Demystifying the Brain
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Lecture – 14
Emotions in the Brain-Segment 2

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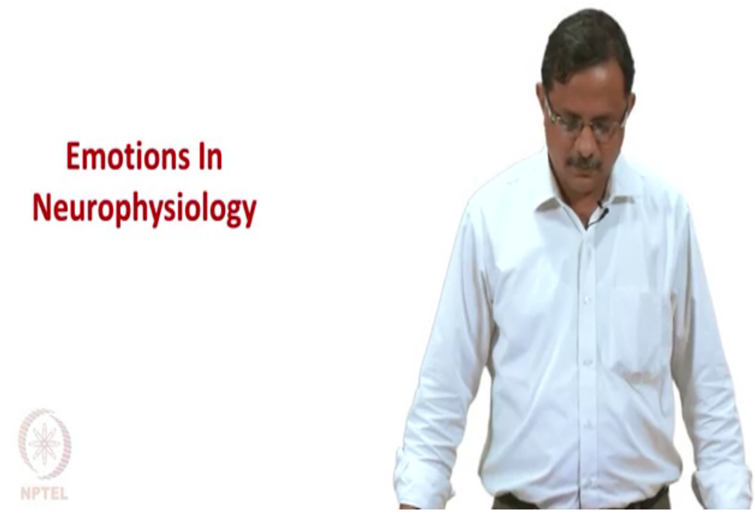

So, so far we have looked at emotions on point of view of psychology or philosophy or in arts. But ultimately, since this course is about brain, we should talk about emotions has occurred in the brain. What is the neural basis of emotions? How does brain process emotions? So, in neuroscience very often, we want to study how, what is the contribution of a given part of the brain, to a given aspect of behavior or experience right. These studies come from say, pathological situations, where something has gone wrong; with that part of the brain.

So, we have seen that, if the temporal lobe is damaged or hippocampus is damaged, they know the individuals have problem with memory storage. So, we know that, that part is involved in memory storage right.

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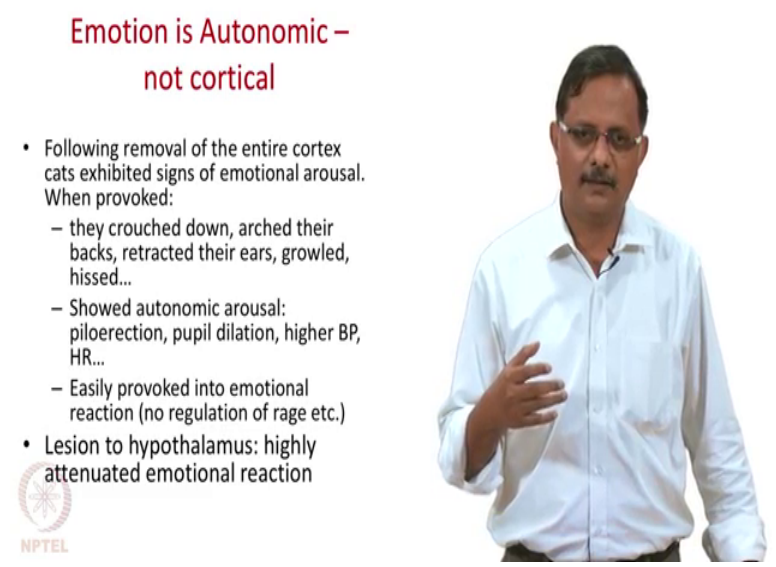

So, similarly in case of emotions also, certain exponents I have shown that, certain parts of a brain contribute emotion experience. In some of the earliest exponents of this kind, which are slightly crew. So, they have actually taken cats in which the cortex is removed. So, you have what is called a, Decorticated Animal preparation. So, they can remove the entire cortex, in surface of the brain. When they did that, the cats exhibited signs of emotional arousal.

So, they would very easily get provoked right, they would crouched down, arched their backs, retracted their ears, they would growl and hiss right, this is all external expression, but in addition they would also show the full autonomic arousal. The activation of sympathetic nervous system, like you know; piloerection and pupil dilation, a higher blood pressure and heart rate and so on, and so forth. So, once the cortex is removed it is as a something, is some inhibition is removed, and that the animal is easily provoked into a rage and an expresses a full blown sympathetic activation.

