# A new window into the brain

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Tübingen neuroscientists have made an important advance in studying the human brain with functional magnetic resonance imaging (fMRI). This imaging technique is used in research endeavours to investigate the interactions between different brain regions – but indirectly: fMRI does not measure neuronal processes, but marks active brain areas on the basis of their blood flow. Dr. Markus Siegel and his team (Werner Reichardt Centre for Integrative Neuroscience – CIN / MEG Center, University of Tübingen) have now shown that interactions measured with fMRI indeed reflect correlated nerve cell activity, and in what form they do so. This will make the imaging method even more attractive for neuroscience research. The study is now published in the prestigious journal *Current Biology*.

The human brain consists of about 100 billion interconnected neurons, clustered in various functional regions. These regions fulfil different specific tasks, but are in constant communication with each other. These interactions between brain regions are the basis of our thoughts and actions. Disorders in these interactions, however, are often at the heart of neurological diseases, such as multiple sclerosis (MS).

To non-invasively investigate interactions between brain regions, neuroscience research is employing fMRI, which indirectly measures brain activity by monitoring blood flow and the blood's oxygen levels in the brain. Nerve tissue uses a lot of energy – our brain consumes about 25% of our daily calories intake –, so active regions of the brain are better supplied with blood than their inactive counterparts. This leads to conclusions about which brain regions are currently "at work" and interacting with other brain regions. However, since fMRI does not directly measure neuronal activity, but blood circulation and oxygenation, it remains unclear if and which neuronal interactions fMRI actually reflects.

To fill this knowledge gap, Dr. Siegel and his team correlated fMRI recordings of human subjects with their magnetoencephalography (MEG) measurements. In contrast to fMRI, MEG directly measures brain activity – it registers the tiny magnetic fields generated by neuronal activity. MEG has poorer spatial resolution than fMRI, but its exquisite temporal resolution allows for resolving different brain rhythms: fast, periodic changes in brain activity. Tübingen University is one of very few German institutions with an MEG facility. Markus Siegel and his team compared the interactions between 450 points in the brain as measured with both fMRI and MEG. The team evaluated about 100,000 individual data points. This effort has paid off: they were able to show a direct relation between neuronal activity and neuronal interactions measured with fMRI. Moreover, they were able to show that that this relation is not the same across the brain. Instead, fMRI reflects interactions between different brain rhythms for different pairs of brain regions. Thus, much of the information provided by fMRI is complementary to that provided by MEG.

These findings provide an important fundament for the use of fMRI in neuroscience research. Furthermore, these results demonstrate the advantages to be gained by combining fMRI with its high spatial resolution and MEG or EEG with their high temporal resolution.  The combination of methods promises to be of use in diagnostics or even during preparation of therapy in the future. The new window will deliver ever clearer pictures of what happens in the healthy and diseased human brain.

**More information:** "BOLD fMRI Correlation Reflects Frequency-Specific Neuronal Correlation." *Current Biology* (2015), May 18, 2015 (online publication) dx.doi.org/10.1016/j.cub.2015.03.049

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