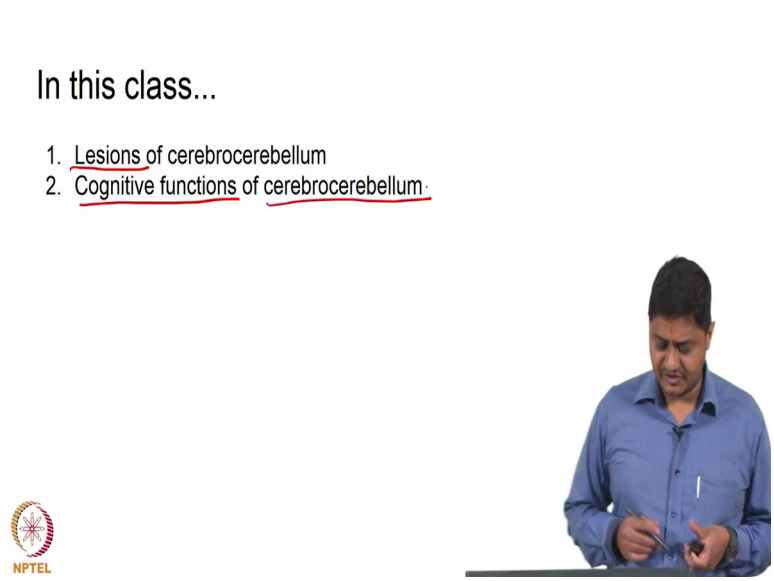
Neuroscience of Human Movement
Department of Multidisciplinary
Indian Institute of Technology, Madras

Lecture – 60
Cerebellum Part – 9

So, welcome to this class on Neuroscience of Human Movement. So, this is part 9 of our discussion on Cerebellum.

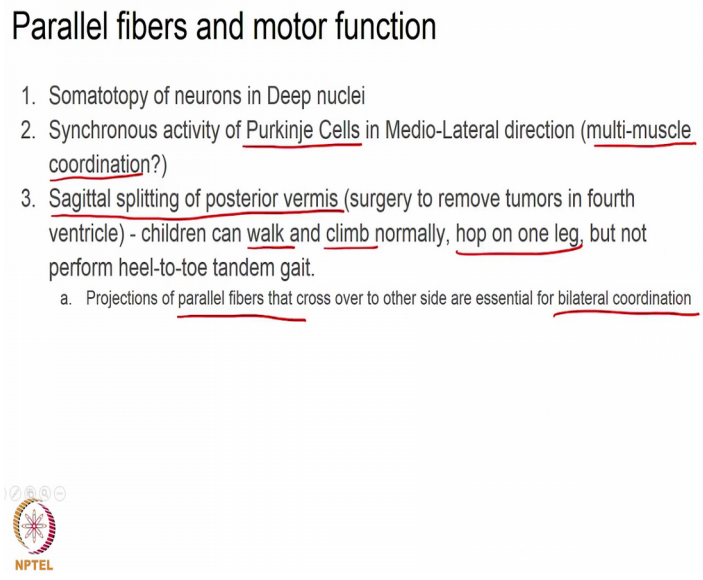
(Refer Slide Time: 00:23)



So, in this class we will be discussing the lesions of cerebrocerebellum. We discussed functions of cerebrocerebellum in the previous class. In this class we will discuss what happens if there are lesions of the cerebrocerebellum, this may be lesions in humans are experimentally induced lesions in animals and are there cognitive functions are there functions other than motor functions for the cerebrocerebellum.

Let us remember early on in our discussion we said, cerebellum has been traditionally considered as a motor part of the brain. But now, there is increasing evidence to suggest that cerebellum also participates in functions other than motor functions such as, cognitive function such as, sequencing such as timing perception etcetera. So, we will discuss some of this in this class ok. So, the cognitive functions of cerebrocerebellum.

(Refer Slide Time: 01:24)



In one of the previous classes, we will discussed the possible role of parallel fibers in motor function we said that, there is somatotopy in the deep nuclei basically dentate nucleus vestigial and interposed nuclei have somatotopy. And there is synchronous activity of purkinje cells in the medio lateral direction, that is along the length of the parallel fibers, which caused us which caused, one to post it that it is possible that this synchronous activity of multiple purkinje cells could mean that there is muscle coordination across the medial and lateral direction.

