Auditory Processing Disorders in Adults
OSHLA 2009
March 6, 2009

Gail M. Whitelaw, Ph.D.
Department of Speech and Hearing Science
The Ohio State University
Columbus, OH
whitelaw.1@osu.edu

Goals for this session: OVERVIEW of auditory processing issues in adults

- Disorders of auditory processing
- Assessment options and protocols
- Remediation considerations
- Influence on amplification and aural rehabilitation decisions

Ideas that frame today:

- Traumatic brain injuries: Clearly often have an impact on auditory processing/listening that is well defined…loci and clear symptomology
- Mild head injuries/post concussive syndrome: Sequalae are subtle and difficult to assess (Peterson, 2000)

Old news applied to new issues:

"The conventional auditory acuity tests have little predictive value of auditory behavior in more complex social situations…."

Karlin (1942)

Some examples:

- Person that has difficult hearing in noise after a head injury
  - The "dodge ball" incident
- Exacerbation of issues:
  - Family with carbon monoxide issues
- Auditory system degradation
  - Encephalitis

Some examples:

- Interaction between hearing loss and auditory perceptual issues
  - Older adult with peripheral hearing loss pre/post stroke
- Overlooking MHI and attributing issues to other causes
  - Post concussive syndrome vs. Meniere's disease

A couple of additional thoughts

- Article in *Neurology* (3/4/08)
  - Described traumatic brain injury as a "hidden epidemic"
  - "Old" injuries that may have been forgotten—a sports injury, fall, blow to the head that may have seemed "nothing" at the time—may have impact years later
  - Baby boomers, etc. that are concerned that they have Alzheimer's—notice cognitive and behavioral problems
  - Often misidentified…points to remember that normal aging changes in the brain can show these changes, which demonstrate notable loss of brain tissue (even with very mild TBI)

Patient in our clinic seen June, 2008

- 33 year old man
- Had stroke on February 15, 2008
- Had normal hearing prior to the stroke
- Reports that he cannot hear from his right ear (stroke effected left side of body)
- Reports that auditory information when noise is present is "lost" for him
- Qualitative issues with listening (iPod, etc.)
- Has had 2 audiograms in past two months—"normal" hearing bilaterally

Role of hearing/listening in the life of the patient

- Hearing is assumed and often overlooked…if that's true for hearing, even more true for listening
- Hearing/listening skills are scaffold for other types of information processing (language, attention, pragmatics, etc.)

Overview Of Auditory Processing

What is auditory processing?

Continuum as a guide

- The "peripheral" and "central" labels are somewhat artificial in terms of addressing functional/behavioral deficits
- Often reported difficulties look similar
- Audiologists guided by results of audiogram lulled into a false sense of security
- Patient leaves with a frustration/embarrassment that "their problem" is all in "their head"
- Issues related to location of deficit probably less relevant than deficits resulting from it

The Auditory System

- Auditory processing skills can be considered on this continuum, however in persons with hearing loss, these issues/skills co-exist with peripheral hearing abilities
- Definitions of APD and the role of peripheral hearing loss
- THE MAIN FOCUS for this presentation are those patients with essentially normal peripheral hearing acuity with auditory "complaints"

Central auditory nervous system

- "…includes all the anatomical and processing mechanisms between the cochlear nucleus in the brainstem to the auditory cortex of the temporal region"
  - Considerable activity in this area, including auditory memories stored in primary auditory cortex, Heschl's gyrus and Sylvian fissure as "auditory processing centers", and left planum temporale as controlling language processing
    - Bamiou, Musiek, and Luxon (2001)

What Is Central Auditory Processing?

- "What we do with what we hear" (Katz)
- "…umbrella term for all operations executed on peripheral auditory inputs, and which are required for the successful and timely generation of auditory precepts, their resolution, differentiation, and identification." (Phillips, 2002)

Site of Lesion vs. functional issues

- History of interest in clinical APD; comes from adults
  - Bocca and colleagues
  - Site-of-lesion focused related to technological limitations, etc.
- Currently:
  - Focus on pediatric cases*
  - Need to address functional behaviors

*Caveat: Currently, renewed interest in adults with auditory processing issues due to veterans presenting with these types of deficits in significant number

Schneider (personal communication). Grant addressing blast injury in soldiers returning from Iraq

Walter Reed Army Medical Center and Portland VA Medical Center (personal communication): Incidence of APD in this population

