Understanding socio-behavioral changes in adolescents with traumatic brain injury using fMRI

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Target Audience: TBI researchers, MRI physicists.

Purpose: Adolescence is a crucial developmental period and is also a high-risk group for traumatic brain injury (TBI) [1]. While cognitive, behavioral, and emotional deficits have been documented after childhood TBI [2] there are only a handful of studies that focus specifically on the impact of TBI on cognitive, and behavior abilities during adolescence [3]. One area of persistent deficit after TBI is social functioning [4], which is comprised of multiple interacting components including social cognition, attention, memory, and executive function [4,5]. Because socio-emotional behavior is so critical to successful outcome in adolescence, and an area of persistent behavioral deficit following TBI [4], the purpose of this study was to use Functional Magnetic Resonance Imaging (fMRI) to 1) identify patterns of activation in adolescents with and without TBI during a social cognitive task of increasing difficulty and 2) to correlate specific brain regions with performance on memory measures.

Method: 7 patients (mean age 20 yrs±1.41) who survived a TBI at least 10 months prior and 9 controls (mean age 20 yrs±0.71) were scanned at 3T using a 12 channel head coil, and bite bar to reduce head motion. Scans included T1-MPRAGE, and two runs of fMRI at 2x2x4mm, 31 slices, TR/TE=2800/29. In each fMRI, a video-based test that required social inferences was performed. The test had questions at 3 levels of difficulty, type1, type 2, and type 3. Questions within type 1 category were the easiest, and type 3 category were the hardest requiring the most difficult mental state social inference. The subject responded to each question using a button box. Each fMRI run was corrected as described in [6], and the two runs were co-registered, and concatenated prior to computing the student t-map using AFNI [7]. Whole brain activated ($t = 4$, and $p<0.0002$) voxels were calculated for each question type. Additionally, a voxel-by-voxel whole brain correlation map was calculated using type 1 student t-map and "general memory", a subtest in Wechsler Memory Scale (WMS-III), which is a neuropsychological test.

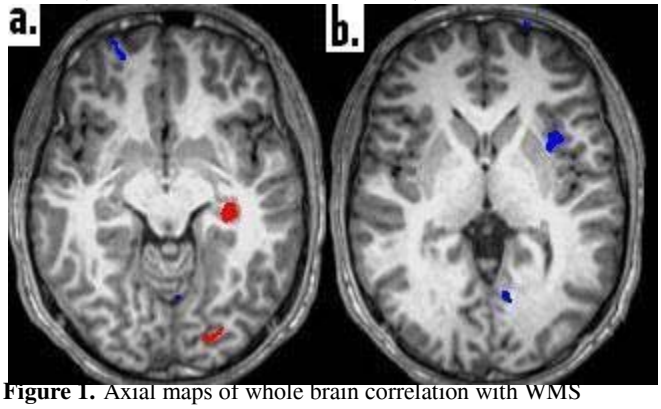

Figure 1. Axial maps of whole brain correlation with WMS subtest showing hippocampal activation in (a), and insula deactivation in controls.

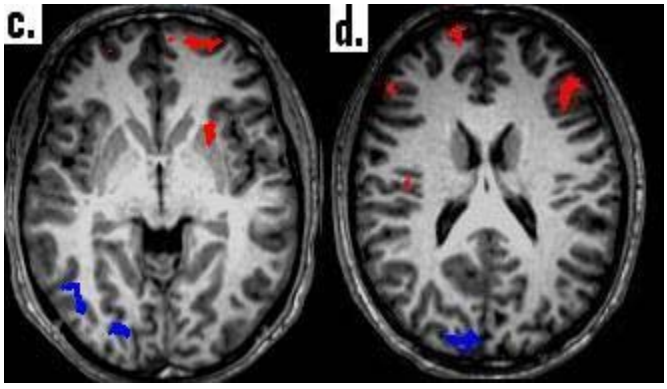

Figure 2. Axial maps of whole brain correlation with WMS subtest showing putamen, and SFG activation in (c), and in (d) DL-PFC activation in patients.

Results and Discussion: There was significant difference in the whole brain activated voxels between patients, and control groups in type 1 questions ($p=0.032$), and between the type 3 questions in patients with type 1 questions in controls ($p=0.017$). In the voxel correlation map, significant ($r\geq0.75$, $p<0.025$) positive activation was observed in hippocampus in controls, and deactivation in insula, while in patients there was significant ($r\geq0.82$, $p<0.025$) activation in insula, superior frontal gyrus (SFG), and dorsolateral prefrontal cortex (DL-PFC). This suggests that different networks are being used in controls, and patients during social cognition tasks. We also observe a lateraled hippocampal, and insula activation in controls, and putamen in patients.

Conclusion: The activated voxels in patients responding to type 1 category questions is significantly lower than type 1 in controls, this might indicate that patients are still somewhat "compromised" in terms of social behavioral performance. In the whole brain correlation map with memory index, strong hippocampal activation seen in controls is absent in patients, which indicates that TBI patients are not recruiting regions normally associated with memory.

References: 1)Walz et al.,Jrnl. of Pediatric Rehab. Med.,2(4),285-295,2009.2)Yeates et al, Neuropsyhcology,16(4),514-523,2002.3) Haten et al.,Neurophsychologia,49(3),486-497,2011.4) Rosema et al., Jrnl. of NeuroTrauma,29,1277-1291,2012.5)Yeates et al., Intnl. Jrnl. Of the Neuropsychological Society,10,412-426,2007.6) Lowe et al., Hum. Brain Mapp.,29,818-827,2008.7)Ward, http://afni.nimh.nih.gov/pub/dist/doc/manual/Deconvolvem.pdf,2006