So, that means, multi muscle coordination. So and we said that obviously, the motor cortex is responsible for control of movements whereas, cerebellum is probably responsible for coordination of movements ok. What we should also remember is that surgery that is performed in children where there is a tumor in the fourth ventricle. So, surgical removal of this tumor causes sagittal splitting of the posterior vermis.

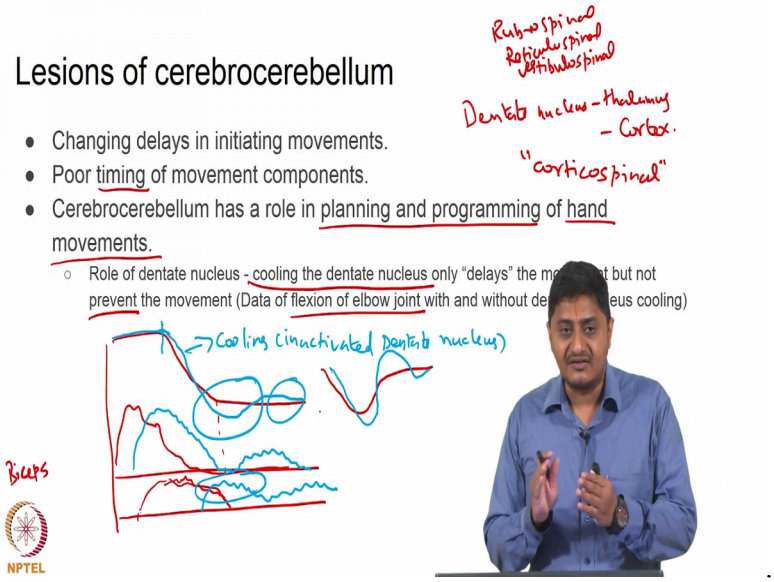
In these in these kids, they can perform many activities daily life activities quite normally. You will not be able to find differences in many activities such as, walking, climbing, hopping on one leg which is a relatively tough task, hopping on one leg, but when you ask them to perform heel to toe tandem gait. So, what is this so, this is so let us consider the situation.

Suppose my two hands are the two legs, the first leg is placed here then, the second leg so and suppose this is the toe of the first leg and this is the heel, the wrist is the heel

suppose so, the toe of one leg must meet the heel of the other leg and then, the toe of that leg must meet the heel of the other leg. This is called as heel to toe tandem gait. So, this is task that requires two side coordination or bilateral coordination. When this surgery is performed what happens is that, there is a splitting of these projection.

So, projections of parallel fibers that, cross over to the other side, so, this these bilateral projections when it is cut, only the bilateral coordination is compromised but not hopping on one leg; hopping on one leg probably in one you know only one leg movement and also walking and claiming is relatively normal right. So, those that require accurate bilateral coordination alone are compromised ok.

(Refer Slide Time: 04:34)



Now, in lesions of cerebrocerebellum what happens is that, whenever that is a lesion in cerebrocerebellum, what happens is there is a delay in initiating movements. So, that means, that there is slowness of movement, first is there is when a muscle is expected to be activated, this muscle is activated a little later than expected. And there is poor temporal coordination of various components are poor sequencing of movement components.

So, our timing of components is compromised. So, this gives to gives rise to the idea that the probably cerebrocerebellum is involved or forming an important role in coordinating or in timing the movement. So, causing if compromise of this area causes a delay and compromise of this area causes poor timing or poor temporal sequencing right.

So, timing and sequencing is performed by the cerebrocerebellum and also cerebrocerebellum is hypothesis to have a crucial role in planning and programming of hand movements. So, one nice method, one nice perturbation approach is cooling selective cooling of deep nuclei of the cerebellum. What this does is this temporarily deactivates these nuclei in animal models of course, in animal models. So, when you cool the dentate nucleus what happens is that, there is a delay in movement.

So, motor cortex receives inputs from the dentate nucleus how does it receive we have discussed this. This pathway is dentate nucleus to thalamus to cortex that is the pathway is it not So, through this pathway so, the cortex receives information from the dentate nucleus and then, appropriately controls or times the movements. Let us remember that it is the cortex that controls muscle activity through projections to the spinal cord. Of course, there are other projections that we have discussed; these are rubrospinal, reticulospinal and vestibulospinal. But those are mostly restricted to the spino cerebellum, here we are discussing cerebrocerebellum.

Here most of the projections to the muscles are through the cartico spinal tract So, the projections from the cerebellum go to the cortex and from the cortex the spinal cord receives information via the corticospinal tract or the pyramidal tract etcetera right. So, when you selectively cool the dentate nucleus the movement is delayed, but it is not prevented.

