"It's all in your head": Abnormal visual processing during magnetoencephalography is associated with mild traumatic brain injury in US Veterans

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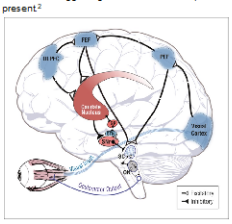
Background

Veterans with mild traumatic brain injury (mTBI) often report persistent sensory disturbances that negatively influence quality of life in the absence of evidence of sensory organ damage.[1] However, it is unclear what pathophysiologic processes contribute to these persistent symptoms.

Magnetoencephalography (MEG) is a neuroimaging technique that provides high temporal resolution to track brain function in real time by measuring magnetic fields generated by neuronal ensembles. This allows researchers to parse early sensory processing responses from higher-order cognitive processes. The visual response to a centrally presented visual stimulus reveals a typical evoked response in healthy individuals with stereotypical latency peaks evident at ~100 and 200 ms post stimulus.

Prior work by our group found reduced amplitude of evoked responses on MEG in sensory cortex and increased amplitude in heteromodal association cortex in civilians with mTBI, suggesting aberrations at multiple levels of sensory processing may be present.[2]



https://www.researchgate.net/figure/Figure-Saccadic-eye-movements-are-supported-by-a-distributed-network-of-cortical-and_fig1_314436601

Figure 2. Left: Neural visual system. DLPFC = dorsolateral prefrontal cortex; FEF = frontal eye fields; PEF = posterior eye fields; SNr = substantial nigra pars reticulata STN = subthalamic nucleus SC = superior colliculus; GP = globus pallidus; ON = oculomotor network. Right: Event-related fields are recorded from various brain regions by the MEG while a participant performs a task.

Hypothesis

We present baseline data from the NAVIGATE-TBI study, in which a prosaccade task was performed during MEG to examine visual processing in veterans with mTBI with chronic sensory symptoms and healthy veteran controls.

Hypothesis: MEG will confirm that a Veteran population with mTBI compared to a control group without mTBI demonstrates decreased activation in sensory cortex and increased activation in cognitive control nodes during a visual prosaccade task.

1 Lew H, Poggola T, Baker E, et al. Prevalence of dual sensory impairment and its association with traumatic brain injury and blast exposure in OEF / OIF veterans. J Head Trauma Rehabil. 2011;26(6):489-496.
2 Hunter MA, Houck J, Quinn DK, et al. Investigating auditory attention in mild traumatic brain injury using magnetoencephalography. Poster Presented at National Neurotrauma Meeting, Lexington KY, June 29, 2016.

Methods

Recruitment: : Forty-two veterans (42.6 ± 10.1 years, 39M/3F) with mTBI between 3 months and 15 years prior to study enrollment, with chronic visual, auditory, or balance symptoms were recruited to participate in a comprehensive neuroimaging study to examine the neural underpinnings associated with sensory processing deficits. Similarly, 36 veterans (46.0 ± 12.4 years, 25M/11F) without history of prior TBI were recruited into the healthy control group (HCs).

Baseline Testing: Participants underwent demographic assessment, postconcussive symptom (PCS) survey, neuropsychological testing, oculomotor assessment, MEG using the 306 sensory MEGIN whole-head system, and magnetic resonance imaging (MRI) using a 3T magnet.

MEG: During the MEG they participated in a prosaccade task in which: 1) a fixation cross was presented in the middle of a screen placed 100 cm in front of the participant, 2) following a short delay the fixation cross was replaced by a circle, centrally located, to direct the participant's attention to the center of the screen, 3) following a variable delay (x to y sec) a target stimulus was presented in two possible positions (5° or 10° from central fixation) in either left or right visual field along the horizontal meridian, and 4) the participant was instructed to saccade to the target as quickly and accurately as possible. Two hundred trials were presented with conditions randomized across the two locations and hemifields.

Analysis: MEG data were preprocessed using Maxfilter to eliminate artifact and correct for head motion during the data session. Additional preprocessing was completed using MNE-Python to eliminate trials with large amplitude artifacts, often due to movement and heartbeat and eyeblink artifact. Finally, epochs for which the participant did not fixate on the central stimulus at the beginning of the trial or did not saccade to the target were eliminated from further processing. The results were signal-averaged and examined at the sensor and source level.

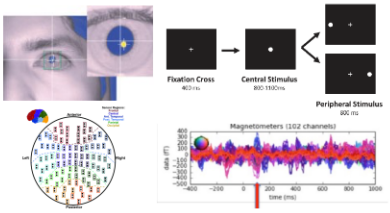
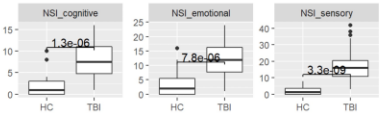


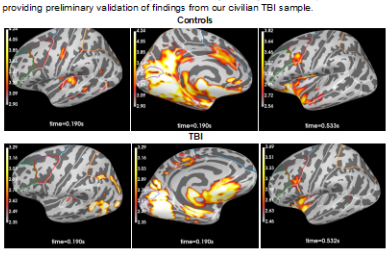
Figure 3. Top left: Eye tracking system used in MEG. Top right: the prosaccade task requires participants to focus on fixation cross, then saccade to left or right target when it appears. Bottom left: MEG sensor distribution. Bottom right: summation of all event-related field changes recorded by a MEG sensor.

Results

The mTBI group reported significantly greater PCS on the Neurobehavioral Symptom Inventory (NSI) compared to HCs on the sensory, emotional, and cognitive subscales (Wilcoxon rank-sum tests, see below; all $p < 0.001$).



On MEG during the saccade task (TBI = 9, HC = 9), lateral (left) and medial (middle) activation of occipital cortex following central stimulus was observed, representing the initial response in visual cortex (time 0.190 s). Following the left peripheral stimulus, left frontal activation at a later time window (~530 ms or 0.530 s) was observed. While data processing and analysis are still ongoing, HCs appear to have larger amplitudes and areas of activation in primary and secondary sensory cortex compared to TBIs, providing preliminary validation of findings from our civilian TBI sample.



Conclusion

The amplitude and spatial distribution of sensory cortex activation on a visual prosaccade task may be diminished in Veterans with mTBI and chronic post-concussive symptoms compared to Veteran controls. Future analyses will include characterizing evoked responses in related sensory tasks including anti-saccades and auditory orienting, and correlating MEG abnormalities with clinical outcomes. At its conclusion, NAVIGATE-TBI will provide a more complete picture of cortical processing dysfunction underlying chronic sensory symptoms after military mTBI.

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