And on the other hand, lesion the hypothalamus, I mean we have seen hypothalamus before, will also be visiting it very soon, right. Lesion the hypothalamus are highly attenuates emotional reaction. So, there are parts of the brain, which when damaged right, have somethingm have influenced emotion in some form or other.

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So, here is a picture of a animal, you know showing all this hissing and in arousal behavior. And the picture you also see on the right, the location of hypothalamus in the brain.

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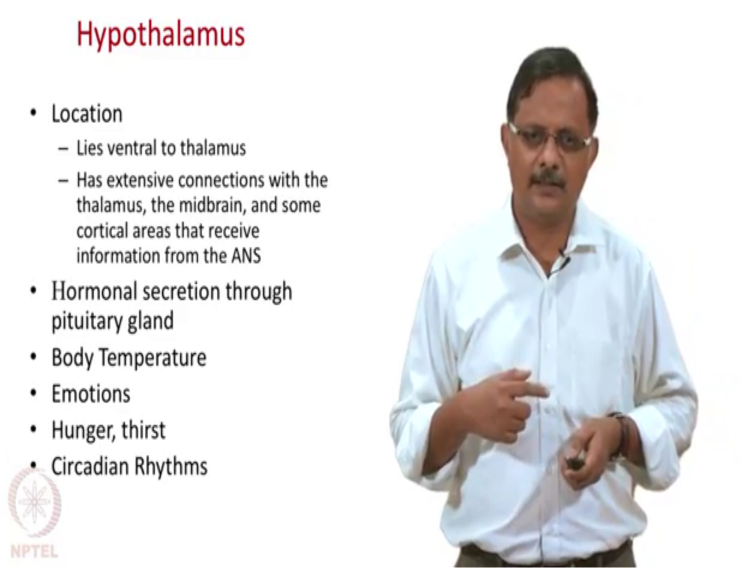

So, we have seen earlier, that hypothalamus lies ventral to thalamus and does extension connection to thalamus and midbrain and also it is a, kind of a, it controls the entire endocrine system; the system of glands, it also receives and controls information from the autonomic nervous system. So, it controls the pituitary gland, just called a master gland of endocrine system and controls it is hormonal secretion, it controls body temperature, emotions, hunger and thirst and circadian rhythms.

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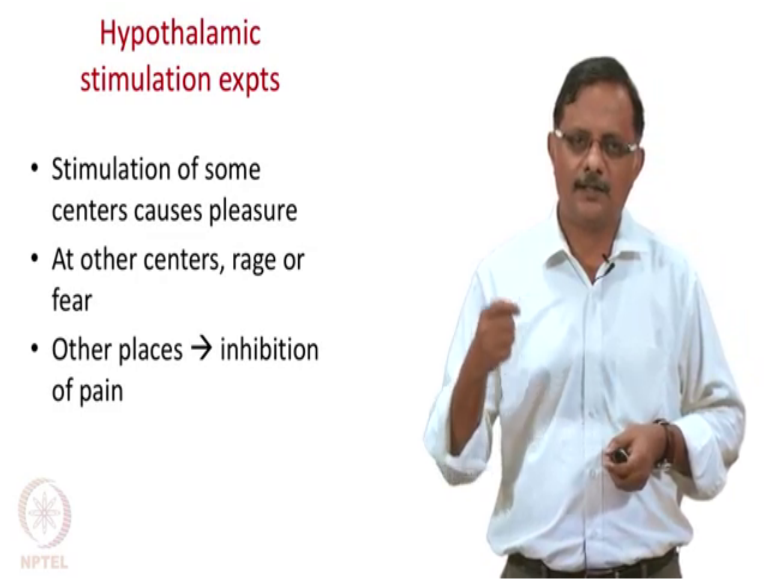

Now, there are certain areas in hypothalamus, which when stimulated all right, produce different kinds of very strong emotions. So, for example, there are some areas which we need to stimulate causes pleasure. Some of the earlier experiments right, with animals where they inserted electrodes in there, in certain locations, anyway in hypothalamus right, the animal prefer to stimulate itself right, by pressing a lever right, and there were the cost of even forgoing food and sorrowing itself to death.

So, these are the pleasure centers of the brain, the other centers in hypothalamus where they are politically stimulated produced a rage or fear, then other places when simulated give inhibition of pain. So, they have hypothalamus is a very, although it is a very small nucleus, it has lot of centers, which when activated have some kind of emotional expression.

