CRITICALLY APPRAISED TOPIC 2

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PICO Question

- In adults with sensorineural hearing loss who wear hearing aids, is there a difference between unaided and aided evoked potentials as assessed by P1-N1-P2 responses?
  - Population: adults with SNHL who wear HAs
  - Intervention: aided evoked potentials
  - Comparison: unaided evoked potentials
  - Outcomes: P1-N1-P2 responses

Search Strategies

- Databases searched (all accessed November 2, 2008):
  - PubMed
  - USF Libraries MetaSearch [PubMed, Health reference center-academic, MEDLINE (CSA), CINAHL]
- Inclusion criteria:
  - Sensorineural hearing loss, hearing aid use, adults, P1-N1-P2, English
- Exclusion criteria:
  - Conductive hearing loss, cochlear implants, children, worse than level IV evidence

Search Strategies (cont.)

- Search Terms:
  - "aided ABR"
    - PubMed: 8 hits, 1 relevant article
    - USF MetaSearch: 68 hits, 1 (same) article
  - "hearing aids, ABR"
    - PubMed: 77 hits, 4 additional relevant articles
    - USF MetaSearch: 80 hits, 1 (same) article
  - "adults, hearing aids, P1-N1-P2"
    - PubMed: 2 hits, 1 additional relevant article
    - USF MetaSearch: 4 hits, 2 additional relevant articles

Search Results

- Studies included (both level II):
  - Billings, C.J., Tremblay, K.L., Souza, P.E., and Binns, M.A. (2007). Effects of hearing aid amplification and stimulus intensity on cortical auditory evoked potentials. *Audiology and Neurotology, 12*: 234 – 246.
    - Includes normal listeners*
  - Tremblay, K., Kalstein, L., Billings, C., and Souza, P. (2006). The neural representation of consonant-vowel transitions in adults who wear hearing aids. *Trends in Amplification, 10(3)*: 155 – 162.
- Excluded studies (reasons):
  - Review article (1)
  - No access (3)

Effects of HA amplification & stimulus intensity on CAEPs

Billings, C.J., Tremblay, K.L., Souza, P.E., and Binns, M.A. (2007). *Audiology and Neurotology, 12*: 234 – 246.

Introduction

- Typically, as stimulus intensity increases, latencies decrease and amplitude increases
- When 20 dB of gain was provided by HA to normal-hearing listeners, no significant differences between unaided & aided response patterns were found
  - Saturation of neural response? Compression characteristics of HA?
- In this study: normal-hearing individuals used; compared low- & high-level stimulus intensities to create intensity growth function; probe tube microphone measurements in EAC
- Purpose: to determine if (1) increasing stimulus intensity results in decreased latencies/increased amplitude in both unaided & aided conditions & if (2) aided & unaided intensity functions differ at lower intensity levels

Materials & Methods

- Procedure
  - CAEP measurements on 13 normal-hearing participants under unaided & aided conditions
  - Tone presented at 7 intensity levels for each condition
  - Amplitude & latency values for P1, N1, P2, & N2 determined for each condition & stimulus level
  - ITC acoustic measures for each participant at all intensities & both conditions
- Subjects
  - 13 normal hearing (<25 dbHL, 250-8000 Hz) young adults (22-34, mean 27.2 yrs); 4 male, 9 female
  - All had excellent speech recognition (≥88%) & normal tympanograms; no hx of otologic or neurologic disorders

Materials & Methods (cont.)

- Stimuli
  - 1000-Hz tone w/rise-fall time of 7.57 ms & duration of 757 ms used
  - Duration ≈ length of speech syllable used in previous study (Tremblay et al., 2006a)
  - Stimuli presented at 0° and 1m from subject in sound field @ 30, 40, 50, 60, 70, 80, & 90 dBpeSPL
  - LE plugged w/foam plug
- Hearing Aids
  - Digitally programmable BTE HA coupled to foam stock earmold
  - Same HA used to test each participant's RE
  - Manufacturer specs: freq. response = 210 – 6500 Hz
  - Omnidirectional mic, VC deactivated
  - HA programmed to provide 20 dB of gain from 250 – 5000 Hz

Materials & Methods (cont.)