Current concepts

- Traumatic brain injury has been labeled as a "signature injury" of the wars of Iraq and Afghanistan
  - Concerns: Possible long term effect of mild traumatic brain injury or consciousness or altered mental status, as a result of deployment related head injuries, particularly those from proximity to blast explosions

(Hoge et al, 2008)

Estimate of number of troops with mild TBI

- Cited as high as 18% by army medical officials
- Persistent post-concussive symptoms including irritability, memory problems, difficulty concentrating, and headache
  - Significant number of subtle visual, language, and hearing /listening related issues reported (Hoge et al, 2008)

Lack of population based studies

- No good civilian data
- No comparison groups
- Question: Would population screening for mild TBI improve health outcomes? (Hoge et al, 2008)
- Biases in the medical professions
- Ability to generalize: assault injuries, MVA's, etc.

Roles of the Central Auditory Nervous System: A functional perspective

- "Processing" rapid signals
- Gating
- Alerting to incoming information
- Communication between the two hemispheres of the brain
- Coordinating or "teaming" between the two ears--they work as a unit

Role of the Central Auditory System

- …To establish a representation of the speech signal that is then available for perceptual or linguistic elaboration (Phillips, 1998)

The concept of redundancy: Internal vs. external

- Intrinsic or internal redundancy: Built into the auditory system (both peripheral and central)…multiple representations
  - Certainly can be impacted by disorder of auditory system, such as tumor, demylinating disease, etc.

The concept of redundancy: Internal vs. external

- Extrinsic or external redundancy: Built into the signal (syntax, morphology, semantics, etc) which enhance comprehension of the signal
  - Can be impacted by issues such as cognitive impairment (e.g. Alzheimer's)

Central Auditory Processes Are Mechanisms and Processes Responsible for the Following Behaviors:

This information provides one schema or model for APD

- Sound localization
  - Role in hearing in background noise
- Auditory discrimination
  - Gross and fine differences in sounds, including speech sounds

Central Auditory Processes Are: (con't)

- Temporal aspects of audition, including:
  - Temporal resolution, temporal masking, temporal integration, and temporal ordering
  - Timing has become more of a focus, as historically audiologists have been focused on frequency and intensity of signal

Central Auditory Processes Are: (con't)

- Auditory performance decrements with competing acoustic signals
  - Listening in the presence of background noise
- Auditory performance decrements with degraded acoustic signal
  - Speakers that speak a dialect which differs from that of the listener

(ASHA, 1996)

Bottom up and top down

- In reality, not linear process but co-exist
- Not "a one way street"
- Thought of as an afferent process
- Also need to consider efferent process
- EXECUTIVE FUNCTIONING SKILLS

Auditory processing:

…the efficiency and effectiveness by which the central nervous system (CNS) utilizes auditory information.

Neural Plasticity ("Brain Flexibility")

- Neural plasticity: alteration of nerve cells to better conform to immediate environmental influences, with this alteration often associated with behavioral changes
- Three types
  - Developmental
  - Compensatory (after lesion)
  - Learning related (Musiek and Berge, 1998)

The auditory system is designed to:

- Be flexible and fast
- Capitalize on it's own redundancies
- Support ("scaffold") other skills
- Operate "automatically"
- PREDICTABILITY AND REDUNDANCY

Disorders of processing auditory information

Bruton Conference (JAAA 2000) Definition of Auditory Processing Disorder

(Jerger and Musiek, 2000)

An auditory processing disorder (APD) is defined as a deficit in the processing of information in the auditory modality.

Auditory Processing Disorders (APD)

- An auditory processing disorder (APD) is defined as a deficit in the processing of information in the auditory modality (Jerger and Musiek, 2000)

Central Auditory Processing Disorders Defined:

A breakdown in auditory abilities resulting in diminished learning (e.g. comprehension) through hearing, even though though peripheral hearing sensitivity is normal

"Listening problems"

- "A problem with hearing that can't be explained by tests of peripheral auditory function" (Moore, 2007)

Auditory processing disorders

…(C)APD may lead to or be associated with difficulties in higher order language, learning, and communication functions. Although (C)APD may coexist with other disorders (e.g., attention deficit hyperactivity disorder [ADHD], language impairment, and learning disability), it is not the result of these other disorders. (ASHA, 2005)

Common presenting issues in adults with APD

- Inordinate difficulty hearing in noisy or reverberant environments (in relation to auditory results)
- Lack of music appreciation
- Difficulty following conversation on the telephone
- Difficulty following directions
- Difficulty following long conversations

