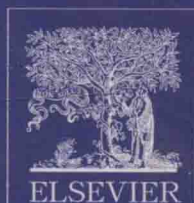
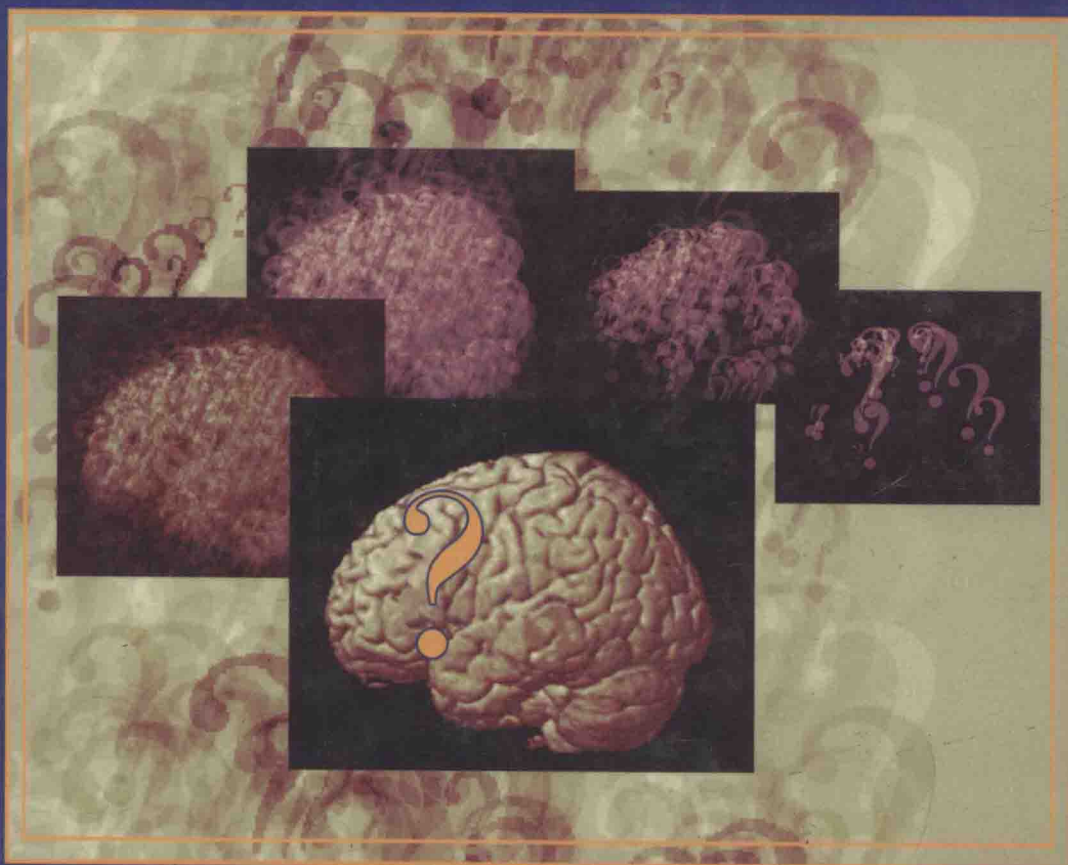


# 人脑功能

Human Brain Function  
second edition

Editors Richard S.J. Frackowiak, Karl J. Friston  
Christopher D. Frith, Raymond J. Dolan,  
Cathy J. Price, Semir Zeki, John Ashburner,  
William Penny



