fMRI in frequency space: relating spontaneous pain to altered resting state fluctuations in chronic back pain

Marwan N Baliki, Alex Baria and A Vania Apkarian.

Chronic pain is maladaptive and its impact on brain function goes beyond pain processing and alters the flow and integration of information between brain regions. Here we investigate the impact of chronic pain using a new approach. We study fMRI in frequency space, subdividing BOLD signal into low (0.01-0.05 Hz), mid (0.05-0.12 Hz) and high (0.12-0.2 Hz) frequency oscillatory bands, which we think reflect the intrinsic features of large-scale neural organization of the brain. We use a power spectral density (PSD) analysis to map and compare the anatomical and functional correlates of the 3 frequency bands in healthy controls and in patients suffering from chronic back pain (CBP).

To investigate the changes in the intrinsic fluctuations of the BOLD signal associated with CBP we scanned 28 patients and 16 healthy subjects during rest. For each subject, we extracted the time series of the BOLD signal from each voxel and computed the PSD for the 3 frequency bands. Group average PSD maps for each group were generated by averaging the power of each voxel across all subjects within each group. In healthy subjects we observe that low frequency is mostly localized to cortical regions including medial prefrontal (MPFC) and posterior cingulate and parietal cortices. Regions such as anterior cingulate cortex (ACC) and insula exhibited power in the mid and high bands. When we performed a t-test to determine the difference in power for each frequency band between the 2 groups, we found that the patients exhibited significant increased high frequency power in the MPFC and to a lesser extent in the ACC and insula. Furthermore the increase in PSD for high frequency showed a correlation with the duration of their pain. In the patients a seed ROI correlation analysis indicated that the brain regions that showed aberrant frequency representation also exhibit increased connectivity to each other when compared to control, and was dependent on the amount of pain the patient reported.

These results show that chronic pain is represented as a high frequency signal that disturbs the resting brain. To corroborate these results, we examined spectrograms of the MPFC signal in patients while rating their spontaneous pain or performing a control visual task. We found that increase in high frequency power of the MPFC was temporally correlated with increased spontaneous pain ratings. No correlation was found for the visual rating task. These observations provide us with novel insight about the nature of CBP, which is associated with increased high frequency events, that signal spontaneous pain and disturbs the resting brain