

Contents

1 Introduction

1.1	From neural activity to functional connectivity	1
	Box 1.1: Neuronal activity and local field potential	3
1.2	What is a resting state network (RSN)?	4
1.3	What can be gained from investigating the resting brain?	6
1.4	Resting state fMRI signal properties	8
1.5	Mapping the human connectome	10
	Summary	10
	Further reading	11

2 Data Acquisition

2.1	Repetition time, voxel size, and coverage	13
2.2	Multiband EPI sequence	15
2.3	Multi-echo EPI sequence	17
2.4	Distortion, shimming, and fieldmaps	18
2.5	Scan duration	20
2.6	Eyes open versus eyes closed	20
2.7	Motion and physiological confounds	21
	Summary	22
	Further reading	22

3 Data Preprocessing

3.1	Sources of structured noise	27
3.2	Conventional preprocessing steps	28
3.3	Low-pass temporal filtering	34
3.4	Nuisance regression	34
3.5	Global signal regression	35
3.6	Physiological noise regression	36
3.7	Volume censoring	37

3.8	Independent component analysis	39
	<i>Example box: Single subject ICA</i>	42
	<i>General statistics box: Multiple linear regression analysis (with the GLM)</i>	44
	Summary	49
	Further reading	49
4	Voxel-based Connectivity Analyses	51
4.1	Seed-based correlation analysis	52
	<i>Example box: Seed-based correlation analysis</i>	54
4.2	Independent component analysis	55
	<i>Box 4.1: The ICA model</i>	55
	<i>Box 4.2: How does the ICA “unmixing” work?</i>	57
	<i>Example box: Group-ICA networks from different datasets</i>	60
4.3	Obtaining subject-wise ICA estimates with dual regression	62
	<i>Example box: Visualizing dual regression group analysis results</i>	66
4.4	Amplitude of low-frequency fluctuations	68
4.5	Regional homogeneity	69
4.6	Group-level analysis for voxel-based methods	70
	<i>General statistics box: Multiple comparisons correction</i>	72
	Summary	80
	Further reading	80
5	Node-based Connectivity Analyses	81
5.1	What is a node?	82
5.2	Node definition	85
	<i>Example box: Examples of node parcellations</i>	89
5.3	Timecourse extraction	89
5.4	Edge definition	90
5.5	Network modeling analysis	94
	<i>Example box: Calculating subject and group network matrices</i>	95
5.6	Graph theory analysis	97
5.7	Dynamic causal modeling	100
5.8	Dynamic and non-stationary methods	101
5.9	When to use voxel-based versus node-based approaches	105
	Summary	106
	Further reading	106

6 Interpretation	109
6.1 The impact of psychology	110
6.2 The effects of BOLD physiology	113
6.3 The effects of methodological choices	115
6.4 Complementary types of connectivity research	125
6.5 Conclusions	130
Summary	131
Further reading	131
<i>Index</i>	<i>133</i>

The human brain represents about 2% of our overall body weight, yet it is thought to consume approximately 20% of the total amount of energy produced by our body, even when it is not performing any particular cognitive task. This fact has intrigued researchers for decades. What does the brain do when we are apparently not doing anything? How does this intrinsic activity relate to cognition, personality, disease, and consciousness? Interest in intrinsic activity (as opposed to extrinsic activity which occurs in response to external stimuli) has steadily increased over the years, and with advances in functional magnetic resonance imaging (fMRI), studying the brain's activity level during rest using so-called "resting state fMRI" has bloomed into a research field in its own right.

Aimed at researchers that are new to the field of resting state fMRI, this book introduces the major concepts and analysis approaches. In the interest of brevity, this primer does not cover all the technical details, or every possible approach. Rather, an overview is presented, and it is hoped that this will provide good preparation for delving into the vast literature on resting state fMRI. Please note that this book specifically does not explain functional MRI itself, more generally, and people who are new to fMRI in general may find it helpful to read the primer *Introduction to Neuroimaging Analysis* that is also part of this series.

1.1 From neural activity to functional connectivity

On a general level, there are two overarching concepts in the field of neuroimaging that inform us about how the brain works. The first of these is localization, which links brain functions to specific regions of the brain. Many researchers use tasks that subjects perform in the MRI scanner in order to link specific brain regions to regions of the brain that activate in response to a specific activity or stimulus. This typically include multiple different conditions (including resting-state fMRI) and the brain's activation is measured and localized by comparing the blood oxygen level dependent (BOLD) signal