Noninvasive optical detection of neural activity in brain tissue

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Functional brain imaging techniques have played an essential role in brain researches and neural engineering applications. In particular, noninvasive techniques are very useful because they do not need the brain surgery implanting electrodes into the brain. One of the most widely used techniques is the functional magnetic resonance imaging (fMRI). Recently, optical methods such as the functional near-infrared spectroscopy (fNIRS) are also utilized because they can be used in the daily-life environment. These two techniques, however, show high latency (several-seconds time delay) due to the neurovascular coupling. This weakness makes them hard to be used in time-sensitive researches despite their high spatial resolution. As the basic study toward developing a low-latency optical technique, we investigated how the fundamental optical property of the brain tissue varies with neural activation. The near-infrared transmission spectrum of the rat brain slice was monitored while neural activity was electrically evoked and recorded. For this purpose, we developed a high-speed near-infrared spectroscopy to obtain one thousand spectrum data per one second. As the result, we found optical changes correlated with the neural activity even in the absence of the neurovascular coupling. The optical changes showed much lower latency (hundred-milliseconds time delay) than the fMRI and fNIRS. This optical response will be applied to development of a new optical neuroimaging technique.

Keywords: neural activity, optical measurement, near-infrared spectrum, fast intrinsic optical signal, neurovascular coupling

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