COGNITIVE SCIENCE

An Introduction to the Science of the Mind

This exciting textbook introduces students to the dynamic vibrant area of cognitive science – the scientific study of the mind and cognition. Cognitive science draws upon many academic disciplines, including psychology, computer science, philosophy, linguistics, and neuroscience. This is the first textbook to present a unified view of cognitive science as a discipline in its own right, with a distinctive approach to studying the mind. Students are introduced to the cognitive scientist's "toolkit" – the vast range of techniques and tools that cognitive scientists can use to study the mind. The book presents the main theoretical models that cognitive scientists are currently using, and shows how those models are being applied to unlock the mysteries of the human mind. *Cognitive Science* is replete with examples, illustrations, and applications and draws on cutting-edge research and new developments to explore both the achievements that cognitive scientists have made, and the challenges that lie ahead.

JOSÉ LUIS BERMÚDEZ is Dean of the College of Liberal Arts and Professor of Philosophy at Texas A&M University. Until 2010 he was Professor of Philosophy and Director of the Philosophy-Neuroscience-Psychology program at Washington University in St. Louis. He has been involved in teaching and research in cognitive science for fifteen years, and is very much involved in bringing an interdisciplinary focus to cognitive science through involvement with conference organization and journals. His 100+ publications include the textbook *Philosophy of Psychology: A Contemporary Introduction* (2005) and a companion collection of readings, *Philosophy of Psychology: Contemporary Readings* (2007). He has authored the monographs *The Paradox of Self-Consciousness* (1998), *Thinking without Words* (2003), and *Decision Theory and Rationality* (2009) in addition to editing a number of collections including *The Body and the Self* (1995), *Reason and Nature* (2002), and *Thought, Reference, and Experience* (2005).

COGNITIVE SCIENCE

An Introduction to the Science of the Mind

José Luis Bermúdez

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore,
São Paulo, Delhi, Dubai, Tokyo, Mexico City

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521708371

First published 2010

Printed in the United Kingdom at the University Press, Cambridge

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data
Bermúdez José Luis.
Cognitive science : an introduction to the science of the mind / José Luis Bermúdez.
p. cm.
Includes bibliographical references.
ISBN 978-0-521-88200-2 – ISBN 978-0-521-70837-1 (pbk.)
1. Cognition. 2. Cognitive science. I. Title.
BF311.B458 2010
153–dc22 2010021896

ISBN 978-0-521-88200-2 Hardback
ISBN 978-0-521-70837-1 Paperback

Additional resources for this publication at www.cambridge.org/bermudez

Cambridge University Press
978-0-521-70837-1 - Cognitive Science: An Introduction to the Science of the Mind
Jose Luis Bermudez
Frontmatter
More information

CONTENTS

Cambridge University Press
978-0-521-70837-1 - Cognitive Science: An Introduction to the Science of the Mind
Jose Luis Bermudez
Frontmatter
More information

BOXES

FIGURES

TABLES

PREFACE

About this book

There are few things more fascinating to study than the human mind. And few things that are more difficult to understand. Cognitive science is the enterprise of trying to make sense of this most complex and baffling natural phenomenon.

The very things that make cognitive science so fascinating make it very difficult to study and to teach. Many different disciplines study the mind. Neuroscientists study the mind's biological machinery. Psychologists directly study mental processes such as perception and decision-making. Computer scientists explore how those processes can be simulated and modeled in computers. Evolutionary biologists and anthropologists speculate about how the mind evolved. In fact, there are very few academic areas that are not relevant to the study of the mind in some way. The job of cognitive science is to provide a framework for bringing all these different perspectives together.

This enormous range of information out there about the mind can be overwhelming, both for students and for instructors. I have had direct experience of how challenging this can be, as Director of the Philosophy-Neuroscience-Psychology program at Washington University in St. Louis. The challenge is to give students a broad enough base while at the same time bringing home that cognitive science is a field in its own right, separate and distinct from the disciplines on which it draws. I set out to write this book because my colleagues and I have not yet found a book that really succeeds in doing this.

Different textbooks have approached this challenge in different ways. Some have concentrated on being as comprehensive as possible, with a chapter covering key ideas in each of the relevant disciplines – a chapter on psychology, a chapter on neuroscience, and so on. These books are often written by committee – with each chapter written by an expert in the relevant field. These books can be very valuable, but they really give an introduction to the cognitive sciences (in the plural), rather than to cognitive science as an interdisciplinary enterprise.

Other textbook writers take a much more selective approach, introducing cognitive science from the perspective of the disciplines that they know best – from the perspective of philosophy, for example, or of computer science. Again, I have learnt much from these books and they can be very helpful. But I often have the feeling that students need something more general.

