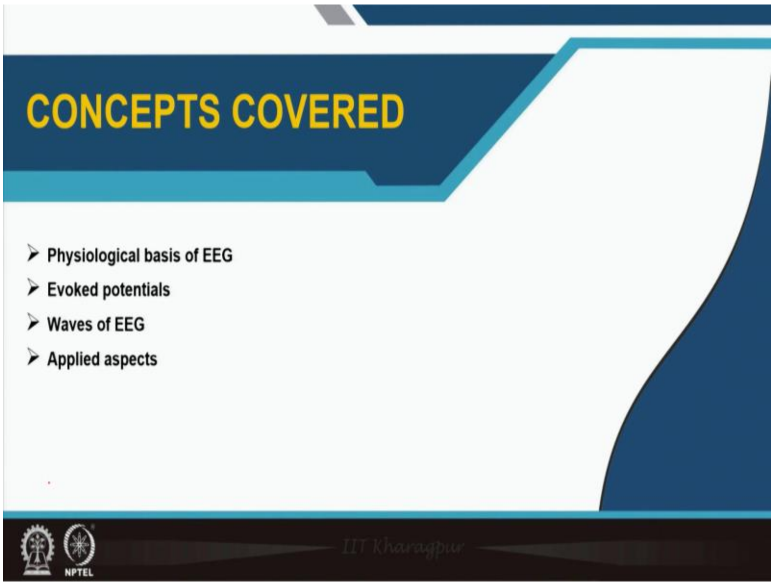
Basics of Mental Health & Clinical Psychiatry
Professor Doctor Arijita Banerjee
Doctor B. C. Roy Multi-Speciality Medical Research Centre
Indian Institute of Technology, Kharagpur
Lecture 11
Electrical Activity of Brain

(Refer Slide Time: 00:30)

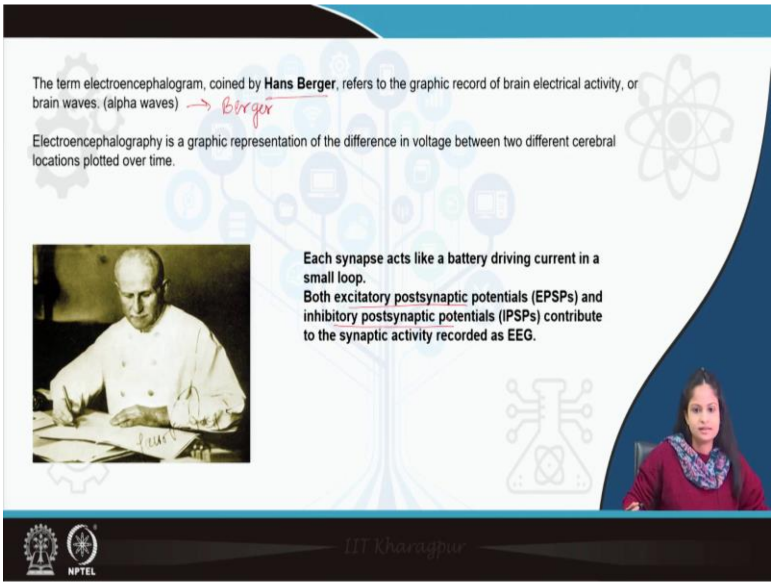
Hello everyone. So today we will start our next lecture that is electrical activity of brain.

(Refer Slide Time: 00:32)



What are the concepts we will cover? We will cover physiological basis of EEG. That is electroencephalography evoked potentials, various waves of EEG and applied aspects.

(Refer Slide Time: 00:46)

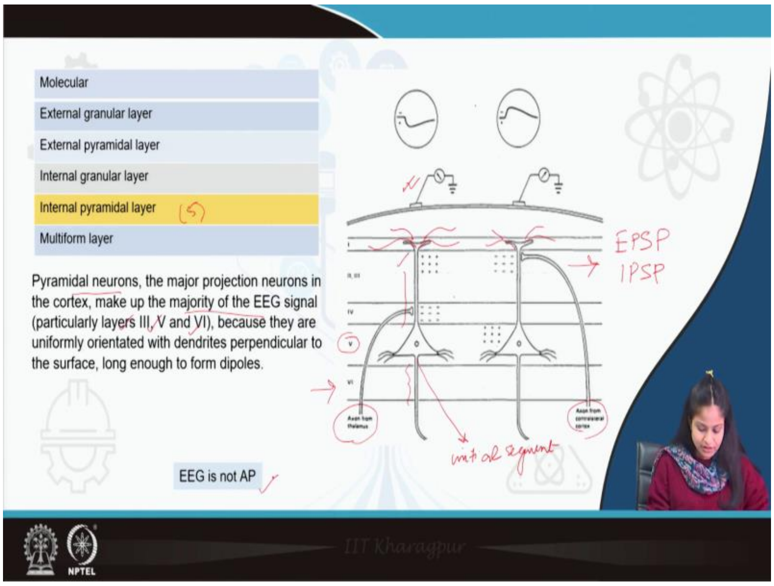


Now the term electroencephalogram is coined by Hans Berger. Now when he discovered this electroencephalograph he actually referred to the alpha waves. So that is why the alpha waves which we get they are also known as known as Berger or Berger waves. So, we call this alpha waves also as Berger waves. Now electric, what do we what do we understand by electroencephalography? Electroencephalography is a graphic representation of the difference in voltage between two different cerebral locations plotted over time. The most important thing we have to remember is electroencephalography is not action potential.