So, crucially the continuous cooling of the dentate nucleus does not prevent the movement. So, what happens is suppose, suppose the task is to perform flexion of the elbow joint right, so this is in a monkey the task is to perform fraction of the elbow joint, so let us see what happens right. So, here I am going to draw the movement trajectories right. So, let us let us let us see what happens in the in the healthy case, or in the control case all right, you are going to have something like this.

Now, that is for the control case and in the case where there is cooling right. So, what happens is that and at around that time is when, you at around that time is when you expect the movement to start actually, that does not happen here because, there is a delay because of the delay it starts around that point it goes like this and then, there is an overshoot and then there is a corruption. This is then there is cooling are inactivated dentate nucleus ok, inactivated dentate nucleus.

So, this is typical of cerebellar disorders cases in which there is an understood or overshoot of movement trajectories. This is typical of though those data that resemble in humans for example, for example, in humans people with cerebellar lesions, produce a typical overshoots and undershoots of movement trajectories So, what you observe in animal models with cooling luckily this is a reversible procedure right, so if I remove the cooling then, the then the movements return to normal.

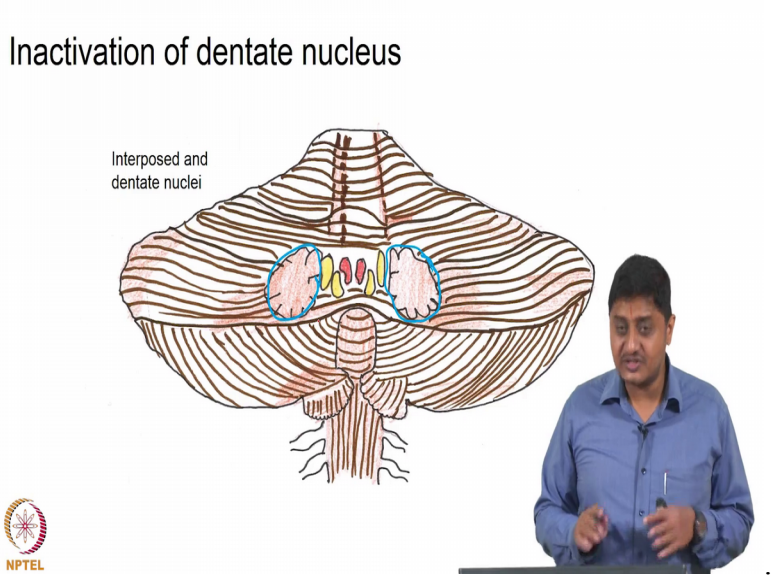
So, I can once again measure the control data right, so, with cooling, you observe movement trajectories that are similar to cerebellar relation so, that is one. Then what happens to EMG right. In the case with there is in the case, when there is no cooling or in the control case what you will say suppose this is biceps activity, let us say this is biceps activity, suppose the biceps activity is starting here and then it is ending there right. And then I am going to draw the triceps activity there.

So, the movement has to end here So, the triceps activity starts around that point and then, you know ends approximately there for example all right. These diagrams are not timed appropriately please check this, so these diagrams are not timed appropriately. But what is more important is the difference between the two cases; obviously, for us that is more important than this. So, what happens with cooling I am going to draw in blue, what happens is that the biceps activity is delayed and does not have proper termination continuous like that.

And what is worse is that the activity of the triceps is delayed and does not have proper termination because of this reason, you are having this feature. Because the triceps biceps activity are poorly coordinated between these two muscles, what you have is poor temporal coordination or poor coordination in terms of smooth ending of movement is what is observed right that is the velocity curve for example.

