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

Lecture – 30
Oligosynaptic and Polysynaptic Reflexes Part 1

So, welcome to this class on Oligosynaptic and Polysynaptic reflexes. So, what is oligosynaptic reflex the reflex that involves more than one synapse and so that means, it could be 2 or 3. Polysynaptic involves many more than three. So, what are these and how do those how are those different from monosynaptic reflexes.

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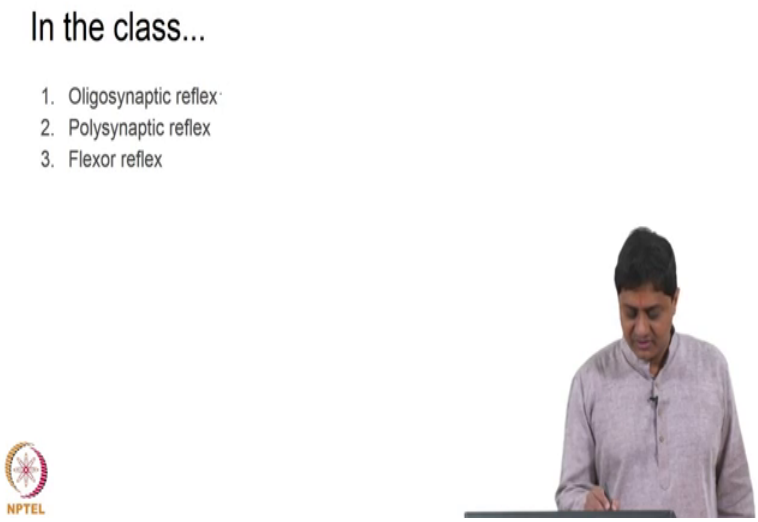

So, in this class we will talk about three things oligosynaptic reflexes we have a couple of examples. We have discuss, some of this earlier. Polysynaptic reflexes we will have a think one or two examples for this also I think. Then flexor reflex or the flexor withdrawal reflex that was mentioned in one of the earlier classes will be discussed in some detail here.

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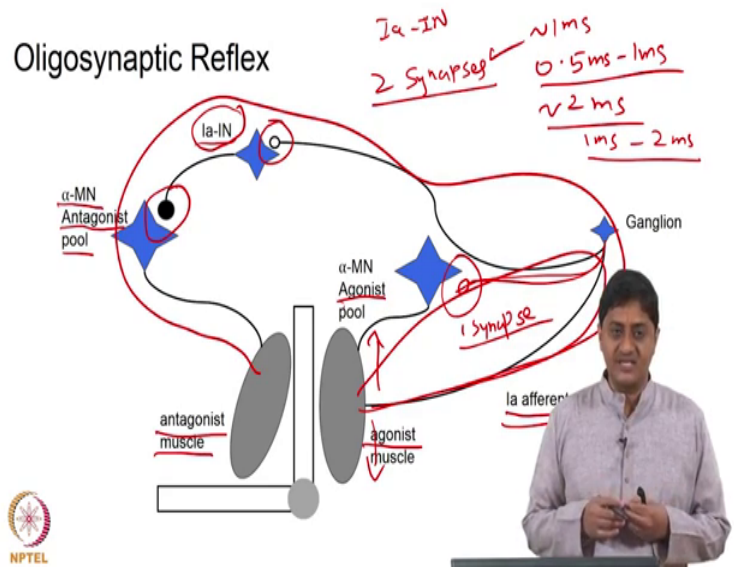

So, the classic example of the oligosynaptic reflex is reflex involving the one a interneuron one a interneuron. As remind ourselves what is the case this muscle is stretching, if thus this muscle is stretching, then the one a afferent gives command not shown in this picture is that it activates a alpha motor neuron of the same muscle. So, it will contract that is one form of negative feedback.

But this is a monosynaptic loop this involves only one synapse one synapse right. This is a monosynaptic loop that we have discussed in the previous classes. But what this one a afferent also does is that it excites a one a interneuron, which inhibits the alpha motor neuron of the antagonist muscle. So, this is the antagonist muscles alpha motor neuron why does this do that?