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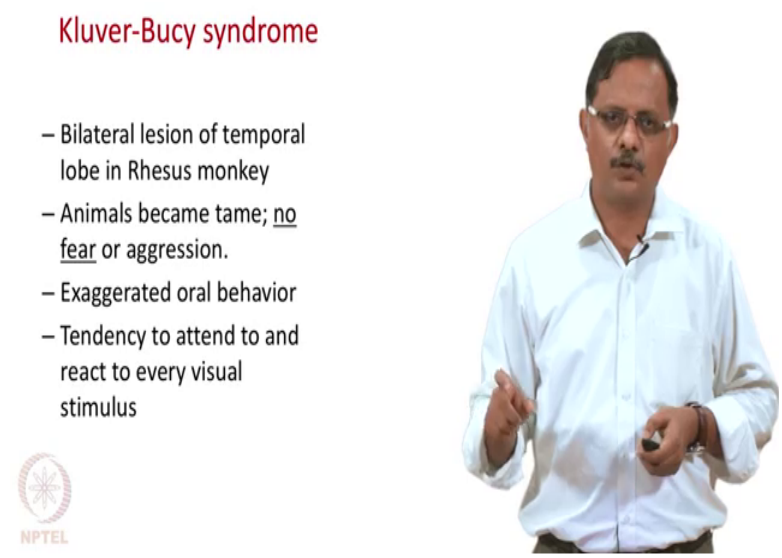

Then there is this syndrome called kluver-Bucy syndrome, right. So, basically in this syndrome is exhibited by animals in, whom there is the temporal lobe is lesion, on both sides. These animals show no fear or aggression, they become very tame, they show exaggerated oral behavior. So kind of they try to put everything that they see in their mouth, our behavior also seen in infants right, you see babies putting everything in their mouth and that they also tend to react and overreact to every visual stimulus.

They also tend to copulate in a kind of abnormal fashion, with any object right, or with animals of other species. So, they again you can see that damaged certain part of the brain can give rises at an abnormal emotional in a behavior.

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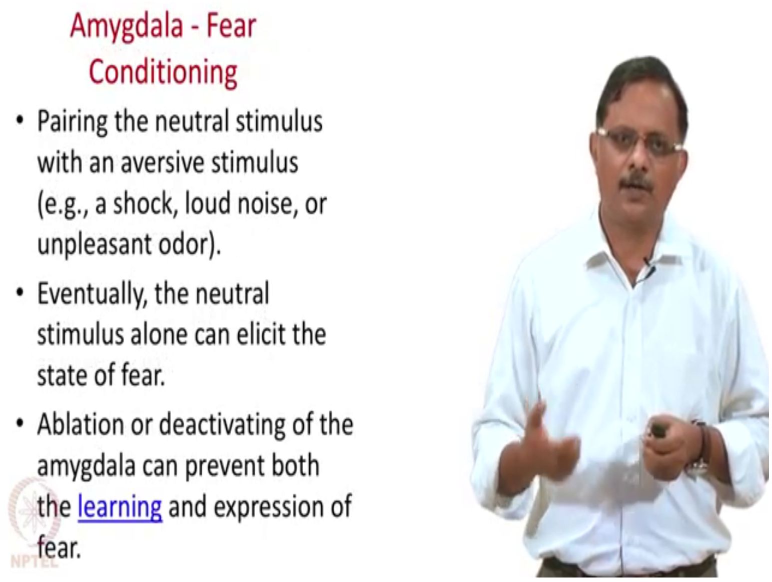

This another organ which is also in the temporal lobe right, a structure, band structure in the temporal lobe called Amygdala right, and if you paid a neutral stimulus with a painful stimulus or an aversive stimulus and the response to the I was the pin, the neutral stimulus can be learned. Let us look at an example.

