difficulties in reading and spelling; sight-word reading good

- Frequently “mis-hears,” asks for repetition
- Very good performance in math and other non-verbal activities
- Some deficiencies in vocabulary
- Early history of phonological disorder (articulation...non-developmental)

CASE #1

Reduced electrophysiologic (MLR and cortical) responses over left-hemisphere electrode sites

Impression: CAPD likely involving left (primary) auditory cortex (e.g., “Auditory Decoding Deficit” in Bellis/Ferre model), including speech-sound representation and auditory closure abilities

“Auditory Decoding Deficit”

- Primary Deficit: Auditory Closure
- Secondary Deficits: Speech-sound discrimination, Temporal processes
- Site-of-dysfunction: Primary auditory cortex (left hemisphere)
- **Associated Difficulties:** Hearing in noise, phonological decoding, vocabulary, auditory fatigue, enhanced performance with visual or multimodality augmentation

- **Environmental Modifications**
  - Acoustic Enhancements
  - Preferential Seating
  - Assistive Listening Devices
  - Preteach new information
  - Repetition
  - Visual/multimodality augmentation

- **Compensatory Strategies**
  - Active Listening Techniques
  - Attribution Training
  - Auditory Closure
  - Vocabulary Building
  - Problem-Solving

- **Direct Remediation Activities**
  - Temporal resolution/integration
  - Phoneme Discrimination
  - Speech-in-Noise Training
  - Phonological Awareness
  - Speech-to-Print (word attack) Skills

**CASE #2**

- **Case #2:**
  - Age 8 years, 1 month
  - Normal peripheral hearing sensitivity and electrophysiology
  - Primary complaint: Difficulty hearing in noisy environments; reading/spelling difficulties
  - AD/HD ruled out
Some bimanual/bipedal difficulties
No improvement with addition of multimodality cues
Parents and teachers reported “auditory comprehension difficulties” despite essentially normal language development

Electrophysiology (ABR, MLR, LEP) normal
Impression: CAPD likely involving interhemispheric transfer of information (e.g., “Integration Deficit” in the Bellis/Ferre Model)

“Integration Deficit”
- Primary Deficit: Binaural separation/integration
- Secondary Deficits: Localization
- Site-of-dysfunction: Interhemispheric pathways (corpus callosum)

Associated Difficulties: Speech in noise, linking prosodic and linguistic elements of speech, sound-symbol association, multimodal complaints

Environmental Modifications
Acoustic Enhancements
Preferential Seating
Assistive Listening Devices
Provide note-taker
Avoid use of multimodality augmentation
Compensatory Strategies
- Attribution Training
- Problem-Solving Skills
- Active Listening Techniques

Direct Remediation Activities
- Localization Training
- Dichotic Listening Training
- Multimodal Interhemispheric Exercises

CASE #3

Case #3:
- Age 27 years, 11 months
- Normal peripheral hearing sensitivity; TBI (auto accident)
- Primary complaint: Difficulty interpreting tone-of-voice cues
- Some topic-maintenance issues and difficulty getting the main idea of a story or communication

- Significant visual/spatial difficulties
- Math calculation difficulties
- Some emotional lability issues; possibly at-risk for depression

CASE #3
MLR, LEP reduced over right hemisphere
MRI: “Swelling” over right hemisphere
Nonspeech discrimination poor, speech-sound discrimination good
Other results WNL
Impression: CAPD likely involving nonprimary (right) auditory cortex (e.g., “Prosodic Deficit” in the Bellis/Ferre Model)

“Prosodic Deficit”

– Primary Deficit: Auditory Patterning/Temporal Ordering
– Secondary Deficits: Nonspeech-sound discrimination
– Site-of-dysfunction: Nonprimary (right) hemisphere

Associated Difficulties:
Comprehension of communicative intent, Gestalt pattern recognition deficits, pragmatics, sequencing, other right-hemisphere sequelae

Prosodic Deficit

Environmental Modifications

– Acoustic clarity less critical
– Avoid “hints” or subtleties
(Placement with “animated” teacher)
(Note-taker may be indicated)

Compensatory Strategies
Memory and Sequencing Techniques
Schema Induction
Key Word/Idea Extraction
Pragmatics
Self-monitoring and regulation

Direct Remediation Activities

– Temporal Patterning
– Nonspeech Discrimination
– Prosody Perception using Temporal Offsets
CASE #4

- 8 y/o boy
- Difficulties listening in the classroom, especially with background noise or other distractors (including visual)
- Inconsistent school performance – often does well, sometimes forgets to turn in homework
- Signs of frustration over difficulties

Case #4

- P300 reduced, other electrophysiology normal
- Gap detection, speech and nonspeech discrimination probably normal, though some inconsistency in performance
- Continuous performance (auditory and visual) – high error rate

What would YOU conclude and recommend for this child?

Summary

Treatment/management recommendations should:

- Arise logically from functional deficits
- Focus on improving access, enhancing top-down skills, and remediating the disorder

So...WHO Treats CAPD?