Because this stretching may be due to the contraction of the antagonist; stretching of the agonist stretching of this muscle may be due to the contraction of this muscle. It is also possible that it could be due to other reasons, but at least this negative feedback ensures that if there is a need for that muscle to contract. The probability that it will contract will be relatively low in future not in the nearest future for the next few tens of milliseconds or hundreds of milliseconds.

So, this involves one synapse here and one synapse there this involves two synapses that not we have seen this earlier. So, what does this do? This is inhibition of the antagonist

muscle alpha motor neurons during stretching of the agonist. This is performed mediated by 1 a interneuron or one a afferents serve as the sensor.

So, this is the sensor and this is the interneuron that is causing this reflex ok. How do we know that this is an oligosynaptic reflex how do you know that this is actually involving more than one synapse? So, what actually is done is the difference between say that monosynaptic loop and that oligosynaptic loop is actually of the order of one millisecond it is actually between 0.5 milliseconds to 1 milliseconds. Since we know are slightly this way or the slightly this is or more. Since we know that the synaptic delay due to neurotransmitters can be between 0.5 and one millisecond. We know that there is just one more synapse that is involved.

If there were two more synapses that were involved, then the delay will be higher way about anywhere between most precisely between one millisecond and two millisecond. So, this is how we know that this involves two synapses through classic neurophysiological methods.

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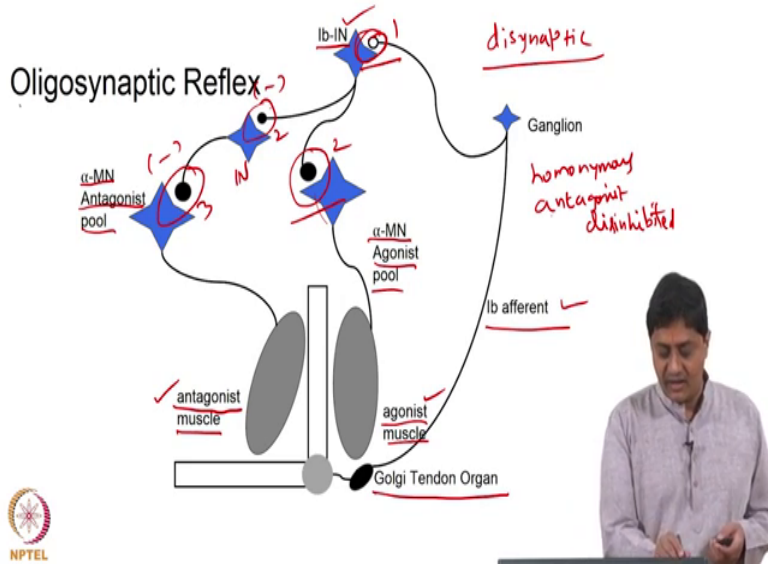

The case of the 1 b afferent, what happens in this case is the muscle say the agonist muscle is contracting.

When the agonist muscle is contracting the Golgi Tendon organ starts firing that is the 1 b afferent. Now what would be an appropriate negative feedback for that? So, if the

muscle is contracting we should reduce the amount of contraction, but let us remember that all the proprioceptive neurons are excitatory by default. So, this 1 b afferent excites a different neuron and interneuron, which inhibits the alpha motor neuronal pool of the same muscle.

So, this is again a disynaptic or involvement of two synapse. In the previous case we saw the monosynaptic case if the stretching is there for it for the muscle to contract I can excite that alpha motor neuron that is happening monosynaptically, but if the muscle is contracting for it to contract less or reduce the amount of contraction or balance the amount of contraction, I have to inhibit that that cannot happen through one synapse, but rather with the it happens with the help of two synapses.

Now so, it inhibits the alpha motor neuron of the same muscle; but what it also does is it inhibits the inter neurons it inhibits the inter neurons which inhibit the alpha motor neuron of the antagonist. Another layer of negative feedback now, what does this do? Every time this Golgi Tendon organ fires or if this muscle is contracting, in a way it is disinhibiting the antagonist pool are is also slightly increasing the probability that the antagonist pool will be excited ok. So, this is inhibition. So, this is one minus and this is another minus. So, that becomes plus at least at least figuratively.

