Neuroscience of Human Movement
Department of Multidisciplinary
Indian Institute of Technology, Madras

Lecture - 68
Basal Ganglia – Various function

Welcome to this class on Neuroscience of Human Movement. This class we will continue our discussion and Basal Ganglia, next time will be discussing about the various functions of the Basal Ganglia.

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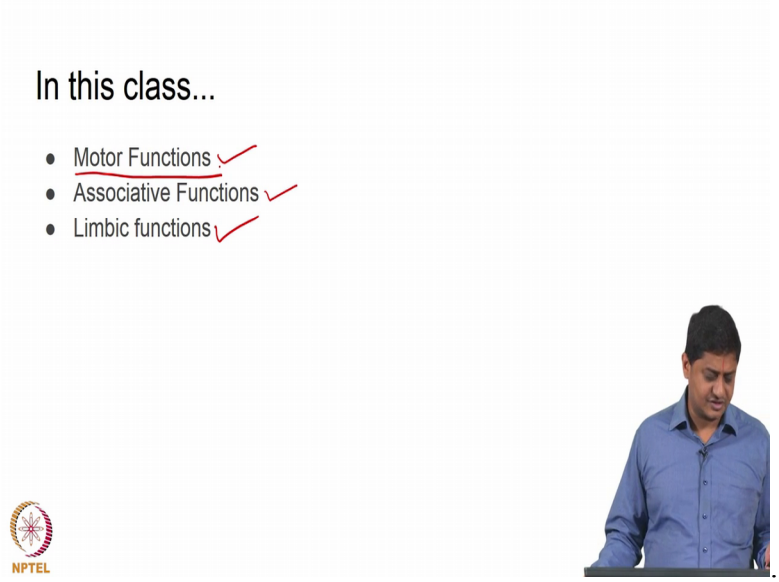

So, in today's class we will be discussing motor functions of the Basal Ganglia. The associative or executive decision making related functions of Basal Ganglia and the limbic functions of the Basal Ganglia. Note that Basal Ganglia is traditionally considered as a motor nuclei or motor nucleolus of the thing.

So, in other words for a long time, it was believed that Basal Ganglia is essentially motor or related to motor function. This is, because Basal Ganglia this function essentially caused several motor problems; that were readily observable. So, in general motor functions and motor areas of Basal Ganglia are relatively well studied; whereas, other functions and other areas of the Basal Ganglia are relatively poorly studied. Even now the cognitive functions of the Basal Ganglia, the associative and executive functions of the Basal Ganglia and also the emotional role of Basal Ganglia.

Although are very important, somehow are studied lesser than the motor aspects. Note, also it is easier to test hypothesis regarding motor function. And in general it is, because why is that? So, note it is also easier to formulate and test hypothesis regarding motor functions when compared with other aspects of Basal Ganglia function. why would one say this, because in general the movements are observable, right. So, basically motor aspects or motor functions or motor related aspects of behaviour are readily observable and measurable when compared with other aspects.

So, the quantification aspect of other functions are challenging. So, hence design of experiments related to other functions are also challenging. Yet, they are an important part of functions that must be studied. So, essentially, Basal Ganglia participates in multiple functions including cognitive associative executive limbic emotional etcetera; however, in this course we will only focus on motor functions of the Basal Ganglia.

And so, in this class alone, I will introduce what are the other security and what are the other functions, but in future classes we will restrict our attention to the motor aspects of Basal Ganglia function.

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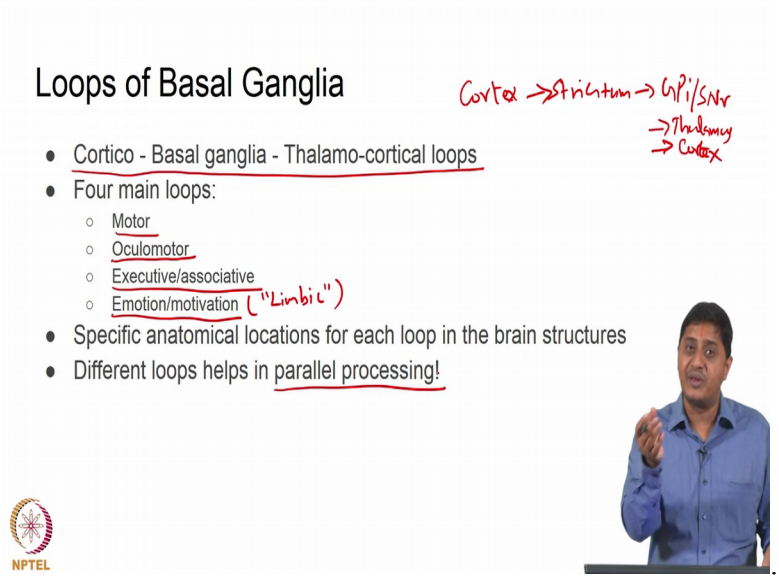