This book aims for a balance between these two extremes. Cognitive science has its own problems and its own theories. The book is organized around these. They are all ways of working out the fundamental idea at the heart of cognitive science – which is that the mind is an information processor. What makes cognitive science so rich is that this single basic idea can be (and has been) worked out in many different ways. In presenting these different models of the mind as an information processor I have tried to select as wide a range of examples as possible, in order to give students a sense of cognitive science's breadth and range.

Cognitive science has only been with us for forty or so years. But in that time it has changed a lot. At one time cognitive science was associated with the idea that we can understand the mind without worrying about its biological machinery – we can understand the software without understanding the hardware, to use a popular image. But this is now really a minority view. Neuroscience is now an absolutely fundamental part of cognitive science. Unfortunately this has not really been reflected in textbooks on cognitive science. This book presents a more accurate picture of how central neuroscience is to cognitive science.

How the book is organized

This book is organized into five parts.

Part I: Historical overview

Cognitive science has evolved considerably in its short life. Priorities have changed as new methods have emerged – and some fundamental theoretical assumptions have changed with them. The three chapters in Part I introduce students to some of the highlights in the history of cognitive science. Each chapter is organized around key discoveries and/or theoretical advances.

Part II: The integration challenge

The two chapters in Part II bring out what is distinctive about cognitive science. They do this in terms of what I call the integration challenge. This is the challenge of developing a unified framework that makes explicit the relations between the different disciplines on which cognitive science draws and the different levels of organization that it studies. In Chapter 4 we look at two examples of *local integration*. The first example explores how evolutionary psychology has been used to explain puzzling data from human decision-making, while the second focuses on what exactly it is that is being studied by techniques of neuro-imaging such as functional magnetic resonance imaging (fMRI).

In Chapter 5 I propose that one way of answering the integration challenge is through developing models of mental architecture. A model of mental architecture includes

1. an account of how the mind is organized into different cognitive systems, and
2. an account of how information is processed in individual cognitive systems.

This approach to mental architecture sets the agenda for the rest of the book.

Part III: Information-processing models of the mind

The four chapters in Part III explore the two dominant models of information processing in contemporary cognitive science. The first model is associated with the physical symbol system hypothesis originally developed by the computer scientists Allen Newell and Herbert Simon. According to the physical symbol system hypothesis, all information processing involves the manipulation of physical structures that function as symbols. The theoretical case for the physical symbol system hypothesis is discussed in Chapter 6, while Chapter 7 gives three very different examples of research within that paradigm – from data mining, artificial vision, and robotics.

The second model of information processing derives from models of artificial neurons in computational neuroscience and connectionist artificial intelligence. Chapter 8 explores the motivation for this approach and introduces some of the key concepts, while Chapter 9 shows how it can be used to model aspects of language learning and object perception.

Part IV: How is the mind organized?

A mental architecture includes a model both of information processing and of how the mind is organized. The three chapters in Part IV look at different ways of tackling this second problem. Chapter 10 examines the idea that some forms of information processing are carried out by dedicated cognitive modules. It looks also at the radical claim, proposed by evolutionary psychologists, that the mind is simply a collection of specialized modules. In Chapter 11 we look at how some recently developed techniques such as functional neuroimaging can be used to study the organization of the mind. Chapter 12 shows how the theoretical and methodological issues come together by working through an issue that has received much attention in contemporary cognitive science – the issue of whether there is a dedicated cognitive system response for our understanding of other people (the so-called mindreading system).

Part V: New horizons

As emerges very clearly in the first four parts of the book, cognitive science is built around some very basic theoretical assumptions – and in particular around the assumption that the mind is an information-processing system. In Chapter 13 we look at two ways in which cognitive scientists have proposed extending and moving beyond this basic assumption. One of these research programs is associated with the dynamical systems hypothesis in cognitive science. The second is opened up by the situated/embodied cognition movement.