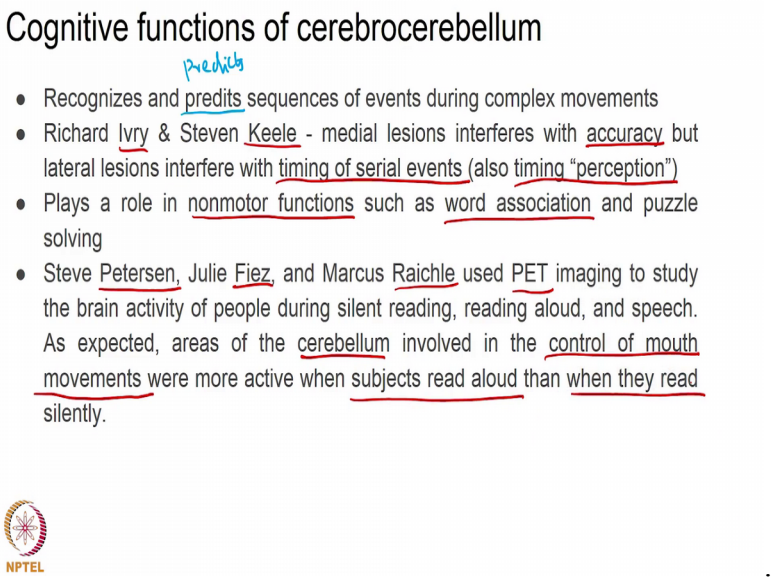
With cooling you are not going to have such a smooth curve, you are going to have other things you are going to have that and that. So, there are multiple peaks leading to so that means, what if there are multiple peaks in the velocity profile; that means, that there is jerks there is not a smooth stoppage so that is that is that is obviously, visible here, but that is also visible in the velocity profile that is also visible in the EMG profile etcetera ok. So, this means that the dentate nucleus plays a crucial role in how multiple muscle activities are timed with respect to each other ok.

(Refer Slide Time: 12:33)



So, as we see here so this is the a dentate nucleus this area, so on two sets left hand right hand side. And let us remember that the left side of the cerebellum controls the left side of the body. This can be through ipsilateral projections are this can be through two crossovers as we have discussed previously ok. So, these are the dentate nuclei and what the procedure to in activate or deactivate the dentate nucleus involves cooling or selective cooling of this nuclei ok.

(Refer Slide Time: 13:07)



So, then the other question is are there functions other than the motor functions for the cerebellum the answer is yes it seems, there are other functions. It appears like the cerebellum recognizes and that is supposed to be predicts. The cerebellum recognizes and predicts sequences of events during relatively complex movements and people have studied this in tapping using tapping finger tapping for example.

Richard Ivry and Steven Keele for example studied finger tapping movements in people with the cerebellar lesions. And they found that people who have median medial lesions only have problems with accuracy but people who have lateral lesions, have problems with timing of serial events. So, there are two things in there are multiples features of movements that can be analyzed So, medial lesions cause only accuracy problems whereas, lateral lesions have problems with timing or sequencing also.

So, that means, it you can hypothesis immediately that lateral lesions are lesions of the cerebrocerebellum, cause problems with sequencing and timing of movements are the cerebrocerebellum probably performs activity that is in line with sequencing and timing of actions. But, it is not just that is something that is a motor act, but it is not just that. It also has a role in perception of timing.

For example, if you ask individuals to classify the timing or whether, a note that was played was short or long. Whether or note that was played was longer than the previous one or shorter than the previous one. People who have lateral lesions or lesions of the lateral cerebellum or lesions of the cerebrocerebellum have limited ability to distinguish the timing of nodes, so auditory nodes that are played. People with lesions cannot distinguish this as well as healthy age matched controls.

So, also it is believed that cerebrocerebellum plays an important role in non motor functions such as, word association and puzzle solving. For example, whenever I say and now you are supposed to say work that is associated with that node say for example, if you say a cat you are supposed to say meows or you know not similar tasks right I am giving a noun and you are suppose to say a verb associated with that.

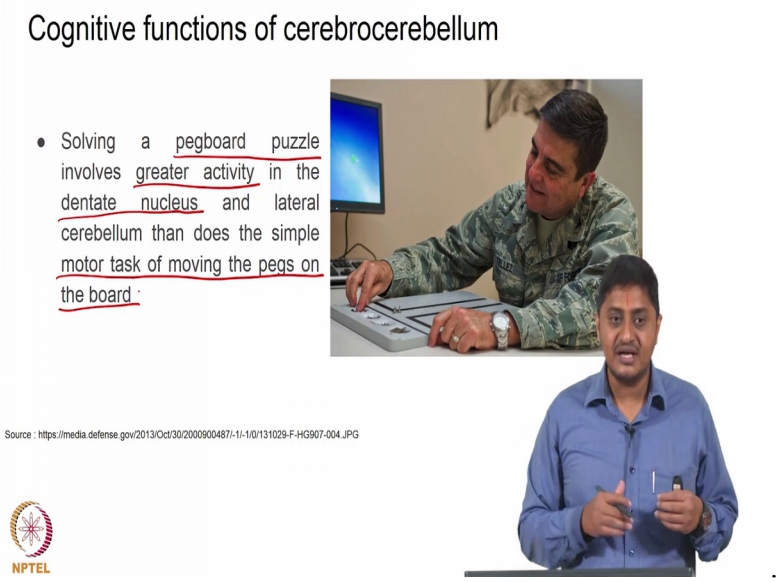
This involves not just speaking out the word, but also association that has cognitive implications right. So, I have to be able to say whether the cat meows or barks for example, right. So, there is some cognitive processing that is required. It seems that individuals with lesions of the cerebrocerebellum this ability is compromised. And