We might confuse electroencephalography with electromyography or electrocardiography because in electrocardiography, we say this is that is the submitted action potentials and in electroencephalography also, we are telling it is the electrical activity of brain, but though we are telling it as electrical activity of brain, it is not capturing the action potentials, then what it is capturing, it is capturing the dendritic potentials or the local potentials.

Now, each synapses acts like a battery driving current in a small loop, both excitatory post synaptic potentials, and inhibitory postsynaptic potentials, they contribute to the synaptic activity in the EEG.

(Refer Slide Time: 02:23)



So, we will see how it happens. Now, as it has been said in previous lecture, cerebral cortex has got histologically six layers and the most abundant number of cells present over there are the pyramidal cells. So, mainly from the fifth layer. So, this is the fifth layer of the cerebral cortex, there we have giant pyramidal cells. So, the from the giant pyramidal cells, so, this is the diagram.

So, this is the giant pyramidal cells present in the fifth layer. There are pyramidal cells also present in our other layers also, but for convenience, we are now taking the fifth layer pyramidal cells. So, pyramidal cell layer this is the axon and these are the dendrites. So, it is getting inputs from the axons from the thalamus it is getting also inputs from the other part of the cortex.

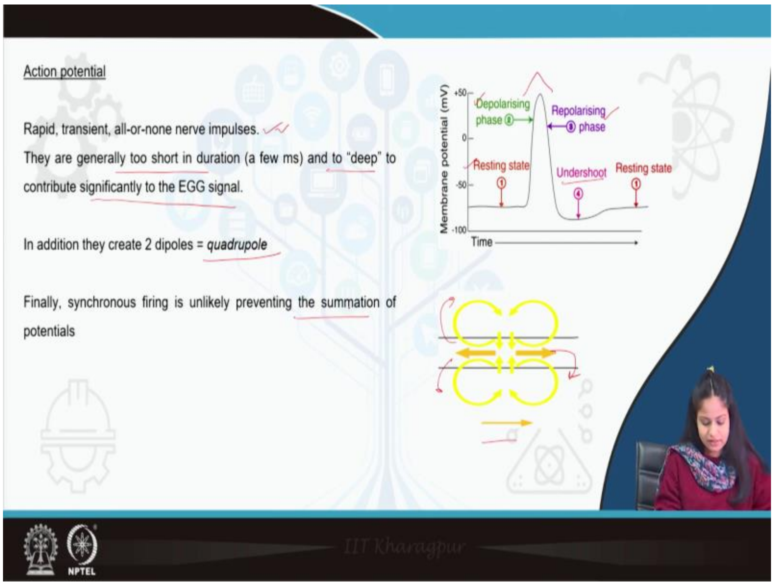
Now, action potential initiation is always at the initial segment of the axon this has been said in previous lecture initial segment of the axon that gives rise to action potential. That is the axon hillock because more number of sodium ion channels are present over there, but you can see the electroencephalography how we record we place the electrode over our scalp, we are not placing the electrode inside it is not an invasive procedure.

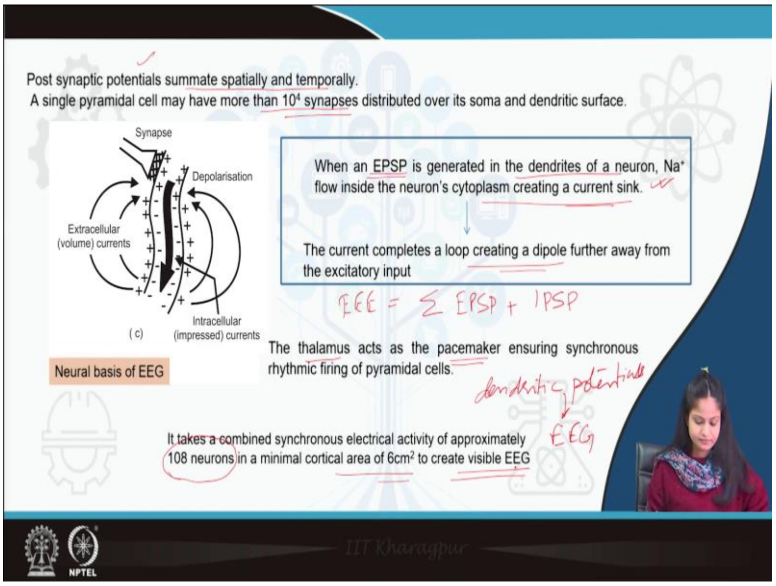
So, we are placing the electrode over the scalp that means, we are recording from the surface. So, action potential is deep inside the fifth layer and the electrode is present in the surface. So, this is the electrode which is present on the surface. So, it cannot take the action that electrode is not able to take that action potential from the initial segment of the exam, but because it is located very deep. So, since it is located very deep, what potentials it will take, it will take the dendrite potential, so, these are the dendrites, which are causing multiple synapses over here. So, these are the dendrites, these are causing multiple synapse over here.