In general, the loops within the Basal Ganglia or loops involving the Basal Ganglia are the following Cortico, Basal Ganglia, Thalamo Cortical loops. So, basically the input starts from the cortex goes to striatum goes to GPI, goes to GPI or SNR from there to thalamus and from there to the cortex.

So, essentially the loop is Cartico Basal Ganglia, Thalamo Cortical loops. And this manifest in four major loops, these are motor are more specifically skeletomotor loop, oculomotor loop involving eye function executive and associative loop and emotional motivation are the limbic loop. And turns out that each of this loop has dedicated a specified area within the Basal Ganglia. So, and their inputs are kept separated they processing load circuit separate and their outputs are also kept separate. So, essentially what you are having is an architecture that is parallel in nature so; that means, different aspects of behaviour are processed parallely by the Basal Ganglia.

So, essentially behaviour is this complicated. So, essentially behaviour is this combination of motor emotional associative executive perception a whole number of different functions, right. And different aspects of these are are processed and different aspects of these are processed in different pathways within the Basal Ganglia. So, essentially the Basal Ganglia performs parallel processing of different aspects of behaviour. In other words, there is an dedicated motor loop, there is a dedicated oculomotor loop and there is a dedicated limbic loop, there is a dedicated executive loop. So, for a given function these four can and will act in parallel simultaneously for a given behaviour.

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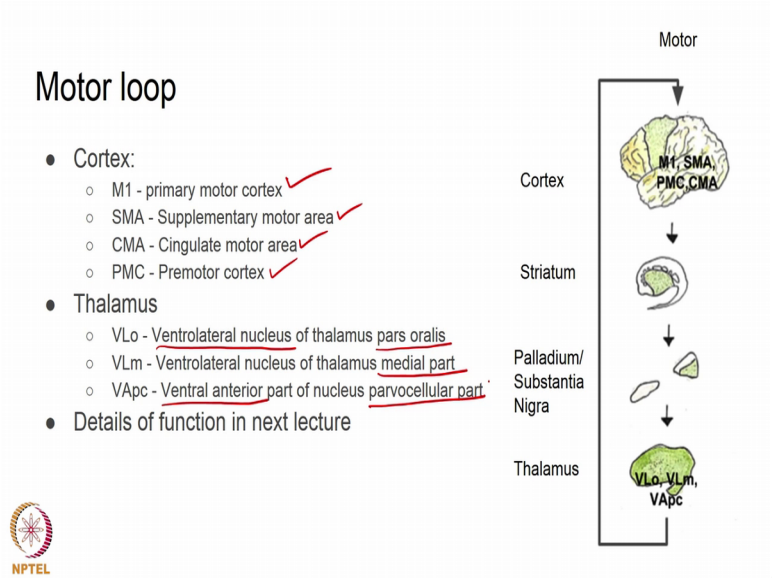

So, regarding motor loop where does this originate well from the motor areas of the cortex, primarily the M, M 1 which is a primary motor cortex and supplementary motor

area, the cingulate motor area and the premotor area. Within the striatum much of this outputs are to two (Refer Time: 06:24) usually many of this outputs from the cortical loops or to the (Refer Time: 06:30) And from there two palladium and are substantia nigro pars reticulate.

And from there to the thalamus and specific nuclei of the thalamus, this is ventrolateral nucleus and ventral anterior nucleus. Note within ventrolateral nucleus, there is this particular part called pars oralis and also the medial part of the ventrolteral nucleus.

And ventral anterior nucleus, the parvaocellular part, right. we will discuss the motor loop in relatively great detail in future classes, right. So, the inputs are essentially M 1 supplementary motor area premotor area and cingulate motor area; the outputs are ventrolateral and ventral anterior nucleus for the thalamus.

