Module:
Biological foundations of mental health

Week 1
Introduction to brain anatomy

Topic 2
Neuroanatomy, neural systems and brain function – Part 3 of 3

Dr John Pizzey
Teaching Fellow - Biosciences Education

Lecture transcript

Slide 2
Now the connections to the cortex are many. Firstly, we have ascending connections. Sensory connections. These are coming up, largely, from the thalamus. Remember its important role as a relay. So, sensory information from the body enters the spinal cord, and is then transferred via the thalamus to parts of the cortex, in particular, the parts of the cortex responsible for processing sensory information, the somatosensory cortex.

In addition, the special senses I mentioned also go through various components of the thalamus - all of them, in fact, except smell. Smell - olfaction - is the most primitive of all our senses, and this goes directly into the olfactory cortex, and it's the only sense which doesn't go through the thalamus. There is a component that goes through the thalamus, but that's just to tell us whether we like or don't like the particular odour. It doesn't tell us what that odour is.

This route directly into the olfactory cortex with very little processing reflects the very primitive nature of olfactory senses.

Slide 3
As well as the ascending connections to the cortex, there are descending connections from it. Now these are mainly motor, to the spinal cord, largely through the corticospinal tract, and to nuclei within the brain stem. If they the terminate on the nuclei of cranial nerves, motorcranial nerves, to innervate facial muscles - muscles of the head and neck - they will be going via the corticobulbar tract. There are also pathways concerned with higher levels of motor control, and go to the basal ganglia and the cerebellum.

And finally, there's projections to the limbic system. This is the part of the brain concerned with determining our emotional states, and there are large areas of the cortex that impact on this. What you can see will have an impact on emotional state, so there's projections from the visual cortex to the limbic system. What you're physically doing can have an impact on your emotional state, so you'll have projections from the motor cortex to the limbic system. In fact, there are multiple cortical projections to the limbic system in determining our emotional state and emotional behaviour.

Now importantly, there are also connections within the cerebral cortex. If they occur on the same side, the same cerebral hemisphere, we refer to them as association files. So for example, this can link parts of the auditory cortex with the visual cortex to help us determine what we're seeing and how we recognise what it is. We might be getting visual as well as auditory clues, for example. Or, connecting taste and smell senses in appreciating exactly the nature of something that we're eating.

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We also have connections between the hemispheres. So between, for example, the somatosensory cortex on one side of the brain with the somatosensory cortex on the other. This is via tracts called commissures-- commissures are just the names for pathways that connect one side of the brain with the other, and the most prominent of these that you may have come across is the corpus callosum, the large band of white matter that you can see in a hemisection of the brain.

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So let's just have a little look at these, and they are shown here. The association fibres are shown in blue, and you can see them linking different parts of the brain on one side.

The commissures cross the midline. Here, for example, is the big commissure of the corpus callosum. Although it's only showing a little bit of it here, it will be radiating out, such that equivalent areas of the cortex on one side are connected to equivalent areas on the other, literally letting one side of the brain know what the other side is thinking or is doing. Inferiorly, we have another commissure, the anterior commissure, which does very similar things, but for the more ventral parts of the brain. Here they're shown connecting the two temporal lobes.

In addition to the association and commissural neurons, we also have projection neurons, and these are neurons that extend, typically, long distances, and frequently connect structures from the brain to the spinal cord, or to the spinal cord from the brain. These are shown in red. Here, they're running through a structure called the internal capsule, which is the main pathway that some major ascending and descending axons make.

So these projection fibres will include motor fibres that are descending from the motor cortex down to the spinal cord, and will also include ascending somatosensory fibres that are bringing information in from the spinal cord and taking it to the cortex. So these are three of the major classes of neurons that we will find connecting cortical structures to other parts of the brain: association, commissural, and projection neurons.

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Now a great deal of advances have been made recently in neuroimaging, and one of the major advances is in the field of tractography. This has really helped us understand much more about the ways in which parts of the brain are connected to another, and in particular, a technique called diffusion tensor tractography-- it's a type of magnetic resonance imaging, a type of MRI-- that relies on looking at the ways in which water diffuses through structures.

It's particularly useful in enabling us to image myelin. So we can plot individual pathways. Here, the so-called seed point-- part has been labelled-- in the right frontal lobe-- and we can follow the axons that are present here as they enter the corpus callosum. Remember, this is a commissural neuron that crosses the midline-- and here are the extensions of these axons from the right frontal lobe across to the left frontal cortex. And you can see them ramifying out, very beautifully. Multiple pathways can be labelled in this way, and then imaged, using computer graphics to build up a pattern of tracts within the brain.

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This is an example of computer-enhanced diffusion tensor imaging, where a large number of pathways have been labelled. You can see some which are crossing from one side to the other. Commissural neurons, commissural axons and others, which are coming down here, entering the pons - and in fact, if we follow these purple ones down, we'd see them going below. Examples of projection neurons here. This approach has been used both in surgical planning, and in understanding, increasingly, how different parts of the brain are speaking to each other. They're helping us greatly understand how the brain is connected, how the parts of the brain are connected, and therefore giving us bigger clues into how it's functioning.

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So let's summarise. What have we seen? We've seen that we can divide the nervous system by functional and anatomical criteria. We have learned that the CNS and PNS can be divided up, and that a good definition of the CNS is an axon or a neuron which is wholly contained within it, and that's perhaps a better one than simply saying a brain or spinal cord neuron.

We've seen that the CNS can be divided up into the hindbrain, midbrain, and forebrain, with the spinal cord below also being a part of the peripheral nervous system. We've seen that the hindbrain consists of the pons, medulla, and cerebellum.

We've seen that we can derive a large amount of the very complex circuitry in the brain by means of neural networks, and this is a property of both the very large numbers of neurons we are dealing with, together with the properties of convergence, whereby a neuron can receive multiple signals, as well as divergence, whereby a single neuron can innovate and form synapse with multiple other neurons. And finally, we've seen that we're starting to learn more about how these structures are put together with some recent advances in neuroimaging. Thank you.