JAMIE WARD

The Student's Guide to Social Neuroscience

SECOND EDITION

A Psychology Press Book

COMPANION WEBSITE

ROUTLEDGE

About this edition:
"Social Neuroscience has vigorously established itself as one of the newest and most exciting sub-disciplines of psychology. Ward's pioneering *Student's Guide* is now updated covering new insights in the biological basis of social behaviour and their relevance to everyday life. Down-to-earth and imaginatively linked with web based materials, it can't fail to inspire the next generation of students."

Chris and Uta Frith, University College London

About the previous edition:
"I stopped using textbooks more than a decade ago, but that's about to change. Given that Ward's is the very first textbook focusing on social neuroscience, I am extremely impressed. It will be the best around for years to come. It is current, broad, and precise. The writing style will be accessible to undergraduates, graduates, and even professors. It is the perfect introduction to this exciting new field."

Matthew D. Lieberman, University of California, Los Angeles

The Student's Guide to Social Neuroscience

Social neuroscience is an expanding field that, by investigating the neural mechanisms that inform our behavior, explains our ability to recognize, understand, and interact with others. Concepts such as trust, revenge, empathy, prejudice, and love are now being explored and unraveled by neuroscientists. This engaging and cutting-edge text is an accessible introduction to the complex methods and concepts of social neuroscience, with examples from contemporary research and a blend of different pedagogical features helping students to engage with the material, including essay questions, summary and key points, and further reading suggestions.

The second edition of this groundbreaking text is thoroughly revised and expanded to reflect the growing volume of evidence and theories in the field. Notable additions include a greater emphasis on genetics and hormones, and the expansion of topics such as cultural neuroscience, emotion regulation, biological markers of autism, power and status, social categorization of faces and people, and new accounts of mirror neuron functioning. The book is supported by a new and updated companion website, including useful features such as lecture recordings, multiple choice questions and web links, as well as PowerPoint slides for lecturers.

Richly illustrated in attractive full-color, with figures, boxes, and 'real-world' implications of research, this text is the ideal introduction to the subject for undergraduate and postgraduate students in fields such as psychology and neuroscience.

Jamie Ward is Professor of Cognitive Neuroscience at the University of Sussex, UK, and Co-Director of Sussex Neuroscience. He has published over 100 scientific papers and several books including the *Student's Guide to Cognitive Neuroscience* (now in its third edition) and *The Frog who Croaked Blue: Synesthesia and the Mixing of the Senses* (now translated into 3 languages), and was the Founding Editor of the journal *Cognitive Neuroscience*.

The Student's Guide to Social Neuroscience

Second Edition

Jamie Ward

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About the author

Jamie Ward is Professor of Cognitive Neuroscience at the University of Sussex, UK, and the co-director of Sussex Neuroscience. He has published more than 100 scientific papers and several books including the *Student's Guide to Cognitive Neuroscience* (now in its third edition) and *The Frog who Croaked Blue: Synesthesia and the Mixing of the Senses* (now translated into three languages). He was the founding editor of *Cognitive Neuroscience*, a journal from Psychology Press.

Preface

This textbook came about through a desire to create an accompanying text to *The Student's Guide to Cognitive Neuroscience* specifically in the area of social neuroscience. Cognitive neuroscience may be the parent discipline of social neuroscience, but it was becoming increasingly clear over the last few years that social neuroscience had now grown up and was trying to establish a home of its own. For example, there are now several excellent journals dedicated to it and many universities have introduced social neuroscience onto the undergraduate curriculum as a separate module distinct from cognitive neuroscience. This textbook aims to reflect the new maturity of this discipline and attempts to convey the excitement of this field to undergraduate and early stage postgraduate students.

My own interest in the field stemmed from the claims surrounding mirror systems, empathy, and theory of mind. At the start of this project, I imagined that this would form the core of the textbook. However, the more that I delved into the literature the more I was taken aback by the volume and quality of research in other areas such as prejudice, morality, culture, and neuro-economics. The resulting book is, I hope, a more balanced view of the field than I initially anticipated. As with my previous textbook, it isn't an exhaustive summary of the field. It isn't my aim to teach students everything about social neuroscience but it is my aim to provide the intellectual foundations to acquire that knowledge, should they wish to become researchers themselves. My ethos is to try to present the key findings in the field, to develop critical thinking skills, and to instill enthusiasm for the subject.

In the absence of previous textbooks on social neuroscience, it was an interesting exercise deciding how to carve the field into chapters and how to order the chapters. For example, the chapter on relationships appeared and disappeared several times (with these sections being divided amongst the 'Interactions' and 'Development' chapters). The first two chapters begin with an overview of the topic and a summary of the methods used in social neuroscience. The 'methods' chapter is a condensed, but updated, version of the more extensive chapters in *The Student's Guide to Cognitive Neuroscience*. The chapter uses examples from the social neuroscience literature to illustrate the various methods. The third chapter covers the evolution of social intelligence and culture. It introduces mirror neurons in the context of imitation, social learning, and tool use. The fourth and fifth chapters deal with the 'primitive' building blocks of social processes, namely emotions and motivation (Chapter 4), and recognizing others (Chapter 5). Chapter 6 is concerned with empathy, theory of mind, and autism. The next two chapters consider social interactions and then relationships, dealing with issues such as altruism, game theory, attachment, and social exclusion. Chapter 9 is concerned with groups and identity, covering the notion of 'the self', prejudice, and religion. Chapter 10 covers antisocial behavior, aggression, and morality. The final chapter considers social development from infancy through to adolescence.

The second edition is thoroughly revised and expanded to reflect the growing volume of evidence and theories. In doing so, I have been careful to ensure that the 'big picture' is not lost in the details. Notable additions to the second edition include a greater emphasis on genetics and hormones, and the expansion of topics such as cultural neuroscience, emotion regulation, biological markers of autism, power and status, social categorization of faces and people, and new accounts of mirror neuron functioning.

Finally, I'd like to thank the many reviewers who provided constructive feedback on drafts of chapters and for Routledge for being so accommodating.

Jamie Ward

Brighton, UK, May 2016

For Katie

CHAPTER 1

CONTENTS

Introduction to social neuroscience

1

Imagine two participants lying in different rooms, each with their heads placed in a very large magnetic field. Crucially, the two participants are interacting with each other in order to win money and this interaction requires trust. By trusting money to the other person they stand a greater chance of getting more money returned to them in the future, but they also run the risk of exploitation. As their brains engage in the decision to trust or not to trust, there are subtle changes in blood flow corresponding to these different decisions that can be detected. The fact that different patterns of thought should result in different patterns of brain activity is perhaps not surprising. The fact that we now have methods that can attempt to measure this is certainly noteworthy. What is most interesting about studies such as these is the fact that activity in regions of one person's brain can reliably elicit activity in other regions of another person's brain during this social interaction. For instance, in a trusting relationship, when one person makes a decision the other person's brain 'lights up' their reward pathways, even before any reward is actually obtained – as illustrated in Figure 1.1 (King-Casas et al., 2005). Cognition in an individual brain is characterized by a network of flowing signals between different regions of the brain. However, social

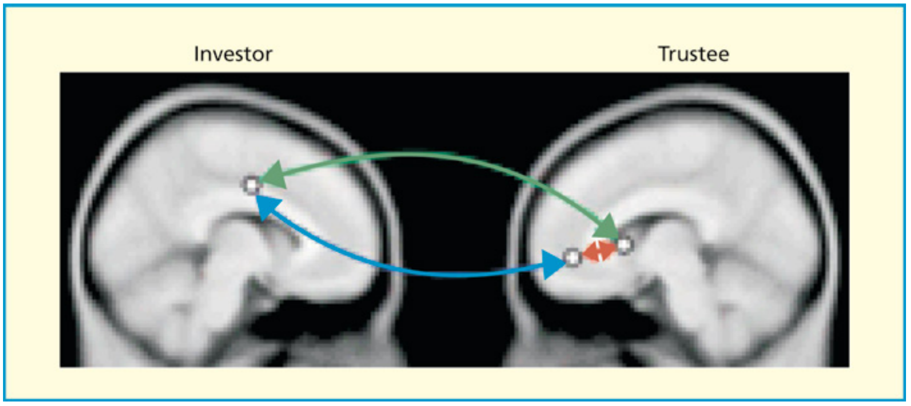

Figure 1.1 The technique of ***hyperscanning*** records from two or more different brains simultaneously (such as MRI scanners): for example, whilst participants in the scanners engage in a social activity (Montague et al., 2002). The details of this particular study, involving a game of trust, are not important here (they are covered in Chapter 7) and hyperscanning is a relatively rare methodology. What is of interest is that neural activity in different regions correlates not only within the same brain (due to physical connections; depicted in red) but also across brains (due to mutual understanding; depicted in blue and green). From King-Casas et al. (2005). Copyright © 2005 American Association for the Advancement of Science. Reproduced with permission.

KEY TERM

Hyperscanning
The simultaneous recording from two or more different brains (e.g. using fMRI or EEG)

interactions between different individuals can be characterized by the same principle: a kind of 'mega-brain' in which different regions in different brains can have mutual influence over each other. This is not caused by a physical flow of activity between brains (as happens between different regions in the same brain) but by our ability to perceive, interpret, and act on the social behavior of others.

This introductory chapter will begin by providing a brief overview of the (brief) history of social neuroscience. It will then go on to consider what kind of mechanisms could constitute the 'social brain' and how they might relate to nonsocial brain processes. Finally, it will consider how different levels of explanation are needed to derive a complete understanding of social behavior, and it will discuss how neuroscience can be combined with other approaches.

KEY TERMS

Social psychology
An attempt to understand and explain how the thoughts, feelings, and behaviors of individuals are influenced by the actual, imagined, or implied presence of others.

Cognitive psychology
The study of mental processes such as thinking, perceiving, speaking, acting, and planning.

THE EMERGENCE OF SOCIAL NEUROSCIENCE

Allport (1968) defined **social psychology** as 'an attempt to understand and explain how the thoughts, feelings, and behaviors of individuals are influenced by the actual, imagined, or implied presence of others'. By extension, a reasonable working definition of social neuroscience would be:

> *an attempt to understand and explain, using neural mechanisms, how the thoughts, feelings, and behaviors of individuals are influenced by the actual, imagined, or implied presence of others.*

Based on this definition, one could regard social neuroscience as being a subdiscipline within social psychology that is distinguished only by its adherence to neuroscientific methods and/or theories. Whilst this may be perfectly true, most researchers working within the field of social neuroscience do not have backgrounds within social psychology but tend to be drawn from the fields of **cognitive psychology** and neuroscience. Indeed social neuroscience has also gone by the name 'social cognitive neuroscience' (the term is less commonly used now). Cognitive psychology is the study of mental processes such as thinking, perceiving, speaking, acting, and planning. It tends to dissect these processes into different sub-mechanisms and explain complex behavior in terms of their interaction. Cognitive psychology has an important role to play in social neuroscience because it aims to decompose complex social behaviors into simpler mechanisms (operating in individual minds) that are amenable for exploration using neuroscientific methodologies. Social neuroscience links together all these disciplines: linking cognitive and social psychology, and linking 'mind' (psychology) with brain (biology, neuroscience). Of course, these divisions themselves are arbitrary. They serve as convenient ways of categorizing research programs, and they become embedded in the way they are taught (lecture courses, textbooks, etc.).

