

## SPIKE-TRIGGERED *f*MRI IN READING EPILEPSY AND BENIGN EPILEPSY WITH CENTROTEMPORAL SPIKES

### Spike-triggered *f*MRI in Reading Epilepsy: Involvement of Left Frontal Cortex Working Memory Area

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**OBJECTIVE:** To determine the origin of epileptiform activity in reading epilepsy (RE) and the association between these regions and regions activated by reading, and to assess brain morphometry in these areas.

**METHODS:** In two subjects with RE, EEG was recorded inside the three tesla MRI while subjects read silently. Spike-triggered *f*MRI images were compared to baseline. In a second *f*MRI study, 30 seconds of silent reading was compared to visual fixation. Morphometry of these areas was assessed using curvilinear surface reconstruction. Left central sulcal patterns in three subjects with RE were compared to three subjects with idiopathic generalized epilepsy (IGE) and 12 normal controls.

**RESULTS:** One subject with RE showed spike-related activity (17 spikes) in the left precentral gyrus, and bilaterally in the central sulcus and globus pallidus. The other showed no definite activation owing to low spike numbers (4 spikes). In both subjects, the block reading task recruited normal visual and language areas including the left posterior middle frontal gyrus. Two subjects with RE showed an unusual gyrus branching anteriorly off the left central sulcus. A similar sulcal pattern was seen in none of the subjects with IGE and only 1 of 12 controls.

**CONCLUSION:** Spike activity overlapped with reading activity in the left middle frontal gyrus, a structure recruited during working memory cognitive tasks. The authors postulate that, because of a local structural anomaly, the spikes of reading epilepsy spread from working memory areas into adjacent motor cortex, activating a cortical subcortical circuit.

### Benign Epilepsy with Centro-temporal Spikes: Spike Triggered *f*MRI Shows Somato-sensory Cortex Activity

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**OBJECTIVE:** We performed spike triggered functional MRI (*f*MRI) in a 12 year old girl with Benign Epilepsy with Centro-temporal Spikes (BECTS) and left-sided spikes. Our aim was to demonstrate the cerebral origin of her interictal spikes.

**METHODS:** EEG was recorded within the 3 Tesla MRI. Whole brain *f*MRI images were acquired, beginning 2-3 seconds after spikes. Baseline *f*MRI images were acquired when there were no spikes for 20 seconds. Image sets were compared with the Student's *t*-test.

**RESULTS:** Ten spike and 20 baseline brain volumes were analysed. Focal activation was seen in the inferior left sensorimotor cortex near the face area. The anterior cingulate was more active during baseline than spikes.

**CONCLUSIONS:** Left sided epileptiform activity in this patient with BECTS is associated with *f*MRI activation in the left face region of the somatosensory cortex, which would be consistent with the facial sensorimotor involvement in BECT seizures. The presence of BOLD signal change in other regions raises the possibility that the scalp recorded field of this patient with BECTS may reflect electrical change in more than one brain region.

### COMMENTARY

**F**unctional magnetic resonance imaging (*f*MRI) is an important diagnostic tool that may be used to identify focal cortical activation during partial seizures or interictal epileptiform discharges. A spike-triggered *f*MRI is capable of detecting the cerebral localization or origin of focal spike discharges (1). These neuroimaging techniques may also be used to evaluate the

pathophysiology of focal epileptogenesis and the mechanisms associated with seizure generation and propagation (1–3).

Reading epilepsy, which has its onset in the mid-teens, is a disorder associated with an increased seizure tendency that is task specific. The key seizure-precipitating factors include reading, concentration, and mathematical calculation. During the period of seizure precipitants, an EEG may reveal conflicting findings, including widely distributed epileptiform discharges that are maximal over the left frontotemporal head region. The unprovoked EEG pattern and structural neuroimaging studies are usually unremarkable in these individuals. The ictal behavior, for individuals with reading epilepsy, may involve myoclonic jerks of the jaw and facial musculature, myoclonus of the extremities, and generalized tonic–clonic seizure activity.

Archer et al., identified two individuals with reading epilepsy who agreed to undergo an *fMRI* study. The study paradigm, using spike-triggered *fMRI*, was similar for the two individuals. An EEG recording was performed at baseline, prior to the *fMRI* study. The EEG recordings were obtained inside a three tesla MRI, while patients read quietly to themselves. In an additional *fMRI* study, 30 seconds of “silent reading” was compared to visual fixation. Curvilinear reconstruction was used to evaluate brain morphometry. A third patient with reading epilepsy did not have a spike-triggered *fMRI* study but did undergo brain morphometry.

Results indicated that spike-triggered *fMRI* activation occurred in the first patient, bilaterally, in the precentral gyrus, central sulcus, and globus pallidus. Evaluation of *fMRI* activation during the reading task showed an “overlap in the posterior extent of the dorsolateral prefrontal cortex.” The second patient had infrequent spikes and no activation. The brain morphometry in both patients revealed an “unusual” left central sulcus—with an abnormal appearing sulcus extending from the left central sulcus towards the left middle frontal gyrus in both patients. The third patient’s structural imaging study did not reveal this anatomical alteration. The authors suggest that a focal seizure discharge in the left dorsolateral prefrontal cortex, a brain region “recruited by the working memory component of the reading task,” may be associated with reading epilepsy. The epileptiform discharges and spike-triggered activation may indicate the diagnosis of partial seizure disorder in these patients with the region of seizure onset usually involving the left

middle frontal gyrus. Subsequently, there is activation of cortical and subcortical structures producing the characteristic ictal behavior.

Benign epilepsy is an idiopathic, localization-related seizure disorder, which also occurs in childhood. The ictal behavior and interictal EEG findings are distinctive and allow proper classification. As with reading epilepsy, the interictal neurological examination and structural neuroimaging studies are usually normal. The EEG shows unilateral or bilateral centrotemporal spikes that are maximal during drowsiness and sleep. Once again, the Archer et al., group reported the result of a spike-triggered *fMRI* and EEG study in a patient with this disorder. The patient evidenced signal activation in the face area of the sensorimotor cortex, which is the supplementary motor area known to be involved in attention and concentration. The spike-triggered *fMRI* localization correlates with the ictal symptomatology of benign epilepsy, including prominent involvement of the face with an increase in salivation. The imaging findings also correspond to the localization of the focal interictal epileptiform discharges in these patients.

These elegant studies provide compelling evidence for the pivotal role of *fMRI* in evaluating focal activation by partial seizures and epileptiform discharges. Innovative functional imaging techniques are now effectively being used to assess the cerebral localization of epileptiform activity as well as the mechanisms of seizure generation and propagation. The spike-triggered *fMRI* findings and brain morphometry in reading epilepsy are provocative and will require further evaluation and confirmation.

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## References

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