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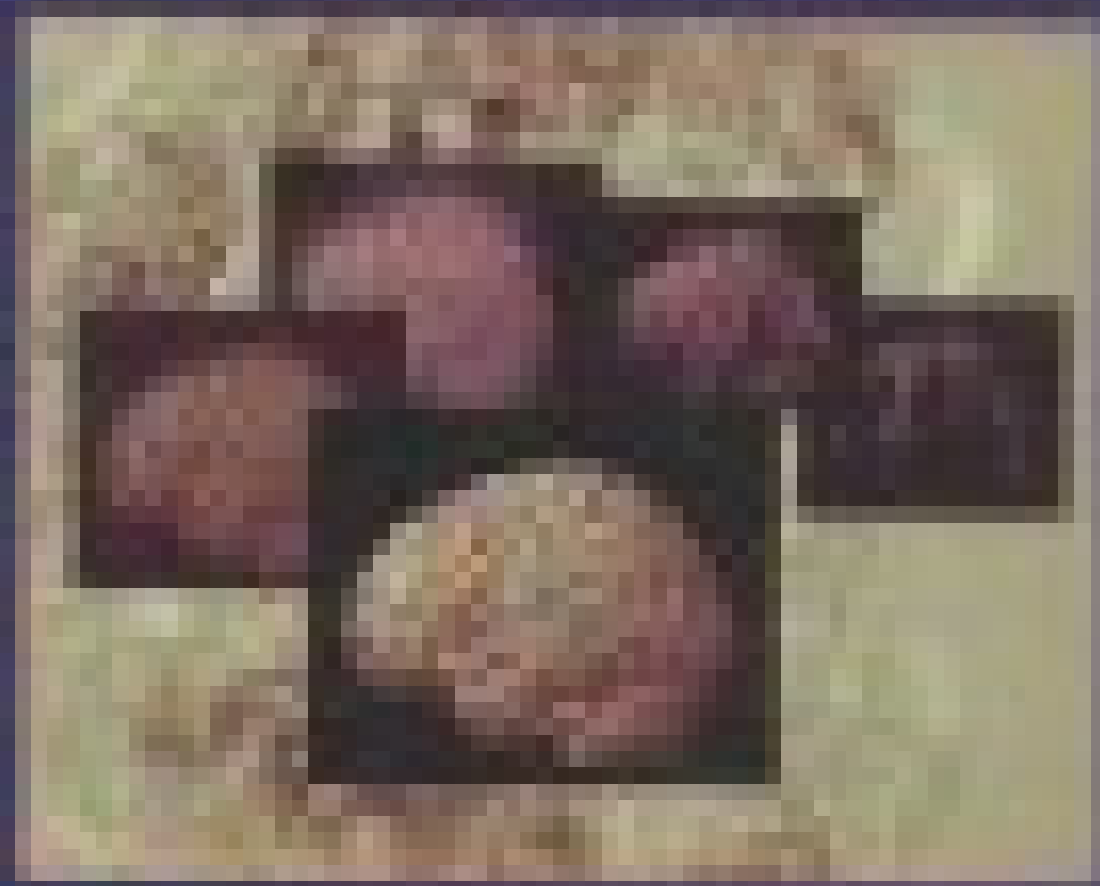
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# 人脑功能

Human Brain Function

主编 王保松  
副主编 王保松 王保松 王保松



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# HUMAN BRAIN FUNCTION

## SECOND EDITION

## 人脑功能

(第二版)

*Editors*

Richard S. J. Frackowiak, Karl J. Friston  
Christopher D. Frith, Raymond J. Dolan,  
Cathy J. Price, Semir Zeki, John Ashburner,  
William Penny

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本书的8位编者均为国际著名脑功能成像研究机构——英国功能成像实验室(Functional Imaging Laboratory, FIL)的核心成员,均系国际上本领域的知名学者。Karl J. Friston在成像技术等方面做出过巨大贡献,与其同事合作开发了国际通用的分析软件——脑功能成像统计参数软件,极大地推动了本领域的发展。Cathy Price在语言认知领域取得过一系列重要成就。Christopher D. Frith专注于额叶功能研究,Semir Zeki专注于视觉研究,Raymond J. Dolan在感觉、情感与认知等多个领域提出了许多新见解。John Ashburner, William Penny研发了许多模型算法,而Richard S. J. Frackowiak在行为、感觉与功能恢复等领域负有盛名。

To our families and loved ones;  
To our students, fellows, teachers, and collaborators;  
And to the memory of Sir Henry Wellcome, philanthropist