Common presenting issues in adults with APD

- Difficulty taking notes
- Difficulty learning a foreign language or technical information where language is novel or unfamiliar
- Social issues—difficulty "reading" others/pragmatic communication issues
- Spelling, reading, writing issues
- Organizational problems
  - » (Adapted from Baran, 1998)

Etiologies of APD

- Trauma
- Tumors
- Degenerative disorders
- Viral infections
- Surgical compromise
- Lead poisoning
- Lack of oxygen
- Auditory deprivation (Schminky & Baran, 1999)

Controversies

- Auditory specific disorder (Keith, 2001) vs. global processing issue (Cacace and McFarland, 1995)
  - – The question of "central"
- If identified, can anything be done—does "labeling" change the course of management/treatment?
- The issues of neural plasticity (Musiek, Shinn, and Hare, 2000; Gatehouse, 1992, Humes and Wilson, 2003)

Incidence and prevalence of APD

- Range of estimates in the general population (issues with test battery, definition, etc.)
- In adults with normal hearing, 5% (Saunders & Haggard, 1989)
- Estimates of long term APD issues in patients with close head injury that are considered to be "well recovered"
  - 58% of this population with APD (Bergemalm & Lyxell, 2005)

Special populations: Traumatic brain injury

- Peripheral hearing loss prior to injury: indicators of auditory processing involvement
  - Previous success with amplification and now perceives hearing aids no longer meet needs
  - New complaints with no measurable changes in peripheral hearing acuity

Special populations: Traumatic brain injury

- Peripheral hearing loss in conjunction with auditory processing involvement as a result of head injury
  - Audiogram does not tell the story
- Considerations critical to speech/language therapy and other types of treatment
  - Aggressive treatment of hearing issues prior to speech/language treatment

An aside: Head injury and audiology

- Generally, think of concussion, etc. resulting in peripheral hearing loss
- Issues of mild head injury/post concussive syndrome
  - Mild head injury (MHI) estimated to account for 75% of over 1 million traumatic brain injuries per year
  - 50% of these estimated to have post-concussive syndrome (Peterson, 2000)

Head injury and audiology

- Post-concussive aspects from an audiologic perspective
  - Vestibular issues
  - Tinnitus/hyperacusis
  - Peripheral hearing loss
  - Issues related to listening in less than optimal environments (despite normal audiometric configuration) (For more information, see Bavarian and colleagues, 1999)

Special populations: Mild head injury (MHI)/Post concussive syndrome (PCS)

- Auditory symptoms most often reported with MHI/PCS
  - Tinnitus
  - Peripheral hearing loss
  - Sound tolerance issues/increased sensitivity to sound/"hyperacusis"
  - Difficulty processing auditory information, often in areas of timing and hearing in less than optimal environments (Peterson, 2000)

Additional considerations

- Case history considerations
  - Aphasia
    - Case consideration:
      - Patient with aneurysm
      - Patient with primary progressive aphasia
  - Progressive neurologic diseases
    - Multiple sclerosis
    - Parkinson's disease
    - Alzheimer disease
    - Encephalitis (case information)
  - Chemotherapy treatment

Special populations: Older adults

"…the understanding of speech in daily life undergoes gradual change with increasing age because of a combination of peripheral and central alterations significantly affect the understanding of speech that is heard under less-than-optimal conditions."

(Bergman, 1980)

The auditory system is "less flexible" with age

Temporal processing issue and aging

- Considerable evidence to support the concept that temporal processing decreases with increases in chronologic age
  - Difficulty with auditory sequencing of auditory information (Humes and Christopherson, 1991)
  - Significant ages effects noted for time altered stimuli with both speech and non-speech stimuli in both quiet and noise listening conditions (Gordon-Salant and Fitzgibbons, 1999)

Auditory processing disorders in older listeners

- Controversy?
  - Older listeners with peripheral hearing loss and auditory processing disorder (as identified with the Synthetic Sentence Identification [SSI] test) consistently rate themselves as more impaired than those without APD (Jerger, Oliver, and Pirozzolo, 1990)
  - Prevalence of central auditory involvement increases with age (Stach, Spretnjak, and Jerger, 1990)

Auditory processing disorders in older listeners

- Controversy?
  - Little evidence to support the concept of "neural presbycusis", a concept put forth by Schuknecht in 1964 and still accepted by many audiologists today
  - Humes (2002) suggests that variation in older listeners can be explained based on degree of peripheral hearing loss and cognitive function (similar to the "central auditory" vs. processing argument made earlier)