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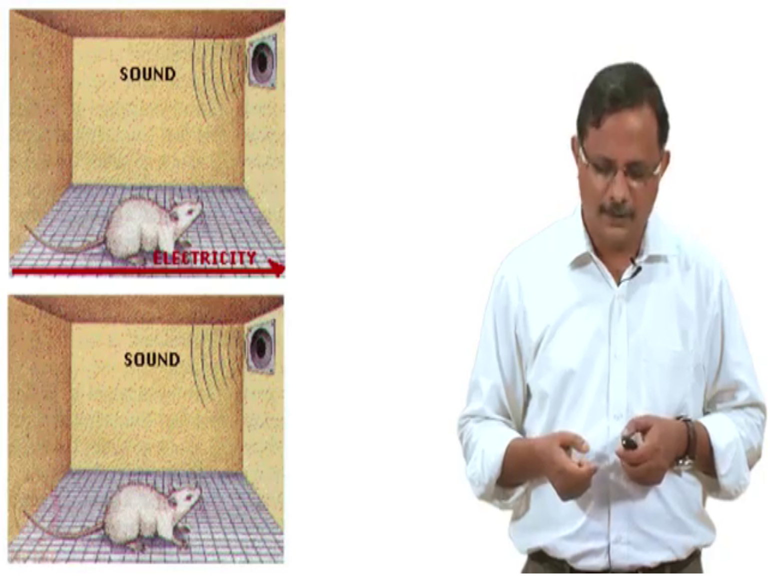

Here in this picture, you have a rat in a cage. So, in the experiment they play a sound which is neutral, emotion neutral and then after this sound after a little delay, a current is passed in the kind of a grid which, at the bottom of the cage and because of the current, the animal receives a shock in it is feet. So, the shock is pretty strong therefore, the animal has a panic reaction and kind of it freezes in it is current position, as a way of expressing it is fear.

So, next one what they do is, they repeatedly paired the sound with the shock and after it is done for a sufficient number of trials, then when the sound alone is played, the animal again shows panic reaction, as if it is also, you know receiving the foot shock always know, actual foot shock. So, this is a kind of a example of a classical conditioning, where there is a pairing of a neutral stimulus with a aversive stimulus. What is interesting is, this pairing does not occur, if the amygdala is lesion. So, which means that amygdala is necessary for learning this expression of fear, for learning to bind this neutral stimulus, would say with the aversive stimulus, which is in this case; the foot shock.

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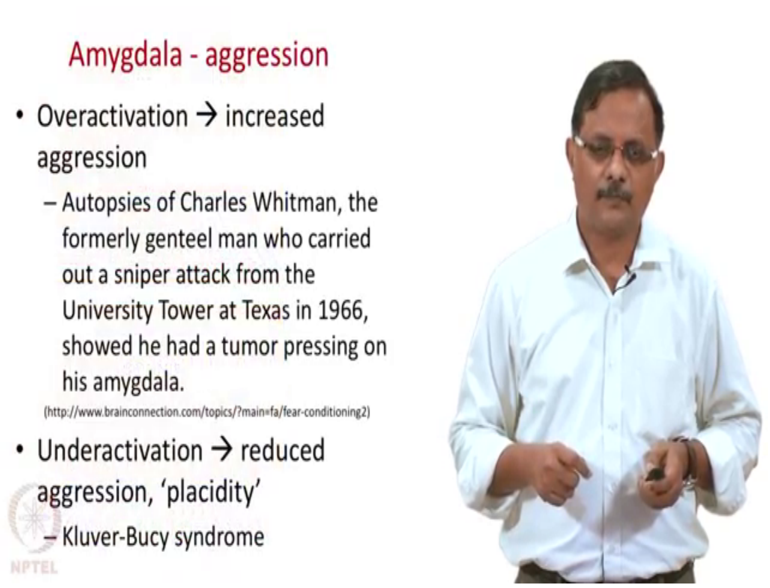

So, also amygdala is also has an involvement in aggression, for example, when it is over activated, that can give rise to increased aggression. So, one example is, there is a case of one person called Charles Whitman, who went on top of this university tower in University of Texas in, 1966 and started shooting you know, blindly. A lot of people died in that accident. When this individuals brain was studied on post mortem, it was found that is amygdala, there is a tumor pressing on his amygdala. So, that therefore, it was getting over activated and that give rise to aggression.

Therefore, under activation or simply, lesioning of amygdala, gives rise to reduce aggression or placidity, which is what you see in kluver-Bucy syndrome. So, you can clearly see a correlation between amygdala and aggression or fear right, or fear at the other side of it in this studies.

