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

Lecture – 49
Primary Motor Cortex Part – 13

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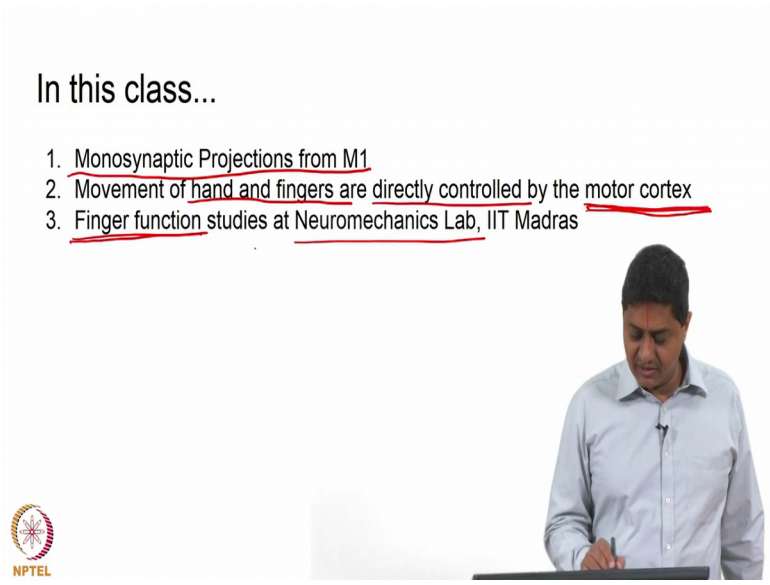

So, welcome to this class on Neuroscience of Human Movement. This is part 13 of our discussion on Primary Motor Cortex.

So, in this class will discuss the crucial nature of how fingers and hands are supplied from the primary motor cortex are they receive Monosynaptic Projections from M 1. So, a crucial aspect of motor control has this feature, where fingers and hands receive Monosynaptic Projection from M 1 whereas, other parts of the body specially the legs for example, and the more Proximal parts of the body such as shoulder for example, do not receive this Monosynaptic Projections.

So, what is the importance of this Monosynaptic Projections? We have discussed this in several previous classes. So, I will again once again briefly introduce this and touch upon it is importance today. So, moment of hand and fingers are directly controlled by the motor cortex so; that means, by studying the movements of hand and fingers, you could get a clear picture, a clearer picture when compared with other parts of the body about the strategies, that are employed by the movement control system, when compared with

other parts the picture is going to be more clear or less made less meddled, when compared with the other parts are more Proximal parts.

So, the distal most parts of the upper limb hand and finger are very special in humans they are very special; which is also the reason, why we study finger function at our lab at IIT Madras. So, we have the Neuromechanics lab at IIT Madras and in our lab, we study hand and finger function. So why? Because, we believe that the hand and fingers serve as the model system for studying the human movement control system.

So, by studying the hand and fingers, we could come to a more general conclusion about the functions of the motor control system in particular the motor cortex and stuff. So, the strategies that are used are clearer from the studies of finger function, which is the reason, why we study finger mechanics at the Neuromechanics lab at IIT Madras. So, will discuss some of our own work in today's class.

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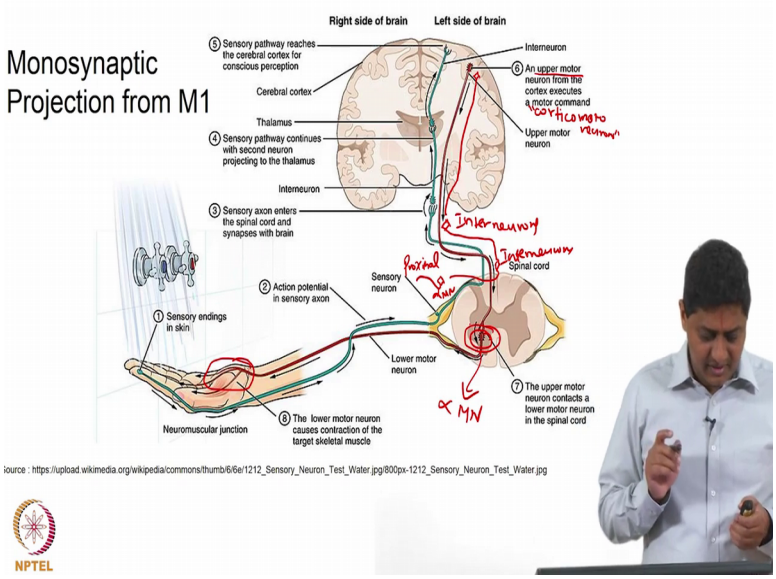

So, let us remind ourselves of the situation. So, the case is that, the control of the hand and fingers. So, this muscle for example, is controlled by the alpha motor neuron here. So, that is the alpha motor neuron. So, this alpha motor neuron is receiving inputs from the motor neuron in the cortex, this motor neurons are called as upper motor neurons. We just discuss in one of the previous classes or that is called as Cortico motor neurons right. So, this Cortico motor neurons, Cortico motor neurons receive or. So, this Cortico motor neuron send commands directly to alpha motor neurons and these alpha motor neurons

innervate muscles that control the distal parts of the upper limb are the hand and the fingers, this is the reason why the control is expected to be clearer the strategies expected to be clear. A questions is how are the other muscles in the body control? There are several hundreds of muscles in the body.