Using this book in courses

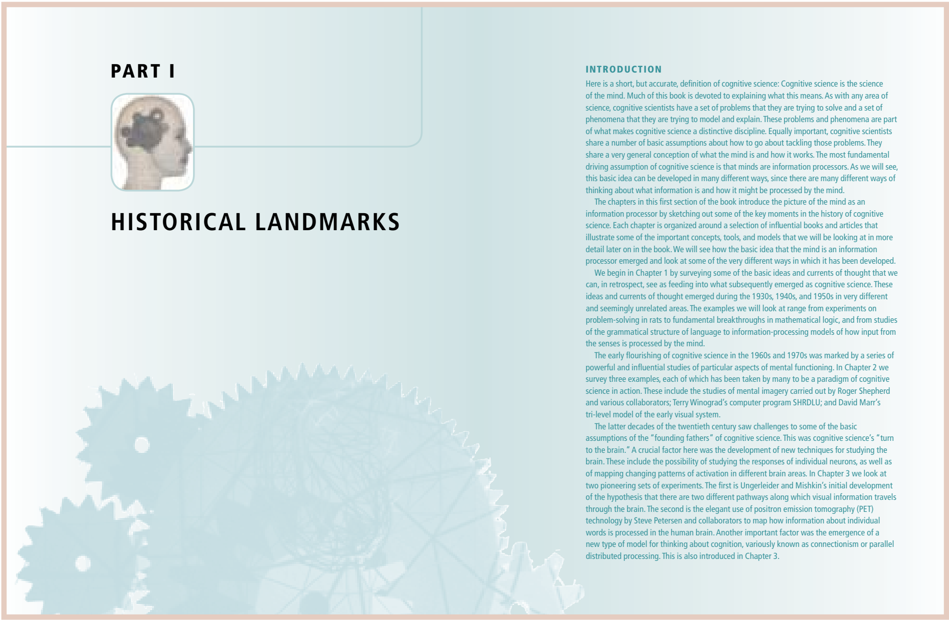
This book has been designed to serve as a self-contained text for a single semester (12–15 weeks) introductory course on cognitive science. Students taking this course may have taken introductory courses in psychology and/or philosophy, but no particular prerequisites are assumed. All the necessary background is provided for a course at the freshman or sophomore level (first or second year). The book could also be used for a more advanced introductory course at the junior or senior level (third or fourth year). In this case the instructor would most likely want to supplement the book with additional readings. There are suggestions on the instructor website (see below).

Text features

I have tried to make this book as user-friendly as possible. Key text features include:

- **Part-openers and chapter overviews**
  The book is divided into five parts, as described above. Each part begins with a short introduction to give the reader a broad picture of what lies ahead. Each chapter begins with an overview to orient the reader.

Cambridge University Press
978-0-521-70837-1 - Cognitive Science: An Introduction to the Science of the Mind
Jose Luis Bermudez
Frontmatter
More information



PART I

HISTORICAL LANDMARKS

INTRODUCTION

Here is a short, but accurate, definition of cognitive science: Cognitive science is the science of the mind. Much of this book is devoted to explaining what this means. As with any area of science, cognitive scientists have a set of problems that they are trying to solve and a set of phenomena that they are trying to model and explain. These problems and phenomena are part of what makes cognitive science a distinctive discipline. Equally important, cognitive scientists share a number of basic assumptions about how to go about tackling those problems. They share a very general conception of what the mind is and how it works. The most fundamental driving assumption of cognitive science is that minds are information processors. As we will see, this basic idea can be developed in many different ways, since there are many different ways of thinking about what information is and how it might be processed by the mind.

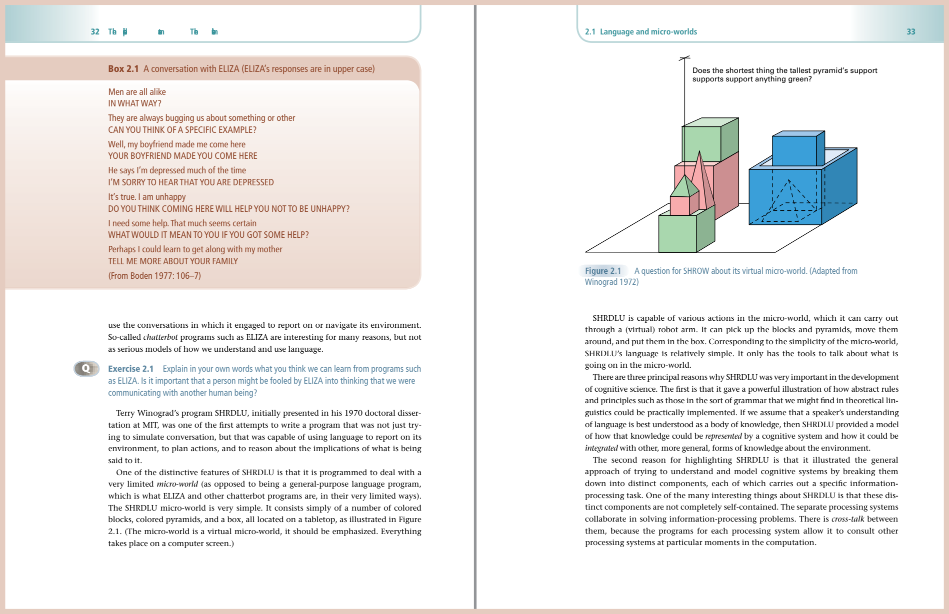
The chapters in this first section of the book introduce the picture of the mind as an information processor by sketching out some of the key moments in the history of cognitive science. Each chapter is organized around a selection of influential books and articles that illustrate some of the important concepts, tools, and models that we will be looking at in more detail later on in the book. We will see how the basic idea that the mind is an information processor emerged and look at some of the very different ways in which it has been developed.