We could say that it increases a probability that this alpha motor neuron will get excited. So that means, the force then that is produced by this antagonist will be in a position to balance the force produced by this agonist, so that is the other way. So, there are two things that the 1 b interneuron does, it inhibits the same muscle homonymous muscle and it disinhibits the antagonist or heteronymous we will just say antagonist.

So, it is not confusing antagonist is disinhibitor this again involves how many loops we said how many synapses? This disininhibition involves one, two, and three synapses whereas, inhibition of the same alpha motor neuronal pool involves one and two synapses.

So, this is again another example of an oligosynaptic reflex ok.

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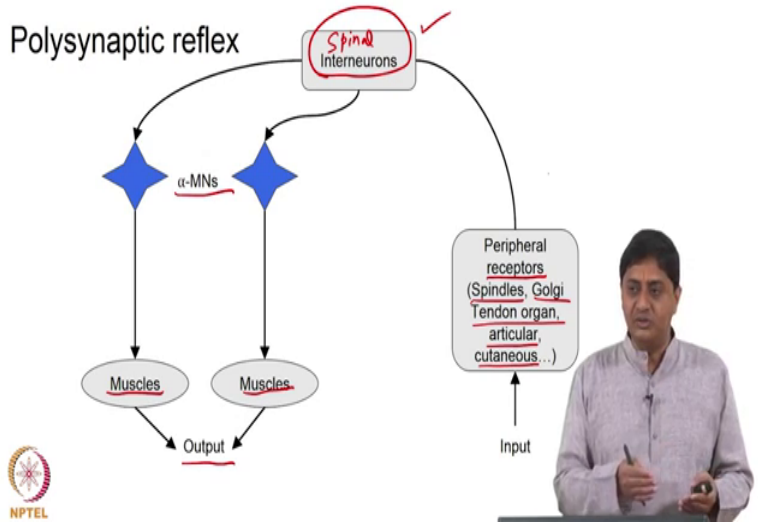

Now what happens in the case of polysynaptic reflexes? Now what happens is that sensory information from receptors actually this could be any number spindles Golgi Tendon organs, articular receptors, cutaneous receptors you know so many of these, too many of these send information to inter neurons in the inter neurons in the spinal card I am just calling them spinal inter neurons.

And depending on the situation, it could excite different muscles or alpha motor neurons of different muscles producing and output. In the previous cases we were able to describe the input output relationships with relative is. In this case its way more difficult to do that because it is not clear what these things do. And actually the picture that is presented in the spinal card is a mess it appears like that or at least when examine that.

It appears like it is a complete mess there is whole network of interneuron that connecting various different ways. Let us remember that is provided for the way purpose of flexibility, and that also reminds us of the limit of the classical neurophysiological approach what is the classical neurophysiological approach? That is this right we excite one for example, we excite this one a afferent and study its effect on the other cases on the case of you know that alpha motor neuronal pool, that alpha motor neuronal pool, that muscle that muscle all those things we study right. But that stops after about two three synapses after that, it becomes you know it becomes like a black box. So, I am going to call this as spinal inter neurons they do something that is depending.

So, and also; that means, that the response is going to be less and less stereotypical. As you travel from monosynaptic to dye synaptic to tri synaptic to polysynaptic right the response becomes less stereotypical and more flexible. And the circuitry neural circuitry that is involved becomes from goes from simple to more and more complicated ok. So, at approximately here the classical neurophysiological approach you know reaches its limits.

