1 Introduction: What Is Philosophy of Neuroscience?

Neuroscience is an interdisciplinary scientific inquiry of neural processes. We commonly identify these processes with the brain, but in fact neurons are distributed throughout animal bodies (we have over 500 million neurons in our guts, constituting what is referred to as the *enteric nervous system*). The reason neuroscience is interdisciplinary is that the research techniques of different disciplines are required to understand neural processes. Most obvious are anatomy and physiology, which address the structure and operation of neurons and the larger structures built out of them. Genetics has proven extremely important both for characterizing neural processes but also for altering them (alteration is required in any experimental study). Often, given the complexity of neural processes, it is helpful to model them computationally, giving computer science an important role in the interdisciplinary mix. One of the reasons neural processes have drawn so much interest is their role in behavior and cognitive function; accordingly, psychology and cognitive science are also important contributors to neuroscience.

What motivates philosophers to examine neuroscience? There are a variety of motives. One is the thought that knowing about the brain tells us important things about ourselves that are relevant to other philosophical inquiries about topics such as whether human action is free, whether we can know our world, and what it is to be conscious. This pursuit often goes by the name *neurophilosophy*, a term introduced by P. S. Churchland (1986). We will take up some questions posed by neurophilosophy in the last section. A second motive is to apply philosophical methods to problems in neuroscience. Philosophers often have skills that enable them to generate hypotheses, integrate different findings, and clarify concepts in ways that are useful to neuroscience. This pursuit might best be termed *philosophy in neuroscience* (the distinction between philosophy of and philosophy in was developed by Brook in the context of cognitive science; see Brook, 2009). This is covered in Sections 9 and 10. Our primary focus will be on a third approach that investigates how neuroscience functions as a science: Which methods are employed? Which organisms are studied? What does a neuroscientific explanation look like? Since these are philosophy of science questions about neuroscience, this approach is best labeled *philosophy of neuroscience*.

Since neuroscience constitutes the subject matter of our inquiry, we will at various points present some of the knowledge developed in neuroscience. Thus, in Section 2, we introduce neurons and neural processes, and in Section 5, we offer four vignettes illustrating what neuroscience has learned about mental processes: situating ourselves in time, navigating through space, seeing the

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world, and making decisions. We will review this content in later sections. In Sections 3 and 4, we address fundamental issues about how neuroscientists gain knowledge: how they study neural processes, and whose neural processes they study. A major aim of neuroscientists is to offer explanations for behavior and cognition, and Section 6 will offer accounts of what is required of an explanation. Sections 7 and 8 focus on more specialized issues of neuroscience explanations: the levels at which explanations are offered and whether explanations should attribute representations to neural processes.

Both in neuroscience and in philosophy it has been common to adopt a cortico-centric view of the brain, but in fact there is extensive research in neuroscience on subcortical areas. Subcortical processing is extremely important in determining how we behave. This is significant since cortical areas constitute a different type of neural processing system than subcortical areas, and in Section 9, we focus on what is distinctive about the neocortex in particular. We then turn to the question of how the whole brain is organized. It is often viewed as organized as a hierarchy with the neocortex at the top, and indeed, one part of the neocortex, the prefrontal region, at the very top, operating as a central executive. In Section 10, we contrast this with a heterarchical perspective that views neural processes as organized in an interactive network, with different regions exercising control over different aspects of behavior and cognition. Finally, in Section 11, we pull from various topics addressed in earlier sections to address the neurophilosophical question of what neuroscience has to teach us about ourselves as agents in the world.

2 What Are Neurons and Neural Processes?

Most people have seen multiple (typically idealized) pictures of the human brain as it would appear if one opened up the skull. The first thing one notices is a highly convoluted gray structure (at the top of Figure 1) in which the projecting areas are known as gyri and the indented areas as sulci. This structure, known as the *neocortex*, is often divided into four lobes: frontal, occipital, parietal, and temporal. As the part of the brain that has most expanded in the lineage of primates, including us, it has assumed a central focus in much philosophical theorizing. However, as the characterization of it as *neo* suggests, there is more to the cortex (often termed the *cerebral cortex*), including very important structures such as the hippocampus. The term *cortex* is derived from the Latin term for the bark of a tree and, as that suggests, it refers just to the outer structure. There is much of the brain beneath the cortex.

In this Element, we seek to avoid the all too frequent cortico-centric take on the brain by focusing as much on what is beneath the cortex and the

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