

Chapter 2

Unlocking the Key to Neuroscience Terminology

Embarking on the study of a new subject always involves a period of gaining a set of tools. Although some of the tools can seem complex before you know them, they become helpful once you gain familiarity with what they are and how and when to use them. What might be slowing you down in your learning is that the words used to help navigate through the brain may seem more confusing than what they are describing. Thus, the first step in navigating the brain's systems is to gather the tools you will need to understand the nomenclature that is commonly used to describe the brain. This chapter helps you build the skills you need.

Think of the terminology used to describe the brain like a map. There are many different kinds of maps, such as road maps, elevation maps, some in 2D and others rendered in 3D. Each map uses a labeling system with a logical rationale at its source. The brain pictures that are commonly shown in neuroanatomy books draw on a number of different mapping systems. What is daunting for beginners is that these rationales are rarely explained. Instead, the viewer is expected to be familiar with the system. Another source of confusion is that different mapping systems are used to refer to the same area. Once you become familiar with the typical maps you will realize how each one contributes to giving a more complete picture of the brain and nervous systems.

This chapter explains the logic behind some of the most commonly used terminology and clarifies the different labeling systems that are commonly used. You may be surprised to discover that with the many maps to guide you, the path lights up to reveal fascinating sights along the way.

Viewing the Different Brain Maps

The brain is depicted in pictures, diagrams, and in various types of brain scans such as fMRI and PET. The body exists in 3D, but these technologies show the brain in 2D pictures. Thus, any number of different perspectives might be used.

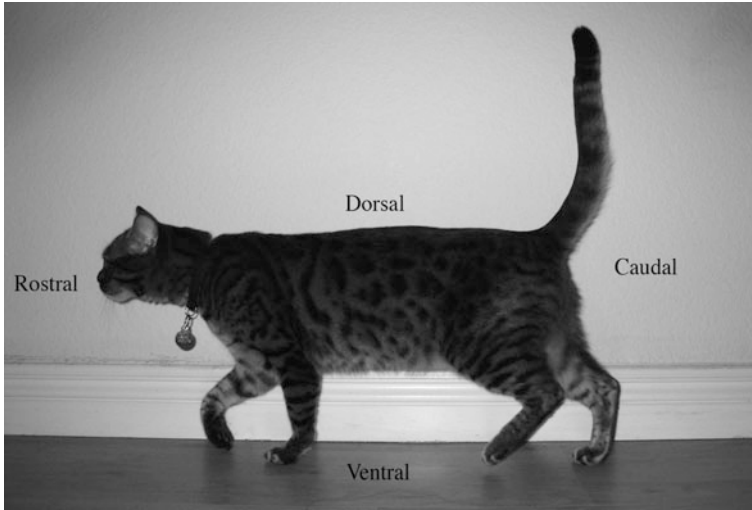


Fig. 2.1 Anatomical Directions

Exterior Perspectives

To view any 3D object from the most revealing perspectives, one would typically begin by inspecting it from the outside, looking at the front, back, top, and bottom. The brain is depicted exactly in this way but with different labels. The four directions are commonly described as *rostral*, *caudal*, *dorsal*, and *ventral*. This labeling system is simple to picture with an animal, such as here (Fig. 2.1).

One axis, the rostral-caudal axis, stretches across from the head to the tail. The head or front of the cat is rostral and the tail or far end is caudal. The other axis, called the dorsal-ventral axis, runs perpendicular (or orthogonal) to the rostral-caudal axis. Here, the top of the cat's back is dorsal and its feet are ventral.

When translated to the human brain, this terminology has to alter a little. This is because the rostral-caudal axis bends 90° around during embryogenesis so that the spinal cord is under the brain, not horizontal to it as in many four-legged animals. Thus, when compared to a cat where the axis is straight across, the labels do not always match up in quite the same way (Fig. 2.2).