We begin in Chapter 1 by surveying some of the basic ideas and currents of thought that we can, in retrospect, see as feeding into what subsequently emerged as cognitive science. These ideas and currents of thought emerged during the 1930s, 1940s, and 1950s in very different and seemingly unrelated areas. The examples we will look at range from experiments on problem-solving in rats to fundamental breakthroughs in mathematical logic, and from studies of the grammatical structure of language to information-processing models of how input from the senses is processed by the mind.

The early flourishing of cognitive science in the 1960s and 1970s was marked by a series of powerful and influential studies of particular aspects of mental functioning. In Chapter 2 we survey three examples, each of which has been taken by many to be a paradigm of cognitive science in action. These include the studies of mental imagery carried out by Roger Shepherd and various collaborators; Terry Winograd's computer program SHRDLU; and David Marr's tri-level model of the early visual system.

The latter decades of the twentieth century saw challenges to some of the basic assumptions of the "founding fathers" of cognitive science. This was cognitive science's "turn to the brain." A crucial factor here was the development of new techniques for studying the brain. These include the possibility of studying the responses of individual neurons, as well as of mapping changing patterns of activation in different brain areas. In Chapter 3 we look at two pioneering sets of experiments. The first is Ungerleider and Mishkin's initial development of the hypothesis that there are two different pathways along which visual information travels through the brain. The second is the elegant use of positron emission tomography (PET) technology by Steve Petersen and collaborators to map how information about individual words is processed in the human brain. Another important factor was the emergence of a new type of model for thinking about cognition, variously known as connectionism or parallel distributed processing. This is also introduced in Chapter 3.

- **Exercises**
These have been inserted at various points within each chapter. They are placed in the flow of the text to encourage the reader to take a break from reading and engage with the material. They are typically straightforward, but for a few I have placed suggested solutions on the instructor website (see below).



32

Box 2.1 A conversation with ELIZA (ELIZA's responses are in upper case)

Men are all alike
IN WHAT WAY?
They are always bugging us about something or other
CAN YOU THINK OF A SPECIFIC EXAMPLE?
Well, my boyfriend made me come here
YOUR BOYFRIEND MADE YOU COME HERE
He says I'm depressed much of the time
I'M SORRY TO HEAR THAT YOU ARE DEPRESSED
It's true. I am unhappy
DO YOU THINK COMING HERE WILL HELP YOU NOT TO BE UNHAPPY?
I need some help. That much seems certain
WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP?
Perhaps I could learn to get along with my mother
TELL ME MORE ABOUT YOUR FAMILY
(From Boden 1977: 106–7)

use the conversations in which it engaged to report on or navigate its environment. So-called *chatterbot* programs such as ELIZA are interesting for many reasons, but not as serious models of how we understand and use language.

Q **Exercise 2.1** Explain in your own words what you think we can learn from programs such as ELIZA. Is it important that a person might be fooled by ELIZA into thinking that we were communicating with another human being?

Terry Winograd's program SHRDLU, initially presented in his 1970 doctoral dissertation at MIT, was one of the first attempts to write a program that was not just trying to simulate conversation, but that was capable of using language to report on its environment, to plan actions, and to reason about the implications of what is being said to it.

One of the distinctive features of SHRDLU is that it is programmed to deal with a very limited *micro-world* (as opposed to being a general-purpose language program, which is what ELIZA and other chatterbot programs are, in their very limited ways). The SHRDLU micro-world is very simple. It consists simply of a number of colored blocks, colored pyramids, and a box, all located on a tabletop, as illustrated in Figure 2.1. (The micro-world is a virtual micro-world, it should be emphasized. Everything takes place on a computer screen.)

2.1 Language and micro-worlds 33

Does the shortest thing the tallest pyramid's support supports support anything green?

