Analysis of fMRI Timecourse and correlation in typical childhood absence seizures

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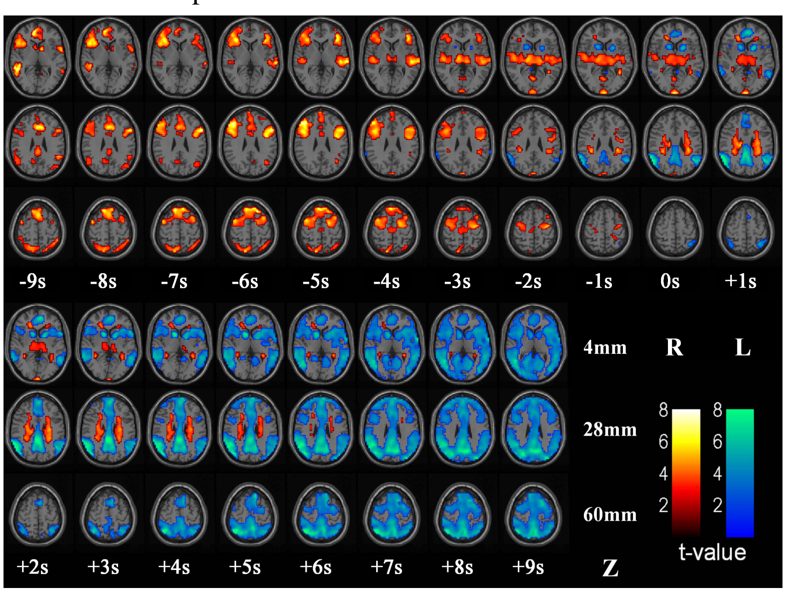
Rationale:
Typical childhood absence seizures are brief 5-10 second episodes, associated with bilateral 3Hz spike-and-wave discharges on electroencephalogram (EEG), and accompanied by brief impairment of consciousness. However, recent studies suggest that more subtle EEG and behavioral abnormalities may occur for many seconds both before and after these brief episodes. Simultaneous EEG and functional magnetic resonance imaging (fMRI) (EEG-fMRI) recordings provide a powerful tool which can be used to investigate longer lasting events in brain networks before and after absence seizures.

Methods:
Simultaneous EEG-fMRI measurements were conducted in 8 children with typical childhood absence epilepsy. A total of 40 seizures were analyzed using three different methods: 1. fMRI data were analyzed using SPM2, but the onset of the canonical hemodynamic response function (HRF) was systematically shifted in 1s increments from -20s to +20s relative to seizure onset. 2. The SPM MRI template Colin27 was segmented into 13 cortical and sub-cortical regions in each hemisphere. SPM activation or deactivation clusters in each anatomic region were used to obtain mean time-courses (percent change of the fMRI signal) for the 13 regions using MARSBAR. 3. Correlation, timing, and PCA analyses were performed on the time courses for the identified regions.

Results:
In the group SPM analysis, the authors found a complex sequence of fMRI increases and decreases which began before seizure onset and continued for at least 20 seconds after seizure end. SPM images with shifted HRFs show early cortical fMRI increases in many regions, followed by large and long-lasting cortical decreases. The predominant region showing increased activity later than the cortex was the thalamus. Regional time course analyses without HRF modeling or time shifts confirmed early cortical fMRI increases in many areas of the frontal lobes. Later peaks in mean activity occurred in rolandic cortex and thalamus 9.8s and 13.1s respectively after seizure onset. Sustained and delayed decreases were seen in most cortical regions. Based on correlation and PCA analyses, regional fMRI changes were summarized to three patterns: 1. small early increases and late decreases (e.g. frontal cortex), 2. mainly late decreases (e.g. parietal cortex), or 3. mainly late increases (thalamus). Analysis of identical time epochs in other data without seizures in patients or in controls displayed none of these changes.

Conclusion:
These results demonstrate a complex sequence of changes in absence seizures, which are not detectible by canonical HRF modeling. Cortical and subcortical network changes happen both before and after absence seizures. These results may be important mechanistically for seizure initiation and termination, and may also contribute to changes in EEG and behavior which precede and follow absence seizures. These findings may also be observed in other forms of epilepsy.



References:
1. Blumenfeld R. et al., Cerebral Cortex 2004. 14:892-902.
2. Gotman J. et al., J Clin Neurophysiol 2004. 21: 229–240.

Fig. 1 Cortical and subcortical fMRI changes during absence seizures in 8 patients with 40 seizures while undergoing behavioral testing. fMRI data were analyzed using SPM2. The onset of the canonical hemodynamic response function (HRF) was systematically shifted from -20s to +20s relative to seizure onset. Results shown are from -9s to +9s.