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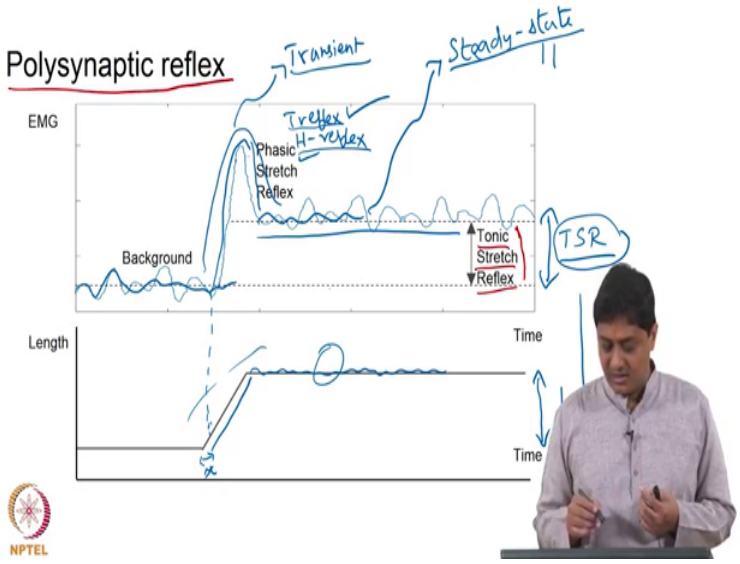

And a classic example of polysynaptic reflex is the tonic stretch reflex is this; now what is this? Let us remember ourselves suppose a muscle is having a background EMG level which is suppose a muscle is having that amount of background EMG level this is the background EMG level of the muscle, some nonzero activity.

And then that muscle is stretched its length is you know increased. If that happens there is going to be an immediate response. So, we will have to see that time. So, the stretch is starts with a very small delay with that delta t there is going to be a response, that response we have called it earlier this is a monosynaptic response we call this earlier variedly as T reflex for mechanical stimuli and H reflex for electrical stimuli.

This is the monosynaptic classic monosynaptic reflex. It is given a different name, it is given phasic stretch reflex phasic stretch reflex. We will talk about what this means in a bit. Now and then it settles and then the length has settled at a new level right here. Now

what happens the response does not go back to here that does not happen this does not happen. What happens is that the response settles around here.

But there is a difference in the previous background response versus the current response depending on the length. This difference is due to what is called as a tonic stretch reflex. This involves not a monosynaptic pathway, but rather a polysynaptic pathway involving several inter neurons and let us remember the so that means what? That means tonic stretch reflex is the response of the system to a level change, the level of the muscle length has changed from one length to another length.

For that the response so, if that is the level change that is the response. If the level change was that much the response will be that for example, the response could be that much in the level change was this much then the response could be this much. So, the level changes the tonic stretch reflex response will change. So, this is not exactly stereotypical this becomes. I told you earlier that this becomes less and less stereotypical and more and more flexible, but not just that there is more. Let us remember that this on the other hand is a phasic phenomenon is it not? This is the monosynaptic response the T reflex h reflex is a monosynaptic response, which we call as the phasic stretch reflex engineers would call this as this response is transient whereas this response is steady state is it not?.

This is what we would call this is what engineers would call this is. A response that is you know transient that is going to last for a brief amount of time in to a stimulus. So, in response to a stimulus that is going to last for a brief amount of time, but the steady state is due to other things due to the level change etcetera. So, approximately this can be called as a transient response. And this can be called as a steady state response transient response is in this case H reflex or T reflex or a monosynaptic reflex or phasic stretch reflex; whereas, steady state response is the tonic stretch reflex, which is response to a level of the stimulus ok.

So, it turns out that the characteristic of the tonic stretch reflex could have important consequences for movement generation. How does this vary we will talk about that in the next few lecture maybe in the next class. Another case of a polysynaptic reflex is the flexor reflex.

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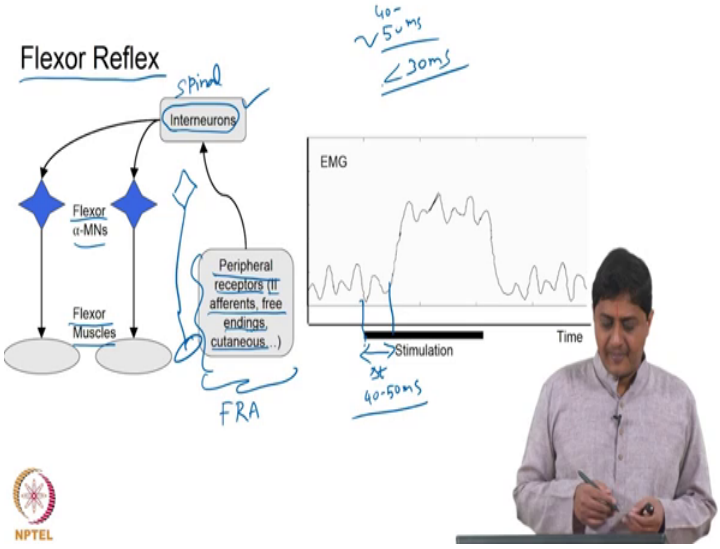