The term *social neuroscience* can be traced to an article by Cacioppo and Berntson (1992) entitled 'Social psychological contributions to the decade of the brain: Doctrine of multi-level analysis'. The term appears twice: once in a footnote, and once in a heading accompanied by a question mark – i.e. 'Social Neuroscience?'. Their particular interest in the topic stemmed from research showing that psychological processes such as perceived social support can affect immune functioning. However, many other areas of study that now fall under the social neuroscience umbrella were already active areas of study prior to 1992. In cognitive psychology, there was a mature literature on face perception. However, this literature was primarily concerned with understanding faces as a type of visual object rather than treating faces as cues to social interactions. There were also detailed accounts of how social behavior breaks down as a result of acquired brain damage (Damasio, Tranel, & Damasio, 1990; Eslinger & Damasio, 1985) or in developmental conditions such as autism (e.g. Frith, 1989). In behavioral neuroscience, there was a longstanding interest in emotional processes such as fear (e.g. LeDoux, Iwata, Cicchetti, & Reis, 1988), aggression (e.g. Siegel, Roeling, Gregg, & Kruk, 1999), and separation distress (e.g. Panksepp, Herman, Vilberg, Bishop, & DeEskinazi, 1980). In social psychology, the field of 'social cognition' applied the approach and methods of cognitive psychology (e.g. response time) to social psychology questions. Finally, the 1990s saw the refinement of the newly established methods of cognitive neuroscience, such as functional magnetic resonance imaging (fMRI) and transcranial magnetic stimulation (TMS), and these methods were directed to social processes as well as to the more traditional areas within cognitive psychology.

By the year 2000, social neuroscience could be recognized as a relatively coherent entity with a core set of research issues and methods and as reflected in prominent reviews of the time (e.g. Adolphs, 1999; Frith & Frith, 1999; Ochsner & Lieberman, 2001). The first journals dedicated to this field, *Social Neuroscience* and *Social, Cognitive and Affective Neuroscience (SCAN)*, both appeared in 2006. The Society for Social and Affective Neuroscience (SANS; www.socialaffectiveneuro.org) and Society for Social Neuroscience (S4SN; www.s4sn.org) were established in 2008 and 2010 respectively. Both societies welcome student members. The first edition of this textbook, published in 2012, was the first single-authored study guide aimed at undergraduate students.

Stanley and Adolphs (2013, p. 822) provide a compelling summary of the current state of the field and point to its future evolution. They summarize it as follows:

> *Although we have moved from regions to networks, the next key step is to identify the flow of information through these networks to follow social information processing from stimulus through to response. This requires an understanding*

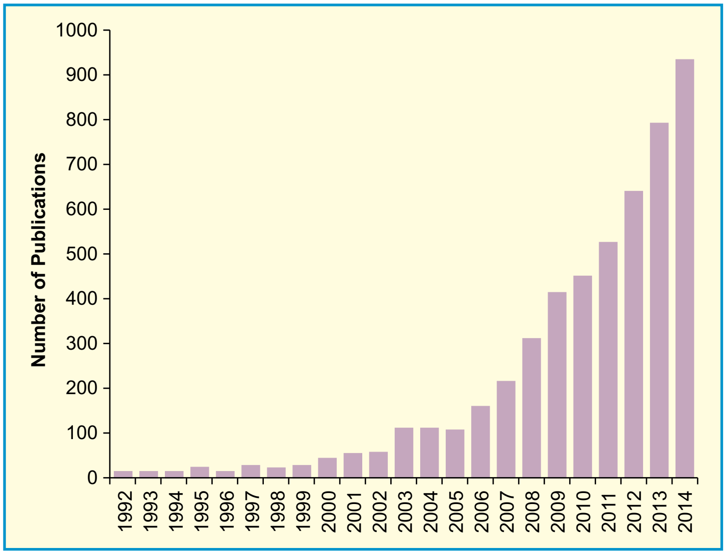

Figure 1.2 The number of publications incorporating the term 'social' and 'neuroscience' has increased dramatically since 2000. This data is based on a search of the Web-of-Knowledge database searching for a conjunction of 'social' and 'neuroscience' in the topic field.

> *of the detailed computations implemented by the different nodes in the networks as well the dynamic interplay between them. One could make the analogy of moving from words (brain areas) to sentences (networks) to propositions (arrangements of network dynamics) to conversations (brains interacting). We are still solidly in the age of sentences and are only beginning to enter the age of propositions and conversations.*

Many of these ideas are explored in more detail throughout the chapter and, indeed, the book. Can we assign unique functions to brain regions or use activity in a given brain region to infer the nature of information processing (e.g. emotional versus rational)? Are there brain regions or networks that can be understood specifically in terms of their contribution to social functioning or do these regions/networks also participate in similar ways in non-social cognition? How can social neuroscience study realistic social interactions? On the latter point, Schilbach et al. (2013) have pointed out that most previous research in social neuroscience has tended to involve observing and interpreting other people and that the neural mechanisms underlying social interactions per se can (metaphorically) be considered the 'dark matter' of social neuroscience. Complementary to this, Willingham and Dunn (2003, p. 669) cautioned social psychologists against changing their research agenda just to make them amenable to a neuroimaging approach:

> *Some of the topics of interest to social psychologists are not amenable to brain localization techniques because of the complexity of the processes; they have embedded in them subprocesses that interact, and such complex processes are difficult to localize. It would be a pity if, in their justifiable enthusiasm for this powerful tool [i.e. neuroimaging], social psychologists subtly shifted their research programs to problems that are amenable to brain localization or shifted their theoretical language to constructs that are localizable.*

What should we make of criticism such as this? Willingham and Dunn (2003) are correct to point out that it is important not to shift the whole social psychology research agenda to fit with trendy neuroscience methods. To a large extent, the shift has to come from the development of neuroscientific techniques that can tackle the questions that matter. However, their characterization of social neuroscience in terms of localization of functions is inaccurate (or, at least, outdated). Social neuroscience should be concerned primarily with the underlying mechanisms, and these are unlikely to be localized to discrete brain regions.

Stanley and Adolphs (2013) also report a number of surveys conducted on Social Neuroscience researchers attending international conferences. Figure 1.3 shows a summary of a survey asking researchers what they presently work on, what is presently lacking in the field, and what the future of social neuroscience will consist of. Current researchers tend to work on topics such as emotion, self-regulation, and decision-making but feel that the discipline as a whole needs more statistical and methodological rigor, needs to be more ***ecologically valid***, and needs more interdisciplinary integration. The future of social neuroscience, in their eyes, lies both in terms of real-world applications and also in terms of an additional level of sophistication afforded by computational approaches to brain networks.

KEY TERM

Ecological validity
An approach or measure that is meaningful outside of the laboratory context.

What Do Social Neuroscientists Say?		
Current Research Interests	**Social Neuroscience Is Currently Lacking**	**Future of Social Neuroscience**
Emotion	Statistical/Methodological Rigor	Applied Science
Clinical Disorders	Ecological Validity	Computational Approaches
Self-Regulation	Interdisciplinary Integration	Networks in the Brain
Development	Computational Approaches	Real-World Behaviors
Decision-Making	Theory	Social Interaction

Figure 1.3 What do social neuroscientists say about their discipline? Stanley and Adolphs (2013) asked researchers in the field about their current interests (left), what is lacking in the field (middle), and what the future should hold (right). The degree of shading represents the rank ordering of responses, with some responses being tied.

THE SOCIAL BRAIN?

One overarching issue within social neuroscience is the extent to which the so-called 'social brain' can be considered distinct from all the other functions that the brain carries out – talking, walking, planning, etc. In other words, is the 'social brain' special in any way? This will be a recurring theme in the book, although Chapter 3 considers it in detail from an evolutionary perspective.

One possibility is that there are particular neural substrates in the brain that are involved in social cognition but not in other types of cognitive processing. This relates to the notions of **modularity** and **domain specificity**. A module is the term given to a computational routine that responds to particular inputs and performs a particular computation on them, that is, a routine that is highly specialized in terms of what it does to what (Fodor, 1983). One core property that has been attributed to modules is domain specificity, namely that the module processes only one kind of input (e.g. only faces, only emotions). One contemporary claim is that there is a module that responds to the sight of faces, but not the sight of bodies or the sounds of people's voices or indeed to any non-face stimuli (e.g. Kanwisher, 2000). Another claim is that there is a module for reasoning about mental states (e.g. people's desires, beliefs, knowledge) but not other kinds of reasoning (e.g. Saxe, 2006). Yet another claim is that there is a module for detecting cheating (Cosmides, 1989). In this modular view, the social brain is special by virtue of brain mechanisms that are specifically dedicated to social processes. Moreover, it is claimed that these mechanisms evolved to tackle specific challenges within the social environment (e.g. the need to recognize others, the need to detect when you are being exploited). To some critics, this view of the mind and brain resembles phrenology (Uttal, 2001) – see Figure 1.4. However, such criticisms are not entirely fair given that modern approaches to addressing the issue of domain-specific social processes are subjected to experimental rigor that was never applied to Nineteenth century ideas of the brain localization of function.

The alternative, diametrically opposite, approach is to argue that the 'social brain' is not, in fact, specialized uniquely for social behavior but is also involved in non-social aspects of cognition (e.g. reasoning, visual perception, threat detection). The evolution of general neural and cognitive mechanisms that increase intellect, such as having bigger brains, may make us socially smarter too (e.g. Gould, 1991). Of course, it is also possible that the reverse is true – namely that the evolutionary

KEY TERMS

Modularity
The notion that certain cognitive processes (or regions of the brain) are restricted in the type of information they process and the type of processing carried out.

Domain specificity
The idea that a cognitive process (or brain region) is specialized for processing only one particular kind of information.

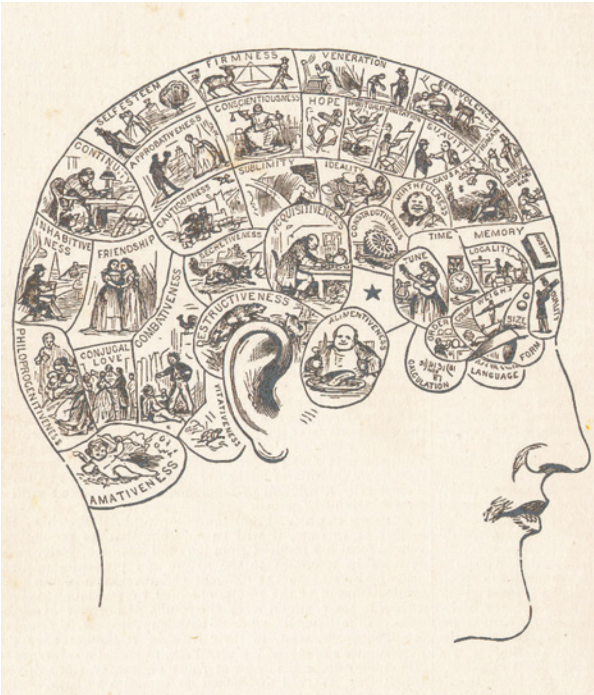

Figure 1.4 The phrenologist's head was used to represent highly localized functions of the brain in the early nineteenth century. It is an extreme form of a modularity view, albeit based on outdated notions of what the core functions are likely to be (e.g. love of animals, conscientiousness) and how individual differences in these functions represent themselves biologically (larger brain regions giving larger bumps on the skull). To what extent is the 'social brain' a set of specialized modules?

need to be socially smarter leads to general cognitive advances in other domains (e.g. Humphrey, 1976). Under these accounts social cognition and non-social cognition evolved hand-in-hand (albeit with one factor driving the other) but, crucially, they did not necessarily lead to highly specialized routines in the brain for dealing with social problems.

Needless to say, there are other positions that lie in-between these two extremes. Mitchell (2009) notes that there are certain regions of the brain (e.g. the medial prefrontal cortex) that are activated in fMRI studies by a wide range of social phenomena such as evaluating attitudes, interpreting other's behavior, and emotional experience. Rather than arguing for a narrowly defined module in this region, he suggests that social psychology is a 'natural kind' that distinguishes itself from other aspects of cognition because it relates to concepts that are less stable and less definite than those involved in, say, perception and action. In this account, the 'social brain' is special because of the nature of the information that is processed (more fuzzy) rather than because it is social (i.e. interpersonal) per se.