Now, there will be synapses, which are causing post synaptic potentials that means, dendrites will cause the local potentials, because of this local potentials, there can be EPSP that means excitatory post synaptic potentials, there can be inhibitory post synaptic potentials of course, they are because multiple synapses are forming because of various dendrites.

So, there is always excitation and there are some inhibitory synapses also. So, electroencephalography is actually the average of the summation of all the excitatory post synaptic potentials and the inhibitory postsynaptic potentials. So, pyramidal neurons, this is the major projection neurons in the cortex, they make up the majority of the EEG signals, particularly third, fifth and sixth layer, because they are uniformly oriented long and the dendrites perpendicular to the surface long enough to form dipoles. So, as you can see, the day million synapses are forming because of millions of dendrites, they are giving rise to dendritic's potentials or the local potential so, that is why EEG is not action potential you have to remember.

(Refer Slide Time: 05:50)





Action potential on the other hand is usually transient. As you can see in this diagram, there is a resting stage there is a deeper rising phase there is a depolarizing phase, this depolarizing and repolarizing phase causes the spike potential, there is an hyperpolarization or undershoot so your this is a rapid transient, all it follows all or none impulse, they are generally for last for too short in duration, and too deep to contribute to the EEG signal.

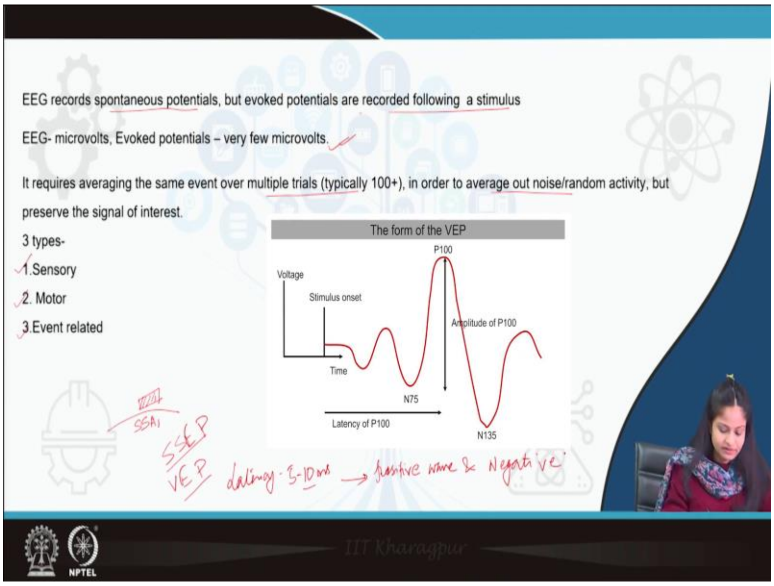
In addition, they create two dipoles over here you can see they are creating one dipole over here, the this portion dipole on this portion dipole, so they are creating actually do two pairs of dipole that is quadrupole. So finally, the synchronous activity which goes on the spontaneous activity which goes on in our brain that prevents the summation of the potentials.

So that is why the EEG is actually the summation of the local potentials or the dendritic potentials. Now, post synaptic potentials, it can be excitatory to be or inhibitory the summation is spatially or temporally, both types of summation occurs it has been saved that a single pyramidal cell it can have more than 10 to the power 4 synapses, as I told you, millions of synapses will be there.

Now, when an excitatory post synaptic potential is generated in the dendrites, what will happen there will be sodium ion influx, I am talking about excitatory post synaptic that means obviously, cations will enter the neuron. So, sodium flow in the neuron cytoplasm will create a current sink, the current completes a loop creating a dipole and further away from the excitatory input. So, because of this, mainly the dendrite potentials because of the dendrite potentials, we get EEG various waves, so we can tell EEG is nothing but the summation of EPSP and IPSP the local potentials not the action potentials.

Now, thalamus over here, it acts as a pacemaker the synchronous spontaneous activity the firing of the neurons is because of the thalamus, and it has been seen in a research that there has to be at least 108 neurons with a minimum cortical area of 6-centimeter square to produce a visible electroencephalographic recording to produce a visible EEG recording there has to be 108 neurons and 6-centimeter square cortical surface area.

(Refer Slide Time: 08:42)



Now, this is all about your EEG, EEG records spontaneous potentials, as told, evoked potentials are mainly the potentials which occurs after a stimulus is given. So, these are the recording which is recorded following a stimulus and the other main differences in EEG also we get the recording in microvolts, but in case of evoked potentials, it is very very few microvolts.

Now, it requires averaging the same event over multiple trials, in order to average out noise or random activity we use filter for that. And there are three types of evoked potentials we get based on the type of stimulus for example, sensory evoked potential, motor evoked potential and event related evoked potential.

Now sensory evoked potential means suppose, I am stimulating a nerve over here, how the nerves are getting stimulated. Obviously, I have the peripheral receptors present over here. So, the peripheral receptors will get stimulated. Suppose I am itching or I am rubbing. I want to see what activity is happening on my sensory cortex or sensory area when I am rubbing the surface.