Assessment of auditory processing disorders

Assessment is interdisciplinary in nature

- Rule out/determine extent of:
  - Cognitive impairment
  - Speech/language impairment
  - Psychological/psychiatric issues
  - Communication and vocational demands
  - Pending litigation

Thorough case history

- Childhood learning disabilities
- History of otitis media
- Family history of communication disorders and/or learning disabilities
- Presence of tinnitus/sound sensitivities/balance issues
- Presence of "soft signs"…subtle but important to ask

Thorough case history

- Medications
- History of illness and injury
- Specifics about head injury and recovery
- Qualitative issues with hearing: changes in music perception, perception of speech
- Vestibular and visual issues
- General communication: How effective and how satisfied as a communicator/listener?

Assessment tools: authentic assessment

- Patient outcomes poorer than would be anticipated based on audiometric results, reported motivation, etc.
  - Diary
  - Addressing outcome measures
  - Performance in less than optimal listening situations
    - Performance in quiet is again a poor predictor of ability in noise

Comprehensive audiologic assessment—always the place to start

- Assessment of peripheral hearing
- Speech in noise testing (such as SPIN or Q-SIN)
- Acoustic reflexes
- OAE's

Audiologic assessment: Additional considerations

- Tinnitus and sound tolerance issues
- Tinnitus assessment
  - Questionnaire: Tinnitus Reaction Questionnaire (TRQ): Can use related to tinnitus and sound tolerance
  - Pure tone audiogram with additional "detail"—evaluate to 12,000 Hz and obtain interoctaves
  - Attempt to quantify the tinnitus
    - Pitch match
    - Loudness match
    - Minimum masking level
    - Residual inhibition

Audiologic assessment: Additional considerations

- Tinnitus and sound tolerance issues
- Sound tolerance assessment
  - Questionnaire: Tinnitus Reaction Questionnaire (TRQ): Can use related to tinnitus and sound tolerance
  - Loudness discomfort levels (LDL)

Auditory processing assessment in adults

- Based on the concept of "taxing" the auditory system and "making it work"
- Pure tone testing, for example, does not do this—no challenge or "push"
- All test materials presented at a suprathreshold level

Behavioral testing

- Reduce the external redundancy of the signal to tax the internal redundancy of the system
- "Oldest" auditory processing test is Filtered Words stimuli, still utilized today

Controversy to provide context

- Is auditory processing different from language processing?
- Need to vary "linguistic loading" when possible on tasks…example is dichotic listening.
  - CV's, digits, words, sentences (binaural separation or binaural integration tasks)

Controversy to provide context

- How to categorize results? Shapes test battery selection and organization
  - Site of lesion approach: May select tests to address probable site of lesion
    - Brainstem: Masking level difference (behavioral), ABR (electrophysiological)
    - Corpus callosum: Frequency pattern sequence test (behavioral)
    - Cortex: P300 (electrophysiological)

Controversy to provide context

- How to categorize results? Shapes test battery selection and organization
  - Functional approach
    - What behavior or skills is being taxed and how does this impact the real world?
      - Examples of speech-in-noise, temporal sequencing, etc.
      - Follows more of the World Health Organization approach to disability

Assessment when normal peripheral hearing acuity is present

- SCAN-A
- Tests from VA-CD (minimizing linguistic information, such as dichotic CV's, MLD, etc.)
- Ability to address signal to noise ratio loss, such as test like the Quick-SIN
- Electrophysiologic measures are often not sensitive enough to address difficulties, however cognitive evoked potentials may provide some insight

Limitations in listeners with peripheral hearing loss

- Most tools designed for behavioral assessment are designed for those with normal peripheral hearing acuity: Some can be modified for mild/moderate hearing losses
- All electrophysiologic measures which may be used for APD assessment are influenced, to some degree, by peripheral hearing loss
- Asymetric hearing loss: Assumed that this will result in dichotic listening issues

Consideration with hearing loss…

- Mild sensorineural hearing loss had detrimental effect on auditory processing test scores, even when presentation level was adjusted for loss of audibility
- Effects of hearing loss can not be separated from auditory processing disorder
  - Neijenhuis, Tschur, & Snik (2004)
  - Behavioral assessment tools that are fairly resistant to effects of peripheral hearing loss (up to maximum conductive hearing loss or mild/moderate cochlear hearing loss), at least in some studies