金 貝  
李 宇文

陳顯國  
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## 导 言

从《人脑功能》第一版酝酿策划到现在，已经过去了将近十年。这本书风格独特，介绍了一个学派，更确切地说是一个实验室的思想和成就。从历史的角度说，本书阐述了两种技术的差异：一个是示踪剂方法在脑成像领域的应用，以局部血流成像的正电子发射断层扫描技术为代表；另一个则是基于磁共振成像的血氧水平依赖技术。在生物学界，单枪匹马从事科学研究的传统占主导，所以相对而言，“合著”书籍这个概念具有不同寻常的意义。人脑成像的发展依赖多学科知识，最初是数学、统计学，之后有物理学、生物学，再到神经学、神经精神病学和神经心理学。因为该学科的研究要依靠各个学科的专家，这就推动了主要研究者要创造一个学术氛围浓厚、交互合作、气氛融洽的实验室环境。该实验室从事功能和结构神经解剖研究，其前身是医疗研究委员会的回旋加速器研究小组，之后衍变为英国维康基金会（Wellcome Trust）资助的功能成像实验室，简称为 FIL。本书的第一版标志着医疗研究委员会回旋加速器研究小组转向为功能成像实验室，并且标志着一门新学科的开端：主要研究人脑功能和结构及其方法学。本书第一版介绍了统计参数软件，但没有涉及功能磁共振成像的进展。

和第一版一样，本书第二版的作者都是功能成像实验室的成员，以及过去的、现在的和长期的合作者。本书编排紧凑，逻辑分明。从这种意义上讲，它保留了我们每个人对现有知识的反思——思维、感觉和行为在人脑中的具体呈现。在过去的六年里，本学科研究方法得到了巨大的发展，包括事件相关功能磁共振功能成像的提出、图像获取与预处理方法的提高以及对经典的相对抑制的规避。本书因为要涉及到以上所有内容，而编者又希望能够在本书中解决一些包括意识、自由意志和情感在内的有趣问题，所以本书有可能内容过多而篇幅有限。因为理论和应用目标一致、密不可分，所以我们此次仍然把理论和应用

放在同一卷书里。

本书由若干篇构成，由各功能成像实验室的负责人编辑。这些负责人在本书的每一篇的撰写中至关重要。本书的理论和分析篇由卡尔·福瑞斯顿编撰，约翰·阿士伯纳和威尔·彭尼给予了支持，本篇以最新的内容，就大脑结构和功能的现代成像应用为读者做了一个既易于理解又专业的全面评述。尽管分工不同，但国际通用分析方法——统计参数软件是卡尔和实验室其他成员共同开发完成的。克里斯·福瑞斯负责额叶功能研究，包括注意和行为控制机理以及这些机理与意识的神经基础的关系。凯茜·普里斯继续修订人类语言组织的心理学理论，并且收集了更多的实验证据，对单纯基于行为观察的旧理论提出了挑战。雷多兰研究的领域较为复杂，包括感觉、情感以及与记忆和认知之间的相互作用。他提出了许多新见解，进一步补充了这个领域中有关动物和基础生物学的知识。塞莫·泽凯专心研究视觉世界，阐述了视觉如何成为神经科学史上一个典型的研究领域。他的研究中不乏争论，但他一贯保持儒雅的学者风范。我负责行为和感觉篇的撰写，同时密切关注功能恢复和现象背后的机理。在做这项工作时，我得到了迪克帕森·海姆的巨大帮助。

这本书对未来会起到什么样的作用？无论是整合自发脑电图还是诱发脑磁图的时间分辨方法，对我们都是巨大的挑战。其他人所做的实验阐明了血氧水平依赖信号的生理学基础和各种变化之间的关系，大大推动了这方面的研究。每一种信号的生物学基础联系在一起，形成一个共同框架，相比较而言，将一种信号叠加到解剖结构上就显得微不足道了。根据这个共同框架，可以对大脑活动分布和这些分布在时间上的相关性，做出新的假设并进行试验。预计，把十多年来实验研究所获得的正常人的结果应用到病人身上，将会是第二个取得巨大进展的领域。对正常功能组织原则有了一定的理解，对实验方法、可再现



