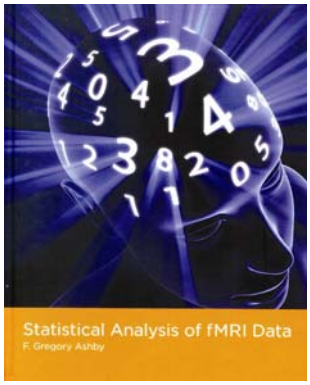

Statistical Analysis of fMRI Data. F. Gregory Ashby. The MIT Press, 55 Hayward Street, Cambridge, MA 02142. 2011. 473 pp. Price: US$ 45.00/£33.95.

Functional magnetic resonance imaging (fMRI) has become the leading non-invasive tool (albeit indirect) to record neuronal activity of human subjects. fMRIs started with a magnetic field strength of 1.5 Tesla. At present, 3 T fMRIs are most popular for clinical applications. For research purposes, 7 T fMRIs (with high spatial resolution) are slowly becoming commonplace and even 11 T machines have started appearing on the horizon (these machines are not yet approved for clinical use). In parallel, sampling rates of fMRI machines have started increasing as researchers want better time resolution. These factors put together have led to an explosion of fMRI data. Given this situation, there is a pressing need to educate researchers in various methods currently available for analysing fMRI data. The book under review is an attempt to fill this gap. Interested readers may also want to have a look at another book (*Handbook of Functional MRI Data Analysis* by R. A. Pollard, J. A. Mumford and T. E. Nichols, Cambridge University Press, New York, 2011) with similar aims and published at around the same time.

The book assumes relatively little mathematical background. Knowledge of basic statistics is all that is required. Some familiarity with calculus is also desirable to understand parts of the book, but is not essential. The necessary matrix algebra background is provided in an appendix.

Chapter 1 starts with a brief but clear introduction to fMRI, scanning procedures, different types of experimental designs and data analysis challenges. Chapter 2 is also a small chapter and describes various fMRI data formats and how to convert one format to another. Chapter 3 is one of the important preparatory chapters of the book. Even though the blood oxygen-level-dependent (BOLD) response (and in particular, the hemodynamic response function) is one of the basic concepts underlying the analysis of fMRI data, it is often not given its due in various treatments of the subject. It is heartening to note that a complete chapter is devoted to describing the hemodynamic response function and its modelling in considerable detail. All the standard models are studied including the canonical hemodynamic response function model. To the reviewer's pleasant surprise, there is even a section on nonlinear models of the BOLD response. The next chapter deals with various pre-processing steps that need to be carried out before one can embark on an analysis of fMRI data. These include standard steps such as slice-timing correction, head motion correction, alignment of the structural and functional images, various smoothing and filtering procedures, etc.

The reminder of the book details various models and methods used to analyse pre-processed fMRI data. One of the most important and widely used models is the general linear model and the entire chapter 5 (the largest chapter in the book) is devoted to its study. The chapter starts with a description of the finite BOLD response method and the correlation method. Both these methods are shown to lead to the general linear model. It is shown that a t-statistic can be estimated for each voxel of the data. This collection of t-values is in fact the well-known statistical parametric map. The chapter ends with a comparison of the finite BOLD response and the correlation methods.

In chapter 6, using the statistical parameter map constructed in the previous chapter, it is shown how to determine the voxels that show task-related activations. As each statistical parametric map can have thousands of t-values, it is important to avoid making a large number of false-positive determinations. This problem is known as the multiple comparisons problem and correcting for multiple comparisons in the presence of non-independent neighbouring t-values is the main topic of this chapter. Advanced topics such as Gaussian random fields needed to solve the multiple comparisons problem are presented in detail. Both single-voxel-based and cluster-based methods are described.

Given the small signal-to-noise ratio of fMRI data, it is imperative to average data over multiple subjects to tease out biologically meaningful results. This leads to various methods associated with group analysis which form the core of the next chapter. Methods to combine statistical parametric maps of individual subjects to yield a group statistical parametric map and inference methods based on this combined map are described. As the correction for multiple comparisons (the subject of chapter 6) can be carried out only after the group analysis (the subject of chapter 7), it would have aided the logical development of the subject if the author had described group analysis prior to the multiple comparisons problem.

Once it is determined which voxels are activated, it is then important to examine if there is functional connectivity between regions of interest. This type of connectivity analysis is the subject of next two chapters. The first of these chapters deals with coherence analysis. Coherence is the spectral analogue of correlation and is the obvious tool that one can use to study connectivity between different regions of interest. The advantages of using a frequency-domain measure are outlined and the method is described in detail. The next chapter looks at an alternate method for computing functional connectivity, called Granger causality. Granger causality has been widely used in analysing EEG and local field potential data to quantify causal relations between different regions of the brain. This method is described in the context of fMRI data analysis in chapter 9. The final two chapters of the book deal with multivariate data analysis. Starting with a preliminary chapter on principal component analysis, the author goes on to describe independent component analysis in some detail in the concluding chapter.

In summary, this book is an excellent introduction to various popular methods of analysing fMRI data and the reviewer has no hesitation in recommending this book to all beginners.

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