Otoacoustic emissions

- DPOAE's: Quick assessment
  - Normal pure tone audiogram in the presence of abnormal DPOAE results has higher incidence in population of listeners with APD (Hall, 2007)

Otoacoustic emissions

- Potential benefit in addressing the efferent auditory system--not much known about this, minimal ability to isolate this pathway behaviorally
- Contralateral suppression of emissions protocol
  - "Gating mechanism"--how the brain controls the ear (Lauter, 2000)

Electrophysiologic assessment

- Suggested as a crucial part of the test battery in the Bruton conference
- Issues of cost, information to be obtained, and philosophical approach (site of lesion vs. functional vs. others)

Electrophysiologic assessment

- Early evoked potentials
  - Auditory brainstem response testing (ABR): generally normal in APD, although if system is taxed (e.g. increase click rate significantly), can see impact (no information rostral to brainstem)
- Later evoked potentials
  - Auditory middle latency response Abnormal with APD
    - Adapted from Hall, 2007

Electrophysiologic assessment

- Cortical potentials:
  - Auditory late response (ALR)
  - P300
  - Mismatched negativity (MMN) (can address temporal processing)
    - All seen to be abnormal in APD
      - Adapted from Hall (2007)

Electrophysiologic input

- Electrophysiologic issues: May use later potentials, but must be aware of impact of peripheral hearing loss on these measures (reports vary significantly based on type of potential being measured)
- Value of this assessment on this type of assessment for this task
  - Generally describing functional deficits with the group of patients of focus here

P300 response in University students with history of mild head injury

- Group of "well-functioning" University students following MHI compared to group of typical University students on P300 responses
- Performance similar on psychometric tasks
- Significant differences in P3 response, both in accuracy on oddball paradigm and significantly reduced P300 amplitudes
- Despite excellent behavioral recovery, subtle information processing deficits involving auditory attention persist
  - Seglowitz, Bernstein, and Lawson (2001)

New electrophysiology protocol: may have potential with adults

- BioMAP: Biological Marker of Auditory Processing
- Biologic Navigator PRO family of equipment
- Developed based on research at Northwestern University
- The BioMAP is reported as "…an electrophysiologic response from the brainstem that mimics characteristics of speech with remarkable fidelity."

BioMAP

- Background: Assumes that accurate reflection of stimulus timing is critical for appropriate processing of auditory information
- The BioMAP characterizes neural activity in response to the presentation of /da/
- Measures of both timing and magnitude are used to describe brainstem neural activity to speech, which is characterized by rapid temporal changes and complex spectral distributions

BioMAP

- http://www.communication.northwestern.edu/brainvolts/clinicaltechnologies
- Additional information regarding temporal processing in this perspective:

  Wible B, Nicol T, Kraus N. (2005) Correlation between brainstem and cortical auditory processes in normal and language-impaired children. *Brain* 128: 417 - 423.

Summary of issues with test battery

- Is focus of testing site of lesion, functional, a combination, or other?
  - Field not served well by the neurological approach alone (Moore, 2007)
- What contributes to the final goal for this patient?
- What gets the most "bang for the buck" in terms of time efficiency and information that contributes to rehabilitation?

Categorizing results

- "Central auditory pathologies need not respect structural or functional boundaries in the brain, and so should be expected to have idiosyncratic presentations." (Phillips, 2002)

Management of APD in adults

Auditory processing issues and management of hearing loss

- More global than just understanding speech recognition…emphasis on temporal processing in recent years
- Contributes to speech recognition, but also to much more
- Heterogeneous patient group with functional communication deficits

Auditory processing issues and management of hearing loss

- If the flexibility of the auditory system is compromised, what options might we consider to compensate for the decrease in intrinsic redundancy
- Keys to managing auditory processing issues are increasing predictability and redundancy in the listening environment

Guideline for hierarchy of treatment/remediation

- Sound tolerance issues
- Tinnitus
- Hearing loss
- Auditory processing disorder

Management Myth

- The problem needs to be cured in order for the treatment to have value…
  - Hearing loss as a model…
  - Options for audiology involvement range from referral to providing treatment
- The conclusion is that since there's no "cure", there's nothing that can be done about APD
- Current research in neural plasticity suggests that changes may happen across a long time frame (long term potentiation of the auditory system)

