Multi-scale coupling of BOLD fMRI and cardiac variability in patients with mild Traumatic Brain Injury

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Target Audience

Clinicians and neuroscience researchers in the domain of concussion and traumatic brain injury, and those interested in using resting-state BOLD fMRI as a clinical assessment tool.

Purpose

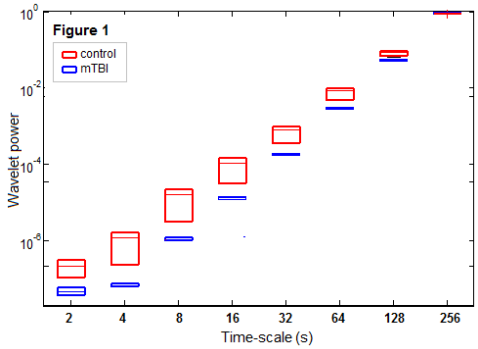
Traumatic brain injury is a major health issue, as even mild TBI (mTBI) may cause significant physical and cognitive impairments, leading to long-term decreases in quality of life. The assessment and treatment of mTBI is therefore critical, in order to plan effective rehabilitation and to minimize further injury. There has been long-standing research establishing heart rate variability (HRV) as a correlate of mTBI outcome[1], reflecting autonomic dysregulation. More recently, it has been shown that brain variability at different time-scales is also altered by mTBI[2]. All though there is a well-established interaction between HRV, neurovascular function and autonomic regulation[3], there are currently no studies examining the relationship between BOLD fMRI dynamics and HRV for mTBI populations. In this abstract, we examine the coupling of cardiac variability and BOLD variability across a range of timescales, which is used to characterize the differences between mTBI patients and healthy controls.

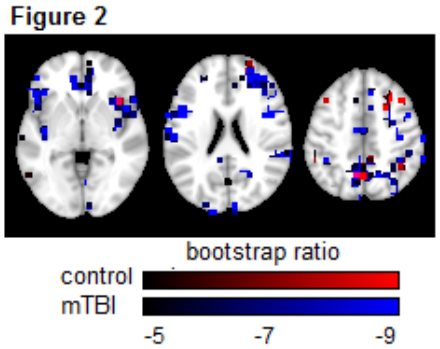
Methods

We acquired ~6 min. of resting-state BOLD data for 5 acute mTBI patients, and 10 controls; we simultaneously measured cardiac pulsation using a photoplethysmograph. The BOLD time-series were decomposed using wavelets (Daubechies wavelets, over 8 dyadic scales), and we computed power (i.e. total brain signal variability) at each time-scale. We computed heart rate variability by interpolating the discrete inter-beat intervals, then downsampling this trace to the same interval as the fMRI data; we again computed wavelet power for the cardiac data, over 8 time-scales. We then used Partial Least Squares analysis to obtain a map of brain regions showing significant coupling between the multi-scale BOLD spectrum and cardiac spectrum. In addition, we computed the bootstrap ratios at each voxel, as a measure of the stability of BOLD-HRV coupling.

Results

Figure 1 plots wavelet power as a function of cardiac scale (with Bootstrap standard error intervals), showing that the mTBI group has consistently lower power, and a different trend in relative power scaling. ***Figure 2*** plots bootstrap salience maps for control and mTBI groups. All significant brain regions showed negative BOLD coupling with cardiac power; the mTBI population showed a more spatially extensive set of regions coupled with HRV, although some region were common to both mTBI and control (i.e. right insula and precuneus).





Discussion and Conclusions

We have demonstrated a novel approach to combining heart rate variability and resting-state BOLD fMRI, in order to characterize differences between controls and patients with mTBI. This approach shows significant promise as a potential diagnostic tool for mTBI populations.

References

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