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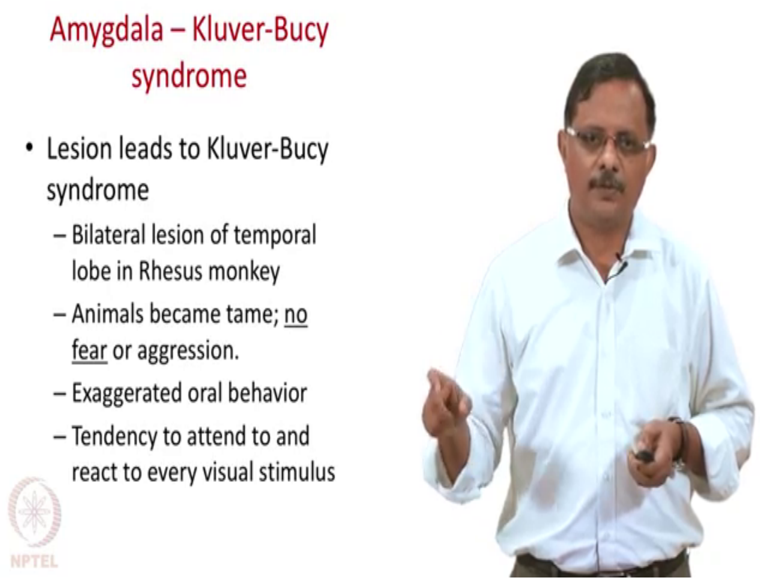

So, Lesion leads to kluver-Bucy right and the lesion of temporal lobe and give rise to lesion of amygdala right, and that. Because of this, animals become tame, there shown no fear or aggression.

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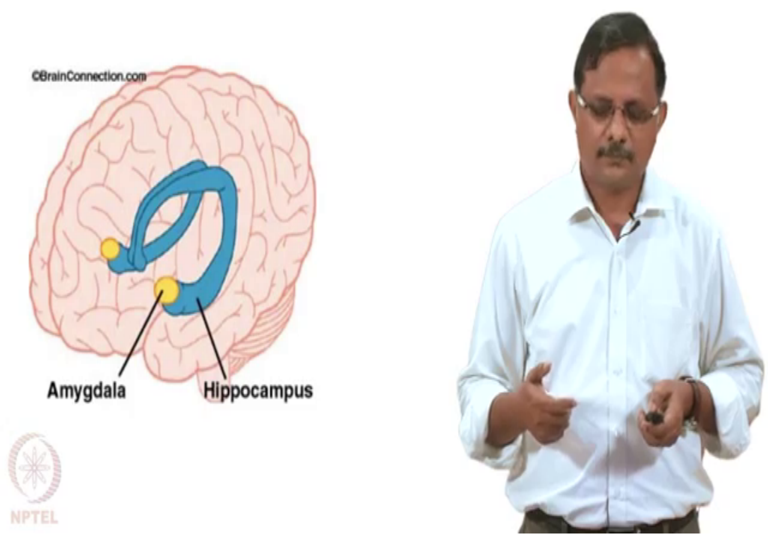

So, in this picture you can see amygdala and which is right next to hippocampus, are both are inside the temporal lobe.

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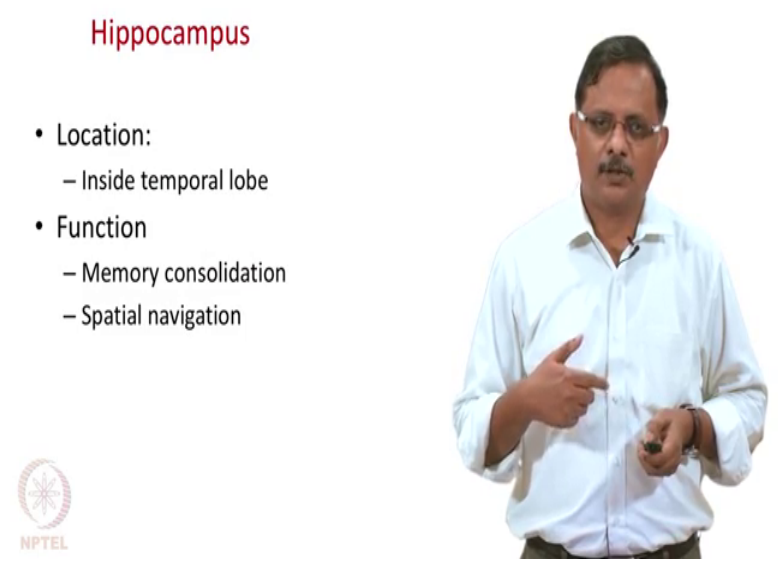