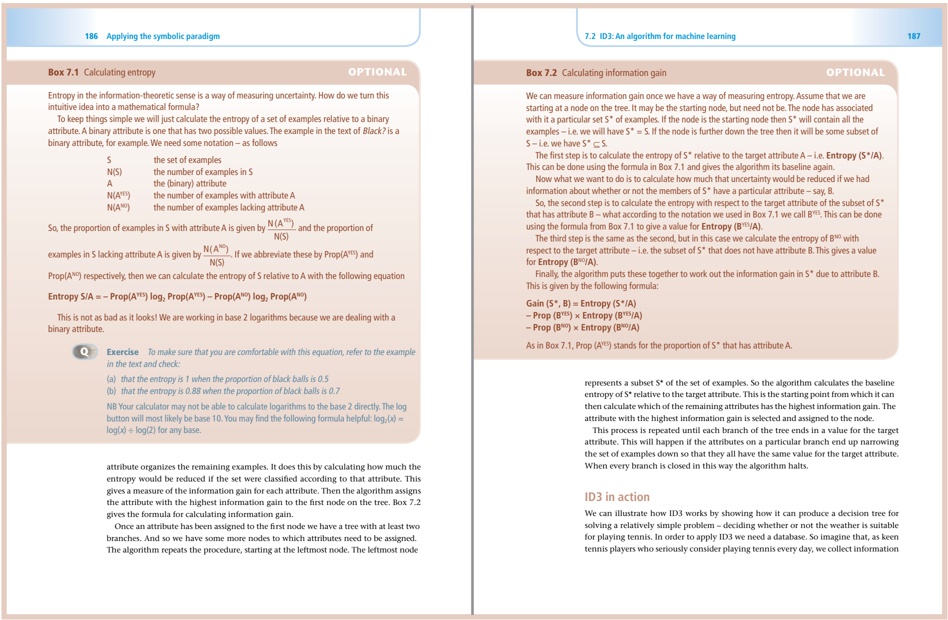
Figure 2.1 A question for SHROW about its virtual micro-world. (Adapted from Winograd 1972)

SHRDLU is capable of various actions in the micro-world, which it can carry out through a (virtual) robot arm. It can pick up the blocks and pyramids, move them around, and put them in the box. Corresponding to the simplicity of the micro-world, SHRDLU's language is relatively simple. It only has the tools to talk about what is going on in the micro-world.

There are three principal reasons why SHRDLU was very important in the development of cognitive science. The first is that it gave a powerful illustration of how abstract rules and principles such as those in the sort of grammar that we might find in theoretical linguistics could be practically implemented. If we assume that a speaker's understanding of language is best understood as a body of knowledge, then SHRDLU provided a model of how that knowledge could be *represented* by a cognitive system and how it could be *integrated* with other, more general, forms of knowledge about the environment.

The second reason for highlighting SHRDLU is that it illustrated the general approach of trying to understand and model cognitive systems by breaking them down into distinct components, each of which carries out a specific information-processing task. One of the many interesting things about SHRDLU is that these distinct components are not completely self-contained. The separate processing systems collaborate in solving information-processing problems. There is *cross-talk* between them, because the programs for each processing system allow it to consult other processing systems at particular moments in the computation.

- **Boxes and optional material**
  Boxes have been included to provide further information about the theories and research discussed in the text. Some of the more technical material has been placed in boxes that are marked optional. Readers are encouraged to work through these, but the material is not essential to flow of the text.



186 Applying the symbolic paradigm

Box 7.1 Calculating entropy OPTIONAL

Entropy in the information-theoretic sense is a way of measuring uncertainty. How do we turn this intuitive idea into a mathematical formula?

To keep things simple we will just calculate the entropy of a set of examples relative to a binary attribute. A binary attribute is one that has two possible values. The example in the text of *Black?* is a binary attribute, for example. We need some notation – as follows

S	the set of examples
N(S)	the number of examples in S
A	the (binary) attribute
$N(A^{YES})$	the number of examples with attribute A
$N(A^{NO})$	the number of examples lacking attribute A

So, the proportion of examples in S with attribute A is given by $\frac{N(A^{YES})}{N(S)}$ and the proportion of examples in S lacking attribute A is given by $\frac{N(A^{NO})}{N(S)}$. If we abbreviate these by $Prop(A^{YES})$ and $Prop(A^{NO})$ respectively, then we can calculate the entropy of S relative to A with the following equation

$$\text{Entropy } S/A = -Prop(A^{YES}) \log_2 Prop(A^{YES}) - Prop(A^{NO}) \log_2 Prop(A^{NO})$$

This is not as bad as it looks! We are working in base 2 logarithms because we are dealing with a binary attribute.

Exercise *To make sure that you are comfortable with this equation, refer to the example in the text and check:*

(a) *that the entropy is 1 when the proportion of black balls is 0.5*
(b) *that the entropy is 0.88 when the proportion of black balls is 0.7*

NB Your calculator may not be able to calculate logarithms to the base 2 directly. The log button will most likely be base 10. You may find the following formula helpful: $\log_2(x) = \log(x) \div \log(2)$ for any base.

attribute organizes the remaining examples. It does this by calculating how much the entropy would be reduced if the set were classified according to that attribute. This gives a measure of the information gain for each attribute. Then the algorithm assigns the attribute with the highest information gain to the first node on the tree. Box 7.2 gives the formula for calculating information gain.

