Binaural Processing in Adults with a History of Traumatic Brain Injury
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Abstract
An auditory processing deficit is a perceptual issue affecting how the central auditory nervous system understands and makes sense of auditory information. Auditory processing deficits are typically associated with the patient population under study, indicating a need for an increased focus on central auditory effects. Traumatic brain injury (TBI) suggests that auditory processing deficits may be present among adults with a history of TBI, indicated with symptoms of an auditory processing deficit often score within the normal range on standard clinical assessments. The objective of the current study, therefore, was to target measures of binaural processing to identify and characterize auditory processing deficits among adults with a history of TBI. Two groups were recruited: adults with a history of TBI and a control group. Binaural processing was measured with: (1) the Revised Speech Perception in Noise test measured in soundfield; (2) dichotic word recognition; and (3) the Listening in Spatialized Noise-Sentences Test. Results suggest that individuals with a history of TBI have lower than normal binaural performance.

Introduction
Some adults have substantial difficulty understanding speech in complex listening situations.

- These adults often have normal hearing sensitivity as measured by a standard clinical evaluation. Unless specialized testing is conducted, auditory processing deficits may go undiagnosed.
- Auditory processing deficits often result in difficulty with communication, frustration, and fatigue. For individuals with mild traumatic brain injury (mTBI), these symptoms are exacerbated (including social isolation and depression).
- When presented with noisy, complex and distracting environments, however, the same individuals can break down both behaviorally and cognitively.
- Research has demonstrated that patients with TBI present with abnormal findings on measures of auditory processing [2-4].
- The ability to make use of sound input from both ears (i.e., binaural processing) is often compromised for adults with auditory processing deficits.
- The purpose of the present study, therefore, was to target measures of binaural processing to identify and further characterize auditory processing deficits within the adult population, with emphasis on those with mTBI.

Methods
Subjects
- Two groups of clinically normal hearing (thresholds ≤20 dB HL) adults participated: 13 adults 20-37 years served as the control group (negative history of mTBI)
- 9 adults 18-59 years with a positive history of mTBI

Materials/Procedures
- Questionnaires
  - Hearing Handicap Inventory for Adults (HHIA) [5]
  - 20-item assessing social and emotional hearing problems
  - Auditory Processing Questionnaire (APQ) [7]
  - 36-items assessing self-report of listening ability in various environments
- Behavioral Binaural Processing Measures
  - Revised Speech Perception in Noise Test (R-SPIN) [8]
  - Monaural right, monaural left and binaural at 4, 0, and +4 dB signal-to-noise ratio (S/N) thresholds
  - Dichotic Word Recognition [9]
  - Unfiltered and with low-pass filtering (4000 Hz)octave with a center frequency of 1500 Hz
  - Response conditions: free recall and directed recall (right and left)
- 500-Hz Masking Level Difference (MLD) [10]
  - SNR and SpN0 thresholds were calculated using the Speech-Kratter method
- Listening in Spatialized Noise-Sentences Test (LiSN-S) [11, 12]
  - Speech recognition thresholds for same voice at 0° (SV0°) and 90° (SV90°), different voices at 0° (DV0°) and 90° (DV90°)

Results

- An auditory processing deficit is a perceptual issue affecting how the central auditory nervous system understands and makes sense of auditory information. Auditory processing deficits are typically associated with the patient population under study, indicating a need for an increased focus on central auditory effects. Traumatic brain injury (TBI) suggests that auditory processing deficits may be present among adults with a history of TBI, indicated with symptoms of an auditory processing deficit often score within the normal range on standard clinical assessments. The objective of the current study, therefore, was to target measures of binaural processing to identify and characterize auditory processing deficits among adults with a history of TBI. Two groups were recruited: adults with a history of TBI and a control group. Binaural processing was measured with: (1) the Revised Speech Perception in Noise test measured in soundfield; (2) dichotic word recognition; and (3) the Listening in Spatialized Noise-Sentences Test. Results suggest that individuals with a history of TBI have lower than normal binaural performance.

- **Revised Speech Perception in Noise Test (R-SPIN)**: Measured in soundfield to assess speech perception in noise.
- **Dichotic Word Recognition**: Evaluated speech discrimination ability in monaural and binaural conditions.
- **Listening in Spatialized Noise-Sentences Test (LiSN-S)**: Assesses speech perception in noise with spatially manipulated cues.

**FIGURE 1.** Mean R-SPIN recognition performance (in % correct) as a function of S/N ratio for the control group (left panel) and the mTBI group (right panel). Recognition performance is plotted as psychometric functions for sentence type (high predictability [HP] circles) and low predictability [LP] squares), and for listening condition: right ear (red), left ear (blue), and binaural (green).

**FIGURE 2.** Mean S/N0 and S/N0 thresholds (in dB SNR) and MLDs (in dB HL) for each subject group: control (green) and mTBI (blue).

**FIGURE 3.** Mean LiSN-S speech recognition thresholds (in dB SNR) for each subject group: control (green) and mTBI (blue). Benefit was defined as the difference between the 0° and 90° conditions for same voice (SV) and different voices (DV).

**FIGURE 4.** Mean dichotic word recognition performance (in % correct) for right ear (RE) and left ear (LE) as a function of subject group: control (left panel), and mTBI (right panel). Data are presented for unfiltered and Relexed words for both response conditions: free recall (blue) and directed recall (green). Although data are not continuous, the RE and LE response conditions: free recall (blue) and directed recall (green). Although data are not continuous, the RE and LE

**FIGURE 5.** Mean HHIA and APQ scores for the control group (green) and mTBI group (blue). Results revealed significantly greater self-perceived auditory difficulties based on the APQ (p < 05) for the mTBI group as compared to the control group.

**TABLE 1.** The number of mTBI subjects with abnormal performance is presented for each of the four binaural measures. Below normal was defined as performance falling below the lower cut-off of the 95% confidence interval relative to the control group for the R-SPIN, LiSN, and DWR tests, and an MLD > 10 dB.

Conclusions
- Self-perceived auditory (i.e., hearing) difficulties were assessed with the HHIA and the APQ questionnaires (see Figure 5).
- HHIA: On average, there was no difference in hearing problems between the mTBI and control groups. Individual data, however, revealed three mTBI subjects with abnormally high HHIA scores, indicating self-perceived hearing problems.
- APQ: On average, mTBI subjects demonstrated significantly greater auditory processing difficulties compared to the control group.
- Based on these preliminary results, the APQ appears to be more sensitive than the HHIA to the auditory (i.e., hearing) complaints reported by individuals with a history of mTBI.
- Preliminary data from individuals with a history of mTBI, on average, demonstrate similar results relative to the control group for all binaural processing measures.
- Individual data indicates abnormal binaural processing for 7/8 (75%) of subjects with a history of mTBI, 2/9 exhibited abnormal binaural performance on three out of four measures
- 5/9 exhibited abnormal binaural performance on two out of four measures
- Preliminary results suggest that individuals with a history of mTBI that present with clinical auditory complaints should be evaluated beyond the standard audiological evaluation.

References