

Module: Biological Foundations of Mental Health

Week 5

Biological basis of learning, memory & cognition

Topic 1

Cerebral cortex and mental health – Part 3 of 3

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Lecture transcript

Slide 3

How do we know that the frontal cortex is important for executive functions? There are at least two sorts of evidence, neuroimaging and neuropsychological cases of acquired frontal lobe damage.

Slide 4

fMRI studies show prefrontal regions are active when volunteers engage in tasks, like those you just tried, the Wisconsin card sorting test, the Tower of Hanoi, the Stroop task, and the N-back task.

Slide 5

Interestingly, frontal regions seem to be particularly important when we're learning new skills. Once a skill is well established, fMRI studies show less frontal involvement. So to respond flexibly to our environment, frontal regions are essential. This is illustrated in a study by Hampshire, et al., 2015. See how the activation in the frontal regions decreases across the blocks of an inhibition task as the volunteers become more practised at the test.

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The second source of evidence for the importance of the frontal lobes in executive functions comes from neuropsychological cases of acquired brain damage. When previously healthy people have a head injury or a stroke that damages their frontal lobes, they typically show impairments in judgement and decision-making.

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A range of psychiatric and neurodevelopmental conditions are also associated with impairments in executive functions and frontal lobe integrity. Autism spectrum disorder, schizophrenia, bipolar disorder, and major depression have all been linked to executive function deficits.

Slide 8

Let's look more closely at autism as an example of a neurodevelopmental disorder where the frontal lobes are implicated.

Autism spectrum disorder, or ASD, is a neurodevelopmental condition characterised by impaired social and communicative development, with rigid and repetitive behaviours and interests. Children and adults with ASD show impairment in executive functions, particularly on planning tasks, like the Tower of Hanoi, and set-shifting, like the Wisconsin card sorting test. Most children and adults with ASD dislike change and have a strong preference for narrow routines and repetition. This is thought to reflect impairments in frontal functions that are necessary for adaptive response to change and novelty.

Slide 9

What about the social and communication problems that define ASD? These are thought to result from an impairment in recognising what others are thinking, so-called “theory of mind.” Because people with ASD find it hard to recognise what others might think or mean, they are often confused by social situations and struggle with communication. Think how confusing it would be to be told to “paint the child next to you” if you couldn’t guess what the teacher meant.

Slide 10

Theory of mind can be tested with a variety of tasks. Watch the following short animation.

Slide 11

What does the small triangle want? What is the big triangle trying to do? Let’s look at some more examples.

Slide 12

Using animations like these, or static cartoons or written stories that also cause healthy volunteers to think about other people’s thoughts, fMRI studies show activation of medial prefrontal cortex, as well as temporal poles and superior temporal sulcus. People with ASD often simply see triangles moving around and don’t attribute thoughts to them. Asked what was going on in the animations, they might say the red one moved right and then the blue one turned 90 degrees. The brain activity of volunteers with ASD doing theory of mind tests is also different, even when they can answer the test questions correctly.

Slide 13

Reduced top-down effects have also been suggested to be important in understanding autism. Remember how seeing the picture of the face helped you see the blobs as a face? People with ASD don’t show that strong top-down effect, especially when they’re looking at faces versus other objects.

Slide 14

Unlike acquired frontal lobe patients, people with ASD do not have circumscribed lesions. Instead, it seems the connectivity of different brain regions is atypical.

Slide 15

In this session we have looked at the association cortex and focused especially on the frontal lobes and their role in executive functions. Acquired or developmental abnormalities in these regions impair the ability to respond flexibly to novel situations. Because of the importance of these functions, frontal involvement is hypothesised to underlie many psychiatric and neurodevelopmental symptoms.