Another possibility is that it is not particular regions of the social brain that are 'special' but rather that there are particular kinds of neural mechanisms especially suited to social processes. For example, Frith (2007) claims: 'I have speculated about the role of various components of the social brain, but in most cases, I believe that these processes are not specifically social. The exception is the brain's mirror system.' Similarly, Ramachandran (2000) predicts that 'mirror neurons will do for psychology what DNA did for biology: they will provide a unifying framework and help explain a host of mental abilities that have hitherto remained mysterious and inaccessible to experiments.' Mirror neurons respond both when an animal sees an action performed by someone else and when they perform the same action themselves (e.g. Rizzolatti & Craighero, 2004). The key insight, with regard to social neuroscience, is that there may be a simple mechanism – implemented at the level of single neurons – that enables a correspondence between self and other. Mirror neurons have been implicated in imitation (see Chapter 3), empathy, and 'mind reading' (see Chapter 6). Although they were originally discovered for actions, it is possible that mirroring is a general property of many neurons (e.g. those processing pain, emotion, etc.) and they may not be tightly localized to one region (Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). Whereas some researchers have argued that mirror neurons serve a specifically social function (Frith, 2007) others have suggested that they arise primarily out of associative learning between action and perception in both social and non-social contexts such as observing one's own actions (Heyes, 2010).

Barrett and Satpute (2013) offer a useful overview of this general debate concerning the nature of the social and emotional brain that is illustrated in Figure 1.5. They consider three broad ways in which the 'social brain' may be implemented. The first

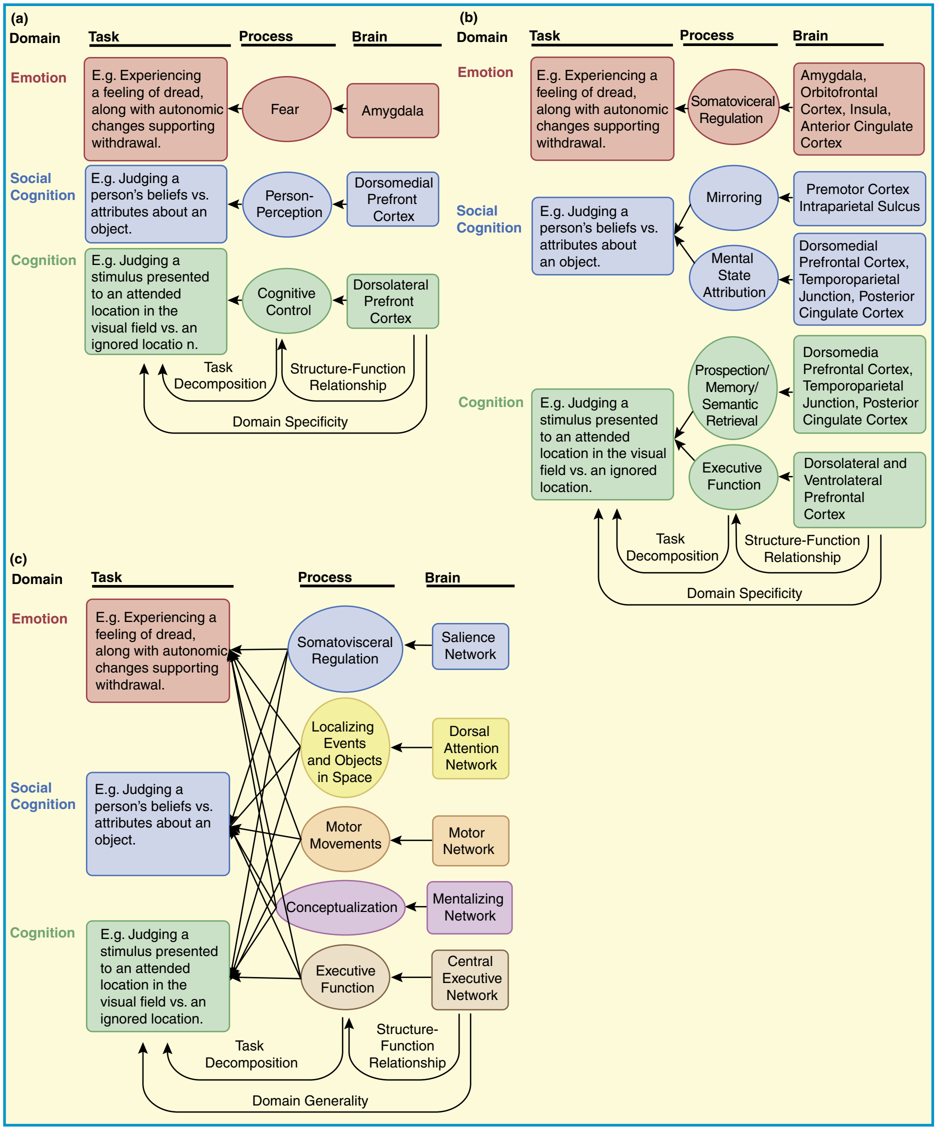

Figure 1.5 Three different ways in which different brain structures might be mapped to different functions (tasks and processes). In (a) there is a one-to-one association between brain structure and function whereas in both (b) and (c) a network of regions may make differing contributions to a given function. In (b) the network consists of specialized units that interact, but in (c) the network consists of interactions between non-specialized units. From Barrett and Satpute (2013).

scenario is a simple domain-specific view consisting of brain regions that are specialized for processing particular kinds of social information (e.g. person perception) and non-social information (e.g. cognitive control). Few, if any, contemporary researchers would endorse such a view. The second and third scenarios involve the idea of brain networks and are more compatible with contemporary ideas in the literature.

The second scenario postulates networks of regions in which each region in the network has a high degree of specialization (e.g. specific to social information), whereas in the third scenario (the one endorsed by these authors) neither brain regions nor individual brain networks are functionally specialized or segregated into social and non-social functions. Of course, it would also be possible to imagine hybrid scenarios that have elements of each (Fedorenko, Duncan, & Kanwisher, 2013). Adjudicating between these different scenarios will require linking evidence from a wide range of techniques. For instance, whilst evidence from functional imaging, reviewed by Barrett and Satpute (2013), often points to the existence of very generic networks, other evidence (e.g. from brain lesions, or using brain stimulation) has tended to reveal more specificity within the networks.

In summary, there is a variety of views concerning the broad nature of the neural mechanisms that support human social behavior. At one end, there is the view that there are highly specialized neural mechanisms. These may be very limited in the type of information they process (e.g. faces, beliefs). At the other end, there is the view that the mechanisms that support social behavior are used for many other functions (possibly including non-social cognition). Whereas the highly specialized viewpoint tends to have been linked to the idea of a small number of contributing brain regions (localizability), it is not incompatible with the idea of brain networks.

IS NEUROSCIENCE AN APPROPRIATE LEVEL OF EXPLANATION FOR STUDYING SOCIAL BEHAVIOR?

Perhaps the most general criticism that could be leveled at social neuroscience is that the brain is not the most appropriate level of explanation for understanding social processes. Surely social processes need to be studied and understood at the social level – that is, at the level of interactions between people, groups of people, and societies. There have been some fascinating studies on neural responses to Black faces by White American students, but what could we ever really learn about racism from brain-based measures without situating them in a social, economic, and historical context?

Of course, this presents a distorted view of what social neuroscience is really all about. Most researchers in the field do not take a strongly reductionist approach. **Reductionism** implies that one type of explanation will become replaced with another, more basic, type of explanation over time. In a reductionist framework the language of social psychology (e.g. attitudes, relationships, conformity) will be replaced by the concepts of neuroscience (e.g. oxytocin, plasticity, medial prefrontal cortex). However, most researchers in social neuroscience are attempting to create bridges between different levels of explanation rather than replace one kind of explanation with another – see Figure 1.6. For example, social neuroscience studies may combine questionnaire measures (the bread-and-butter of social psychology research) with neuroscience data.

Another common way in which neuroscience data are used to bridge levels of explanation has been termed the **reverse inference** approach (Poldrack, 2006). The reverse inference approach is an attempt to infer the nature of cognitive processes from neuroscience (notably neuroimaging) data. Examples of this abound in the social neuroscience literature. For example, activity within the amygdala may be taken to imply the involvement of a fear-related (or more broadly emotion-related)

KEY TERMS

Reductionism
One type of explanation will become replaced with another, more basic, type of explanation over time.

Reverse inference
An attempt to infer the nature of cognitive processes from neuroscience (notably neuroimaging) data.

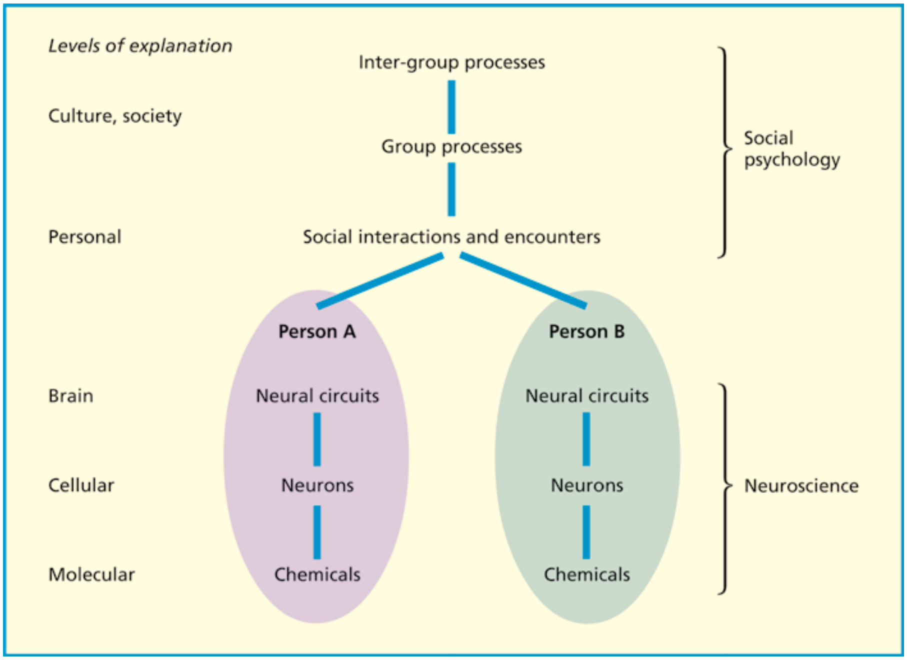

Figure 1.6 Social psychology and neuroscience employ different levels of explanation. Social neuroscience aims to create bridges between these different levels of explanation.

mechanism in studies of race processing (Phelps et al., 2000). The nature of various moral dilemmas has been inferred on the basis of whether the dilemmas activate regions of the brain implicated in emotion or in higher order reasoning (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). If the hippocampus is activated, then long-term memory is involved; if the right temporo-parietal junction is activated, then 'theory of mind' is involved; etc. Is reverse inference necessarily good practice? It goes without saying that the reliability of this inference depends on what is known about the functions of given regions. If these regions turned out to have very different functions then the inference would be flawed. Also the function of regions is not resolutely fixed but depends on the context in which they are employed. Poldrack (2006) argues that reverse inference may be improved by examining networks of regions or examining more precise regions (e.g. not just the 'frontal lobes'). Another more general methodological point is the importance of not being over-reliant on neuroimaging data, but to look at other sources of evidence such as TMS in which behavior itself is normally measured (and hence does not suffer from the problems of reverse inference in the same way). Reverse inference is a legitimate approach, but it is not problem free.

An example of a forward and reverse inference in social neuroscience. Even if the forward inference is correct, then it doesn't necessarily imply that the reverse inference will be.

Forward inference: If someone is frightened their amygdala is activated.

Reverse inference: If the amygdala is activated then someone is frightened.

KEY TERM

Blank slate
The idea that the brain learns environmental contingencies without imposing any biases, constraints, or preexisting knowledge on that learning.