people have studied so, several colleagues Petersen Fiez and Raichle have used imaging techniques.

So, pet positron emission tomography imagings to study brain activity during silent reading. So, a person is given a text and they are reading and when you are reading aloud from the book, so they are given a book and they read reading aloud. And speaking in general, they have compared. So, what one would expect is that, areas of the cerebellum involved in control of mouth, so speaking out means movement of muscles of the mouth right. So, in control of mouth movements were more active when they read aloud.

So, when you read aloud that is active. So, when you keep quiet or when you silently read, there is a different level of activity showing that there is a motor related activity and there is nonmotor activity both ok.

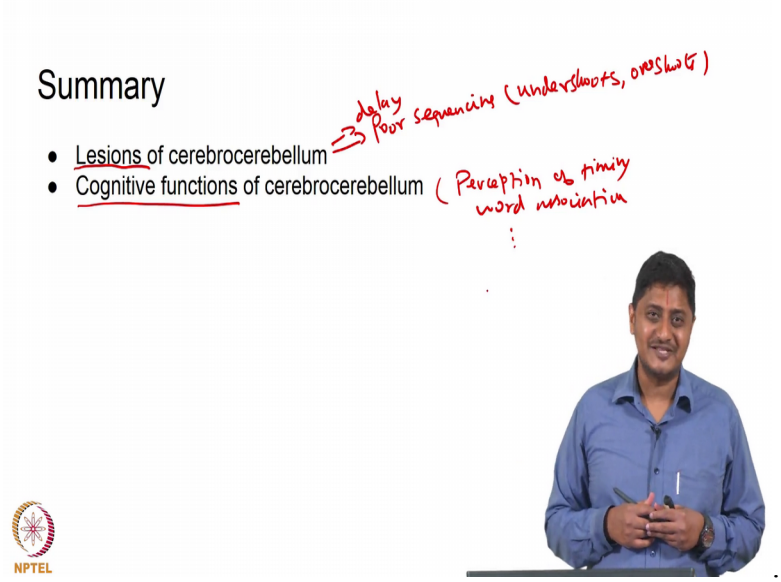
(Refer Slide Time: 17:49)



Also, suppose you have a pegboard right and you are required to randomly move make movements alone with no particular task with no particular goal for example, you are suppose to make movements alone from one point to another. Then, what happens individuals and their activity of the cerebellum is recorded at this time right, what has what was found was it when compared with mere movements on the pegboard if you ask them to solve the pegboard related puzzle that you have to follow a set of rules to ensure that you know, you solve this puzzle. That involves cognitive processing or sequencing this activity. Solving a pegboard puzzle involved greater activity in the dentate nucleus.

So, that means what, that means that, this nucleus has some role in cognitive processing or basically, cerebrocerebellum contributes to non motor functions such as cognitive functions right. Then there is simple motor task of moving. So, if I simply move the task that is one thing, but if I perform a perform a task that requires me to solve a puzzle; that means, there is activity that is greater meaning that, that processing is probably performed or at least partially performed by the dentate nucleus. So, that means, that lesions of the dentate nucleus will also cause will also compromise this abilities other than the motor function. So, there will be motor related problems and there will be cognitive related impairments.

(Refer Slide Time: 19:31)



So with this we come to the end of this class. So, what did we see in this class we have seen lesions of the cerebrocerebellum and their effect. So, what is the effect delay, poor sequencing and what that means is, under shoots and over shoots, typical of cerebellar disorders ok. And what are the cognitive functions of the cerebrocerebellum, this means perception of timing for example, not just timing of motor activities, but also perception of timing perception of timing, word associations for example and solving puzzles etcetera ok. So, with this we come to the end of this class, in future classes we will discuss the possible role of cerebellum in motor learning.

Thank you very much.