How are the others controlled? Well it is suppose different case, let us take a different case. So, here then neuron it is going to project to a different segment in the spinal cord and there is another neuron there probably, that is going to project at to a different segment in the spinal cord maybe or maybe not. It may be in the same segment also and then that is going to project horizontally to an alpha motor neuron and that is going to control a more Proximal part of the body more Proximal parts of the body means what? So, Proximal part of the body.

Now, first to that part of the body that is closer to the centre is it that. So, when I the fingers are further away from the centre of the body, when compared with say the rest, when compared with say the elbow and the shoulder. So, a particular joint can be simultaneously Proximal and distal with reference to different joints. Let us consider the case of elbow joint, the elbow joint is Proximal is closer to the centre of the body, when you look at it from the rest point of view or in other words, Proximal to the rest is the elbow joint whereas, when considered from the shoulder joints point of you, it is distal, it is further away from the centre of the body.

So, but in, but from the point of view of fingers there is no point, that is distal from the tip of the finger that is distal most point right. So, when I say the more Proximal parts of the body are controlled by several Interneurons. These are Interneurons, this is another Interneuron, this is an alpha motor neuron. You know what is an alpha motor neuron? Alpha motor neuron is this motor neuron that controls the muscle function that innervates a several muscle fibres and the alpha motor neuron and all the muscles fibres innervate by at all together called as a water unit. We have studied this in one of the previous classes.

So, when I say Proximal we are talking about for example, shoulder joint for example, other parts of the body also the distal. Most the distal, most point of the leg or also controlled through Interneurons. So, it is not a case of what is distal or what is Proximal. In other words, the distal most points of the upper limb are control by the Monosynaptic

Projections, where as the toes for example, the toes of the leg are not controlled by the Monosynaptic Projections from Cortico motor neurons, there are Internuerons when it comes to leg control which is also the reason why our legs are toes of the leg or not show distrust, you cannot pick up objection manipulate objects with the leg, where as you can do that with the hand right.

So, the so, this means the hand and fingers are very special, special to the extent that only these receive this direct projections from the Cortico motor neurons or the direct Monosynaptic Projection from the Cortico motor neurons and must be very good reason, why very good reason and this is more pronounced in humans, this the number of such neurons, that receive the number of such alpha motor neurons that receive such Monosynaptic Projection from Cortico motor neurons is higher, much higher in humans when compared with other species.

So, this is the reason why our hand and fingers are. So, dexterous we are able to manipulate tools and objects with is when compared with other animals right also to note is that this not only is the number higher. So, one is that the number of neurons that receive this is higher why is this higher? We discussed in one of the previous classes, why this is required in humans, but this is present in humans, but not in other animals. Humans are special in that they are proper bipeds right.

So, their hands of free, they do not have to use hands for walking hands for you know locomotion or the upper limbs or the 4 limbs are not used for locomotion, when compared with other animals. So, that means, there is a and this gave advantages to when you are able to stand up in a grassland and see an approaching predator for example, right. So, you have distinct advantage of you know escaping from the predator, but when you are and all fours when all your 4 limbs are on the ground, what are the hands that you are going to be able to escape and approaching predator, who is going to be able to run faster than you lower comparatively lower right.

So, evolution advantage of having Bipedalism or standing up is first then, this led to the freeing of the hand right. So, then came the regime of tool use and further to tool use. So, when you want to use tools find control is needed this probably, necessitated the requirement of direct Cortico motor neuronal Monosynaptic Cortico projections, 2 alpha motor neurons, these are hypothesis these are the various hypotheses that are prevalent

about us to, why this is the case? At least we know now the this is the case and this is now well known that accepted that the hand and fingers received direct Cortico motor neuron projection to alpha motor neurons controlling the their muscle ok, not seen in other animals, not seen in other parts of the body within human.