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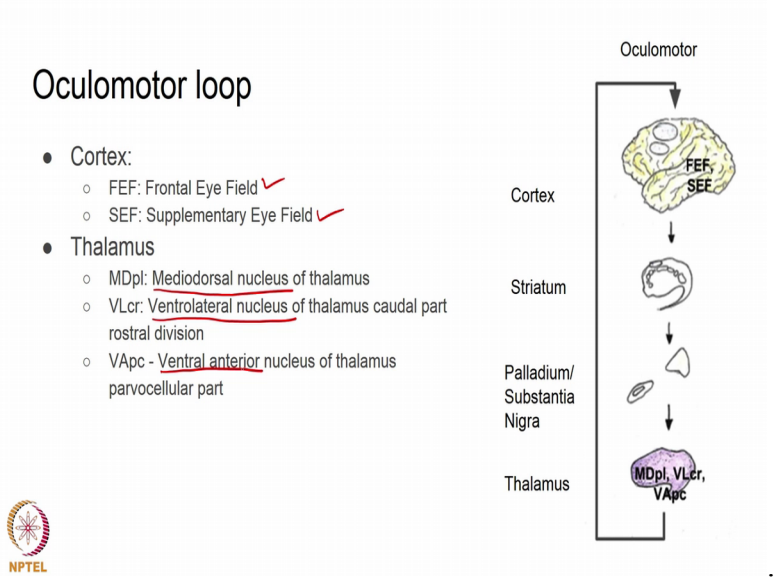

The oculomotor loop, the inputs are cortical inputs are from frontal eye field and the supplementary field it in the, in the frontal cortex, right.

The outputs are through the thalamus, but different areas in the thalamus earlier we said it is VA VL thalamus, right. So, here we said VLo and VLm thalamus here it is actually mediodorsal nucleus of the thalamus and ventrolateral nucleus of the thalamus. This is an area that is shared with the motor which is basically the ventral anterior nucleus of the thalamus in the Parvaocellular part, right that shared with the Skeletomotor theory.

So, the ventral anterior nucleus is present both in the oclomotor loop and then the Skeletomotor loop. It is not necessary for you to remember all this terminology which particular nucleus of the thalamus is responsible, but it is important for you to remember that different nuclei act as output nuclear from the thalamus., basically the reason why this is important is, because there is segregation; it is important to understand the concept of segregated inputs are kept segregated in the processing loops and outputs are also segregated. So, this is the important concept of graph, it is probably not important to remember every little detail and memorize the names of this. Of course, if you are interested you can always try read about this and get more information.

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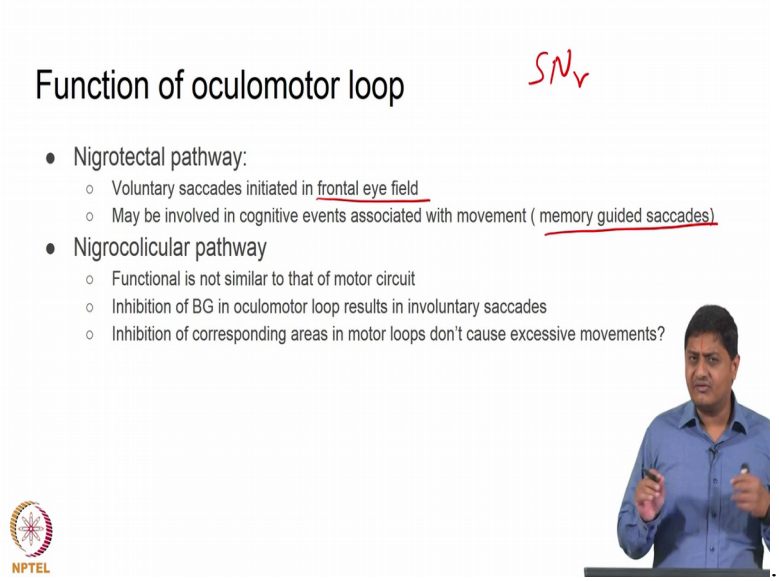

So, what is the oclomotor loop responsible for? So, there are two pathways the nigrotectal pathway and the nigrocolicular pathway. So, here when we say nigrotectal and the nigrocolicular pathway, we are talking about substantia nigra pars reticulata, not substantia nigra pars compacta substantia nigra pars compacta, since (Refer Time:09:36) output to the striatum when substantia nigra pars reticulata since outputs to the areas that control eye movements, right