Logically, there is one scenario in which brain-based data could have no significant impact on our understanding of social processes – and that is the **blank slate** scenario. In the blank slate scenario, the brain just accepts, stores, and processes whatever information is given to it without any pre-existing biases, limitations, or knowledge. According to the blank slate, the brain is not completely redundant (it still implements social behavior) but the nature of social interactions themselves is entirely attributable to culture, society, and the environment. According to the blank slate, the structure of our social environment is created entirely within the environment itself, reflecting arbitrary but perpetuated historical precedents. Thus, culture, society, and the nature of social interactions invent and shape themselves. A more realistic scenario is that the brain, and its underlying processes, creates constraints on social processes. For example, it is claimed that the number of close friends that we have is predicted by the size of the human brain, extrapolating from known group sizes and brain sizes in other primates (Dunbar, 1992). The tendency to form monogamous attachments is dependent on brain chemistry (Carter, DeVries, & Getz, 1995). Apparently arbitrary social conventions, such as the rules governing right and wrong (e.g. the law), may not be entirely arbitrary but may reflect a basic tendency to empathize with others and reason about causes and effects (Haidt, 2012). Even in the first few hours of life, infants appear to treat social and non-social stimuli differently. They enter the world with a preference for social stimuli and even appear to have rudimentary knowledge about how faces should be structured (Macchi Cassia, Turati, & Simion, 2004). Social processes are *all* in the brain, but some of them are created by environmental constraints and historical accidents (and learned by the brain) whereas others may be caused by the inherent organization, biases, and limitations of the brain itself.

Aggression as an example of interacting levels of explanation

To give a feel for this debate, consider the topic of aggression. Many current social psychology textbooks (e.g. Hogg & Vaughan, 2011) are dismissive of the role of biological factors in aggression, noting, for instance, the huge variability in levels of aggressive acts such as murder across cultures. However, we can consider this in terms of two questions: What causes aggression and what causes variability in levels of aggression? These questions may generate quite different answers. To give a non-social analogy, the typical number of fingers that we have on our hands (i.e. ten) is almost entirely down to our biology, whereas the *variability* in the number of fingers we have on our hands is almost entirely down to environment, such as industrial accidents (this example is from Ridley, 2003). Figure 1.7 shows that there is indeed huge cross-cultural variability in murder rates of developed countries. This is likely to reflect differences across cultures: USA and Finland have some of the highest rates of gun ownership whereas Singapore has the lowest. However, the pattern is not random and is linked to income inequality (the magnitude of difference between the highest and lowest earners). Whilst income inequality is itself cultural, and not biological, the fact that aggression is linked to resource control and perceived injustice is likely to be independent of culture. Cultural differences may act as an 'accelerator' or 'brake' on biological tendencies. To give a specific example of the interaction between cultural and biological factors, consider the effects of the hormone testosterone (a biological factor) and socio-economic status (SES, a cultural factor). Levels

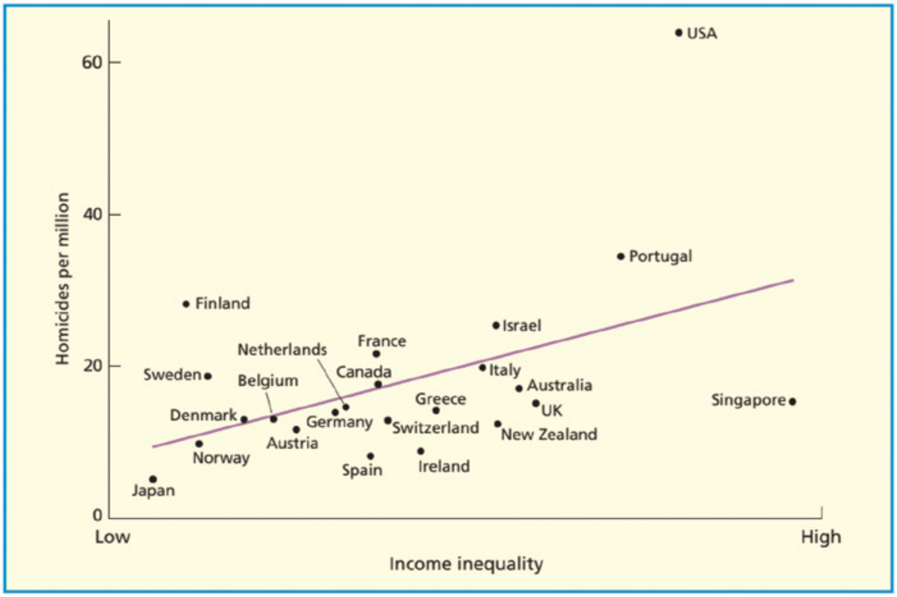

Figure 1.7 Murder rates vary considerably from country to country, but does this imply that we should understand murder from a purely social perspective? There may be underlying factors, perhaps reducible to particular kinds of cognitive mechanisms (e.g. perceived inequality), that explain this variability rather than reflecting random variability. From Wilkinson and Pickett (2009). Copyright © 2009 Penguin Books Ltd. Reproduced with permission.

of testosterone in males are correlated with levels of aggression in people of low SES individuals but not high SES (Dabbs & Morris, 1990). So high SES acts as a brake on biological influences (these people are already at the top of the social ladder), but low SES may bring to the fore biologically bound instincts for achieving status and securing resources.

A biological basis for culture?

The same logic can be applied to other domains, including culture itself. The answer to the question 'what causes culture?' might be something like 'a set of mechanisms that enables people to transfer skills, beliefs, and knowledge from each other and retain these as a relatively stable pattern across individuals' (this being a cognitive mechanistic explanation). A more neuroscientific answer could be 'neural mechanisms that respond to the repeated patterns of behavior in others, whom we affiliate positively with, and increase the likelihood that our own neural mechanisms will generate those behaviors'. This is not intended as a truly accurate answer, but merely conveys what a reductive neuroscience concept of conformity (a central aspect of culture) *might* look like. But note that it would be an entirely circular argument to say that culture creates itself. To take that argument to a logical absurdity, culture cannot create itself in the absence of appropriate biological entities! As to the question of what creates *variability* in culture, the answer could be quite different. It may reflect,

KEY TERMS

Cultural neuroscience An interdisciplinary field bridging cultural psychology, neurosciences, and neurogenetics

Gene-culture co-evolution Culture can influence gene frequencies in a population, and genes have an impact on cultural evolution via psychological predispositions.

for instance, the different environments that people live in and arbitrary historical precedents. However, the number of cultural variants may not be limitless. Hauser (2009) speculates that there could be some cultural forms that will never be created or, if they are, will rapidly die out because they are too difficult to acquire – that is, biology may go as far as to specify which cultural variants are likely, possible, or virtually impossible. This might seem surprising if one thinks of the variety of cultures that exist. For example, slavery is a possible culture (although abhorrent to modern eyes) and some cultures that used slavery, such as the ancient Egyptians, flourished for millennia. However, the existence of a cultural variant such as slavery may require particular kinds of neurocognitive mechanisms: for instance, the switching off of empathic processes towards the slave group and particular kinds of thoughts that drive this switching off (e.g. dehumanization). An impossible culture could therefore be a system of slavery associated with high levels of empathy and humane cognitions towards the slave group. The impossibility is created by the nature of brain-based mechanisms, even though it manifests itself in terms of the nature of social processes.

Gene-culture co-evolution

One good illustrative attempt at linking multiple levels of explanation in social neuroscience comes from a newly coined sub-discipline termed **cultural neuroscience** (e.g. Han et al., 2013; Kim & Sasaki, 2014). Cultural neuroscience is an interdisciplinary field bridging cultural psychology, neurosciences, and neurogenetics that explains how neurobiological processes give rise to cultural values, practices, and beliefs as well as how culture shapes neurobiological processes (Chiao, 2010). That is, it explicitly assumes that not only will cultural differences influence the brain (the top-down in Figure 1.6) but also that the brain will impact on culture itself (the less intuitive bottom-up approach in Figure 1.6). The scope of cultural neuroscience encompasses such things as examining how immersion in different cultural systems (e.g. collectivism, individualism; large-scale or small-scale communities) affects the functioning of different brain networks (e.g. those involved in trust or compassion), and also how differences in biology (e.g. genetic differences) might be linked to cultural practice. Perhaps not surprisingly, there has been some healthy skepticism to this approach. Denkhaus and Bos (2012) have argued that: 'Putting subjects from the United States and China in an MR tomograph and scanning their brains while they are performing a set of specialized tasks is not exactly what most people would regard as a promising way of unpacking the complexities of culture.' Of course it is an open question as to whether any genuinely novel insights will emerge from this approach, but already there are intriguing results. In this section, I shall consider the evidence for **gene-culture co-evolution**, and Chapter 9 considers cross-cultural and group differences more generally. Those less familiar with the basic principles of genetics are referred to the box in Chapter 2.

According to the principle of gene-culture co-evolution (e.g. Boyd & Richerson, 1985) certain genotypes may predispose people to create particular features in their environment (thus influencing cultural selection) and – at the same time – aspects of a given culture may tend to favor individuals of a given genotype (thus influencing genetic selection). The outcome of this iterative process is that there is a good fit between a particular genotype and a particular cultural practice. A commonly cited example in the literature is the genetic disposition to lactose tolerance (which has occurred relatively recently in human history and is not culturally universal) and the cultural practice of cattle domestication and dairy farming.

More recently, researchers have investigated the prevalence of various genetic sub-types linked to social sensitivity in cultures that vary in their degree of individualism and collectivism (see Way & Lieberman, 2010). In a **collectivist culture** the goals of the social group are emphasized over individual goals (e.g. in East Asian countries such as China). In an **individualist culture** the goals of the individual are emphasized over the social group (e.g. in Western countries such as USA). There is evidence that genes linked to increased social sensitivity are more prevalent in collectivist cultures, whereas genes linked to reduced social sensitivity are more prevalent in individualist cultures (see Figure 1.8). One possible conclusion is that genes and culture have co-evolved. The serotonin transporter gene occurs in two variants, or alleles, termed short and long. Carriers of the short allele show more mental health problems (e.g. depression) following a negative life event (such as divorce, Caspi et al., 2003), but also show more responsiveness to positive life events particularly in the social realm (Way & Taylor, 2010). That is, the short gene confers social sensitivity rather than being, say, a 'gene for depression'. The short is more prevalent in collectivist cultures (Chiao & Blizinsky, 2010). The mu-opioid receptor exists in two allelic variants (termed G and A), and the G version is linked to greater sensitivity to social rejection as measured by fMRI and questionnaires (Way, Taylor, & Eisenberger, 2009). The G version is more prevalent in collectivist cultures (Way & Lieberman, 2010). Finally, monoamine oxidase A (MAO-A) is an enzyme that breaks

KEY TERMS

Collectivist culture
The goals of the social group are emphasized over individual goals.

Individualist culture
The goals of the individual are emphasized over the social group.