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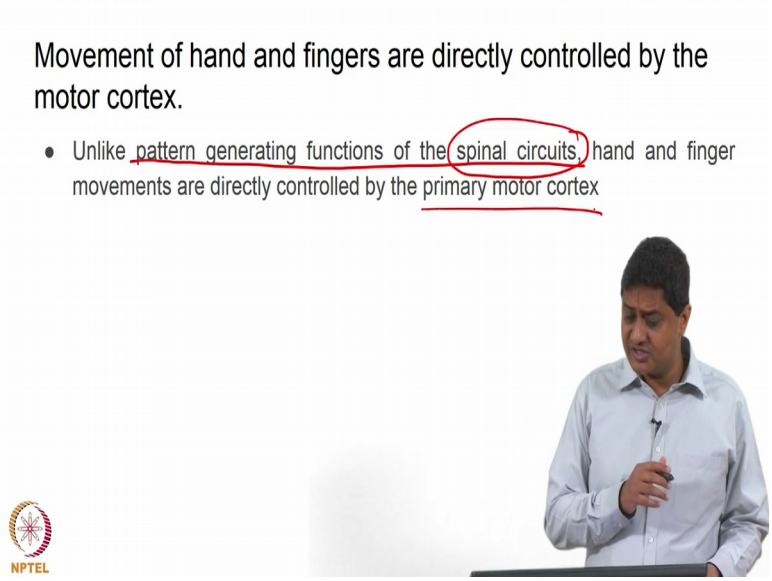

So, very very special mention for the hand and fingers.

So, unlike pattern generating functions of the spinal circuits, what do you mean by that? So, what is mentioned here is that for example, in lower animals presumably hypothetically in humans also that is a matter of debate at least in lower animals, it is now well known and accepted that there are these central pattern generators of the spinal pattern generator that a responsible for locomotor functions these produced oscillator like movements. Oscillator like function that oscillator like activity that produces locomotor like function that is present, that is prevalent in the spinal cord in the spinal circuits whereas, the hand and fingers their control is from the primary motor cortex. So, very unique feature in humans this and of course, let us not get in the controversy of the presence of spinal pattern generators in humans that is a different topic.

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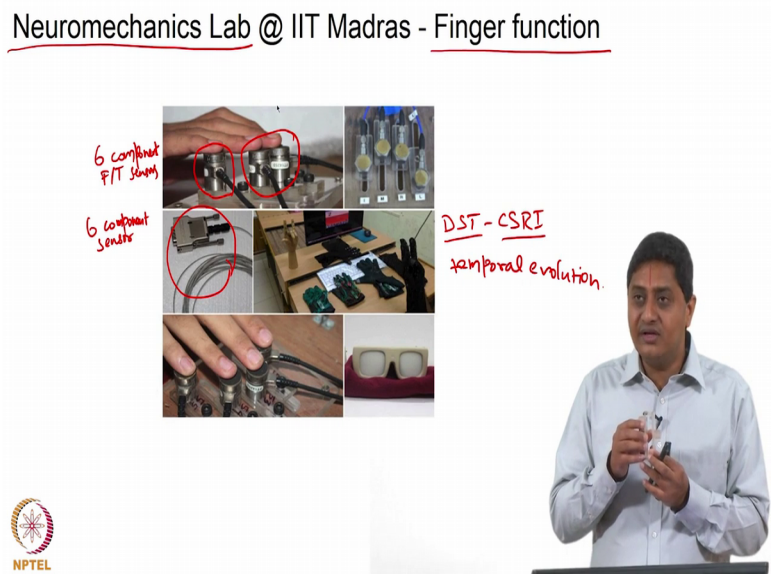

So, where do we stand? What is our own work here? So, in Neuromechanics lab at IIT Madras, which is my lab we study finger and hand function. Now also the reason as to why we study finger and hand function, we are interested in understanding the brain strategies in movement control and we believe that hand and fingers and mechanics of hand and finger function can give us information about how the movement control system functions are in other words, we considered the hand and fingers as the model system for studying human movements. So, here are some examples that I would like to show we have this (Refer Time: 12:38) nanosensors that measure fingertip forces in all 3 directions. So, the small forces and moments and the small moments that are produced by the fingers, while manipulating objects and we also have this electromagnetic tracking sensor.

So these from polymers, these can track movements of individual finger segments linear and angular displacement. So, each of these are these are 6 component sensor both of this, one is the 6 component, 4 track sensor. Now other one is the 6 component kinaltic sensor. So, the polymers 1 measures linear and angular displacement in all 3 directions to that, we can do for each individual finger segments, we also built our own instrumentation for studying hand and finger function. For example, in one of our study is that is funded by DSTS Cornetic Science Research Initiative, we ask the question how do people learn to perform sequential movements? Are learnt a motor sequence and how

do people become an expert at this? For this purpose we developed instrumental glove I am showing the glove here.

So, each of the segments, if you touch for example, if you touch. So, this glove is one with the on the hand and when different parts of the different fingers attached for example, the distal most segment of the index finger, if it is touched a particular alphabet is going to be typed on the screen and we have several such alphabets and people learn to type this using practice, practice over several days.