数据处理方法有了详尽描述，这项研究应该是可行的。我们的研究结论不太可能成为诊断的主要标准，但会引发一些想法，增加对疾病机理，以及通过治疗改变这些机理的方法的了解。精心选择合适的小规模病人组来评估药效，可以取代长期的、耗资巨大的大样本研究，这种可能性需要探索。大脑系统工作中的相关变化和异常蛋白质的鉴别以及它们的缺失有助于从基因学角度研究大脑疾病，如果原始数据不支持这一点，这个观点就应该摒弃。在脑衰老或神经退行性疾病中，通过神经成和行为相关研究获得的生理学数据，会帮助破译蛋白组数据。

决定出版这本书可能稍显狂妄，希望读者原谅这一点。这个科学领域的研究使我们情不自禁地想与他人分享研究成果。我们知道全世界同仁均对这门科学做出了杰出贡献，没有他们，本书中的大部分内容就不可能存在。这个领域如此广博，我们不敢奢望该书面面俱到。本书未涉及的内容，相信读者可以通过别的途径找到，其中一

部分内容可参照本书第一版。在本书印刷和出版过程中，书中部分内容可能已变得陈旧过时。然而，对一个发展迅速的学科而言，相关书籍应该在展示内容的同时，展现知识获得的过程。在网络信息时代，一本书所起的作用是单独阅读文献所达不到的。我们希望读者在阅读本书时分享我们的激情，也希望本书能启发读者思考。如果该书引发了读者的不同意见并进行新的实验来反驳或支持书中观点和假设，在我们看来，那就是一种成功。

最后，我谨代表全体同事感谢英国维康基金会的慷慨资助。1994年维康基金会决定资助功能成像实验室，1999年再次提供基金。没有这些资助，本书绝大部分工作都不可能实现。

理查德

伦敦

2003年9月



## INTRODUCTION

It is almost a decade since the first edition of *Human Brain Function* was conceived and planned. It was a unique book in that it tried to set out the thoughts and achievements of a school, or more accurately a laboratory working in the field of functional and structural human neuroanatomy. Historically, it marked the border between the application of tracer-based methods to brain imaging, exemplified by the PET technique of local blood flow mapping, and the blood oxygen level dependent (BOLD) technique based on magnetic resonance imaging (fMRI). The concept of a 'group' book was comparatively unusual in the biosciences where the tradition of the solitary scientist (often assisted by 'juniors') was still the dominant ethos. The evolution of human brain mapping depended on much diverse expertise from mathematics and statistics, through physics and biology to neurology, neuropsychiatry, and neuropsychology. The realisation of this dependence on the expertise of many individuals from many disciplines motivated the principal investigators to create a laboratory environment that was collegiate, interactive, collaborative, and also amicable. That laboratory emerged from the Medical Research Council's Cyclotron Unit and was incarnated in the then nascent Wellcome Trust funded Functional Imaging Laboratory, known as The FIL. The first edition marked the emigration of that group from the MRC CU to the FIL and represented the beginning of a new enterprise focussed on understanding the functional and structural architecture of the human brain and methodological developments that supported the achievement of that mission. The beginnings of statistical parametric mapping (SPM) were already described, but the advances made possible by fMRI did not make it into the first edition.

This second edition, like the previous one, is written exclusively by members of the FIL, past and present and long-term collaborators. The chapters are knit together like a book rather than a series of reviews. In that sense the book remains a 'personal' reflection on the state of our knowledge of how human thinking, feeling, and action are instantiated in the brain. However, the methodological advances of the last 6 years that include event-related fMRI, massive improvements in image acquisition and pre-processing and an escape from the relative constraints of classical inference are huge. These combined with a courageous, sometimes foolhardy wish to attack interesting problems that include consciousness, free will, and feelings make it possible that the book is becoming perhaps too big for its boots. We think this may be the last time we can put together theory and application in a single volume, even though they would be focussed by a common mission.