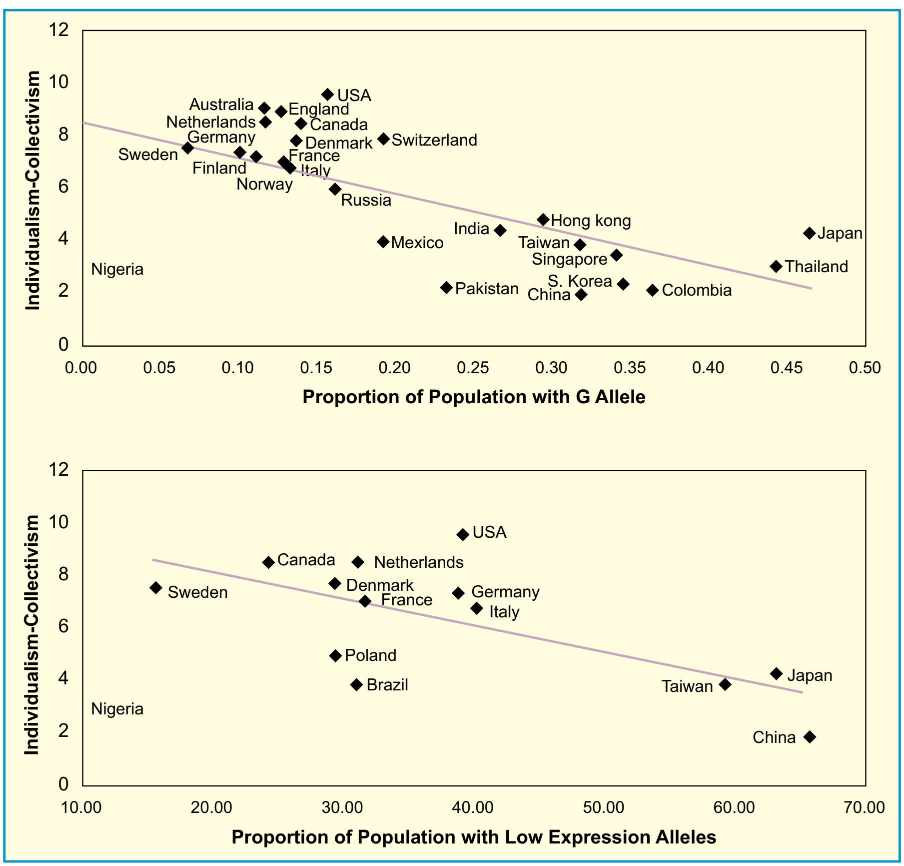

Figure 1.8 The G allele of the mu-opioid receptor gene and the low expression allele of the MAO-A gene are both linked to increased social sensitivity. Their prevalence in a given country is correlated with the degree of collectivism in that culture. Is this evidence for gene-culture co-evolution? From Way and Lieberman (2010).

down serotonin and dopamine and exists in different variants. The low expressing variant has been linked to anti-social behaviors following negative life events (such as neglect/abuse; Caspi et al., 2002) but this genotype often reports the lowest psychological problems following positive life experiences (Belsky et al., 2009). That is, it conveys social sensitivity. It is also more common in collectivist cultures (Way & Lieberman, 2010).

There is an obvious, and hard to disprove, criticism of these findings: namely that the evidence is all correlational in nature. However, the fact that the pattern occurs across multiple genes that convey social sensitivity makes it unlikely to be a chance occurrence. If true, it suggests that differences at the lowest level of analysis in neuroscience (e.g. a single change in the genetic code) interact with the highest level of analysis in social psychology (whole cultures) – albeit interacting over multi-generational timescales.

OVERVIEW OF SUBSEQUENT CHAPTERS

This chapter has offered a taster to some of the big issues that dominate research in social neuroscience, as well as outlining its conceptual and historical underpinnings. The chapter can perhaps be best appreciated by reading it again after tackling some of the detailed topics covered later on. From an assessment perspective, most essays on social neuroscience could be enhanced by insightfully discussing concepts such as reverse inference, localization, appropriate levels of explanation (and so on), together with the relevant evidence-base for the specific topic of the essay.

The next chapter provides an overview of the methods used by social neuroscientists, and also offers further critique of their limitations. Chapter 3 revisits many of the issues outlined in the current chapter specifically from an evolutionary (cross-species) perspective. Chapters 4, 5, and 6 discuss what can be regarded as the 'core' mechanisms that underpin social behavior (e.g. face processing, emotions, mirroring, and mentalizing) and are the most commonly touted candidates for being specialized and modular mechanisms. The remaining chapters consider more complex social behaviors (e.g. altruism, morality, group behavior) that depend, to a large part, on core mechanisms such as emotional processes.

SUMMARY AND KEY POINTS OF THE CHAPTER

- Social neuroscience can be defined as an attempt to understand and explain, *using neural mechanisms*, how the thoughts, feelings, and behaviors of individuals are influenced by the actual, imagined, or implied presence of others.
- There are various ways in which a 'social brain' (i.e. a set of neural routines for dealing with social situations) could be implemented. At one level, there may be domain-specific routines that evolved for serving specific functions. At the other extreme, the same set of routines may be used in both social and non-social situations. Other positions are neural routines that are predominantly used for dealing with social situations

but serve a more generic function, or non-modular solutions implemented throughout the brain (e.g. mirror systems).
- Social neuroscience aims to create bridges between different levels of explanation of social behavior. The brain, and its workings, is likely to create causal constraints on the way that social interactions are organized rather than merely soaking up the social world (as a blank slate).
- Gene-culture co-evolution is one example of interactions between different levels of explanation that determines how culture selects genes and, more controversially, for how genes select cultures

EXAMPLE ESSAY QUESTIONS

- Is the 'social brain' highly modular?
- How can neuroscience and social psychology inform each other?
- Is cultural neuroscience likely to be a promising way of unpacking the complexities of culture?

RECOMMENDED FURTHER READING

- Frith, C. D. (2007). The social brain? *Philosophical Transactions of the Royal Society, 362*, 671–678.
- Mitchell, J. P. (2009). Social psychology as a natural kind. *Trends in Cognitive Sciences, 13*, 246–251.
- Stanley, D. A., & Adolphs, R. (2013). Toward a neural basis of social behavior. *Neuron, 80*, 816–826. An interesting review of the current state of social neuroscience and how it is likely to develop in the future.
- Willingham, D. T., & Dunn, E. W. (2003). What neuroimaging and brain localization can do, cannot do, and should not do for social psychology. *Journal of Personality and Social Psychology, 85*, 662–671.

ONLINE RESOURCES

- Become a student member of an academic society: the Society for Social and Affective Neuroscience (SANS; www.socialaffectiveneuro.org) or Society for Social Neuroscience (S4SN; www.s4sn.org).
- References to key papers and readings
- Talks and lectures by Joan Chiao, Lisa Feldman Barrett, Ralph Adolphs, V. S. Ramachandran, and others
- Recorded lecture given by textbook author, Jamie Ward
- Multiple choice questions and interactive flashcards to test your knowledge
- Downloadable glossary

CHAPTER 2

CONTENTS

The methods of social neuroscience

2

Social neuroscience is too recent a field to have developed a distinct methodology of its own. As such its methods are borrowed from disciplines such as psychology (both cognitive and social psychology) and neuroscience (particularly cognitive neuroscience). The chapter will begin by considering various psychological methods such as performance measures (e.g. response times), observational studies, and questionnaires. It then goes on to consider methods linked to cognitive neuroscience – psychophysiological responses (e.g. skin conductance response) and electrophysiological responses – before turning to functional imaging, effects of brain lesions, and brain stimulation. Most of these methods are covered in more detail in Ward (2015). However, specific examples from the field of social neuroscience are used to illustrate the different methods and to explain the complementary nature of the different methods.

The main methods of cognitive neuroscience can be placed on a number of dimensions as illustrated in Table 2.1 below and Figure 2.1:

- The **temporal resolution** refers to the accuracy with which one can measure when an event is occurring. The effects of brain damage are permanent and so this has no temporal resolution as such. Methods such as electroencephalography/event-related potential (EEG/ERP), magnetoencephalography (MEG), TMS, and single-cell recording have millisecond resolution. Positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) have temporal resolutions of minutes and seconds, respectively, that reflect the slower hemodynamic response.
- The **spatial resolution** refers to the accuracy with which one can measure where an event is occurring. Lesion and functional imaging methods have comparable resolution at the millimeter level, whereas single-cell recordings have spatial resolution at the level of the neuron.

TABLE 2.1 THE DIFFERENT METHODS USED IN COGNITIVE NEUROSCIENCE

Method	Method type	Invasiveness	Brain property used
EEG/ERP	Recording	Non-invasive	Electrical
Single-cell (and multi-unit) recordings	Recording	Invasive	Electrical
TMS	Stimulation	Non-invasive	Electromagnetic
tDCS	Stimulation	Non-invasive	Electrical
MEG	Recording	Non-invasive	Magnetic
PET	Recording	Invasive	Hemodynamic
fMRI	Recording	Non-invasive	Hemodynamic

KEY TERMS

Temporal resolution
The accuracy with which one can measure when an event is occurring.

Spatial resolution
The accuracy with which one can measure where an event is occurring.

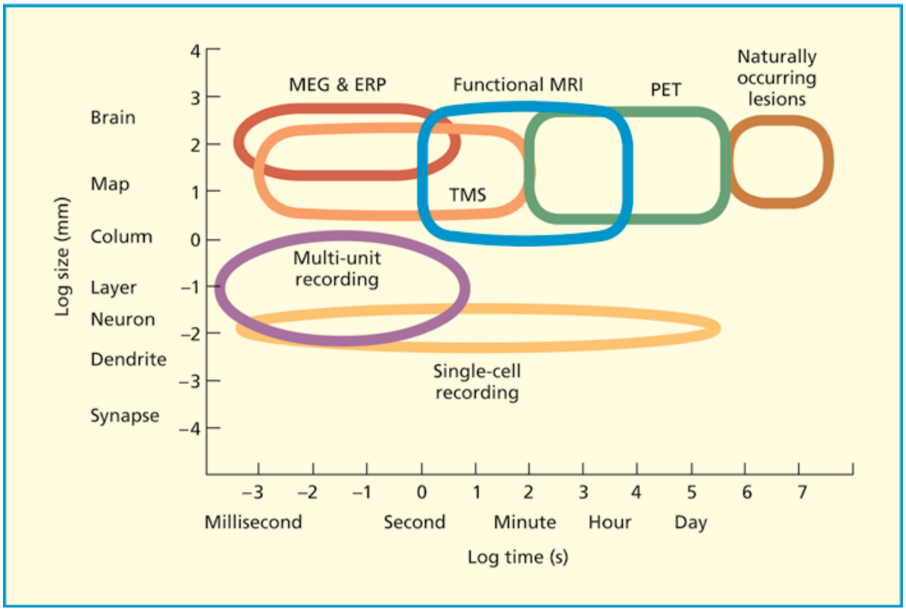

Figure 2.1 The methods of cognitive neuroscience can be categorized according to their spatial and temporal resolution. Adapted from Churchland and Sejnowski (1988).

KEY TERM

Invasiveness
Whether or not the equipment is located internally or externally.

- The **invasiveness** of a method refers to whether or not the equipment is located internally or externally. PET is invasive because it requires an injection of a radiolabeled isotope. Single-cell recordings are performed on the brain itself and are normally only carried out in non-human animals. Methods such as TMS are not strictly invasive (because the coil is located entirely outside the body) even though it leads to stimulation of the brain.

MEASURING BEHAVIOR AND COGNITION: PSYCHOLOGICAL METHODS

Almost all experiments in social neuroscience measure behavior in some way, given that it is social behavior that they are trying to explain. In functional imaging experiments, the participant is given a set of instructions on how to respond even if the main dependent measure is brain activity rather than behavior per se. In social neuroscience, it is also common to correlate neurophysiological responses (e.g. during functional imaging) when performing a task with individual differences on a psychological measure such as empathy or personality (assessed outside the scanner using a questionnaire).

In this section, an overview will be provided of three different ways of measuring behavior and cognition: performance-based measures (where the dependent measures are typically response times or error rates); observation-based measures (where the dependent measure is often a frequency count of how often something occurs); and first-person-based measures (where the dependent measure may be scores on a questionnaire).