Here is how the human brain is labeled using this terminology. The rostral-caudal axis places the rostral in the front of the brain (toward the forehead) while caudal is at the back, close to the neck. The dorsal-ventral axis follows the vertical direction of the brainstem and spinal cord. The dorsal side is toward the top of the head and the ventral is lower.

A second system of labeling is also commonly used and in many ways is more familiar and thus easier to apply: Superior (the top), inferior (the bottom), anterior (the front side), and posterior (the back side). Medial and lateral gives one more type of description, where medial is toward the center and lateral is out to the

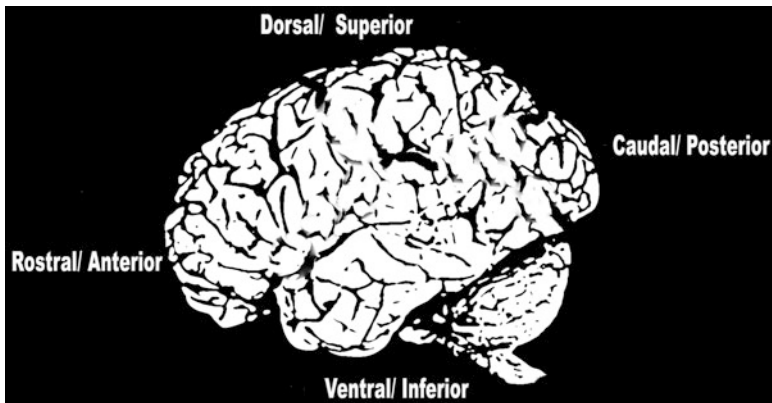


Fig. 2.2 Brain Directions

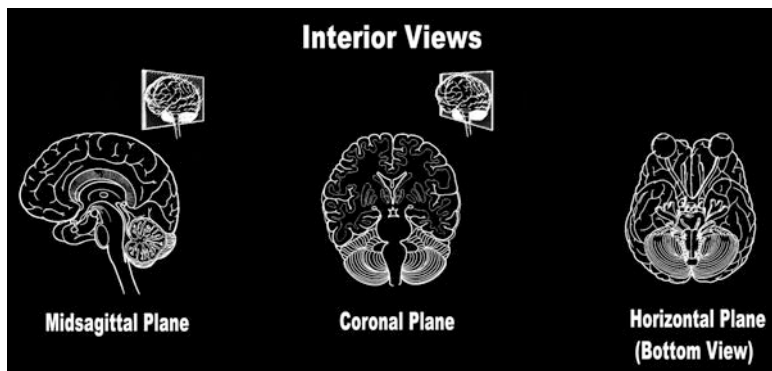


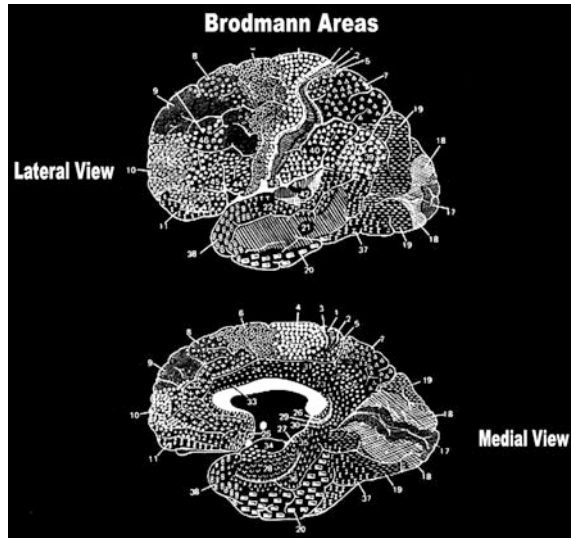
Fig. 2.3 Interior views of the brain

sides. Thus, the medial–lateral axis, looks horizontally, from the inner midline (medial) to the outer edges (lateral). If two areas are on the same side they are ipsilateral, and if on opposite sides they are contralateral.

