Title: A deep learning approach for training human selective attention with a real-time brain-computer interface (BCI)

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Description: The brain is among the most complex of biological systems, with the billions of neurons and trillions of connections among these neurons. Despite this rich machinery, we effectively encode only a small portion of the sensory world around us, guided by a cognitive process known as “selective attention”. In this project we will attempt to answer the following questions: How does the ability to pay attention emerge in the brain? Can this ability be improved with training? In particular, can subjects train their attention using signals measured from their own brain?

To answer these questions we will employ a real-time brain computer interface by recording brain signals with high-resolution functional magnetic resonance imaging (fMRI). fMRI is a non-invasive approach to indirectly measure activity in the human brain. By scanning human subjects inside an fMRI scanner when they perform attention tasks, we can answer specific questions such as, which location or what object is a person attending to? How much attention is the subject paying to this location or object? Based on this “decoding” analysis, we can provide “neuro”-feedback to subjects to make them aware of their level of attention, and potential lapses of attention.

However, there is a challenge: fMRI recordings have a very high spatial dimensionality (~million voxels). Data at this level cannot be directly presented to human subjects for neurofeedback. Therefore, we need to reduce the data’s dimensionality to generate clean, accessible, low-dimensional representations for neurofeedback. For this, we will apply deep learning (representation learning) approaches using convolutional neural networks. This low-dimensional real-time neurofeedback will then be used to help subjects "train" their attention.

The project lies at the intersection of computer science, neuroscience, neuroimaging and deep learning domains.