So, the Nigro tectal pathway, voluntary circuits initiated in the frontal eye field. So, essentially this maybe there is speculation that this may be involved in events associated with movement such as memory guided saccades, right. Then the other pathway is nigrocolicular pathway, function is not similar to that of motor circuit. So, in this case

what happens is that inhibition of Basal Ganglia in oclomotor loop results in involuntary saccades; so, somewhat different from the motor function, right. Inhibition of corresponding areas in the motor this actually do not cause excessive moment. So, slight difference in function, but not complete difference, right. So, this is the oculomotor loop.

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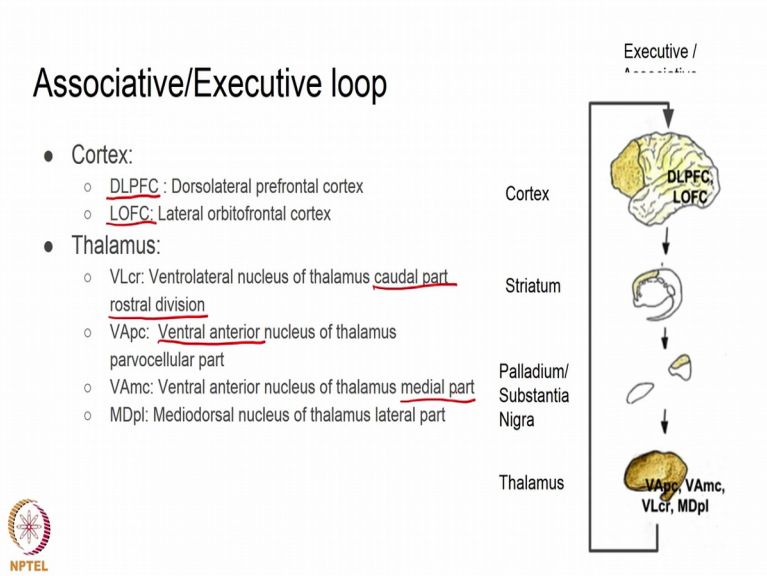

The executive loop,right this the origin of this loop is in the so, called dorsolateral prefrontal cortex and lateral orbitofrontal cortex. These two areas are now gaining. So, the origins of the associative and executive loops are the so, called dorsolateral prefrontal cortex and lateral orbitofrontal cortex. These two areas are gaining tremendous attention and traction these days going to home interest in studying reward related behaviour, in studying, motivation related behaviour, in studying decision making executive decision making, etcetera.

Ah so, neuroeconomics neuromarketing kind of studies involved observation of activity in DLPFC and LOFC in a, in a great manner, but here the restrict or attention to the Basal Ganglia related function, right. So, from the cortex, the inputs come from DLPFC and LOFC essentially dorsolateral prefrontal cortex and lateral orbitofrontal cortex and the outputs through the VL caudal part of the rostal division. So, in the ventrolateral thalamus, but and different area in the ventrolateral thalamus when compared with the motor loop. And the VA nucleus parvocellular part and the ventral anterior nucleus, the medial part and the mediodorsal nucleus the more lateral part yes, all right.

So, in other words again it is not necessary for you to remember every little detail, but it is necessary for you to remember that these areas are different from the motor areas. So, this segregation is maintained throughout the Basal Ganglia loops, all right.

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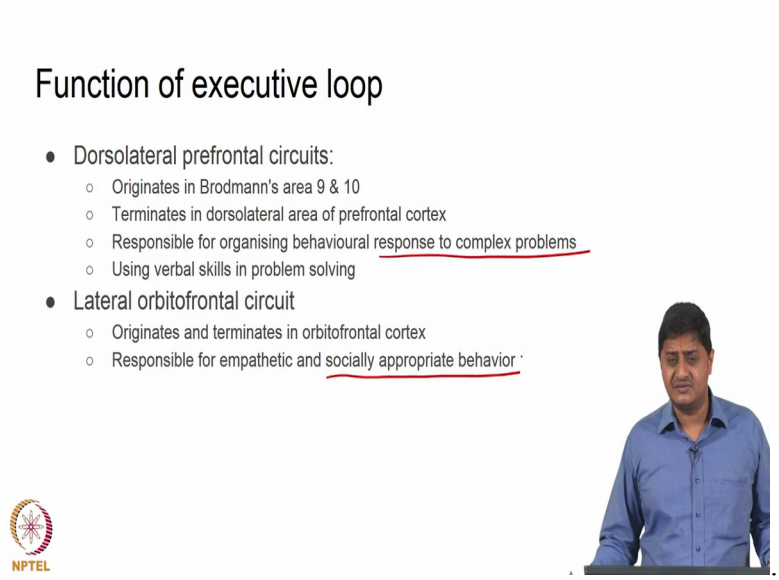