So, suppose several receptors are there these receptors since a danger to the limbs right. So, these are two afferents free afferent free nerve endings cutaneous afferents together all these things I am going to call all these things together as flexor reflex afferents FRA ok. Flexor Reflex Afferents these they all send information about potentially dangerous stimuli to the spinal cord.

So, there are inter neurons in the spinal cord. So, this is a spinal inter neurons. These inter neurons then react in such a way to cause flexion are withdrawal from the painful stimulus we discussed this earlier right in the pre in yesterday's class in the previous class that, if this is a nail and you know a person is touching the or if it is a hard body and the person touching that is withdrawal that is not exactly a monosynaptic response, but rather a polysynaptic response it in.

So, it could happen. So, what could be the delay that could it could be approximately 40 to 50 milliseconds whereas, the monosynaptic response is you know usually below 30 milliseconds. Characteristic right if the response is below 30 milliseconds, you can be sure approximately sure can be almost sure that this is monosynaptic reflex it is above 40 50, then you are talking about a polysynaptic response. So, and the response is also tuned to the properties of the stimulus. More danger this could happen in more number of muscles. So, if the stimulus is perceived as more dangerous, than more muscles are more stronger alpha motor neuronal activation of the flexors will happen.

In such a way that the withdrawal can involve multiple limbs multiple segments of the body. That means, that there is going to be coordination of multiple muscles, because it you know the muscles that perform flexion extension of the wrist versus flexion extension of the elbow. And the flexion extension of the shoulder are different yet they all coordinate together to withdraw from the painful stimulus.

So that means, there must be coordination between alpha motor neurons that send commands to all these three muscles. And they all are controlled or given the command at approximately the same time by these spinal inter neurons right. Now let us say that the stimulation is happening at approximately that time right and the response starts the approximately that time you know that is the delay.

This delta t is what I said is about 40 to 50 may change depending on a case two case three cases example typically this is what happens. Now what also happens is the case of crossed extension reflex and other things which we will discuss in future classes.

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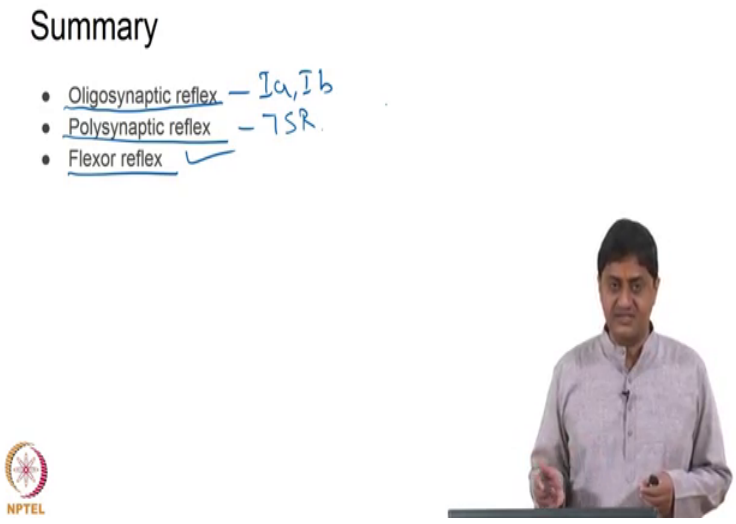

So, far in this class; so what we have seen so far is the oligosynaptic reflex which is a 1 a, 1 b etcetera polysynaptic reflex this is the tonic stretch reflex, flexor reflex and another example of the polysynaptic reflex is the flexor reflex.

So, with this we come to the end of this class. We will discuss the other cases in the future classes.

Thank you.