- Acoustic Measures
  - EAC measures made for 11/13
  - REDD measured for each participant at 1000 Hz using audiometer-presented stimuli @ 70 dBHL
- Electrophysiology
  - Each stimulus presented 400x in homogeneous train w/interstimulus interval of 1910 ms
  - Stimulus presentation order randomized across participants
  - Pts. instructed to ignore stimuli & watch close-captioned movie of their choice
  - EP activity recorded using 32 electrodes (Neuroscan system)
  - Ocular activity monitored; > ±70 µV rejected
  - Recording window = 100 ms pre-stimulus to 1400 ms post-stimulus

Results

- Effect of Intensity
  - Increase in stimulus intensity affected all CAEP components
  - P1, N1, P2, & N2 latencies decreased significantly
  - N1, P2, & N2 amplitudes increased significantly
  - Large effect sizes for intensity

(30-90 dB)	P1	N1	P2	N2
Avg. latency shift	32.6 ms	35.9 ms	49.9. ms	30.7 ms
Avg. amplitude shift	0.06 µV	3.42 µV	3.44 µV	3.65 µV

Results (cont.)

- Effect of Amplification
  - No main effects of amplitude for latency or for any CAEP component
  - Amplitude effect sizes smaller than those for intensity
  - No significant interactions for latency or amplitude except for P2 amplitude with a simple main effect at the highest intensity level (aided amp. at 90 dBpeSPL larger than unaided amp.)
  - In-the-Canal Acoustic Recordings
    - Difference between unaided & aided output demonstrates ~20 B of gain provided by HA through most of intensity range
    - Decreases in gain at higher intensities show activation of compression circuitry

Discussion

- Effect of Intensity
  - Unaided results consistent w/previously-published findings (as stimulus intensity increases, peak latencies decrease & peak amplitudes increase)
  - Results demonstrate these intensity effects occur even when sound processed & presented through HA
  - Plateau in intensity growth function not observed (perhaps b/c of longer interstimulus interval)
- Effect of Amplification
  - No significant differences in waveform morphology due to HA amplification of approximately 20 dB
  - Aided growth functions did not shift by 20 dB, even at low intensities

Discussion (cont).

- Effect of Amplification (cont.)
  - Results using ITC SL, unaided & aided stimulus encoded differently
    - Distinct functions for unaided & aided conditions, suggesting that HA is changing more than just intensity of stimulus, leading to fundamental differences in the way aided stimuli are interacting w/CAS
    - 20 dB of HA gain ≠ 20 dB stimulus intensity change
  - HA changes stimulus rise characteristics, alters SNR, & introduces amplitude overshoot by compression circuitry
  - Results demonstrate need to understand interaction between HA & evoked CAS activity
  - This study 1st step in establishing basic effects of HAs on CAS

The neural representation of CV transitions in adults who wear HAs

Tremblay, K., Kalstein, L., Billings, C., and Souza, P. (2006). *Trends in Amplification, 10(3)*: 155 – 162.

Introduction

- Important to determine whether ACC can be recorded in hearing-impaired listeners who wear HAs
- Useful in determining if successful HA users have different neural patterns vs. unsuccessful users
- Factors that may negatively affect neural patterns:
  - Auditory deprivation (changes in central auditory system)
  - Alteration of signal by HA
- Hypothesis: P1-N1-P2 for /ʃi/ will be earlier vs. /si/ in HA users as well

Methods

- Subjects
  - 7 adults, 50 – 76 y.o. (mean = 63.8 y.o.)
  - Mild to severe bilateral SNHL w/normal immittance measures
  - No Hx of Meniere's disease or any neurological disorder
  - ≥ 6 mo. bilateral HA experience
- Stimuli
  - Naturally produced /ʃi/ (654.98 ms) and /si/ (756.30 ms) from UCLA NST
  - All subjects able to correctly behaviorally ID /ʃi/ and /si/

Methods (cont.)