Now, the question that we ask is how does expertise involved? So, it is well known of course, it is general studies that are done in this sort of domain in this domain is to compare experts with novices; obviously, the performance of the experts will be much different from the performance of the novices. So, when you take for example, this is true in any sport or any art or any particular motor function.

Somebody who has been practicing for a long time at take their action and somebody who has not at all been practice or naïve, new enter into the field, I assume to perform and I say these to a different that is obvious, everybody knows that every all appreciate that, you know novices and their movements are going to be different from experts and their movements in this project that is founded by DSTS Cornetic Science Research Initiative.

We ask the question, how is this motor skill acquired? What is the evolution of the expertise? A person becomes an expert, but we will study the temporal evolution of what are the various stages that you can you become an expert? And then after that suppose I perturb suppose I disturb your expectation, where you have to unlearn and relearn something suppose earlier in this glow, when you touch the index fingers distal most segment or the tip of the index finger saying a is typed. After you learned I am saying q will get type for example, when that happens and I am asking you to type the same word as previously.

Now, suddenly I have disturbed your learned association how? So, you will have to unlearned what has been previously learnt and learn a new association, how is that getting affected? That is the other question that, we asked thanks to generous funding from department of science and technology. So, these are some of the things that we do the other thing that, we are doing is with the study of fingertip forces in object

manipulation here, I have a model of a handle or a hand held objects. So, I have these are dummy senses is a not real sensors, these are dummies of the actual sensors that are use these are made of a acrylic, the stainless steel the handle itself is made of acrylic. So, but the real system will have these (Refer Time: 17:23) nanos, these (Refer Time: 17:25) nanos are very expensive. So, I cannot bring this to this place and show. So, when I press and hold this object, I produce a vector of force on this right.

So, on basically it is going to be oriented in any given direction, any arbitrary direction depending on the physics of the task or what I am trying to do with this object. If for example, I am trying to do that or that for example, or that or any of this or I am trying to rotate, I am trying to translate this or a combination of this, I am performing in general plane motion or any of this suppose, I know the physics of the task well suppose, I know that the trajectory I know all the physics suppose then the question is how does the fingers coordinate? Or how does the finger system coordinate to produce? This known physics, I know what to do and I am doing what I should be doing, but yet it is not clear, how individual fingers coordinate to produce the desired outcome.

So, precise control of the physics is required and we do this all the time, we are able to do this the question is how are we doing this? That is the question that, we ask in our lab and try to answer this to that end this object is a relatively well studied object. It is mechanics has been relatively well understood. So, we are building objects whose mechanics are more complicated than obvious. So, those who are interested can visit our lab website to know more a right to me, I will be happy to explain.

So, we reproduce objects, whose mechanics are not obvious are completely non intuitive and we ask people to adjust to such objects, how does the human system adjust to such perturbations? Is the question that, we ask those were interested can check it out.

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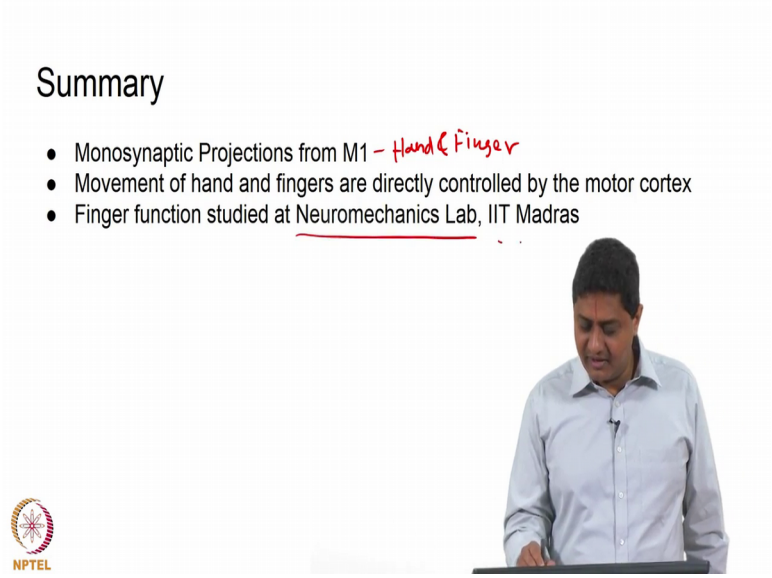

So, in summary we say that, there are Monosynaptic Projections from M 1 to the hand and finger areas or hand and finger muscles and movement of hand and fingers are directly controlled by the motor corex, which is the reason we study finger function and hand function at Neuromechanics lab at IIT Madras.

Thank you very much for your attention.