So, if you were to ask me that whether you can record this activity. Yes, we can record this activity, we have to place the electrode just above the sensory area. Suppose this is the sensory area number 1 sensory, somatosensory area 3 1 2 area. So, suppose the sensory area number 1, if we just place the electrode above this sensory area number 1, and then we give a stimulus, suppose I am giving a stimulus over here or suppose I am stimulating the nerve over here or the peripheral receptors, then we can record this activity that has sensory somatosensory evoked potential.

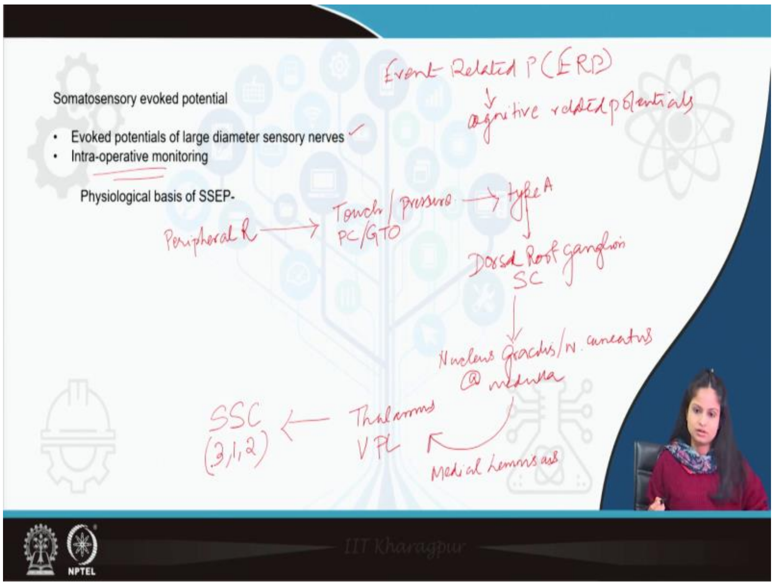
Now, here we are giving the stimulus indicate other stimulus we can give like any visual stimulus, if we give visual stimulus, it will be visual evoked potential, others somatosensory evoked potential, other we have the auditory evoked potentials if we give auditory stimulus, suppose we are giving a click sound, and then we want to check for the evoked potentials the activity in the brain.

So, all these are evoked potentials based on a stimulus. Now, whenever we are giving a stimulus, there has to be some latent period, as it is shown in the diagram, there has to be a latent period, normally this latency or latent period is of five to 5 milliseconds in case of evoked potential, this does not happen in case of EEG, because EEG is a spontaneous activity.

So, there is no latency and here in evoked potentials, we are giving a stimulus. So, when we give a stimulus and then there will be the recording the started the action will be started. So, there that gap is the latent period that latency is usually 5 to 10 milliseconds in case of evoked potential and which is usually followed by a positive wave and negative wave. So, as shown in the diagram, there has to be a positive way and a negative way.

Similarly, we have motor evoked potentials, if we deep stimulus is given to the muscles and we want to check the activity then we get motor evoked potentials, then we have event related evoked potentials.

(Refer Slide Time: 12:22)



Event related evoked potentials are mainly cognitive evoked potentials. So, event related, mainly, it is in short form, we call it as ERP, these are usually also known as cognitive related potentials. These are mainly related to higher functions on when the person has to differentiate one stimulus from the other stimulus. So, somatosensory evoked potentials evoked potentials are usually of large diameter sensory nerves. And this evoked potentials are mainly what are the applied aspects by be used such evoked potentials.

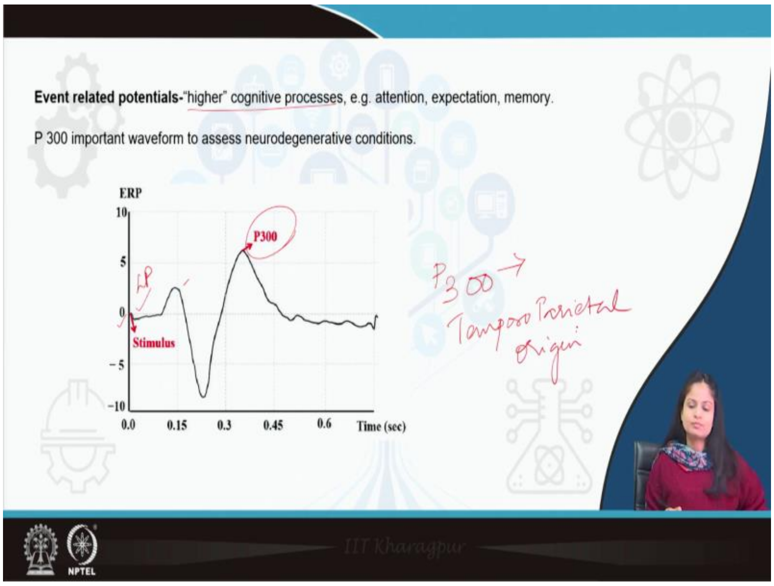
This is mainly done for the intraoperative neuro monitoring, so intraoperative neuro monitoring, we do this evoked potentials. Now, physiological basis of somatosensory evoked potential is nothing but the sensory pathway, we will anyway be going through the sensory pathways in the further lectures, but still I would tell you suppose the peripheral receptors are there, like the peripheral receptors over here, it is present various types of receptors are present on the skin, there are touch receptors, tactile receptors, special receptors, various receptors are present. So, peripheral receptors are present.