Performance-based measures: response times and accuracy rates

Mental chronometry can be defined as the study of the time-course of information processing in the human nervous system (Posner, 1978). The basic idea is that changes in the nature or efficiency of information processing will manifest themselves in the time it takes to complete a task. For example, participants are faster at verifying that 4 + 2 = 6 than they are in verifying that 4 + 3 = 7, and this is faster than verifying that 4 + 5 = 9 (Parkman & Groen, 1971). What can be concluded from this? First of all, it suggests that mathematical sums such as these are not just stored as a set of facts. If this were so, then all the reaction times would be expected to be the same because all statements are equally true. It suggests, instead, that the task involves a stage in processing that encodes numerical size together with the further assumption that larger sums place more limits on the efficiency of information processing (manifested as a slower verification time). To give an example more relevant to social neuroscience, it has been found that the response time to identify a face (e.g. by naming it) depends on whether or not the face displays an emotional expression – decisions are faster if the face is smiling (Gallegos & Tranel, 2005). This is shown in Figure 2.2. What can we conclude from this? First of all, many models of face processing assume that recognizing who a person is and recognizing their expression are separate (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000). These results speak against this, to some extent. However, there are various possibilities. One is that known faces tend to be stored in the brain in an expressive pose (e.g. smiling) rather than a neutral pose as generally assumed. This would make them more efficient to process. Similarly facial identity can be computed, in part, from idiosyncratic facial movements, and smiles (even static smiles) may provide this additional information – that is, it might be motor/movement cues rather than emotion itself that drive the effect. An alternative is that familiar face recognition and expression recognition really are separate but can interact, such that the latter can provide a boost to the former in certain situations. These competing ideas could be explored with further response time studies (e.g. comparing smiling vs. angry expressions) or with other methods such as EEG, which can be used to determine whether the effect is early or late in time (i.e. consistent with an interaction at either the perceptual or decision-making stage).

Aside from response times, the other main performance measure is accuracy. This can be measured in terms of error rates, percentage correct, or percentile performance in which individual scores are recalculated relative to the population mean (e.g. IQ scores). Accuracy is obviously crucially related to whether certain knowledge is present/absent rather than to processing efficiency (which is more closely related to response time). However, accuracy and

KEY TERM

Mental chronometry The study of the time-course of information processing in the human nervous system.

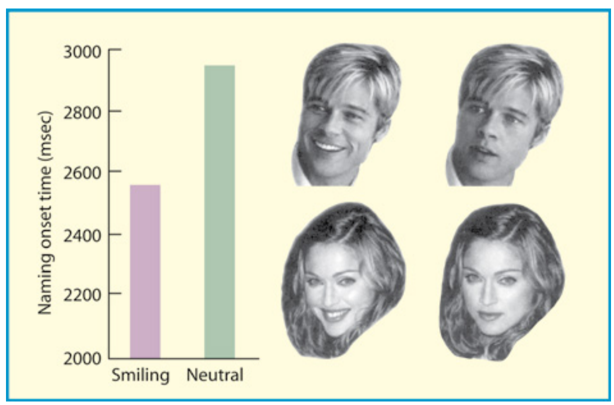

Figure 2.2 People are faster at identifying faces when they are smiling relative to a neutral pose. How can evidence from response times, such as this, be used to guide theories in social neuroscience? What might such a result mean and how could we explore these hypotheses using other studies? Graph based on data from and images taken directly from Gallegos and Tranel (2005). Copyright © 2005 Elsevier. Reproduced with permission.

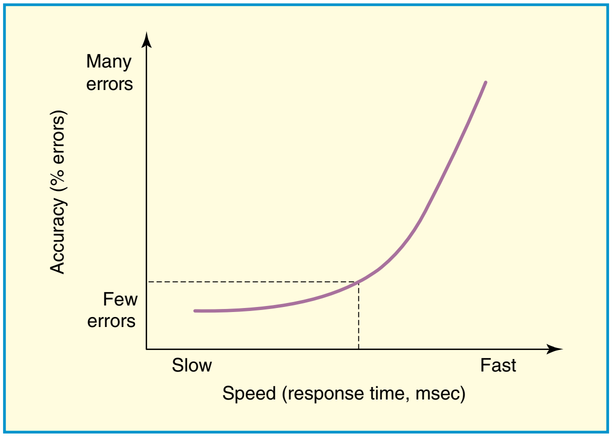

Figure 2.3 Many cognitive psychology studies instruct participants to be 'as fast and accurate as possible'. In practice, these two factors tend to be in opposition – faster responses tend to be less accurate, and very accurate responses tend to be slower. This is termed speed–accuracy trade-off.

KEY TERM

Speed–accuracy trade-off
If people are forced to respond faster, they will tend to be less accurate.

efficiency are related in certain circumstances. For example, if people are forced to respond faster they will tend to be less accurate, a so-called **speed–accuracy trade-off**. This is shown in Figure 2.3.

Summary of performance measures

- *Advantages*: They reflect actual behavior; they are simple to analyze and interpret.
- *Disadvantages*: They are hard to link directly to neural substrates (unless combined with other measures). There is not always a clear relationship between laboratory tasks and real-world behavior.

Observational measures

If performance-based measures measure 'how well' or 'how fast' something is done, observational measures tend to code 'what' is being done or 'how often' something is done through one person observing the behavior of others. There are certain situations in which observational measures are used in place of the more common performance-based measures:

- Observational measures are the norm in infancy research because the infant cannot be trained or instructed to perform a task.
- Observational methods may often be used for understanding non-human species for similar reasons to those used for human infants. Although training is possible here, there is still a need to know how (untrained) animals behave in the wild. For example, researchers have documented how often different primate species engage in deception in the wild and have correlated this with brain size (Byrne & Corp, 2004).
- Observational measures might be appropriate when the experimenter does not want the participant to know the true nature of a task. For instance, one study in human adults scored their behavior in terms of how often they imitate a given action (e.g. nose rubbing) whilst performing a cooperative task (e.g. Chartrand & Bargh, 1999).

Two specific observational methods in the infant literature are preferential looking and habituation. In **preferential looking** paradigms the infant is presented with a number of stimuli (normally two) and the amount of time that the infant spends looking at each of them is scored. A deviation from chance (e.g. 50/50 for two stimuli) implies that the infant is able to discriminate between the two stimuli (i.e. can tell they are not the same) and has a preference for one (although the reason for the preference is harder to infer). In **habituation** paradigms, the same stimulus (or the same kind of stimulus) is presented repeatedly and the infant's attention towards the stimulus (measured in terms of looking time) diminishes. The critical phase of a habituation experiment occurs when a new stimulus is presented. If the infant's attention is increased it implies that he/she can recognize that it is different, whereas if it is not it implies that he/she treats it as the same. Results using preferential looking and habituation reveal that infants have a preference for social stimuli (e.g. faces) over nonsocial stimuli (e.g. Johnson, Dziurawiec, Ellis, & Morton, 1991). Coding the imitative behavior of infants (e.g. whether they produce tongue protrusions or lip rounding) is another example of the use of observational methods in this group (Meltzoff & Borton, 1979; Meltzoff & Moore, 1977).

There are several methodological problems that need to be borne in mind when using observational measures, primarily because the scoring system is open to human error. First, there is the issue of **inter-rater (or inter-observer) reliability**, that is, the extent to which two independent observers would generate the same answers. This is typically dealt with by recording the experiment and having two people independently scoring a randomly selected subset of the behaviors. The second issue is whether the observer knows the hypothesis and might be biased to report what they expect to see. In such instances, the observer should perform **blind scoring** of behavior. For example, in preferential looking paradigms the observer typically would not know which stimulus the infant is being presented with on a given trial. To some extent, this problem

KEY TERMS

Preferential looking
In infant research, a number of stimuli (normally two) are presented and the amount of time that the infant spends looking at each of them is scored.

Habituation
In infant research, the same stimulus (or the same kind of stimulus) is presented repeatedly and the infant's attention towards the stimulus (measured in terms of looking time) diminishes.

Figure 2.4 "... I can therefore conclude that the primates are indeed social animals."

KEY TERMS

Inter-rater (or inter-observer) reliability
The extent to which two independent observers generate the same answers.

Blind scoring
The observer is unaware of the status of the event that is being scored.

KEY TERM

Masking
The presentation of junk visual material after a stimulus (to eliminate persistence of a visual image).

can be overcome by having computerized scoring methods, but this only applies in some domains (e.g. infant eye movements) and not others (e.g. primatology field research).

Summary of observational measures

- *Advantages*: They can be used when it is impossible or inappropriate to give instructions to a participant; they can be used in naturalistic settings.
- *Disadvantages*: There are difficulties associated with scoring and observer biases (although methods such as eye tracking can limit this).

HOW TO MEASURE THE UNCONSCIOUS

Much of what we know is computed prior to us becoming aware of knowing it. Moreover, there is some information that we never become aware of but that can still guide behavior. Here, we will consider how we can measure the effects of stimuli that have been processed unconsciously.

The standard way of presenting a visual stimulus unconsciously is to present it for a brief duration (e.g. less than 50 ms) and follow it with junk visual material (termed **masking**). This prevents an afterimage of the briefly presented stimulus from persisting. This method is an example of subliminal perception and research in this area has shown that people can detect whether a stimulus was present/absent above chance even when they claim to be guessing (Cheesman & Merikle, 1984) and that subliminally presented stimuli are subsequently judged as more pleasant than non-presented stimuli (Zajonc, 1980). Both studies imply that the stimulus was seen, because it influences behavior, but in the absence of conscious report. An alternative methodology in this literature is to present stimuli for longer durations, but such that they remain outside of the locus of attention (e.g. Simons & Chabris, 1999). This normally requires that the attended task is demanding (e.g. Lavie, 1995). This method can apply to hearing as well as vision.

How can we know whether something was conscious or unconscious? One strategy is to rely on verbal reports: for example, analyzing only those trials in which participants claim to be guessing whether something was seen or not. Another method that has recently been used is wagering in which participants are asked to bet on their performance on a given trial (Persaud, McLeod, & Cowey, 2007). A rather different approach is to use measures of which the participant has no (or very little) volitional control, such as the skin conductance response, electromyography, eyeblink startle responses, and so on. In this case, the participant may (or may not) be conscious of the stimulus, but they are unlikely to be able to consciously influence this response.

Survey measures: questionnaires and interviews

Survey methods involve questioning participants using questions and a set of responses that are fixed in advance (e.g. most questionnaires) or questions and a range of responses that are open-ended (e.g. interviews). These are first-person methods in that the participant is expressing his/her own thoughts that cannot be objectively labeled as right or wrong (in contrast to performance measures described above). For example, contemporary assessments of individual differences in personality (e.g. Costa & McCrae, 1985) or empathy (e.g. Davis, 1980) involve presenting participants with a list of statements (e.g. 'I get easily distressed by the sight of someone else crying') and participants are asked the extent to which they agree or disagree with them.

The **reliability** of questionnaire measures can be assessed by asking participants to repeat the same questionnaire at another time point, and/or by including items in the questionnaire that tap the same knowledge but may require a different response (e.g. 'I like caring for others' / 'I do not like caring for others'). The latter is important because there is a tendency for people to opt for 'agree' more than 'disagree' during surveys. This is termed an **acquiescence bias**. Survey methods can also be used to explore whether lay concepts such as empathy can be fractionated into several underlying variables. For example, if one devises a questionnaire with 40 items on it, one may find 20 questions that are reliably answered in the same way and another 20 questions that also are reliably answered in the same way but differ from the first set. In this example, this would imply an influence of two different underlying variables (statistically, this is assessed using a method called **factor analysis**).

Whereas observational methods measure how people actually behave, survey methods ask people how they think they might behave. As such, one could argue that survey methods have lower **external validity** than observational methods. However, survey methods do have some advantages. Many researchers are interested in what people think and feel, rather than simply how they behave. The fact that our thoughts and behavior may sometimes appear to contradict each other is of interest in its own right, rather than necessarily reflecting a methodological flaw. Pragmatically, questionnaires are easier to carry out, especially using the internet. The external validity may be improved by administering the surveys anonymously and confidentially (the latter being the normal ethical standard). This is because participants may be more inclined to give an honest answer in these situations, rather than presenting themselves in a positive light.