Interior Perspectives

All of the brain systems cannot be accessed simply from the outside: We need to see what is underneath and inside as well. Thus, another typical way to view the brain is by slicing through, like slicing open an apple to see the core. Conventions for viewing the inside of the brain and the body are fairly universal and consistent with three slices (Fig. 2.3).

A vertical slice from front to back is a sagittal plane (Latin for *arrow*) view. When the sagittal slice goes through the center in this direction it is referred to as the midsagittal plane. A vertical slice going from side to side across is a coronal

Fig. 2.4 Brodmann areas

(Latin for *crown*) or transverse plane. Finally, a horizontal section parallel to the floor is the third perspective. This same set of conventions is used for viewing the interior of the human body as well. When labeling brain scans of sagittal and coronal views, you will often see a label of dorsal at the top and ventral at the bottom of the picture, whereas the horizontal plane will place a label of rostral on the side that shows the front (forehead side) and caudal on the side that pictures the back of the brain. These combinations help to clarify what view is being shown.

Brodmann Areas

An early system for labeling the cortex, the outer layer of the brain, was created by Korbinian Brodmann (1868–1918). He divided the surface of the cortex into 52 different sections based on the organization of cells, or cytoarchitecture. He published a map in 1909 (Brodmann 1909/1994). He thought the anatomical arrangement was similar in all animals, but this idea turned out to be incorrect since animals have much smaller cortical structures than humans. Scientists have worked on refining Brodmann’s map for a century. The areas are referred to as Brodmann’s areas along with the number of the area. For example, Broca’s speech and language area is located in Brodmann areas 44 and 45; the primary somato-sensory cortex is referred to as areas 1, 2, and 3; the primary motor cortex is area 4; and the primary visual cortex is area 17. Brodmann’s areas are no longer considered precise or complex enough to account for the many connections between hemispheres and within hemispheres (Zillmer et al. 2008). But the system is still used frequently when referring to an area of the cortex, and so it is helpful to have an understanding of this mapping system (Fig. 2.4).

Terminology for Parts of the Brain

Different areas of the brain are given names, somewhat like other structures in the body such as the lungs or stomach. Sometimes a structure has a straightforward name that reflects the shape of the structure, such as the olfactory bulb, which is an organ with an elongated, rounded shape, or the amygdala, (Latin for *almond*), which has a curved shape much like an almond.

These structures can be located in the brain and have a distinct form similar to a small organ. But other structures are less physically differentiated. Instead, cells located in particular areas perform unified functions. These groups of neurons that are clustered together are given names to distinguish them. They are sometimes referred to in a way that makes them sound like they function separately and yet, they might be better understood as a system. For example, the basal ganglia are often referred to as if they are one thing, and yet they are a group of structures that function closely together, involved in movement. The limbic system is another group of structures that act together as part of our experience of emotion.

Several different types of terminology are used to refer to such structures. One commonly used word is *nuclei* (plural form), or *nucleus*, (singular). A *nucleus* refers to a group of nerve cells located in the brain that has a specialized function such as, for example, the caudate nucleus, one of the structures in the basal ganglia. The word *ganglia*, (plural of ganglion), is another term often used to denote a densely packed group of neurons connecting the spinal cord and peripheries to areas in the brain. Ganglia are located on either side of the spinal cord and are involved in the stress response and the fight- or- flight stress response. There is an exception, where the word *ganglia* is used to distinguish an area inside the brain, the basal ganglia, the group of nuclei involved with controlling movement. Some believe this is a misnomer and should be called the basal nuclei because it is located within the brain itself. But since it is linked to movement, which involves the spinal cord and PNS, the name makes sense. When areas of the basal ganglia do not do their work, certain subcortical movement disorders result, such as Huntington's disease and Parkinson's disease. ADHD is also linked to the basal ganglia.

Gyri and Sulci

The cortex has many folds with high and low areas. These highs and lows are also given labels to distinguish them: *Gyrus* (plural *gyri*), ridge, and *sulcus* (plural *sulci*), valleys are two other terms that are used to refer to the bulges and creases. Sometimes a particular high or low area is given a name, such as the cingulate gyrus, which is a strip of cortex in each hemisphere involved in emotion and directing attention, or the central sulcus, which divides two of the lobes. Various gyri and sulci are given names and referred to as such (Fig. 2.5).