So, when peripheral receptors are present, this peripheral receptors, suppose, they are touch receptors or pressure receptors, those can be Pacinian, corpuscles or Golgi tendon organs, these are present on the joint capsules, joint muscles and tendons. So, whenever this peripheral receptors, these are stimulated, they carry the sensation with the help of type a fiber to the dorsal root ganglion of the spinal cord. Dorsal root ganglion or the spinal cord with the help of type A fibers.

Now, from the dorsal root ganglion, this sensation will be carried at the level of medulla via nucleus grassless or nucleus cuneate us it depends from where it is coming whether it is coming from upper limb or lower limb, this is at the level of medulla. Now, from here, this sensations will be carried to the level of thalamus with the help of medial meniscus tract, thalamus to which nucleus, mainly be VPL. And from thalamus through thalamocortical radiations, it will finally move to the somatosensory area or the somatosensory cortex area number 3 1 and 2.

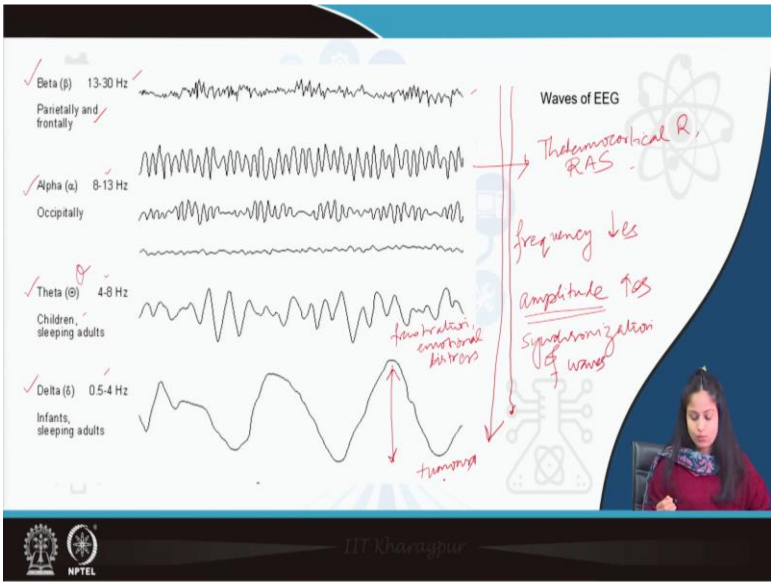
So, since you can see the signals is moving from the peripheral receptors to the somatosensory cortex. So, this is what we are recording basically from the evoked potentials. So, evoked potentials, this is all about you have to remember it is very important for the neuro intraoperative monitoring.

(Refer Slide Time: 15:51)



Now, coming to the this is event related potentials, which I already discussed about which tells us about the higher cognitive processes and very important thing is P300 is a very important waveform in case of event related potential to measure the neurodegenerative conditions, this P300. As you can see, there is a positive wave and a negative wave followed by, proceeding there is a latency period this is a stimulus is a latent period and there is a negative wave and there is a positive wave this is event related potential this is nothing but another evoked potentials of higher function this P300 is usually seen from temporo parietal origin, the origin, temporal parietal origin usually P300.

(Refer Slide Time: 16:41)



Now, after this let us talk about the waves of various EEG in in electroencephalography what are the waves we see. Normally we get, you have to remember the four waves, b for beta, a that is alpha, then theta then delta very easy to remember beta alpha theta delta. So, these four waves you have to remember which we mainly get in EEG or electroencephalography.

Now, once you see this beta alpha theta and delta the waves from up to down you can see the frequency of this waves decreases frequency of the waves decreases means, the frequency means number of waves you are getting per second you can see in the beta waves you get a number with too many of waves okay you cannot even count the alpha waves little bit you can count then theta waves you can count and delta waves you can very nicely count so, the frequency decreases when we go down from beta to delta.

