2b | Structure of the Brain

We're now going to move on to the main structures of the brain. We'll begin with the phylogenetic division. This division of the brain organizes brain structures in terms of the order in which they are thought to have evolved.

In the following figure, you will see the main structures of the phylogenetic division. These are the hindbrain, the midbrain, and the forebrain. We are going to primarily focus our discussion on the forebrain, and specifically the cerebral cortex in the forebrain. The reason we're going to focus on this part of the brain is because the vast majority of tasks that we're interested in, that is the vast majority of cognitive abilities and capacities, take place within the forebrain. That is, the forebrain is where cognition happens. Whereas regions in the hindbrain and the midbrain are mainly responsible for lower level, non-cognitive functions, such as basic life support and relay of information from the spinal cord to the rest of the brain. We'll now focus on the forebrain.

The forebrain can be generally broken down into two sub-sections. Those are subcortical structures and cortical structures. The following figure highlights these sub-cortical regions of the brain. And the sub-cortical regions are those regions of the brain that sit beneath or under the cerebral cortex. I will highlight here some of the most critical sub-cortical regions that support cognitive processes.

First, you will find located right in the centre of the brain, the thalamus. Now the thalamus has many functions, but one of its main functions is a switching or relay station for sensory information around the brain. That is, information that gets perceived and processed by multiple regions of the brain can become integrated and can cross-modaly communicate with each other via the thalamus.

Located right next to the thalamus is the hypothalamus. Now the hypothalamus also has many functions. One of its main functions though is to regulate basic biological functions including hunger, thirst, temperature, sexual arousal, and basic emotional reactions.

The final two subcortical structures that I'm going to talk about are the hippocampus and the amygdala.

The hippocampus, which is located again sub-cortically right under the temporal lobes of the brain is a very important and critical structure for learning and memory. In fact, what we'll learn later in this course, if a person has damage to the hippocampus they often no longer have the ability to consciously recollect personal events.

Located right next to the hippocampus and related to the hippocampus in terms of supporting cognitive processes is the amygdala. The amygdala, like many structures in the brain, is

involved in a number of cognitive processes. Primarily however, it seems to be involved in emotion and aggression. In addition, and this is why it's important to think about the amygdala in terms of its relationship with the hippocampus, it also is involved in memory, specifically the emotional content of memories. Here, it is thought to modulate the strength of memories in terms of its emotional content.

We're now going to switch our discussion from the sub-cortical regions of the forebrain to the cortical regions.

The cerebral cortex is the outer most layer of the brain. It contains several layers of densely packed neurons with white matter underneath. The white matter connects the cerebral cortex to the sub-cortical regions of the brain. The following figure provides a more detailed view of all the different sub-components of the cerebral cortex. At the most macro level, the cerebral cortex can be divided into four main lobes: the frontal lobe, which sits underneath the forehead; the parietal lobe, which sits underneath the top rear part of the skull; the occipital lobe, which is at the back of the head; and the temporal lobe, which is on the side of the head. In addition, there are two hemispheres of the brain, each containing frontal, parietal, occipital, and temporal lobes. There are no direct connections between these two lobes in the cortex. However, information between the two cerebral hemispheres of the brain can be communicated back and forth sub-cortically via the corpus callosum and the anterior commisure. We'll discuss the major functions of the lobe of the cerebral cortex in more detail later. However, I will just touch on a couple of the main functions of each lobe right now.
Parietal lobes support many cognitive functions such as spatial processing and attention. In addition, the parietal lobes contain a structure known as the somatic sensory cortex, which is involved in sensing information from the body, such as pain, pressure, touch, or temperature.

The occiptal lobes are primarily responsible for processing visual information. This includes processing the very low level features of visual stimuli, such as orientation, shape, and colour, to more complex aspects of the stimuli involved in recognizing what objects are.

The temporal lobes, on the other hand process auditory information. In addition, because the temporal lobes are right above the structures, such as the amygdala and hippocampus that are known to be involved in memory, they also support functions associated with the encoding and the retrieval of information from long-term memory.

Finally, to best understand the functions of the frontal lobe, it is best to sub-divide the frontal lobes into three separate regions. First, the motor cortex located at precentral gyrus, right next to the parietal lobes, the furthest back regions of the frontal lobes, directs fine motor movement. The premotor cortex, located just anterior to the motor cortex, seems to be involved in planning such movements. Finally, we have the largest part of the frontal lobe which is called the prefrontal cortex. This involves everything anterior to the premotor cortex. The premotor cortex supports a wide range of cognitive functions. Most generally, it is involved with

what neuroscientists refer to as executive functioning. This involves planning, making decisions, implementing strategies, inhibiting inappropriate behaviours, and using working memory to process information. For example, anything that you're working on or thinking about in your mind right now, at this very minute, likely involves your prefrontal cortex.

In the later sections of this module, we're going to look at some of the research methodologies that have been used that allow us to determine what sorts of cognitive processes are supported by which brain regions.