Lobes is another term used to describe the cortex in different sections, as will be described fully in Part III. The four lobes are frontal, parietal, temporal, and occipital.

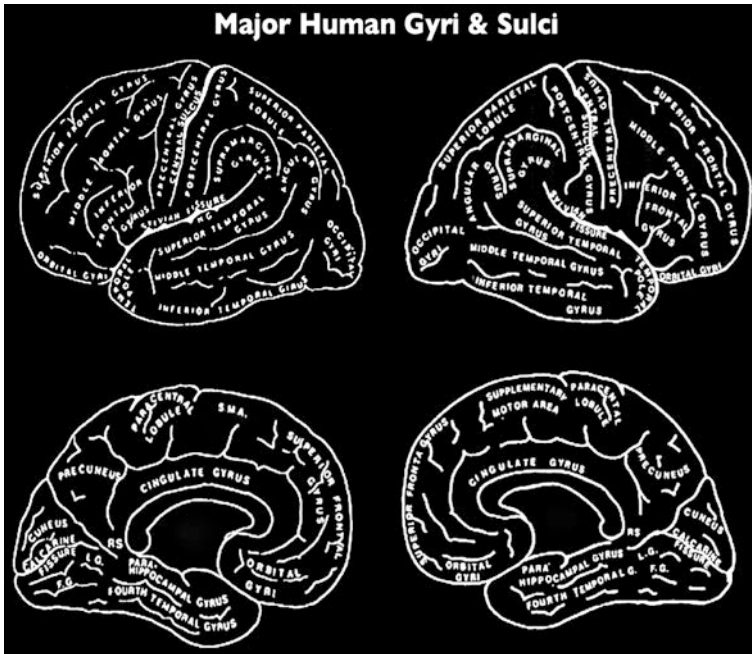


Fig. 2.5 Gyri and sulci

There are two sets of lobes, in the right hemisphere and in the left hemisphere. Although the functions are similar, there are distinct differences between the right and left sides.

These lobe divisions are helpful for getting a general sense of the location for certain functions. For example, the control of vision is located toward the back of the brain in the occipital lobe. The sensory areas are found in the parietal lobe. The frontal lobe performs higher level processing whereas the temporal lobe is involved in auditory functions. Lobes are easily seen without a microscope, as distinct sulci ridges. *Lobule* is another term used to refer to parts of a lobe. Lobules are also clear divisions, but they are only visible if viewed under a microscope. See [Chap. 9](#) for a picture of the four lobes.

White Matter and Gray Matter

Another way to distinguish parts of the brain is by the grayscale shades of the tissues. When we look at brain tissue fixed in formaldehyde under a microscope, some parts appear white while other parts look gray. The white areas have been labeled *white matter* and the gray areas, *gray matter*. Cell bodies and dendrites, the branches from the cell body that bring input signals to the neuron, appear gray

under the microscope, and therefore, the cell bodies and dendrites are the parts of the neurons that make up the gray matter. Myelinated axons are the white matter. The myelin is a covering on many axons, the long fibers that carry output signals from one neuron to another. The myelin functions like insulation on a wire. When it is fixed in formaldehyde and looked at under a microscope, it appears whitish in color, so these deeper areas of the cortex are known as the white matter. The brain is made up of white matter and gray matter. Gray matter is found along the outer surface of the cortex and cerebellum, following the hills and valleys in the tissue. It is also found deep inside the brain and around the spinal cord. The white matter is located deep in the brain and cerebellum and in the superficial parts of the spinal cord.

Conclusion

Familiarize yourself with the terminology, and you will have an easier time finding your way through the literature about the brain and how it relates to cognitions, emotions, and behavior. The time spent on these preliminaries opens a rich new world of potential for your therapeutic work.

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