- Treatment of CAPD is a multidisciplinary endeavor
- Treatment/intervention should be ecologically valid and based on the individual’s unique needs
**Conclusions**

- Pattern analysis is the key to accurate diagnosis and ecologically valid intervention
- CAPD should never be diagnosed or treated “in a vacuum”

**Questions???

**Supplemental Material:**

**Common Intervention Strategies and Activities**

- Preferential seating
- Pre-teach new information/vocabulary
- Check frequently for understanding
- Consider use of hearing assistive technology
- Modify acoustic characteristics of classroom
- Make appropriate use of multimodal cues

**Some Common Classroom-Based Accommodations**

- Note: The appropriateness of each of these suggestions relies entirely on the individual child in question. Avoid the use of over-generalized lists of suggestions appropriate for “all” children with CAPD!

- Repeat or rephrase information
- Provide a note-taker
- Practice principles of “clear speech”
- Gain child’s attention before speaking
- Avoid open classroom settings
- Use a “buddy system”
- Make generous use of positive reinforcement
Avoid auditory fatigue by planning breaks from auditory-demanding tasks

When all else fails, consider alternative placements

Compensatory Strategies/
Central Resources Training

Becoming an active listener
- Take responsibility; self-monitor
- Use alert posture
- Lean body or head toward speaker
- Watch and listen (no dancing!)
- Engage in one task at a time
- Refocus attention when needed

Metacognitive Strategies
- Attribution training/cognitive behavior modification
  - Self-instruction/self-direction
  - Problem-solving training
  - Self-regulation procedures
  - Reciprocal teaching
  - Engagement of top-down skills

Metalinguistic Strategies
- Discourse Cohesion Devices
  - Tag words (e.g., first, last, next, before, after)
  - Causal words (e.g., because, since)
  - Adversative terms (e.g., but, however, although)
  - Pronouns
  - Other relationship words (e.g., neither, nor, or, either, etc.)
- Schema Induction (formal and informal)
- Contextual Derivation

Metamemory Strategies
- Chunking
- Elaboration
- Transformation and visual “sketchpad”
- Reauditorization/verbal rehearsal
- Paraphrasing
- External aids (calendars, filing systems, whiteboards, PDAs, etc.)

Auditory Closure
- Purpose: To assist child in learning to fill in missing components of the message and arrive at a meaningful whole
- Examples:
  - Missing word exercises
  - Missing syllable exercises
  - Missing phoneme exercises
  - Skills in noise
3. Direct Remediation Techniques (bottom-up; formal and informal)

To improve auditory performance by altering the way the brain processes sound

Involve targeted activities that maximize neuroplasticity

Direct Remediation Activities

- **Temporal Resolution Training** (formal)
  - Purpose: To improve temporal resolution and integration skills, a foundation skill for phoneme discrimination
  - Examples:
    - Duration DLs
    - Gap Detection
    - Forward and Backward Masking

- **Phoneme Training** (formal and/or informal)
  - Purpose: To develop accurate phoneme discrimination, analysis, and related phonological awareness and speech-to-print skills.
  - Examples:
    - Minimal contrast pair discrimination
    - Discrimination in context (syllables, words)
    - Segmentation, blending, and related skills
    - Speech-to-print skills

- **Prosody Training** (primarily informal)
  - Purpose: To train recognition and use of prosodic aspects of speech (e.g., rhythm, stress, intonation)
  - Examples:
    - Syllabic stress (e.g., convict vs. convict)
    - Prosodic alterations within sentences
    - Tone of voice
    - Nonverbal cues
    - Key word extraction
    - Reading aloud with exaggerated prosodic features

- **Temporal Patterning Training** (formal and/or informal)
  - Purpose: To learn to discriminate differences in, analyze, and imitate rhythmic patterns of auditory stimuli.
  - Examples:
    - Differences in speech (ISI)
    - Differences in loudness
    - Differences in rhythm

- **Vocabulary Building** (4 steps):
  1. Reauditorization
  2. Contextual Derivation
  3. Immediate Provision of Definition
  4. Reinforcement of Definition
Binaural Interaction Training (formal and/or informal)
- Purpose: To improve binaural listening and localization skills.
- Examples:
  - Localization of sound sources in quiet and noise at varying azimuths.

Dichotic Listening Training (formal and/or informal)
- Purpose: To improve binaural listening skills and speech-in-noise skills; to address significant ear advantages.
- Examples:
  - Interaural intensity offsets (e.g., DIID, the Bellis “Harry Potter” approach)
  - Interaural temporal offsets.

Interhemispheric Exercises (mostly informal)
- Purpose: To stimulate the corpus callosum and improve interhemispheric transfer of information.
- Examples:
  - Verbal to left-hand motor transfers
  - Left-hand to verbal transfers
  - Bimanual motor transfers
  - Music (e.g., piano lessons, listening to music with attention to comprehension of lyrics)
  - Video games requiring bimanual and visual hemifield skills.

Recommended General Readings