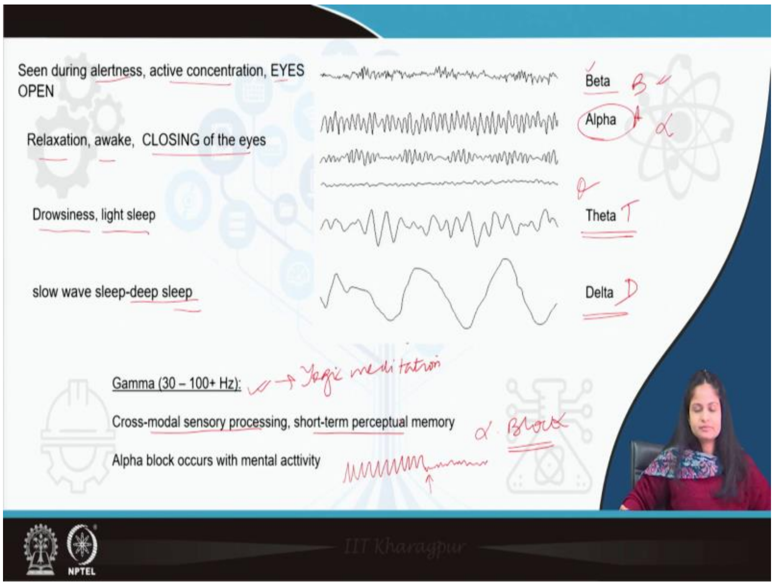
The another one thing is the amplitude. The amplitude increases when we go down from beta to delta amplitude of the wave increases when we go from beta to delta you can see the beta frequency is around 20 to 30 hertz then alpha 8 to 13 hertz, theta 4 to 8 hertz and again very less delta point 5 to 4 hertz so, frequency decreasing amplitude what you are seeing amplitude you can see the delta waves amplitude I mean the wavelength you can see this amplitude is quite larger quite high in case of delta waves, but you can see you hardly you could make out the amplitude in case of beta waves.

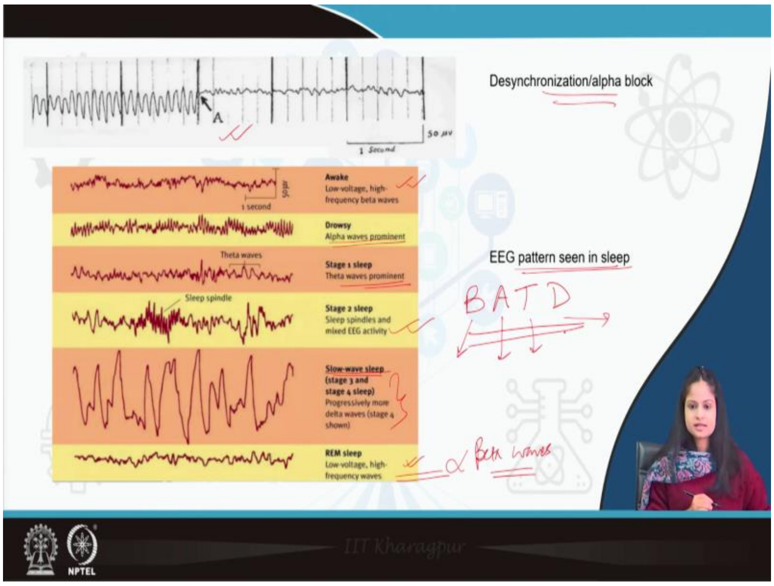
So, frequency usually tells how much your brain is active, the more your brain is active the more will number of waves you will get per second that means the frequency will increase. And amplitude usually tells about the synchronization or the voltage of the waves that is synchronization of waves. So, you will get in volts that is around 200 microvolts you will get in case of delta waves whereas, very less than 50 microvolt you will get in case of beta waves. So, this is frequency and amplitude. The next thing is the origin.

Now, the beta waves are usually seen in case of fronto parietal region the origin is usually fronto parietal origin, the alpha waves are mainly seen in the occipital region. Besides very important origin of alpha waves is thalamo cortical column or cortical region or reticular formation or reticular activating system in previous lecture, I had already told you the reticular formation and reticular activating system is the system which keeps us awake or it is very important for arousal.

So, alpha waves are seen occipitally or thalamocortical region or reticular activating system theta waves you can see, this is usually seen in children or this is seen in sleeping adults, even delta waves are also seen in sleeping adults. Now, this theta waves are also seen whenever a person is having frustration, or emotional disturbances, wherever the person is having frustration, you are not you have not done well in exams, so you are frustrated, you are not getting your rank. So, frustration or emotional distress use get theta waves and delta waves is usually seen in deep sleep, but it is also seen in pathological conditions like that of tumor. In case of brain tumors and also certain behavioral disorders, we get delta waves.

(Refer Slide Time: 21:02)





Besides this, what are the changes of ECG we see during sleep that we have to know for example, the first we will talk about beta waves. Now, it is very easy to remember be used stick the first letter B, A, T and D, B A T D, bat dance that in, that way you can remember so, the beta waves are mainly seen whenever you are alert, the person is alert active concentration eyes are open.

Suppose you have gone to the examination center you are well prepared with the you can see the question paper and you are ready for answering the questions you are very much alert you are very much awake and you, your eyes are open. So, at that point of time, if I measure your electrical activity of the brain, I will get beta waves. Now, the next scenario is suppose you want to recollect some question answer you are not able to recollect what we do. Sometimes we close our eyes and we try to relax, then we could perhaps we could remember the answer of the question.

So, when you close your eyes, but you are not asleep, you are just relaxing, relaxation, awake, closing of the eyes, you are closing your eyes, you are relaxing yourselves, but you are awake, that that time we get alpha waves. So, alpha waves and beta waves. Now, if you are not able to answer the questions, if your exams is going very boring, you are not able to answer any questions, what do you do, after some time you will feel drowsy, because it is based off giving the exam anyway you know the result. So, you will feel drowsy.