Once an attribute has been assigned to the first node we have a tree with at least two branches. And so we have some more nodes to which attributes need to be assigned. The algorithm repeats the procedure, starting at the leftmost node. The leftmost node

7.2 ID3: An algorithm for machine learning 187

Box 7.2 Calculating information gain OPTIONAL

We can measure information gain once we have a way of measuring entropy. Assume that we are starting at a node on the tree. It may be the starting node, but need not be. The node has associated with it a particular set S* of examples. If the node is the starting node then S* will contain all the examples – i.e. we will have S* = S. If the node is further down the tree then it will be some subset of S – i.e. we have $S^* \subseteq S$.

The first step is to calculate the entropy of S* relative to the target attribute A – i.e. **Entropy (S*/A)**. This can be done using the formula in Box 7.1 and gives the algorithm its baseline again.

Now what we want to do is to calculate how much that uncertainty would be reduced if we had information about whether or not the members of S* have a particular attribute – say, B.

So, the second step is to calculate the entropy with respect to the target attribute of the subset of S* that has attribute B – what according to the notation we used in Box 7.1 we call B^{YES}. This can be done using the formula from Box 7.1 to give a value for **Entropy (B^{YES}/A)**.

The third step is the same as the second, but in this case we calculate the entropy of B^{NO} with respect to the target attribute – i.e. the subset of S* that does not have attribute B. This gives a value for **Entropy (B^{NO}/A)**.

Finally, the algorithm puts these together to work out the information gain in S* due to attribute B. This is given by the following formula:

$$\begin{aligned} \text{Gain}(S^*, B) &= \text{Entropy}(S^*/A) \\ &- \text{Prop}(B^{YES}) \times \text{Entropy}(B^{YES}/A) \\ &- \text{Prop}(B^{NO}) \times \text{Entropy}(B^{NO}/A) \end{aligned}$$

As in Box 7.1, Prop (A^{YES}) stands for the proportion of S* that has attribute A.

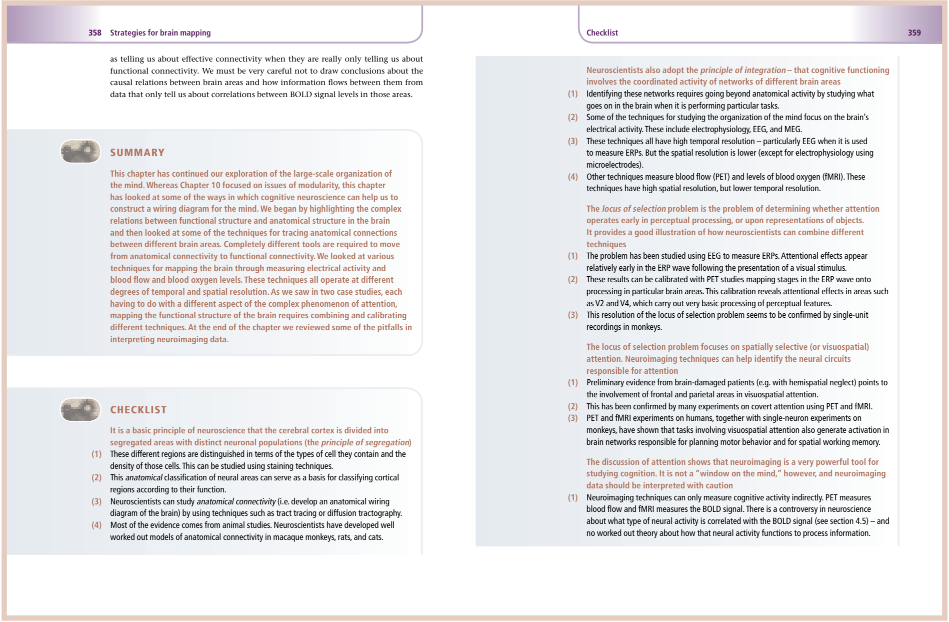
represents a subset S* of the set of examples. So the algorithm calculates the baseline entropy of S* relative to the target attribute. This is the starting point from which it can then calculate which of the remaining attributes has the highest information gain. The attribute with the highest information gain is selected and assigned to the node.

This process is repeated until each branch of the tree ends in a value for the target attribute. This will happen if the attributes on a particular branch end up narrowing the set of examples down so that they all have the same value for the target attribute. When every branch is closed in this way the algorithm halts.

