Chapter 8

Discussion

As was said at the start of this thesis, the field of fMRI is rapidly finding clinical application and is exciting scientists from a range of disciplines including neurologists, psychiatrists and psychologists. However, there is still much research and development that needs to be done on the technique itself.

The effect of echo time (TE) on the ability to detect signal change due to the BOLD effect is striking, in particular the lack of detectable BOLD contrast at low echo times (< 15 ms). The results from the echo time measurement experiment described in Chapter 4, that the most suitable echo time to use for fMRI of the auditory, visual or motor cortices 3.0 T being between 30 and 40 ms, takes some of the guess work out the choice of imaging parameters to use when engaging in a new fMRI study. There are other parameters that may also have a significant effect on the level of BOLD contrast, such as slice thickness, voxel size and repetition rate (TR), and these will need to be investigated. The single shot T_2^* measurement technique not only provides a quick and reliable way to find the optimum echo time, but also provides a way to map the actual changes in T_2^* upon functional stimulation. This will give a more direct handle on one of the effects of changes in blood oxygenation, and may prove useful in determining the underlying mechanisms of the BOLD effect.

Image quality is always important in MRI, since artefact can be misleading to a clinician trying to interpret results. The N/2 ghost is one of the most obvious artefacts in echo planar images, and its presence not only spoils the appearance of the images, but can also prevent the detection of signal changes due to the BOLD effect. The assessment of various methods for correcting this particular artefact in Chapter 4 suggested that the method by Buonocore, which does not require a reference scan, is the most appropriate to use on fMRI data. However this result will have to be verified by its routine use on 'real' fMRI data sets. The second artefact correction technique described in Chapter 4, the removal of the effect of external r.f. interference, is purely cosmetic, however its use again means that the final activation images are clearer for clinical assessment.

The fast inversion recovery pulse sequence presented has enabled the reduction in the time a subject spends in the scanner. Any such methods for reducing the experimental duration are desirable, not only since they make precious scanner time more efficient, but also because subject discomfort is reduced. The standard experimental protocol, as given in Appendix A, and explained in Chapter 4, gives a framework to enable the consistent acquisition of fMRI data. The activation maps show a great deal of variability between subjects, and some variability within subjects scanned at different times, due to physiological effects, and so any standardising procedure that reduces variability in the way that the scanning is carried out is helpful. The protocol will need to be developed with time, as changes in scanner hardware and software are made, and as new information on optimum imaging parameters becomes available.

The main conclusion from the experience of using interleaved EPI for high resolution fMRI, is that methods for correcting the effect of subject movement need to be developed if the technique is to provide useful results. However the results that are shown in Chapter 5 indicate that effort in this area is worthwhile, since greater detail can be obtained from sub-millimetre resolution fMRI. In the meantime, the technique will be useful in reducing the distortion in activation images or for providing high resolution anatomical images with identical distortion to the overlaid activation maps.

The statistical analysis of fMRI data is being actively researched in many functional imaging centres and much effort is needed in this area. The new methods for the non-directed analysis of data explained in Chapter 6 offer the possibility of detecting regions of activation exhibiting many different time courses and allow the analysis of single event cognitive paradigms. More techniques of this kind are needed, all of which must be put on a firm statistical footing, and methods that are powerful in detecting activations and statistically robust will find great application amongst clinicians not familiar with the fMRI analysis. In the suite of programs that have been developed, and that are documented in Chapter 6, a straightforward and minimal input way of analysing fMRI data has been offered.

The results presented in Chapter 7 show that single event functional imaging, where the subject undertakes a single task, relatively infrequently, can yield important neurological results. The separation of motor planning events from execution has confirmed the sub-division of supplementary motor area, and its role in motor function.

It has now been firmly established that magnetic resonance imaging can be used to map brain function. The main impetus of research and development of the technique, needs to be directed in several areas if fMRI is to become more than ’colour phrenology’, intriguing in its results yet having little clinical value. The mechanisms behind the BOLD effect need to be better understood, as does the physiological basis of the observed blood flow and oxygenation changes The combination of the functional imaging modalities needs attention, since it is unlikely that any one method will provide the full picture. Finally, robust and simple techniques for data analysis need to be developed, allowing those who do not specialise in fMRI, to carry out experiments and interpret results. All that said, functional MRI offers possibilities for basic neurological research and clinical application that could not have been imagined ten years ago, and I am sure that the next ten years will be just as exciting.

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