- Procedure
  - R ear tested only, foam plug in L ear
  - All pts. fit with Phonak Piconet2 P2 AZ BTE (analog)
  - HA settings:
    - Omnidirectional
    - VC inactivated
  - Electroacoustic properties of HA
    - Freq. response = 210 – 6500 Hz

Methods (cont.)

- Electrophysiology
  - Pts. seated in sound-attenuated booth 1 m from speaker at 0°
  - Output calibrated to be 70 dB peSPL
  - Each stimulus presented 250 times in homogeneous sequence with interstimulus interval of 1910 ms
  - Order of presentation counterbalanced across subjects
  - Pts. instructed to ignore stimuli and watch a closed-captioned video of their choice
  - EEG activity recorded with 32-channel Neuroscan system
  - Eye-blinks monitored through another channel
  - Recording window = 100-ms pre-stimulus & 1400-ms post-stimulus

Results

- The negative peak (N1 = N332) evoked by CV transition appears 29.57 ms earlier for /ʃi/ than for /si/
  - Mean = 331.86 ms for /ʃi/ & 361.43 ms for /si/
  - Bonferroni-corrected paired *t* test → significant difference
  - Amplification did not produce a significant latency or amplitude difference

Discussion

- /ʃi/ & /si/ elicited distinct ACC neural response patterns
  - 29-ms difference resembled 30-ms difference in vowel onset time found by Tremblay et al. (2003)
  - "Surprising" because speech signals altered by HA & delivered to a system that had experienced years of auditory deprivation
  - CV transition preserved by HA
- Results may vary with different signal-processing characteristics
- Perception is more than physiologic detection of stimuli – involves attention, memory, & cognition

Summary of Findings

First Author and Year of Publication	Location	Comparison	Control Patients	Number of Participants	Outcomes
Billings, 2007	USA	Unaided AEP responses	Concurrent	13 young normal hearing individuals	P1-N1-P2-N2 responses, elicited by tones
Tremblay, 2006	USA	Unaided AEP responses	Concurrent	7 adults with mild to severe SNHL	P1-N1-P2 responses, elicited by CV syllables

Summary of Findings (cont.)

- Neither study randomized
- Billings et al. (2007) focused on normal-hearing listeners vs. listeners with SNHL in Tremblay et al. (2006)
- Billings et al. (2007) used pure-tone stimuli vs. CV-syllable stimuli used by Tremblay et al. (2006)
- Tremblay et al. (2006) looked at latency of response only
- Tremblay et al. (2006) used analog HAs vs. digitally-programmable Has used by Billings et al. (2007)
- Both studies showed no significant changes in waveform morphology between unaided & aided conditions

Conclusion

- In adults with sensorineural hearing loss who wear hearing aids, is there a difference between unaided and aided evoked potentials as assessed by P1-N1-P2 responses?
  - Differences in responses are seen with changes in stimulus intensity (Billings et al., 2007)
  - Latency differences between responses to different CV syllables are preserved when presented through HA (Tremblay et al., 2006)
  - No significant changes in waveform morphology when comparing unaided vs. aided responses (Billings et al., 2007; Tremblay et al., 2006)
  - HA characteristics (e.g., compression) may affect signal differently (Billings et al., 2007; Tremblay et al., 2006)

References

- Billings, C.J., Tremblay, K.L., Souza, P.E., and Binns, M.A. (2007). Effects of hearing aid amplification and stimulus intensity on cortical auditory evoked potentials. *Audiology and Neurotology, 12*: 234 – 246.
- Tremblay, K., Kalstein, L., Billings, C., and Souza, P. (2006). The neural representation of consonant-vowel transitions in adults who wear hearing aids. *Trends in Amplification, 10*(3): 155 – 162.