Although survey methods play a central part in social psychology, they have a more supporting role in social neuroscience. In social neuroscience, questionnaire results tend to be correlated with other measures (e.g. from fMRI, EEG) in order to identify the neural correlates of attitudes, feelings, and traits. One particular challenge for this approach stems from the fact that in methods such as fMRI the brain is divided into tens of thousands of regions (termed voxels) and statistical tests may be performed on each and every voxel. As such, the chance of getting a significant, but meaningless, result somewhere in the brain becomes high – called a **Type I error** (contrast with a **Type II error** in which a null result is obtained even though there is a real effect). Type I and Type II errors are a problem for *all* inferential statistics no matter the discipline. However, one specific problem linked to social neuroscience has been extensively debated and has been termed 'voodoo correlations'.

Vul, Harris, Winkielman, and Pashler (2009) noted that the reliability of many questionnaire measures is no more than about .8 (i.e. if the same questionnaire is repeated twice, the correlation between answers on the two occasions is about .8). The reliability of fMRI is of a similar magnitude or less, at around .7 (i.e. if the same experiment is done twice then the correlation between activity levels on the different occasions is about .7). However, many studies in social neuroscience report correlations between brain activity and questionnaire measures greatly in excess of what is

KEY TERMS

Reliability
The extent to which the same measure would yield the same results if repeated.

Acquiescence bias
A tendency to respond affirmatively in surveys, irrespective of the content of the question

Factor analysis
A statistical method for reducing a data set (e.g. in questionnaires, 20 questions may be grouped into a smaller number of factors)

External validity
The extent to which a measure relates to something useful in 'real life'

Type I error
Getting a significant result in a statistical test when, in fact, there is no real effect

Type II error
Getting a nonsignificant result when in fact there is a real effect

considered theoretically possible ($\sqrt{.8 \times .7}$ =.74). This suggests that some key findings are Type I errors or, at least, an inflation of the true size of the effect. This has informally become known in the social neuroscience literature as a 'voodoo correlation'. There are various steps that one can take to minimize this when correlating questionnaires with brain imaging data relating, for instance, to whether the correlation is performed on a voxel that has already been selected for its statistical significance (Lieberman & Cunningham, 2009; Vul et al., 2009). However, as a general point it is worth noting that social neuroscience methods – despite technological sophistication – are not invulnerable to flawed designs or analyses.

Summary of survey measures

- *Advantages*: They can be used in situations where an experimental manipulation is not possible or unethical (e.g. exposure to repeated violence); they measure thoughts and attitudes rather than behavior.
- *Disadvantages*: Participants' self-reports may not reflect their true behavior; much social cognition may occur unconsciously.

STRUCTURE AND FUNCTION OF THE NEURON

All **neurons** have basically the same structure. They consist of three components: a cell body (or soma), **dendrites**, and an **axon**. All neurons have the same basic structure and function (see Figure 2.5). The cell body contains the nucleus and other organelles. The nucleus contains the genetic code, and this is involved in protein synthesis (e.g. of certain neurotransmitters). Neurons receive information from other neurons and they make a 'decision' about this information (by changing their own activity) that can then be passed on to other neurons. From the cell body, a number of branching structures called dendrites enable communication with other neurons. Dendrites receive information from other neurons in close proximity. The number and structure of the dendritic branches can vary significantly depending on the type of neuron (i.e. where it is to be found in the brain). The axon, by contrast, sends information to other neurons. Each neuron consists of many dendrites but only a single axon (although the axon may be divided into several branches called collaterals).

The terminal of an axon flattens out into a disc-shaped structure. It is here that chemical signals enable communication between neurons via a small gap termed a **synapse**. The two neurons forming the synapse are referred to as pre-synaptic (before the synapse) and post-synaptic (after the synapse),

KEY TERMS

Neurons
A type of cell that makes up the nervous system.

Dendrites
Branching structures that receive information from other neurons.

Axon
A branching structure that carries information away from the cell body towards other neurons and transmits action potentials.

Synapse
The small gap between neurons in which neurotransmitters are released, permitting signaling between neurons.

reflecting the direction of information flow (from axon to dendrite). When a pre-synaptic neuron is active, an electrical current (termed an **action potential**) is propagated down the length of the axon. When the action potential reaches the axon terminal, chemicals are released into the synaptic cleft. These chemicals are termed **neurotransmitters**. (Note that a small proportion of synapses, such as retinal gap junctions, signal

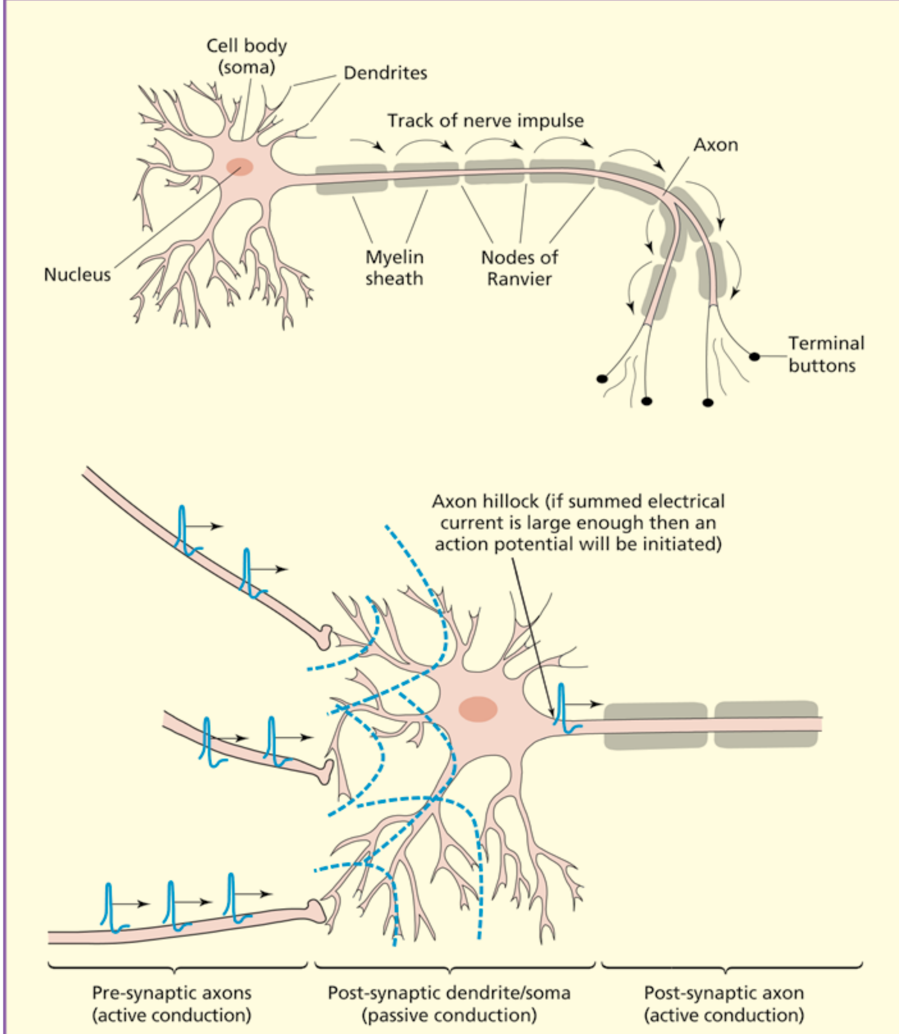

Figure 2.5 The structure and electrical functioning of neurons (top and bottom, respectively). Neurons consist of three basic features: a cell body, dendrites that receive information and an axon that sends information. In this diagram the axon is myelinated to speed up the conduction time. Electrical currents are actively transmitted through pre-synaptic axons by an action potential. Electrical currents flow passively through dendrites and soma of neurons but will initiate an action potential if their summed potential is strong enough at the start of the axon of the post-synaptic neuron (called the hillock).

KEY TERMS

Action potential
A sudden change in the electrical properties of the neuronal membrane in an axon.

Neurotransmitters
Chemical signals that affect the synaptic functioning of neurons.

electrically and not chemically.) Neurotransmitters bind to receptors on the dendrites or cell body of the post-synaptic neuron and create a synaptic potential. Depending on the nature of the chemical reaction, the potential can either be excitatory (i.e. promote further firing) or inhibitory (i.e. reduce the likelihood of further firing). The synaptic potential is conducted passively (i.e. without creating an action potential) through the dendrites and soma of the post-synaptic neuron. If these passive currents are sufficiently strong when they reach the beginning of the axon in the post-synaptic neuron, then an action potential (an active electrical current) will be triggered in this neuron. It is important to note that each post-synaptic neuron sums together many synaptic potentials, which are generated at many different and distant dendritic sites (as opposed to a simple chain reaction between one neuron and the next). Passive conduction tends to be short range because the electrical signal is impeded by the resistance of the surrounding matter. Active conduction enables long-range signaling between neurons by the propagation of action potentials.

The amplitude of an action potential does not vary, but the number of action potentials propagated per second varies along a continuum. This rate of responding (also called the 'spiking rate') relates to the informational 'code' carried by that neuron. For example, some neurons may have a high spiking rate in some situations (e.g. during speech) but not others (e.g. during vision), whereas other neurons would have a complementary profile. Neurons responding to similar types of information tend to be grouped together. This gives rise to the functional specialization of brain regions.

KEY TERMS

Autonomic Nervous System (ANS)
A set of nerves located in the body that controls the activity of the internal organs.

Somatic nervous system
Part of the peripheral nervous system that coordinates muscle activity.

Sympathetic system
A division of the ANS that increases arousal (increased heart rate, breathing, pupil size) but decreases functions such as digestion.

Parasympathetic system
A division of the ANS that has a resting effect (decreased heart rate, breathing, pupil size) but increases functions such as digestion.

MEASURING BODILY RESPONSES

The central nervous system consists of the brain and the spinal cord. In contrast, the peripheral nervous system consists of nerves sending and receiving signals to other parts of the body. The peripheral nervous system is itself divided into two further systems: the **autonomic nervous system (ANS)** and the **somatic nervous system** (see Figure 2.6). The somatic nervous system coordinates muscle activity whereas the autonomic nervous system controls and monitors bodily functions such as heart rate, digestion, respiration rate, salivation, perspiration, and pupil diameter. The autonomic nervous system is divided into two complementary divisions. The **sympathetic system** increases arousal (e.g. increased heart rate, breathing, pupil size) and decreases functions such as digestion. The **parasympathetic system** has a resting effect (decreased heart rate, breathing, pupil size) and increases functions such as digestion (see Figure 2.7).

Several methods in social neuroscience rely on measurements related to the peripheral nervous system. Electromyography (EMG) is an electrical measure of muscle contraction, implemented by the somatic nerves. Measures of autonomic system functioning include the skin conductance response (SCR), measures of heart rate

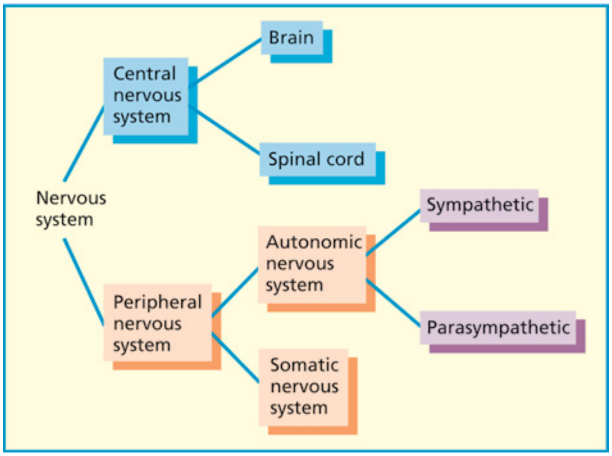

Figure 2.6 Various methods, including skin conductance response, electromyography (EMG), and pupil size, rely on measures of activity of the peripheral nervous system.

and breathing (e.g. the traditional lie detector, or polygraph, measures various autonomic functions including these), and also pupilometry (measuring changes in pupil dilation). The use of EMG and SCR is considered in more detail here.

