Module:
Biological Foundations of Mental Health

Week 5
Reward, emotion & action

Topic 2
The structure and function of the Basal Ganglia – part 5 of 5

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Lecture transcript

Slide 2

Now let's look at something that is more considered like a food for thoughts, and that is what basal ganglia might have to do with voluntariness and free will.

Slide 3

Remember the experiments from that an Anatol Kreitzer's lab where he used optogenetics to artificially activate the direct D1 pathway or the indirect D2 pathway, and remember when the indirect pathway was artificially activated, it suppressed activity of the mouse.

Now, you could ask, does that mean that the mouse was deprived of her freedom to do what she wants? I'm well aware this is a very anthropocentric view, but nevertheless, isn't voluntariness conceived as a key concept of free will?

Slide 4

And in fact, it was the philosopher Kant who said that a person acts freely if he does of his own accord what must be done.

Now, think of people with basal ganglia dysfunctions. They are impaired in their actions and, if you like, in a way they are deprived in expressing their free will.

Slide 5

Now, according to Kant, we are on the one hand determined by natural law and on the other hand free because of our capacity to obey moral law. Now, think of people with basal ganglia dysfunctions who are impaired in their judgments.

Slide 6

So with that, I would like to end this little thought experiments and I would like to ask you, so, what is free will, and has it anything to do with the basal ganglia? And just as a reminder, Stan Grillner, a researcher at the Karolinska Institute once said, "The only output of the nervous system is the motor system, whether in in cognition or action." And without the functional basal ganglia, you inevitably have problems to express voluntariness.

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Slide 7

Now, apart from the possible connection to free will, I would also give you a very brief introduction into another aspect, and that is where does the basal ganglia potentially come from? Where did it evolve from? We recently carried out a study where we compared the basal ganglia to a region in the insect brain which is called the central complex. So on the right hand side, you can see it. There is an insect head with a compound eye.

When you look into the central brain, there is this ochre region which is called the central complex. It comes in various nucleides, the protocerebral bridge, the fan-shaped body, the ellipsoid body, and the noduli. And experiments quite similar to the one by Anatol Kreitzer's group showed that, if you inactivate this central complex, you have problems with actions.

Slide 8

And in most recent studies, we showed that also, the central complex and its sub-components are connected by so-called re-entrant loops. These are parallel projecting loops that integrate and convey sensory motor representations that select and maintain behavioural activity.

Slide 9

Now, what is striking is, when you look at the behavioural manifestations that are regulated by the neural activity of the virtual basal ganglia in the insect's central complex-- and in this table, they are shown next to each other-- you may appreciate that there is quite a substantial overlap, even though those brain regions look so different. But we now know that similar genetic programmes actually underlie their formation and function, and those behavioural manifestations can be regarded as shared action selections.

Slide 10

This is also re-emphasised by the fact that, if you have a dysfunction of the basal ganglia and the central complex, you see homologous pathological manifestations such as motor abnormalities, impaired memory formation, attention deficits, affective disorders, and sleep disturbances. So once more, let me re-emphasize. Although these structures are so different, not only in size, but also in appearance, they seem to regulate similar behavioural manifestations and pathology.

Slide 11

And the final slide shown here actually made us to suggest that there is a corresponding circuit organisation of the basal ganglia and the central complex. And indeed, there are new results which suggest that, also, the centre complex in insects is involved in, if you like, voluntariness. That is, with that region in the brain of a fly, for example, this is necessary to explore your environment and to look out for the new and open.