Linking assessment to rehabilitation and management

- Environmental modifications
- Compensatory strategies
- Direct intervention

Most adults with APD will live with these disorders throughout their life

"Life-long approach" with emphasis on "self-management" is critical

(Masters, Stecker, and Katz, 1998)

Environmental modifications

- Address the listening environment, most often in the work setting
- Improve acoustics
- Often easier than would be in a school based setting
- Role of Americans with Disabilities Act (ADA)

FM technology and APD:

- FM is not necessary the primary or only recommendation
- Depends on the type of APD, work setting, etc.
- Benefits of sound field amplification for ALL has been well documented (churches, large learning space)
- Personal technology has less data but arguments are compelling

Evidence to support use of FM technology in this population

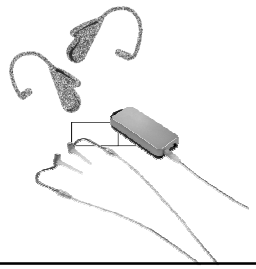
- Use of personal FM technology with APD (Stach, et al, 1987; Stein, 1998)
- ASHA 1990 technical report
- Provide greater signal to noise ratio enhancement

Newest ear level options

- Ear level devices specifically designed for those with normal peripheral hearing acuity
  - Phonak iSense

The NEW Dynamic FM system for those with normal or near-to-normal hearing

iSense Micro & iSense Classic with inspiro



iSense is compatible with all existing Phonak transmitters

iSense Receivers

iSense Micro

iSense Classic

iSense Micro

- **Lightweight**
- Ergonomic design
- Flexible and secure
- Small in size
- 6 colors
- 312 battery

Addressing the environment: Sound field FM

- Soundfield FM options
  - Lightspeed
  - Phonic Ear/Front Row
- Infrared options
  - Phonic Ear Front Row series
  - http://www.phonicear.com/frontrownews.asp

Direct therapeutic approaches

Listening/auditory training

- Recent evidence supports the impact of training on neural plasticity and in turn on functional auditory behaviors.
- Phillips (2003) points out changes in the auditory cortex, representing the neuroplasticity of the system, as a result of behavioral training, have been well documented in animal models.
- Thompson (2000) describes how treatment/therapy enhances the "representational plasticity" of the CANS, resulting in the ability to engage new neural networks post-treatment.

Listening training

- Some of the best evidence for changes in auditory function related to environmental changes and experiences are from both children and adults that have received cochlear implants.
- Improvements in communicative behaviors following implantation appear to be positively influenced by the rate of plastic changes in central auditory pathways (Sharma et al., 2004).

Listening training

- In addition, studies with both normal hearing and subjects with cochlear implants using later evoked potentials demonstrate both longer periods of plasticity in the brainstem and cortex than traditionally believed and the ability to able to demonstrate neural activity changes associated with training and auditory rehabilitation (Gordon, Papsin, and Harrison, 2003; Tremblay et al, 2001).

Specifics about this type of auditory training

- All research, however, points to the need for stimulation or treatment to be :
  - Varied
  - Challenging
  - and developmentally appropriate in order to capitalize on the experience-dependent neuroplasticity available in the auditory system (e.g. McCall and Plemons ,2001).
- Significant implications for developing auditory processing skills in young children and to remediate auditory processing disorders in both children and adults

Specifics about this type of auditory training

- This is the early stages of development of such programs, as is noted with the Fast ForWord program (Tallal, Miller, Bedi, Byma, Wang, Nagarajan, Schreiner, Jenkins, and Merzenich, 1998) and in dichotic listening therapy (Musiek, Shinn, and Hare, 2002), as these programs as a foundation for remediation and auditory training programs
  - ADAPTIVE—can change with the learning and document this change
  - Acoustically enhanced
  - Evidence-based
- In addition, techniques to measure effectiveness of a given program are needed and will continue to be developed (Jirsa, 2002)

Approaches that incorporate this research

- Newer approaches that provide direction for APD training/habilitation/rehabilitation
  - Moncrieff: Dichotic listening skills—Dichotic interaural intensity difference training
  - Sweetow, LACE
  - Jirsa, P-300 research; Kraus, BioMAP research

Principles of auditory training (Musiek and Chermak)

- Age and language appropriate
- Motivating
- Varying tasks
- Progressive difficulty
- Success/failure criterion: Adaptive presentation

Principles of auditory training (Musiek and Chermak)

- Sufficient time for intensive therapy
- Monitoring progress and providing feedback
- Acoustical control

