

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

**Lecture - 81
Parietal and Premotor Cortex - Part - 5**

Welcome to this class on Neuroscience of Human Movement. This is part 5 of our discussion on Parietal and Premotor Cortex, right.

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In this class...

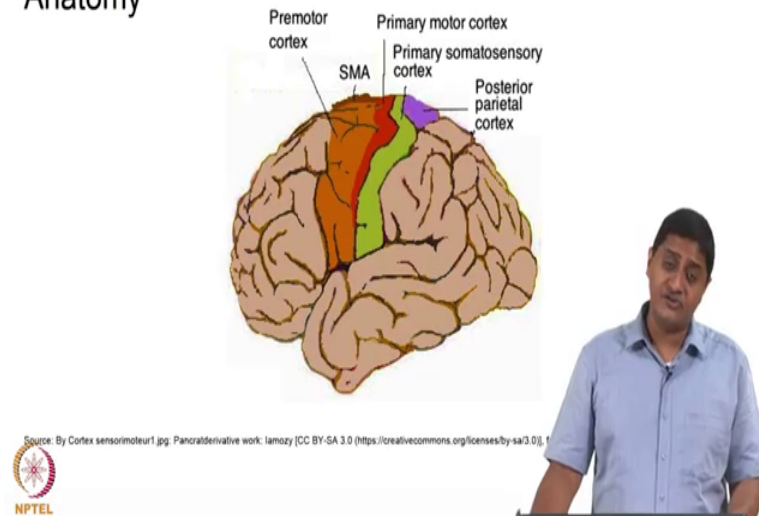
- Supplementary Motor area
- Disorders of supplementary motor area



So, in this class will discuss the critical role the supplementary motor area in motor function, and discuss disorders of the supplementary motor area.

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Anatomy

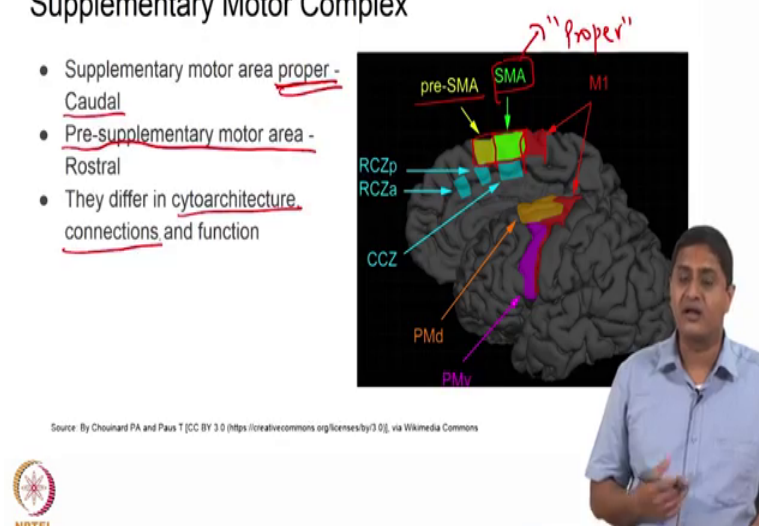


Let us remember where the supplementary motor area is. So, rostral through the central cells is primary motor cortex. Rostral to the primary motor cortex is the supplementary motor area. So, this was classified using the classic studies of Clinton Mulshibroadman and others right. So, remember in good old days it was called as a premotor cortex, then it was called as a supplementary motor cortex.

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Supplementary Motor Complex

- Supplementary motor area proper - Caudal
- Pre-supplementary motor area - Rostral
- They differ in cytoarchitecture, connections and function

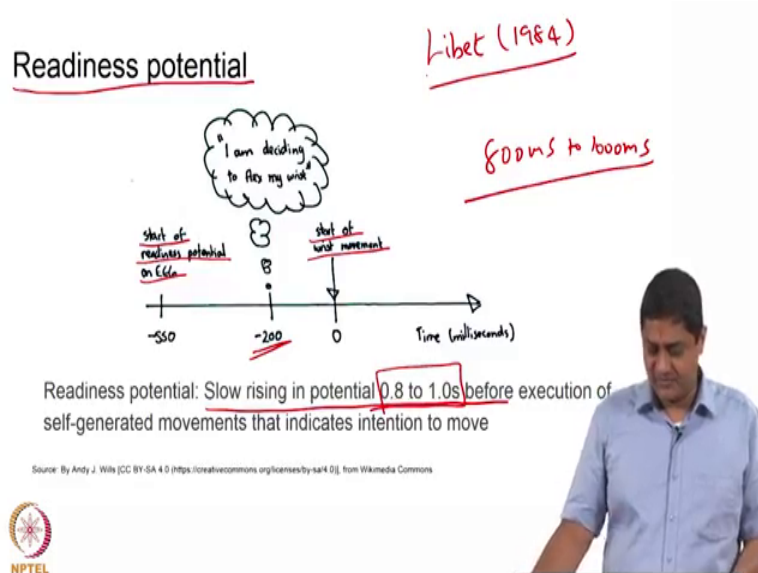


But later on it was divided into 2 regions. So, this is M 1, this is the strip that is just rostral to the central cells precentral (Refer Time: 01:14) right. Rostral to the primary

motor cortex, you have an area that was earlier called supplementary motor cortex, but the cytoarchitecture of this area has at least 2 distinct areas or sub areas within itself. These 2 have come to be called as the SMA proper or the supplementary motor area proper right.