The book is now organised in sections, edited by each of The FIL's Principal Investigators who have promoted their component of the common programme. The theory and analysis section edited by Karl Friston, abetted by John Ashburner and Will Penny, is entirely up to date and gives readers an approachable and yet professional overview of all that is possible with modern imaging of brain structure and function. The adoption of a common analytic approach internationally, though sometimes in different guises, means that this section contains contributions from 'honorary' FIL members who have worked with Karl in the context of developing and supporting SPM. Chris Frith tackles the roles of the frontal lobes including mechanisms for

attention and control of action and the relevance of these mechanisms to understanding the neural correlates of consciousness. Cathy Price continues her revision of the psychological theories of the organisation of human language by marshalling more and more experimental evidence that challenges older theories based purely on behavioural observation. Ray Dolan explores the difficult areas of feeling, emotion, and their interaction with memory and cognition and provides many new insights that complement the explosion in knowledge in this area that has occurred in animal and basic biology. Semir Zeki explores the visual world that has become his unique domain and extends our understanding of why it constitutes such a paradigmatic sensation in the history of neuroscience. He approaches the problems with his usual panache and delight in intellectual exploration through controversy. I deal with action and sensation with an ever-vigilant eye on implications for recovery of function and mechanisms underlying this phenomenon. I am abetted in this work by Dick Passingham whose contributions have been massive.

What of the future, for which this volume will act as our springboard? The integration of temporally resolved methods such as EEG and MEG, spontaneous or evoked, is a big challenge. It is a challenge that has received a major boost from experiments by others that have elucidated the physiological correlates of the BOLD signal and the relationship between changes in each. Mapping one type of signal onto the anatomy of the other is trivial compared to relating the biological basis of each into a common framework. A common framework should result in inferences that lead to new predictions and experiments which focus on distributions of brain activity and their correlation in time. The second area where we foresee great advances is in the application of the knowledge obtained in over a decade of experimentation in normal humans to the diseased condition. An understanding of the principles of normal functional organisation and an elaboration of experimental approaches and principled, reproducible methods of data now make this task feasible. The questions to be asked are unlikely to be primarily diagnostic but will generate ideas and facts about disease mechanisms as well as information about how these can be altered by therapy. The possibility of assessing drug effects on small well-defined groups of patients instead of by costly large population studies that last years will have to be explored. The idea that the genetic understanding of brain disease will be aided by a description of correlated changes in the working of brain systems and associated with the identification of abnormal proteins or their absence might be dismissed as a flight of fantasy except for the fact that preliminary data suggest otherwise. In brain diseases of ageing or neurodegenerations it is entirely possible that proteomic data will most readily be interpreted by a mixture of physiological data obtained via human imaging neuroscience and behavioural correlation.

We hope that the reader will forgive the hubris that underlies the decision to produce this volume. This scientific field has excited us so much that we see no reason to hide our enthusiasm to communicate it. However, it should not be thought that we do not recognise the enormous contribution of many others worldwide to this science. Without that, much that is recorded in this book would not have been possible. The field is now so huge that one volume cannot hope to cover it completely. There is much missing in these pages that will be found elsewhere; some of it in the first edition. There is much that in the time required for printing and publication will already be out of date. However, when a field is expanding fast, a book should try to convey the process of acquisition of knowledge as much as content. In the internet-based information age, it is perhaps that function which a book can fulfill in a way that papers themselves, read individually cannot. So, we hope the reader will share our excitement when reading this volume; that the reader will be stimulated at times and at others perplexed. We will even consider it a success if the book irritates the reader or causes reflection that leads to new experiments that refute (or support) the claims and speculations based on our work recorded within.

It remains for me to thank, on behalf of all my colleagues, the Wellcome Trust for its munificence. Without the decision to fund the FIL in 1994 and to renew funding in 1999 very little of the work contained in this volume would have been possible.

*Richard S. J. Frackowiak*  
*London*  
*September 2003*