Dichotic listening training

- Dichotic interaural intensity difference training (DIID)
- Building less dominant ear…promising in ear dominant deficits
- Similar protocol with more data to be commercially available soon from Moncrief

LACE

- Listening and Communication Enhancement (LACE) program (developed by Robert Sweetow, Ph.D, distributed by Neurotone http://www.neurotone.com/)
  - Developed to address listening deficits in adults with peripheral hearing loss

Direct treatment

- Communication repair strategy development—build in top down skills
- Multiple modality input may be beneficial (however in some cases, global processing issues arise).
  - Pilot data suggests that for at least some adults and children with APD, benefit from use of vibrotactile cues to enhance auditory information/comprehension
    - May not be practical
  - Encourage speechreading skill development

Managing/Treating APD

- Empirical question of effectiveness of treatment regimes for APD
  - All learning involves plastic changes in the brain, thus newer training stratgies are not unique
  - What may make them “special" is the effectiveness with which they can target an impaired process
  - This link may be as individual as individual listeners
    - Phillips, 2002

Compensation strategies

Communication can be influenced by the speaker

- "Clear speech" Series of seminal papers that address the impact of speakers rate, mode, etc. on listener comprehension
  - Where basic science and clinical practice come together
  - See references for specifics, however basic principles are related to Friel-Patti, etc.

Auditory fatigue

- Recognize that listening is fatiguing, particularly for those who are "high risk" listeners
- Schedule "listening" activities early in the day
- Alternate "listening" activities with those that require less listening
- Provide a quiet place to do work
- Opportunities for physical activity to reduce stress and improve attention

Hearing aid considerations in APD

Hearing aid effectiveness

- Central nervous system involvement may compromise success with amplification
- Defining auditory processing issues can help to direct management and may direct selection of amplification/assistive technology and/or counseling

Hearing aid considerations

- Directional microphones
- Digital technology, based on anecdotal reports—further research needed
- Technologies that capitalize on temporal/spectral information—expand beyond the concepts of frequency and intensity and/or maximizing speech audibility

Additional considerations for amplification

- Options for addressing "predictability" of the signal
  - Ear-level FM options, such as the Phonak MicroLink or Phonic Ear Lexis products that couple to hearing aids
  - Products designed for listeners with normal hearing acuity, such as Phonak MicroEar or EduLink products
    - Relatively small and address issues that hearing aids cannot

Additional amplification considerations

- Counseling may differ with this population than from the more "typical" patient wearing a hearing aid
  - Setting up realistic expectations even more critical
  - Less reliance on hearing aids, more reliance on other issues, including room acoustics and visual cues
    - For example, temporal processing issues may make reverberation a bigger concern for patients in this population than for those with a greater degree of peripheral hearing loss only

Final thoughts

- "The reality of CAPD can no longer be doubted. It is a distinct entity across the entire age range. It appears to derive from at least two analogies of auditory perception--loss in the ability to separate auditory foreground from auditory background and failure of the fine temporal resolution necessary to the analysis of speech…" (Jerger, 1998)

References and Sources of Information

American Speech-Language-Hearing Association Task Force on Central Auditory Processing Consensus Development (1996). Central auditory processing: Current status of research and implications for clinical practice. *American Journal of Audiology, 5(2),* 41-54.

Bamiou, D., Musiek, F. & Luxon, L. (2001). Aetiology and clinical presentations for auditory processing disorders—A review. Archives of Disease in Childhood, 85 (5), 361-366.

Baran, J. (1998). Management of Adolescents and Adults with Central Auditory Processing Disorders. In Masters, M.G., Stecker, N.A., and Katz, J. (Eds). *Central Auditory Processing Disorders: Mostly Management.* Needham Heights, MA: Allyn and Bacon.

Barzarian, J.J., Wong, T., Harris, M., Leahey, N., Mookerjee, S. & Dombovy, M. (1999). Epidemiology and predictors of post-concussive syndrome after mild head injury in an ER population. *Brain Injury, 13*, 173-89.

References and Sources of Information

Beregmalm, P. & Lyxell, B. (2005). Appearances are deceptive? Long-term cognitive and central auditory sequelae from closed head injury. *International Journal of Audiology, 44*, 39-49.

Chermak, G.D. (Ed.) (2002) Management of Auditory Processing Disorders. *Seminars in Hearing*. 23(4)

Chermak G.D. and Musiek, F.E. (2002). Auditory Training: Principles and Approaches for Remediating and Managing Auditory Processing Disorders. *Seminars in Hearing,* 23 (4): 297-308.