So, within the supplementary motor area, the more caudal of these 2 areas is the supplementary motor area proper, and the more rostral one is called as the pre supplementary motor area or the pre SMA right. Importantly they differ in cytoarchitecture, they differ in connections. So, obviously they also differ in functions right.

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An important concept in understanding moment and moment related functions is a the notion of readiness potential right. If a moment is performed by intention for example, then readiness potential is this potential that is slow in rising at about 0.8 to 1 second before the execution of movements self-generated or self-initiated intentional voluntary movements; 1 second, 1 second is long time in neuronal terms. We have been talking in the order of tens of milli seconds. Remember, when it came to reflexes I said 30 milli second is approximately, the mono synaptic delay 40 50 for oligosynaptic, and polysynaptic about 70 or 80 for the trigger reactions, and above 200 milli seconds is the delay that you get for voluntary action.

But let us remember these discussions are in response to stimuli is it not. So, a stimuli is presented it takes about 200 millisecond for the first voluntary response to appear right. This is in response to stimuli but, suppose there is an intention to act how much in advance is there a preparation that is going on. In that case the preparation can be about 800 milliseconds to 1000 milliseconds in advance. So, start of readiness potential. So, this readiness potential is something that can be easily observed in eg right.

So, the start of the readiness potential happens earlier than 600 milliseconds or 550 milliseconds before the start of the movement 0, here is the start of the movement. But about 200 milliseconds before the start of the movement is when you become actually aware of the movement. Please note these 2 are different, I have already made the decision to make a movement, that is made before 500 milliseconds, but at around 200 milliseconds before the movement is then I think I know, there is a difference between these 2; because it is easy to confuse the 2.

We think we know when the movement is about to start that that you have decided, but you have decided even before you think you have decided. Essentially, the idea that we control our movements, we control our actions that and we are aware of our actions. And it is this awareness that gives us this notion of control is really not such a strong argument really. For example, I have already made the decision to make a movement, but only later I come to know that I have may I have made this decision right.

So, that means, my awareness itself are my denotation that I am controlling my actions itself is being questioned somewhat. This has been challenged this idea has been supported by evidence and important line of evidence in this line of research was provided by Benjamin Libet 1984. Please you check this paper a very interesting philosophical treaties of the idea that we think we know. Please you check those who are interested, please do check this paper, right.

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Features of SMC

- Non detailed map of contralateral side
- SMC does not map to specific area in like hand or legs
- Stimulation of SMA requires high current and produces complex movements
- Readiness potential peaks in SMC
- SMA controls execution of movement in "motor acts" encoded in lateral-parietal and prefrontal circuits.



Also importantly the supplementary motor cortex contains map of the contralateral side of the body; crucial to know the difference between the map that is found in the primary motor cortex, and the map that is found in the supplementary motor cortex. In the primary motor cortex, you have detailed map right. In the supplementary motor cortex what you have is a relatively non detailed map of the contralateral side of the body; so, this is different right. And unlike the primary motor cortex which maps to specific areas such as hand and legs, they are supplementary motor cortex does not map to specific areas such as hand and leg right.

Also the stimulation required to produce the moment in the primary motor cortex is much less than compared with the stimulation, this is not simulation, but rather stimulation, the stimulation that is required to produce a moment through SMA and supplementary motor area. And the movements produced are not necessarily simple movements. The movements produced are complex movements, as you would aspect from higher order control centers such as supplementary motor area.

I am using this term it is a controversial term without the actually providing the evidence to support that idea. But essentially what you would aspect from an area such as supplementary motor area is coordination and control of the higher order aspects of movement. Not necessarily the nitty gritty details of the movements right. And also the readiness potential as it speak in the supplementary motor cortex.

The supplementary motor area, it controls execution of movement in motor acts encoded in lateral parietal and prefrontal circuits right.

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Functions of SMC

- Organisation and execution of movement sequences
- Acquisition of motor skills
- Executive control of behavior:
 - Switch between actions, plans and strategies
 - Suppress previously intended movement
- Contextual control of movement



And what are its functions? What are its functions, right? Importantly organization and execution of movement sequences; let us take a movement and understand what this means. Take dance form bharathnatyam for example, what does this involve? It essentially involves graceful movements right, that is a pleasure to watch. So, it can also be classified.

