

fMRI: From Basic to Intermediate Brain Connectivity. Pushing Temporal & Spatial Resolution.

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Highlights :

- Novel fMRI techniques can yield unprecedented spatial and temporal resolutions, allowing the investigation of BOLD changes in smaller functional units and at higher frequencies.

Target audience: Neuroscientists looking to apply the latest fMRI acquisition techniques and methodological researchers with an interest in the development of novel processing methods for high temporal and spatial resolution fMRI data.

OUTCOME/OBJECTIVES: Participants will get an overview of the state of the art in fMRI methods for improved temporal and spatial resolutions, and will understand the current benefits and pitfalls associated with these techniques.

PURPOSE: Compared to other functional neuroimaging modalities, fMRI is generally characterized as having excellent spatial resolution. However, conventional spatial resolutions (~3mm) still do not reach the scale of neuronal clusters such as cortical layers and columns. Additionally, the poor temporal resolution of fMRI, several orders of magnitude slower than neuronal activity, has been a long-known issue.

METHODS: Hardware developments such as high field scanners and multi-channel coils are gaining more and more widespread usage. By pushing the boundaries of signal-to-noise ratio (SNR), images can be acquired with increasing spatial resolution. Moreover, cutting-edge parallel imaging techniques can be used to significantly accelerate image acquisition times.

RESULTS: Efficient acquisition trajectories combined with parallel imaging reconstruction results in acquisition times under 100 ms for whole-brain fMRI [1]. This allows the accurate sampling of un-aliased physiological noise and yields increased statistical power for the detection of BOLD activations. Accelerated imaging also plays a crucial role in high spatial resolution fMRI at high fields, where otherwise long readouts may result in significant distortions due to field inhomogeneities. It then becomes possible to resolve BOLD signal changes at the scale of cortical layers [2].

DISCUSSION: While technical improvements allow the acquisition of fMRI images with increased spatial and temporal resolutions, there are intrinsic limitations due to the indirect nature of the BOLD signal as a correlate of neuronal activity. On the one hand, BOLD changes may occur in draining veins at a distance from the source of the activity, although high field acquisitions increase the relative contribution of signals originating from tissue as opposed to large vessels. On the other hand, the temporal resolution is limited by the relative sluggishness of the hemodynamic response; there is nevertheless evidence that functional connectivity information can be extracted from fMRI time series at higher frequencies [3].

CONCLUSION: Advances in high spatial and temporal resolution fMRI open up new avenues for the investigation of functional cerebral activity. Novel methods will need to be developed to investigate BOLD changes at these spatial and temporal scales.

REFERENCES: 1. Assländer J, Zahneisen B, Hugger T, Reisert M, Lee HL, LeVan P, Hennig J. Single Shot Whole Brain Imaging Using Spherical Stack of Spirals Trajectories. *Neuroimage* 2013 (In press)

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