And what are the functions well essentially; this is responsible for organising or coordinating response to relatively complex problems, right such as using verbal skills or in solving of problems, right. The other one, the lateral orbit of the frontal circuit, you know is believed to be responsible for what is considered socially appropriate behaviour. So, there are disorders of Basal Ganglia where sometimes some people manifest or show symptoms where they lack and ability to appropriately behave in the society.

So, they do not so, normal person would not pick up somebody else pen from a table, for example. So, there is an inhibition to do something that is that is that is socially unacceptable and this inhibition is tonically cause due to the is probably due to the tonic inhibition coming out of the Basal Ganglia, right.

So, basically the Basal Ganglia output is essentially tonically inhibited. So, this is what causes the social. So, this is what causes the social inhibition that may have. So, for example, if there is a pen of someone else in a table and that someone else is sitting right in front of me, I would not pick up the pen and put it in my pocket, if I am a normal person, right.

People with this disorder for example, wooden really have that inhibition. So, they will pick up somebody else pen when they will do things that are considered inappropriate in social location. So, again giving us inside; about the important role of Basal Ganglia in behaviour.

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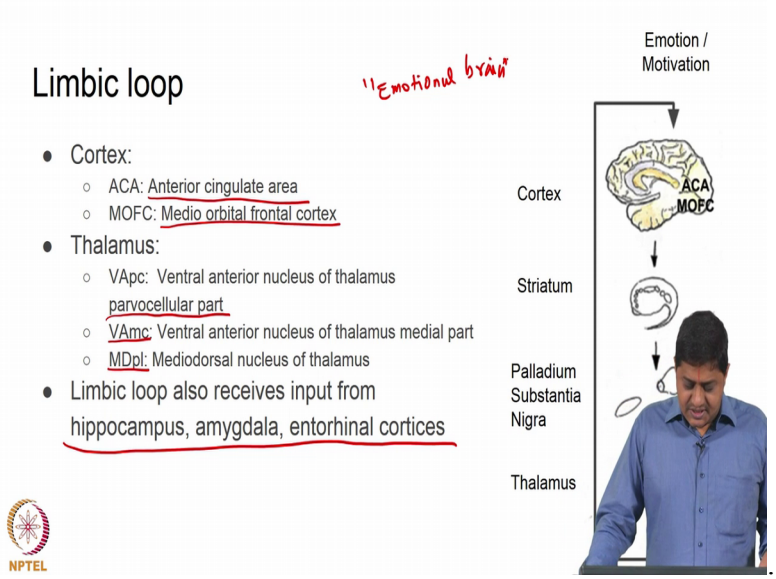

So, then the limbic loop from the frontal cortex the inputs come from the media orbitofrontal cortex, also from the anterior cingulate area, right. In the thalamus the outputs go from the, the parvocellular part, this is an area that since to participate practically in all the functions, right VA parvocellular part is an area the, that practically participates in all the functions, right.

And the medial part and the mediodorsal part of the thalamus.Note, importantly limbic loop this is input of course, from amygdala hippocampus entorhinal cortices ; obviously, limbit loop receives inputs from the emotional brain, right. So, the emotional brain is the amygdala, right a lot of function related to emotions is performed by the so, called emotional brain. There is a book on this topic those who are interested can read this book, you could Google for this the emotional brain, right.

So; obviously, Basal Ganglia also received inputs from the emotional part, the emotional brain. Once again, the important function of the limbic loop is relatively poorly

understood. So, what exactly is the contribution of Basal Ganglia to emotions is relatively poorly understood when compared with say the motor loop, right.