So, movement travelers like me who are observing Bharatanatyam of course, I do not have the flare or the aptitude for appreciating art probably. But what I do have the aptitude for is to appreciate movements in it is entirety right. So, whatever I see instead of seeing the art, I look at the movements. So, when you see this art form what I see is a set of discrete movements that have been concatenated, that have been attached to one another right. But these discrete movements have not been attached in a discrete fashion, it is not like there is a jerky jump from one discrete movement to another discrete movement; but rather what is happening is, that there is a graceful shift from one movement to another movement.

So, essentially this dance form can be considered to be sequence of movements. And expertise is when you are not able to observe that it is sequence movements, but rather as a whole right. So, essentially when you observe the dance form, if it is in expert who is

performing it, you will not be able to see the discreteness there. What you are seeing is smooth graceful artistic beautiful movements of the person. But these are essentially discrete movements that have been concatenated and smoothen very nicely. It is this practice that gives rise to the smoothing. It is the practice that gives rise to smoothening of these movements (Refer Time: 10:11) not. So, essentially motor performance or any given motor skill can be considered to be a performance of a set of motor sequences right.

So, supplementary motor cortex probably plays an important role in the organization and execution of movement sequences, and acquisition of motor skills just now I was talking about the Bharatanatyam, but this also applies to other art forms may be even sports right. So, essentially motor skills acquisition. So, essentially playing a sport involves performing a set of motor acts in the particular sequence within a particular time, is it not? So, that also is probably crucially dependent on the function of supplementary motor cortex.

And probably some role in executive control behavior such as: switching between actions. Just now I have said that there are different actions in and you want to jump from one action to another, but you do not want it to be a jerky jump. Or suppose depending on the context you want to switch between one action plan to another action plan, is it not? Plans and strategies right and suppose there is a situation in which you have to inhibit yourself. You wanted to do something that you would do in private, but somebody else enter and you do not want to do it; that is, suppression of previously intended movement right.

Suppose you are starting to write and somebody comes into have a chat, you are putting the pen down right, suppression of a previously intended movement for example and importantly contextual control of movement. Compare this with the primary motor cortex which is primarily an execution engine, is it not? Primary motor cortex or M1 is an execution engine. We discuss at length about what it could be encoding right. Is it kinematics? Is it kinetics? Is it muscle function? Etcetera, right, we also discuss what happens during recessions of the motor neurons in the primary motor cortex right.

How does it affect movement function? These are things that we discuss. In this case, in the supplementary motor area case what you have is the contextuality, it is not the

execution engine, but it is something that provides the appropriateness or contextuality to the movement right.

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Lesions of SMA, prefrontal area

Disorders of Initiation

- Akinesia
- Mutism ✓



Disorders of Suppression

- Forced grasping
- Groping movement
- Alien hand syndrome
- Utilisation behavior – Compulsive grabbing without social consideration



Source: <http://elamoresindo1.blogspot.com/2015/03/champu.html>

What happens if there are lesions to the prefrontal area are the supplementary motor area. Essentially, if there is disorders of initiation, this could be akinesia or mutism, the person cannot move the mouth for example, or it could be disorders of suppression right. In this case this could be due to forced grasping, groping movement. So, you are seeing an object you know that it is somebody else's object, but you pick it up. Sometimes even when it is socially inappropriate to do, let say that somebody's pen is kept on his table and you go there, but you have this habit of picking up pens wherever you see it.

Say for example, then what happens is the even though you know even though everybody knows that it is socially inappropriate to take someone's pen and put it your pocket, turns out that some of these individuals who have lesions to the supplementary motor area will actually do this in a compulsive manner, right, compulsive grabbing without social consideration. And sometimes these individuals actually do not have control of their arm or hand, this is called as a alien hand syndrome.

Of course this results in a tremendous amount of embarrassment and difficulties for these individuals is it not. So, when you grab something without your own control right it could put you in very big trouble from time to time, is it not? So, for example, if you are picking up a meal from somebody's plate. Somebody is eating, and you go there you see

a nice eatable on tray, and you just pick up bite. It does not exactly look good right it; so, it does give them tremendous amount of embarrassment and difficulty right.

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Summary

- SMC is situated anterior to PMC
- SMC is responsible for executive and contextual control of behavior
- Lesions of SMC results in difficulties for movement initiation and suppression .



So, in summary the supplementary motor area is located at area to the; supplementary motor area is divided into the proper supplementary motor area, SMA proper and the pre supplementary motor area or the pre SMA. The supplementary motor cortex is responsible for executive and contextual control of behavior right. And lesions of the supplementary motor cortex results in difficulty of movement initiation and movement suppression; sometimes leading to very embarrassing or difficult situation for people who have this problem ok. So, with this we come to the end of this lecture.

Thank you very much for your attention.