And then after some time you will go into enter the light sleep sometimes you get sleepy also. So, when you are getting drowsy and you are entering into light sleep, at that time we get theta waves. And after that, if a person is going into deep sleep, at that time deep sleep is also known as slow wave sleep. Why it is called slow wave sleep? We will discuss in the philosophy of sleep chapter. So deep sleep the person is going into deep sleep you will be get delta waves. So, these are the four waves which are very important in case of sleep physiologic also.

So, when a person is very easy to remember, I am very much alert. I am very much concentrated, I am awake, and I am opening my eyes. So, I am getting beta waves. Suppose I am relaxing, and I am closing my eyes. But I am not asleep, I am awake, I will get alpha waves. Suppose I am very much drowsy and I am entering and feeling sleepy, I will get theta waves. And when I am actually sleeping very much, I am still going into deep sleep and deep or delta so I will get delta waves. Now, very important thing is suppose I am relaxing and closing my eyes. I am not asleep.

Obviously, I will get alpha beeps during that time if somebody suddenly makes a sound or awakens me because of any sensory stimulation. So, suppose someone clap their hands. So what will happen I will immediately open my eyes. So, at that time what will happen? You are getting alpha waves alpha waves, alpha waves when your eyes are closed and you are relaxing. Suddenly you give a sensory stimulus over here and you open your eyes. The moment you open your eyes, there will be beta waves. So, this is known as desynchronization or alpha block. Because you are blocking the alpha waves and the brain. The brain is showing the beta waves activity.

Besides this we get gamma waves also gamma waves. It's mainly ranging between the hertz of 32, 80 to 3200 Hertz. And this is mainly seen in case of yogic person those who do yogic meditation, not me and you doing meditation in yogic meditation, where there is more binding of neurons require with yogic meditation, cross modal sensory processing and short term perceptual memory in case of this scenarios, we gave gamma waves.

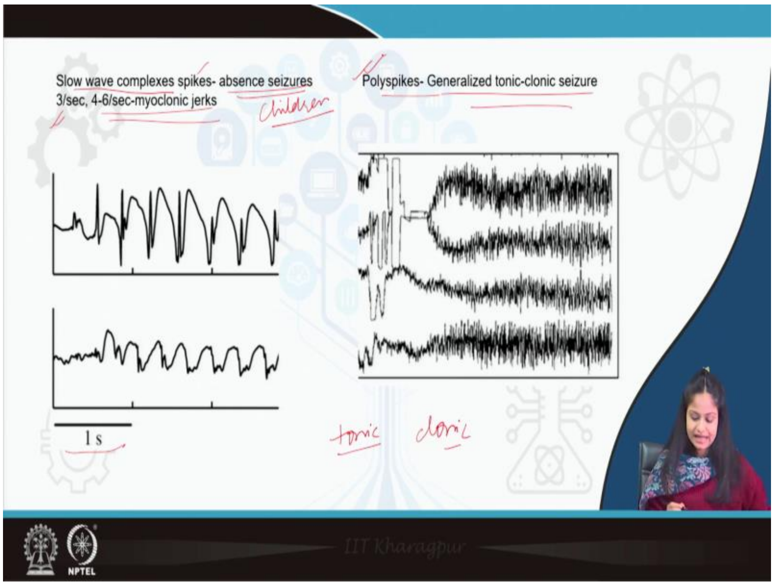
Alpha blockers with mental activity as I told you, I am relaxing and closing my eyes and suddenly I get a sensory stimulation, I will open my eyes. So, at that time, what happens is the alpha blocker desynchronizations. This is nothing but the EEG pattern which is seen in sleep, initially the person is awake, you can see the low voltage when the person is awake as I told you will get the low voltage high frequency beta waves, then the person is getting drowsy the when the person is getting drowsy means when the person is relaxing the stage the person is relaxing we get alpha waves prominent actually.

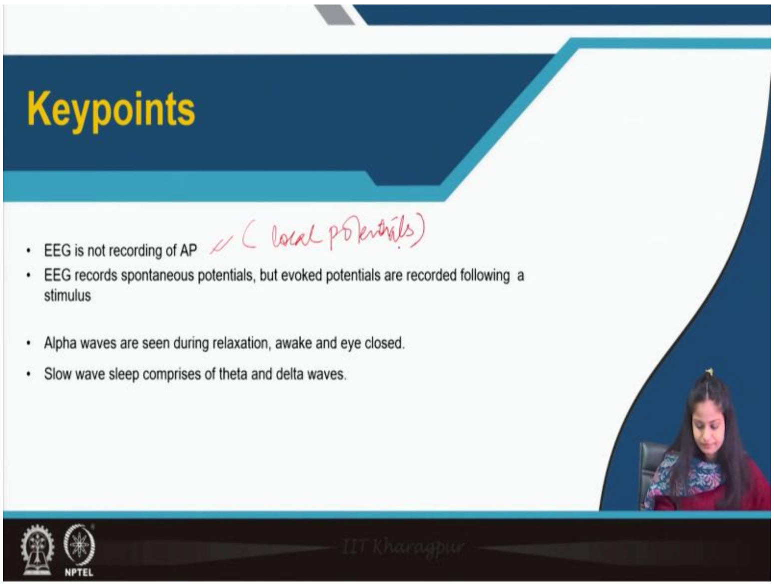
But when the person is going into the light slip at that time, we get theta waves prominent further in the other stage also we get theta waves along with sleep spindles and that we see various mixed EEG activity. And finally, in the stage three of sleep that is low in the deep sleep or slow wave sleep, we get delta waves now, this classification is based on the old classification nowadays we do not have stage four sleep stage till stage three sleep only. So, till here we will get the delta waves.