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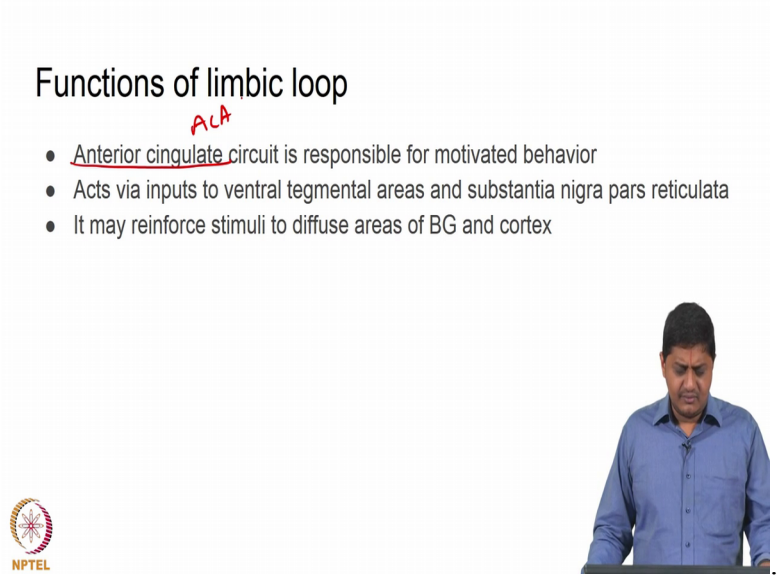

So, for example, the ACA or the anteriors cingulate area, right is responsible for motivation related behaviour. So, these acts via multiple inputs including ventral tegmental area and substantia nigra pars reticulate. Again it may reinforce different stimuli to multiple areas of Basal Ganglia and cortex. So, again very little understanding of the limbic loop, but whatever is available is presented here.

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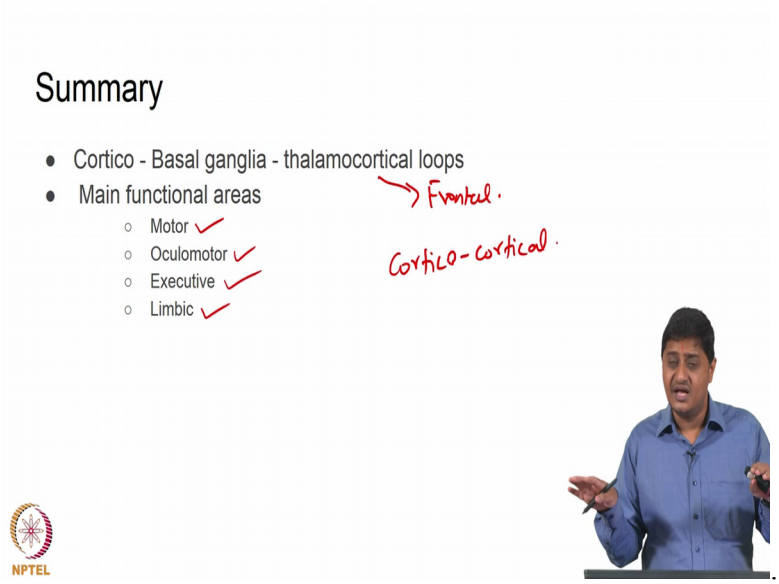

The loops involved in Basal Ganglia are essentially Cortico Basal Ganglia thermocortical loops. And there are four functional areas motor or skeletomotor areas oclomotor areas excecutive or association and limbic or emotional. An important point to note is that the regardless of which part of the cortex input to the Basal Ganglia comes from the output of the Basal Ganglia always goes to the frontal cortex, important to note that the Basal Ganglia or the striatum receives inputs from almost the entire cortex except the primary visual and primary auditory cortex, but the Basal Ganglia output is almost always restricted to the frontal areas in the cortex, right. So, also note if there is extensive connection within the cortex so, more extensive the Cortico cortical networks, right; if the Cortico cortical networks is more extensive between two areas of the cortex.

In other words, there is a there is lot of information sharing between one area of the cortex and another area of the cortex. And if these two area of, of the cortex project to the Basal Ganglia their projections overlap. If there is less projection from one area of the cortex to another array of the cortex and these two areas project to the striatum then these two areas do not overlap or overlap less in the striatum,. So, with this we come to the end of this lecture, we will continue our discussion in future classes.

Thank you very much.