ID3 in action

We can illustrate how ID3 works by showing how it can produce a decision tree for solving a relatively simple problem – deciding whether or not the weather is suitable for playing tennis. In order to apply ID3 we need a database. So imagine that, as keen tennis players who seriously consider playing tennis every day, we collect information

- **Summaries, checklists, and further reading**
  These can be found at the end of each chapter. The summary shows how the chapter relates to the other chapters in the book. The checklist allows students to review the key points of the chapter, and also serves as a reference point for instructors. Suggestions of additional books and articles are provided to guide students' further reading on the topics covered in the chapter.



358 Strategies for brain mapping

as telling us about effective connectivity when they are really only telling us about functional connectivity. We must be very careful not to draw conclusions about the causal relations between brain areas and how information flows between them from data that only tell us about correlations between BOLD signal levels in those areas.

SUMMARY

This chapter has continued our exploration of the large-scale organization of the mind. Whereas Chapter 10 focused on issues of modularity, this chapter has looked at some of the ways in which cognitive neuroscience can help us to construct a wiring diagram for the mind. We began by highlighting the complex relations between functional structure and anatomical structure in the brain and then looked at some of the techniques for tracing anatomical connections between different brain areas. Completely different tools are required to move from anatomical connectivity to functional connectivity. We looked at various techniques for mapping the brain through measuring electrical activity and blood flow and blood oxygen levels. These techniques all operate at different degrees of temporal and spatial resolution. As we saw in two case studies, each having to do with a different aspect of the complex phenomenon of attention, mapping the functional structure of the brain requires combining and calibrating different techniques. At the end of the chapter we reviewed some of the pitfalls in interpreting neuroimaging data.

CHECKLIST

It is a basic principle of neuroscience that the cerebral cortex is divided into segregated areas with distinct neuronal populations (the *principle of segregation*)

(1) These different regions are distinguished in terms of the types of cell they contain and the density of those cells. This can be studied using staining techniques.
(2) This *anatomical* classification of neural areas can serve as a basis for classifying cortical regions according to their function.
(3) Neuroscientists can study *anatomical connectivity* (i.e. develop an anatomical wiring diagram of the brain) by using techniques such as tract tracing or diffusion tractography.
(4) Most of the evidence comes from animal studies. Neuroscientists have developed well worked out models of anatomical connectivity in macaque monkeys, rats, and cats.

Checklist 359

Neuroscientists also adopt the *principle of integration* – that cognitive functioning involves the coordinated activity of networks of different brain areas

(1) Identifying these networks requires going beyond anatomical activity by studying what goes on in the brain when it is performing particular tasks.
(2) Some of the techniques for studying the organization of the mind focus on the brain's electrical activity. These include electrophysiology, EEG, and MEG.
(3) These techniques all have high temporal resolution – particularly EEG when it is used to measure ERPs. But the spatial resolution is lower (except for electrophysiology using microelectrodes).
(4) Other techniques measure blood flow (PET) and levels of blood oxygen (fMRI). These techniques have high spatial resolution, but lower temporal resolution.

The *locus of selection* problem is the problem of determining whether attention operates early in perceptual processing, or upon representations of objects. It provides a good illustration of how neuroscientists can combine different techniques

(1) The problem has been studied using EEG to measure ERPs. Attentional effects appear relatively early in the ERP wave following the presentation of a visual stimulus.
(2) These results can be calibrated with PET studies mapping stages in the ERP wave onto processing in particular brain areas. This calibration reveals attentional effects in areas such as V2 and V4, which carry out very basic processing of perceptual features.
(3) This resolution of the locus of selection problem seems to be confirmed by single-unit recordings in monkeys.

The locus of selection problem focuses on spatially selective (or visuospatial) attention. Neuroimaging techniques can help identify the neural circuits responsible for attention

(1) Preliminary evidence from brain-damaged patients (e.g. with hemispatial neglect) points to the involvement of frontal and parietal areas in visuospatial attention.
(2) This has been confirmed by many experiments on covert attention using PET and fMRI.
(3) PET and fMRI experiments on humans, together with single-neuron experiments on monkeys, have shown that tasks involving visuospatial attention also generate activation in brain networks responsible for planning motor behavior and for spatial working memory.

The discussion of attention shows that neuroimaging is a very powerful tool for studying cognition. It is not a "window on the mind," however, and neuroimaging data should be interpreted with caution

(1) Neuroimaging techniques can only measure cognitive activity indirectly. PET measures blood flow and fMRI measures the BOLD signal. There is a controversy in neuroscience about what type of neural activity is correlated with the BOLD signal (see section 4.5) – and no worked out theory about how that neural activity functions to process information.