Gordon-Salant, S. and Fitzgibbons, P.J. (1999). Profile of Auditory Temporal Processing in Older Listeners. *Journal of Speech, Language, and Hearing Research, 42*, 300-311.

References and Sources of Information

Hall, J. (2007). Electroacoustic and electrophysiologic assessment of auditory processing disorders. Presentation at *APD: 30 Years of Progress*, October 25, 2007, Cincinnati, OH.

Hoge, C.W., McGurk, D., Thomas, J.L., Cox, A.L., Engel, C.C., and Castro, C.A. (2008). Mild Traumatic Brain Injury in US soldiers returning from Iraq. The New England Journal of Medicine 358, (5), 453-463.

Humes, L.E. (2000) Factors underlying the speech-recognition performance of elderly hearing-aid wearers. *Journal of the Acoustical Society of America, 112* (3), 1112-1131.

Humes, L.E., Coughlin, M. and Talley, L. (1996). Evaluation of the use of a new compact disc for auditory perceptual assessment in the elderly. Journal of the American Academy of Audiology, 7, 419-427.

Humes, L.E. and Christopherson, L. (1991). Speech identification difficulties of hearing-impaired elderly persons: The contributions of auditory processing deficits. *Journal of Speech and Hearing Research. 34*, 686-693.

References and Sources of Information

Jerger, J. and Musiek, F.E. (2000). Report of consensus conference on the diagnosis of auditory processing disorders in school-aged children. *Journal of the American Academy of Audiology, 11*; 467-474.

Jerger, J., Oliver, T.A., and Pirozzolo (1990). Impact of central auditory processing disorder and cognitive deficit on the self-assessment of hearing handicap in the elderly. *Journal of the American Academy of Audiology, 1*, 75-80.

Moore, B.C.J. (1991). Characterization and simulation of impaired hearing: implications for hearing aid design. *Ear and Hearing*. 154S-161S

Moore, D. (2007). Development and standardization of an APD test battery.
Paper presented at *APD: 30 years of progress*, October 25, 2007, Cincinnati, OH.

References and Sources of Information

Mueller, H.G. and Sedge, R.K. (Eds.) (1987) Audiologic Aspects of Head Trauma. *Seminars in Hearing, 8* (3).

Musiek, F.E., Shinn, J., and Hare, C. (2002). Plasticity, Auditory Training, and Auditory Processing Disorders. Seminars in Hearing, 23 (4), 262-275.

Neijenhuis, K., Tschur, H. & Snik, A. (2004). The Effect of Mild Hearing Impairment on Auditory Processing Tests. *Journal of the American Academy of Audiology, 15*, 6-16.

Noffsinger, D., Wilson, R.H., and Musiek, F.E. (1994). Department of Veterans Affairs Compact Disc (VA-CD) recording for auditory perceptual assessment: Background and Introduction. *Journal of the American Academy of Audiology, 5*, 231-235.

References and Sources of Information

Peterson, J. (2000). *Multisensory assessments as possible indicators of post-concussive syndrome following mild head injury.* Unpublished Master's thesis.

Phillips, D.P. (2002). Central Auditory System and Central Auditory Processing Disorders: Some Conceptual Issues. *Seminars in Hearing, 23*(4), 251-262.

Potter, D.D., Bassett, M.R.A., Jory, S.H. & Barrett, K. (2001). Changes in event-related potentials in a three-stimulus auditory oddball task after mild head injury. *Neuropsychologia, 39*, 1464-1472.

Segalowitz, S.J., Bernstein, D.M., & Lawson, S. (2001). P300 Event-related potential decrements in well-functioning university students with Mild Head Injury. *Brain and Cognition, 45*, 342-256.

References and Sources of Information

Stach, B.A. (2000) Diagnosing Central Auditory Processing Disorders in Adults. In Roeser, R.J., Valente, M. and Hosford-Dunn, H. (Eds.) *Audiology Diagnosis*. New York: Thieme.

Stach, B.A., Spretnjak, M.L. and Jerger, J. (1990). The prevalence of central presbycusis in a clinical population. *Journal of the American Academy of Audiology, 1*, 109-115.

Watson, C.S. and Kidd, G.R. (2002). On the lack of association between basic auditory abilities, speech processing, and other cognitive skills. *Seminars in Hearing, 23* (1), 83-93.