The skin conductance response (SCR)

A common way of measuring increased activity of the sympathetic system is to monitor small changes in conductivity as a result of mild sweating (Berry Mendes, 2009). Heightened arousal can lead to more sweat even without overt sweating taking place, and this sweating response (from eccrine glands) is separate from the thermoregulatory sweating response. The SCR is measured by applying a weak electrical current to the skin. During a sweating response (e.g. elicited by an emotional stimulus) there is decreased conductivity of the skin and the electrical signals flow more easily. This is termed the **skin conductance response (SCR)** or galvanic skin response (GSR). The electrodes are normally placed on two adjacent fingertips with gel in-between the fingers and electrodes to improve contact. A peak SCR occurs between one and five seconds after stimulus presentation and this is normally recalculated relative to some baseline (e.g. pre-stimulus) activity (see Figure 2.8). Boucsein et al. (2012) report a consensually agreed set of experimental and publishing guidelines for researchers using this method.

Tranel and Damasio (1995) report how the SCR is affected by a number of brain lesions. Lesions to the ventromedial frontal lobes abolish SCR to psychological stimuli (e.g. risk) but not physical stimuli (e.g. bangs), whereas lesions to the anterior cingulate cortex abolish both. Functional imaging also points to a key role for the anterior cingulate in the production of the SCR (Critchley, Elliott, Mathias, & Dolan, 2000).

Electromyography (EMG)

Facial **electromyography (EMG)** has been used in social neuroscience research to measure muscle activity associated with emotional expressions in response to seeing expressions in others (e.g. Dimberg, Thunberg, & Elmehed, 2000;

KEY TERMS

Skin Conductance Response (SCR)
Small changes in conductivity as a result of mild sweating

Electromyography (EMG)
A method for assessing electrical activity associated with muscle movement

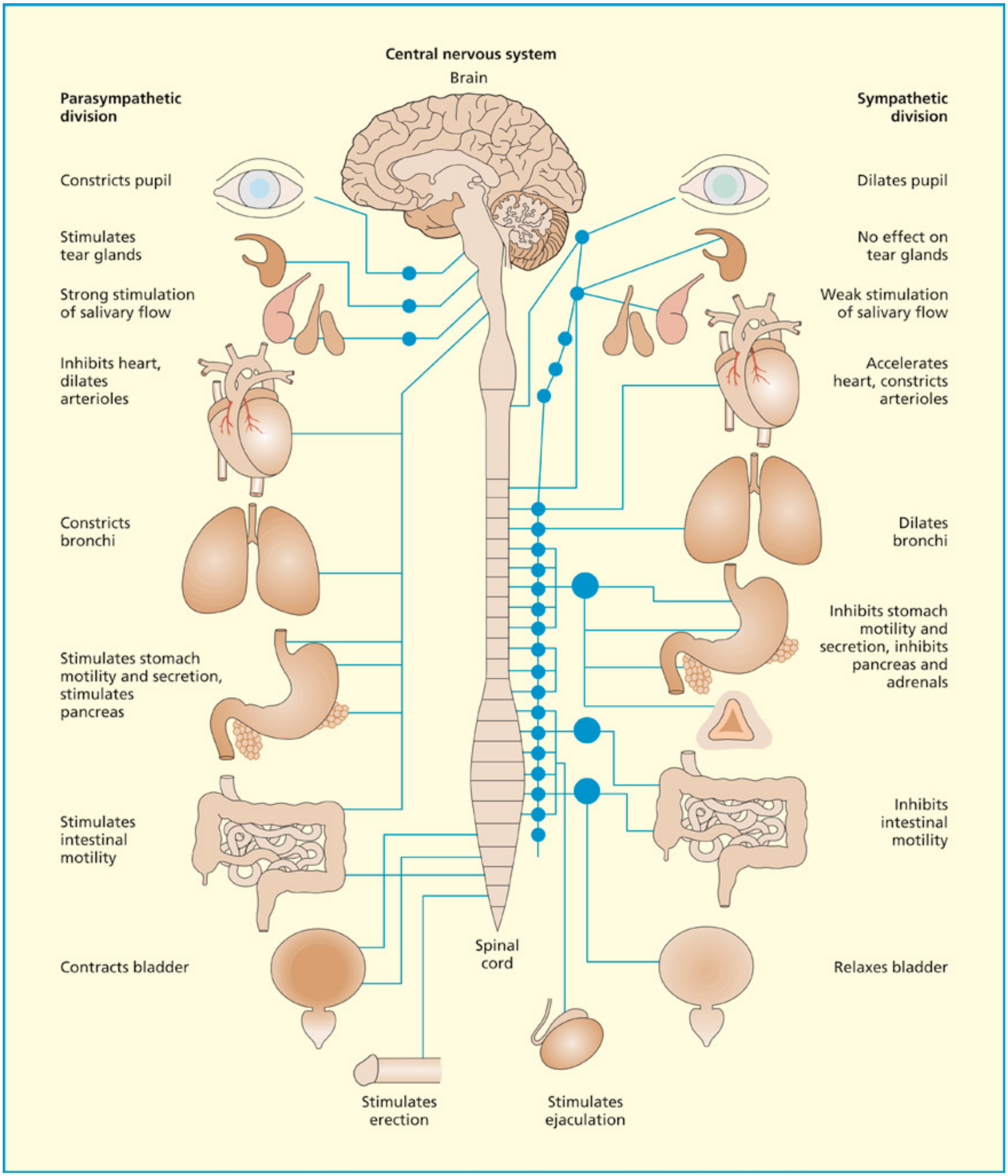

Figure 2.7 The autonomic nervous system (ANS) is divided into two complementary divisions. The sympathetic system increases arousal and decreases functions such as digestion. The parasympathetic system has a resting effect and increases functions such as digestion.

Hess & Blairy, 2001) or as a potentially implicit measure of prejudice (Vanman, Paul, Ito, & Miller, 1997). It is also used to measure the **eyeblink startle response**, which is elicited by a startling sound but is further modulated by the participant's present emotional state (Lang, Bradley, & Cuthbert, 1990).

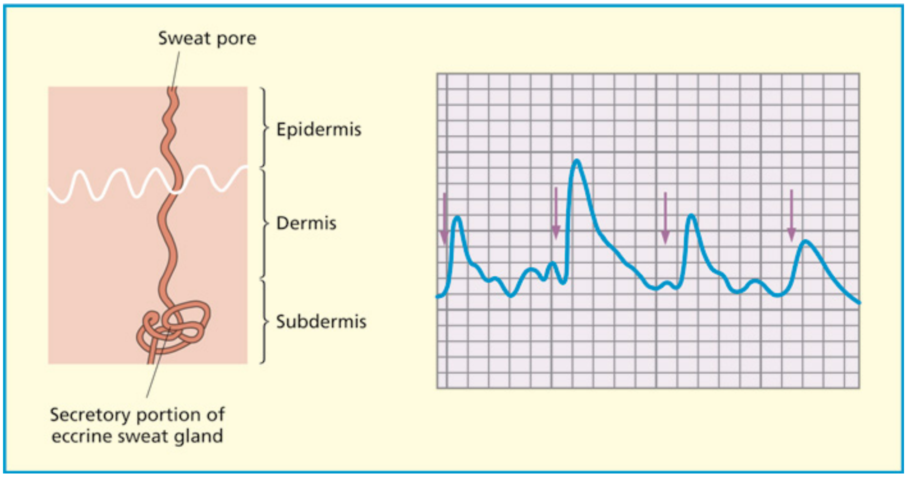

Figure 2.8 The skin conductance response (SCR) method involves recording changes in electrical conductivity on a person's skin on the hand. A person's SCR can be plotted as a continuous trace throughout the experiment. A peak SCR occurs between 1 and 5 seconds after stimulus presentation.

KEY TERM

Eyeblink startle response
A motor response (measured via EMG) that is normally elicited by a loud unexpected sound but is further modulated by the participant's emotional state

Electromyography (EMG) is a measure of electrical activity associated with muscle contraction (Fridlund & Cacioppo, 1986; Hess, 2009). These changes come about because of an increase in the number of action potentials in muscle fibers during muscle contraction. The greater the force produced by the muscles, the greater the electrical activity (Lawrence & DeLuca, 1983). However, individual action potentials are not measured. Instead the EMG signal is the sum of many such potentials, including those that cancel out because the muscle fibers are not completely aligned. The EMG signal is recorded by placing two small electrodes close to each other and measuring the potential difference (in microvolts) between them. The frequency and amplitude range of the EMG signal are comparable with those of electrical signals generated by the brain (in EEG) and heart (ECG or electrocardiogram). In order to reduce the influence of the latter two sources, the two measurement electrodes are compared to a third electrode (the ground) placed elsewhere (e.g. the center of the forehead is often used in facial EMG). Fridlund and Cacioppo (1986) offer guidance on the placement of EMG electrodes associated with various facial muscles (see Figure 2.9). In addition to electrical activity from other bodily sources it is also common practice to reference the EMG signal to a baseline measure, such as a rest phase or the period before a stimulus is presented. This is because muscle activity is rarely zero and may fluctuate over time (e.g. due to tension in the participants).

Summary of measures of bodily responses

- *Advantages*: Bodily responses are often present in the absence of awareness of a stimulus and may occur in the absence of a specific task; they are relatively easy to record and analyze.
- *Disadvantages*: It is not straightforward to link bodily responses to brain and cognition.

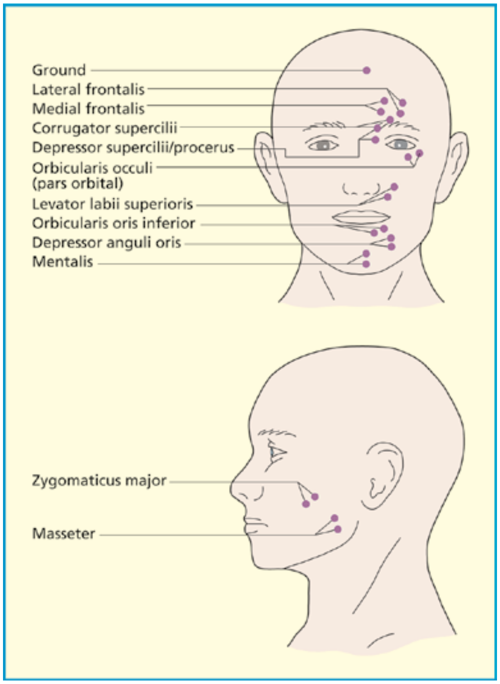

Figure 2.9 Recommended placement of pairs of electrodes for recording facial EMG. Adapted from Fridlund and Cacioppo (1986).

ELECTROPHYSIOLOGICAL METHODS

By measuring changes in the responsiveness of a neuron to changes in a stimulus or changes in a task, it is possible to make inferences about the building blocks of cognitive processing. The action potential is directly measured in the method of single-cell recording, whereas EEG is particularly sensitive to post-synaptic dendritic electrical activity.

Single-cell recording

Single-cell recordings can be obtained by implanting a very small electrode either into the axon itself (intracellular recording) or outside the membrane (extracellular recording) and counting the number of times that an action potential is produced (spikes per second) in response to a given stimulus (e.g. a face). This is an invasive method. As such, the procedure is normally conducted on experimental animals only (see Figure 2.10). It is occasionally conducted on humans undergoing brain surgery (Engel, Moll, Fried, & Ojemann, 2005). It is impossible to measure action potentials from a single neuron non-invasively (i.e. from the scalp) because the signal is too weak and the noise from other neurons is too high. Technology has now advanced such that it is possible to simultaneously record from 100 neurons in multi-electrode arrays. This is termed multi-cell recording.

To give one example from the literature, Quiroga, Reddy, Kreiman, Koch, and Fried (2005) recorded the firing rates of neurons in humans undergoing brain surgery.

KEY TERM

Single-cell recording
A method of recording the electrical activity (action potentials) of neurons