Course website

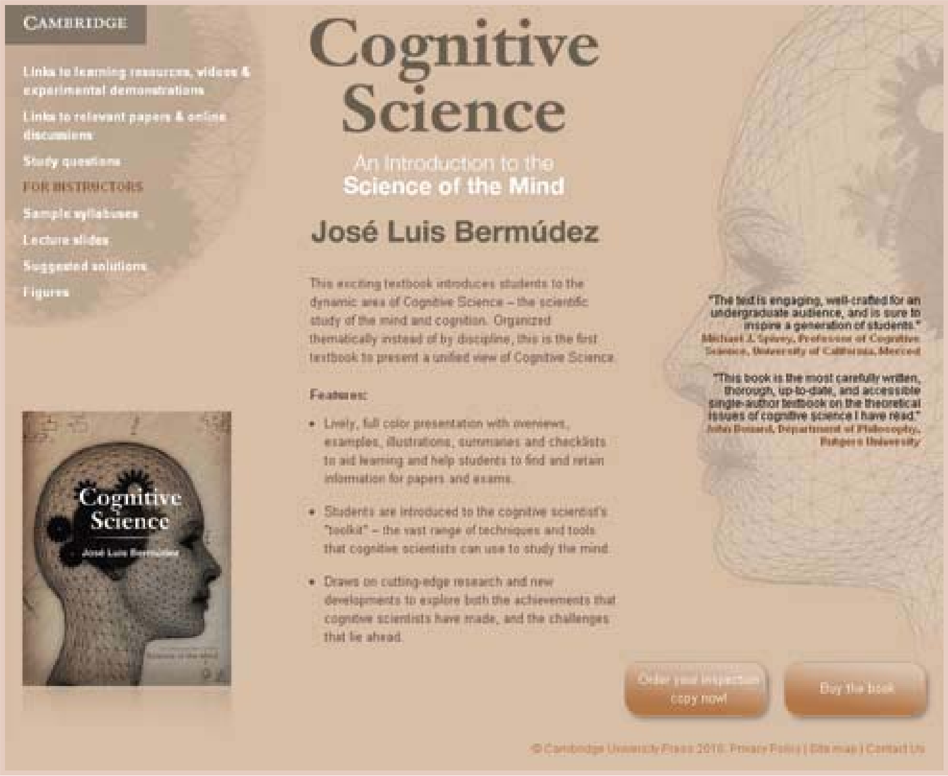
There is a course website accompanying the book. It can be found at www.cambridge.org/bermudez. This website contains:

- links to useful learning resources, videos, and experimental demonstrations
- links to online versions of relevant papers and online discussions for each chapter
- study questions for each chapter that students can use to structure their reading and that instructors can use for class discussion topics

Instructors can access a password-protected section of the website. This contains:

- sample syllabi for courses of different lengths and different level
- PowerPoint slides
- electronic versions of figures from the text
- suggested solutions for the more challenging exercises and problems

The website is a work in progress. Students and instructors are welcome to contact me with suggestions, revisions, and comments. Contact details are on the website.



ACKNOWLEDGMENTS

Many friends and colleagues associated with the Philosophy-Neuroscience-Psychology program at Washington University in St. Louis have commented on sections of this book. I would particularly like to thank Maurizio Corbetta, Frederick Eberhardt, David Kaplan, Clare Palmer, Gualtiero Piccinnini, Marc Raichle, Philip Robbins, David Van Essen, and Jeff Zacks. Josef Perner kindly read a draft of Chapter 12.

I have benefited from the comments of many referees while working on this project. Most remain anonymous, but some have revealed their identity. My thanks to Kirsten Andrews, Gary Bradshaw, Rob Goldstone, Paul Humphreys, and Michael Spivey.

Drafts of this textbook have been used four times to teach PNP 200 Introduction to Cognitive Science here at Washington University in St. Louis – twice by me and once each by David Kaplan and Jake Beck. Feedback from students both inside and outside the classroom was extremely useful. I hope that other instructors who use this text have equally motivated and enthusiastic classes. I would like to record my thanks to the teaching assistants who have worked with me on this course: Juan Montaña, Tim Oakberg, Adam Shriver, and Isaac Wiegman. And also to Kimberly Mount, the PNP administrative assistant, whose help with the figures and preparing the manuscript is greatly appreciated.

A number of students from my Spring 2009 PNP 200 class contributed to the glossary. It was a pleasure to work with Olivia Frosch, Katie Lewis, Juan Manfredi, Eric Potter, and Katie Sadow.

Work on this book has been made much easier by the efforts of the Psychology textbook team at Cambridge University Press – Raihanah Begum, Catherine Flack, Hetty Reid, Sarah Wightman, and Rachel Willsher (as well as to Andy Peart, who signed this book up but has sinced moved on). They have been very patient and very helpful. My thanks also to Anna Oxbury for her editing and to Liz Davey for coordinating the production process.