The Royal Academy of Engineering

Research Fellowship

Imaging Brain Function and Connections

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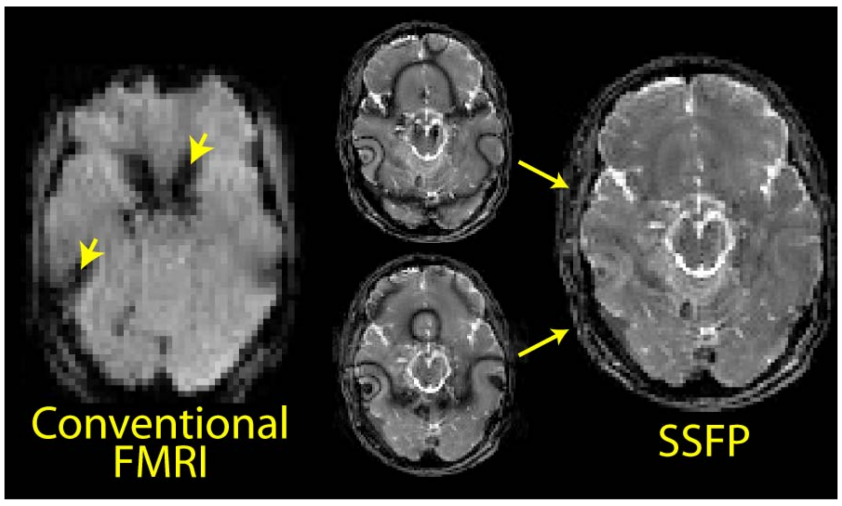
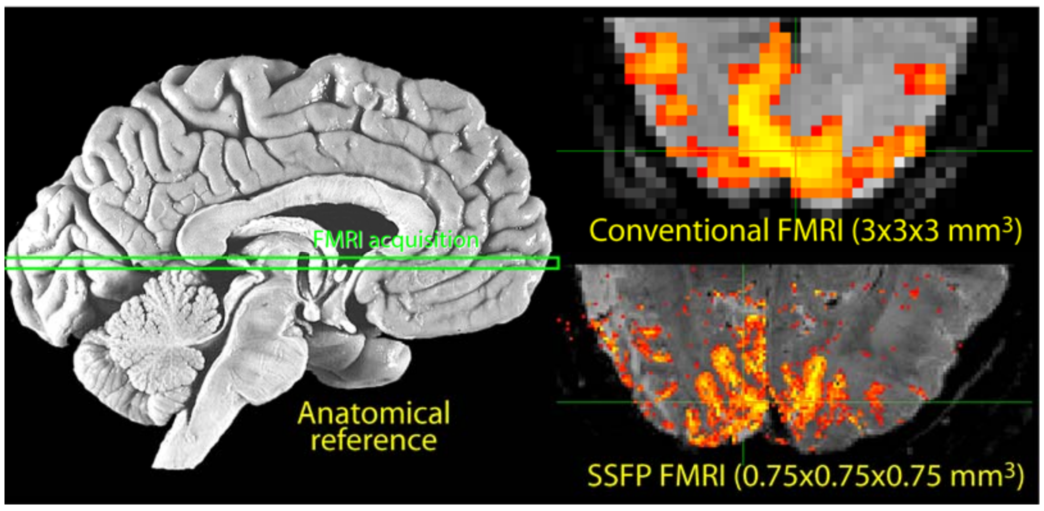
Dr Karla Miller
FMRIB Centre, Oxford University

Image Quality in MRI



Magnetic Resonance Imaging (MRI) requires a **strong, homogeneous magnetic field** to localize tissue and thereby make an image of the body. In practice, the object being imaged distorts the magnetic field, particularly in areas that have abrupt changes in the magnetic susceptibility (e.g., air pockets in the head). This **distorts the image**, particularly if the entire image is acquired rapidly in a single data collection step, as occurs in techniques for imaging brain function and connections. It also introduces signal voids to the image, which make imaging essentially impossible in some brain regions. Recent advances in MRI hardware have enabled the use of **steady-state free precession (SSFP)**, which trades these distortions and voids for more benign artefacts (see above).

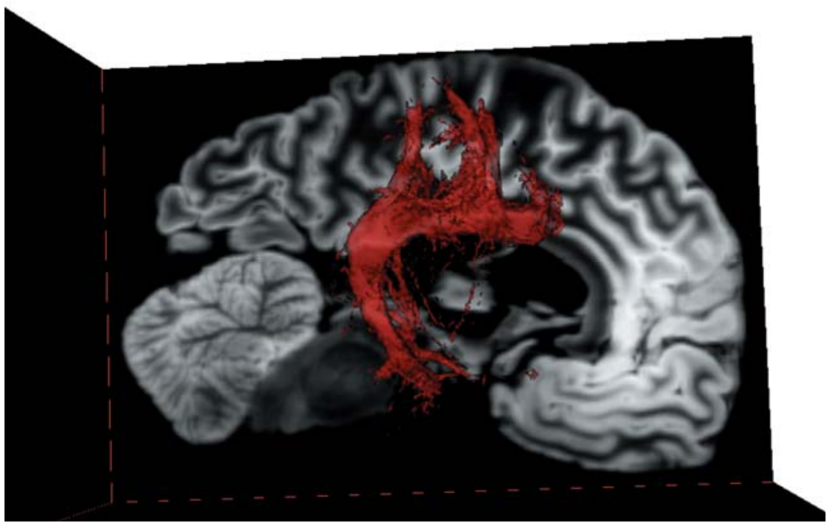
Functional MRI: Imaging Brain Activity



Functional MRI (FMRI) detects brain activity based on blood flow changes. In conventional FMRI, the signal is slow to accrue, so that **signal is coupled to serious image artefacts.** SSFP avoids this compromise because it retains and re-uses signal over a longer period of time. This creates signal in the "black holes" in conventional FMRI images. It also shows **great promise for high-resolution FMRI**, since it enables multi-acquisition imaging.

Diffusion MRI: Imaging Brain Connections

Diffusion MRI detects connections in the brain by tracing the preference of water molecules to diffuse along (rather than across) the waxy coating on white matter neurons. In order to detect the minute motion of water diffusion, imaging becomes **extremely sensitive to subject motion.** Diffusion-weighted SSFP was long considered too sensitive to motion to be useful, despite its strong diffusion contrast. However, my group has developed motion correction algorithms for SSFP, and is currently working on a Bayesian (MCMC) method for tracking brain connections (an example pathway is shown on the right, in a post-mortem brain).



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