Proximal and Distal Effects of Subconcussive Head Impacts on fMRI Activity in Asymptomatic High School Football Players

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Purpose: High school American football players, in the absence of diagnosis or symptoms of concussion, have exhibited changes in brain metabolism (measured by fMRI) correlated with the history of subconcussive head impacts.[1] While shown using a verbal task, literature suggests that visual deficits may be more prevalent in concussion.[2] Both verbal and visual tasks were used to assess effects of subconcussive blows in asymptomatic high school football players.

Methods and Results: 53 male football players from two local high schools participated in the study. Head impacts were measured by accelerometers installed in their helmets (HIT System, Simbex). Hits were assigned to one of four helmet regions (*top-front*, *facemask*, *side*, and *back*). Players participated in MRI sessions prior to the start of the season (*pre-season*), and during the season (*in-season*). For each session, players completed verbal and visual N-back (2-, 1-, and 0-back) tasks[3] in the scanner (TR/TE = 1500/30ms; 35^0 flip angle, 34 slices; 3.8 mm isotropic). The verbal task used letters for stimuli; the visual task used line designs. *In-season* fMRI activation (2- vs. 0-back and 2- vs. 1-back) for each of these tasks was compared to *pre-season* for each subject. Changes from *pre-season* to *in-season* were averaged within each of 116 MarsBaR[4] regions and compared to prior week and cumulative hit totals in each of the four helmet regions using a stepwise regression analysis. Through this analysis, regional activation changes are estimated as the linear sum of the contributions of the different hit types (Fig 1). There is an apparent proximal-distal effect of hit type. This effect was quantified for *top-front*, *facemask*, and *back* hits using a Bernoulli trial model, where regions are assigned to anterior and posterior halves of the brain based on the y= -20mm plane. Each region is treated as a trial, and 'success' is defined as a significant negative correlation for a region in the half proximal to the hit or a significant positive correlation for a region in the half distal to the hit. See Table 1 for results.

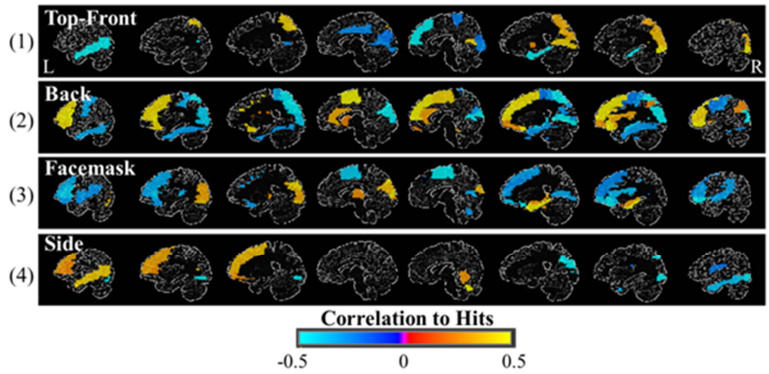

Figure 1: Correlations between 2-back vs. 0-back visual task and hits to helmet locations. Regions are colored based on the direction and strength of the correlation. Stepwise regressions used the z-scores of all vectors. Color bar units are zscore/zscore slope of the relationship.

Table 1: Estimate of significance of volume effects			
Verbal 2-back vs. 1-back		**Verbal 2-back vs. 0-back**	
TopFront	***p*=0.027**	*TopFront*	*p*=0.330
Facemask	*p*=0.071	***Facemask***	***p*=0.027**
Back	*p*=0.166	***Back***	***p*=<0.001**
Visual 2-back vs. 1-back		**Visual 2-back vs. 0-back**	
TopFront	***p*=0.003**	*TopFront*	*p*=0.071
Facemask	***p*=0.009**	***Facemask***	***p*=0.003**
Back	***p*=0.027**	***Back***	***p*=<0.001**

Discussion and Conclusions: In addition to confirming previous results of significant brain changes that correlated with hit history in a cohort of asymptomatic high school football players, we further characterize these changes as having proximal and distal effects with hits. This was true for both tasks and both contrasts, but most noticeable in the visual 2- vs. 0-back contrast, which was also the contrast with the greatest difference in difficulty. While these changes cannot be attributed to coup and contre-coup effects (no player experienced solely hits to one location), these results do suggest that there may be multiple brain structures (e.g. neurons, vasculature, glia) affected by repetitive head trauma, as it is unlikely that a single structure would demonstrate linear summations of injuries.

References: 1. Talavage TM et al. J Neurotrauma. *In Press*. 2. Galetta KM et al. J Neurol Sci 2011 309(1-2):34-9. 3. Ragland JD et al. Neuropsychology 2002 16(3):370-9. 4. Brett M, et al 8th Int Conf on Func Brain Mapping 2002.