Simultaneous DBS and fMRI in the rodent brain

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Deep Brain Stimulation (DBS) is a promising treatment for neurological and psychiatric disorders. However, the underlying mechanism of action of DBS remains unknown. The effects of DBS have been studied primarily by electrophysiological and neurochemical studies, which lack the ability to elucidate DBS related responses on a whole-brain scale. Visualization of whole-brain effects of DBS requires functional imaging techniques such as functional Magnetic Resonance Imaging (fMRI), which reflects changes in blood oxygen level dependent (BOLD) responses throughout the entire brain volume. In order to visualize BOLD responses to DBS, we have developed an MR-compatible electrode and an acquisition protocol for simultaneous DBS and BOLD fMRI. With this study, we aimed to demonstrate that DBS during fMRI is a valuable technique to investigate the whole-brain effect of DBS. Four adult male Sprague-Dawley rats were stereotactically implanted with a custom-made MR-compatible DBS-electrode in the right hippocampus. Electrical Poisson distributed stimulation was applied (amplitude 75mA, pulse duration 100μs, frequency 130Hz) using a block-design paradigm (20s on/40s off). MR images were acquired on a Pharmascan 7T (Bruker) using a rat brain volume coil. Rats were sedated with medetomidine during all fMRI acquisitions. Data were processed by means of independent component analysis. Clusters were accepted as significant if p-values were 0.05 or less after correction for multiple comparisons. Each resultant statistical map was co-registered onto a structural MR image for anatomical correlation. Our data indicate that real-time hippocampal DBS evokes a bilateral BOLD response in hippocampal and thalamic substructures. We present that simultaneous DBS and fMRI can be used to explore the whole-brain effect of modulating neural circuitry, making this technique potentially powerful for exploration of cerebral changes of DBS in animal models of neurological or psychiatric disorders.

Short comment:
This research investigates the whole-brain effect of deep brain stimulation (DBS) on the cerebral oxidative metabolism in rats. This is significant because despite the remarkable clinical success of DBS, there are still about 25% of non-responders to the treatment. A better understanding of the whole-brain effect of DBS is therefore necessary to improve treatment efficacy in patients. Successful translation of this research to patients might reduce the number of non-responders to this expensive and invasive treatment.