And, we have other type of sleep also, that is REM sleep, where we get almost beta waves like activity that is that is slow, the low voltage waves and high frequency waves, this is almost similar to betta like waves like activity. So various stages of sleep are there. So, whenever a person is sleeping, so we get different types of EEG waves, we do not get only one type of waves, we get various types of mixed pattern of EEG waves.

So, first and foremost, what you have to remember is whenever you just remember this pattern B A T D, that is bat dance. Beta waves is when the person is awake, alert. Alpha waves is when the person is closing the eyes and relaxing. The moment a person will open his eyes there will be alpha block. And again, regeneration of the beta waves, theta waves, light sleep drowsiness and delta waves is deep sleep.

(Refer Slide Time: 28:13)





So, with this we will move on to the applied aspects of electroencephalography. Electroencephalography is very important, major or important instrumentation we can tell to check for the various types of seizures activity or epilepsy. Now, what is epilepsy or what a seizure you should not diagnose, you should not over diagnose a seizure with epilepsy and you should not under diagnose also.

Because if you over diagnose a person with epilepsy, suppose the person is having seizure and you are giving him anti-epileptic drugs, then there will be side effects of that person because you are not given the drug for one day, you give the drug antiepileptic drugs for a prolonged period long period three to four years. So, there will be side effects of the drug. So, it is very important to diagnose a seizure and epilepsy.

Now, whenever there is an abnormal electrical activity in the brain, in our brain, suppose the electrical activity which is going till now, what we have seen spontaneous normal electrical activity, if any abnormal electrical activity happens in the brain, which leads to abnormal motor or sensory experiences, that is known as seizure. Now, that is known as seizure, if this occurs once and if this seizure or if this abnormal activity leading to motor and sensory disturbances if it is occurring recurrent number of times, so many times, then that is known as epilepsy.

And epilepsy is usually based on the motor experiences or motor disturbances. It is usually classified in various types I would tell a few types for example tonic epilepsy. Tonic epilepsy means we have you know to sit straight or to maintain posture of our body we have a agonist muscles or an antagonistic muscles the muscles which causes flexion of our body and the some muscles which will cause extension of our body. So, if any point of time because of the abnormal activity, because till now, we have seen our brain how and the spinal cord the super spinal centers how it controls our motor activities.

So, if the agonist and the antagonistic muscles they are contracting together So, what will happen the whole body will become stiff. So, that is known as tonic epilepsy. Now, what will happen if the agonist and the antagonistic muscles are contracting alternately, suppose you are doing flexion and certainly your antagonistic muscles contract you do extension.

So, what will happen? It will there will be constant jerk, there will be this constant jerk this I am showing have only been sort of muscles of the hand if this happens throughout the body you can understand there will be constant jerk. So, this is clonic epilepsy, there is an epilepsy where it starts with stiffness and then it moves to jerk that means it starts with tonic epilepsy and then it moves to clonic I mean tone then cloners then that is known as tonic, clonic epilepsy then, there is an epilepsy when the all the tone of the body gets lost and the person falls down.

So that is our tonic epilepsy in case of children there is known as absence seizures in absence seizures or Pettit mole epilepsy in children usually we see for some time says few seconds, the children will keep on staring and give a very blank look and they will just get unconscious for some time and they will give a blank look and stare look. So that is usually absence seizures seen in many children. And also, there is another feature known as myoclonic jerk myoclonic jerk means when they this jerk or this contraction happens only once.

So, with this brief description of epilepsy, what are the electroencephalographic features we see, we see slow wave complexes, the abnormal activity of the brain can be exaggerated activity or it can be decreased activity from the normal. So, when there is slow wave complexes or spikes, that is seen in absence seizures This is seen mainly in case of children as I told you in Pettit mole epilepsy, you can see this is one second and you can see the waves per second three waves are coming for 3 per second at 3 hertz you can see and myoclonic jerks four to 6 per second we get this type of slow waves, the other type is the generalized tonic clonic seizures, tonic clonic seizures means it the first stiffness will be there and then there will be jerking.

So, there you can see excess activity is going on in the brain. So, there will be so many poly spikes you cannot even count how many spikes are there. So, number of spikes, polly spikes you can see if you see in the electroencephalographic recording that means it is off the telling of the tonic clonic seizures.

So this much you have to remember of electroencephalography you have to remember the normal waves which we get the four normal waves that is beta alpha theta delta and what is the genesis of these waves and applied aspects where it gets deranged. And also, you have to remember that EEG is not the recording of action potentials rather it is the recording of local potentials.

(Refer Slide Time: 34:14)

So, with this, I would like to conclude today's topic. Thank you.