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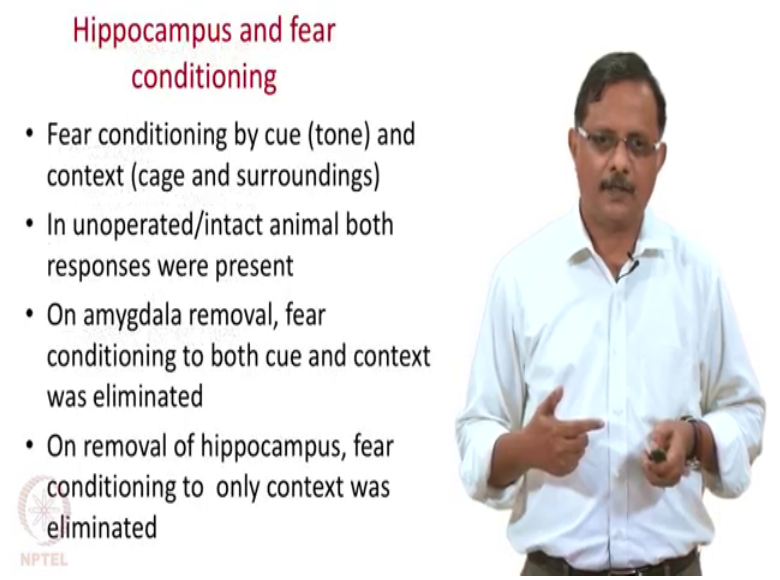

We have already seen hippocampus before in the context of memory, but hippocampus also has connection to emotions. Hippocampus, we know is involved in memory consolidation and spatial navigation, but it is also involved in fear conditioning. So, for example, the fear conditioning by cue, which is in this case a tone right, is one way of, one kind of conditioning, but the conditioning can also be done by the context, for example, in this cage that we have just seen, that the animal is in the cage and when you play the sound, when sound is play with the foot shock, but next time when you play the sound alone, the animal shows fear reaction or a panic reaction. But suppose animal is in certain cage, when this kind of a pairing occurred and next time where on when you bring back to the same cage, immediately it can show a fear reaction to the cage.

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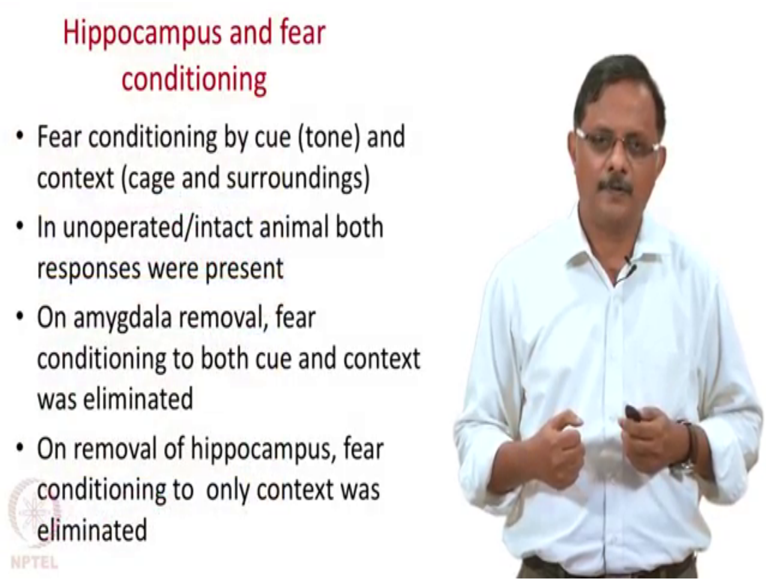

Because, in this case the animal has learned to pair the, it is context its surroundings with the painful stimulus which is foot shock. So, there are 2 kinds of pairing that happens in these experiments, the pairing of the tone or the cue with the aversive stimulus and the pairing of the context, which is the cage itself with aversive stimulus. So, it turns out that on amygdala removal, their fear condition to both cue and the context was eliminated, but on removal of hippocampus, fear conditioning only to the context was eliminated. So, hippocampus as a role and fear conditioning are 2 only the context.

So, we have seen several brain structures, all of which contribute to emotion experience in some form or other. So, when people have studied different parts of the brain, which have a particular influence on emotion, they put all these studies together and have created this idea of a limbic system which is the subcortical network, which forms our emotion system.

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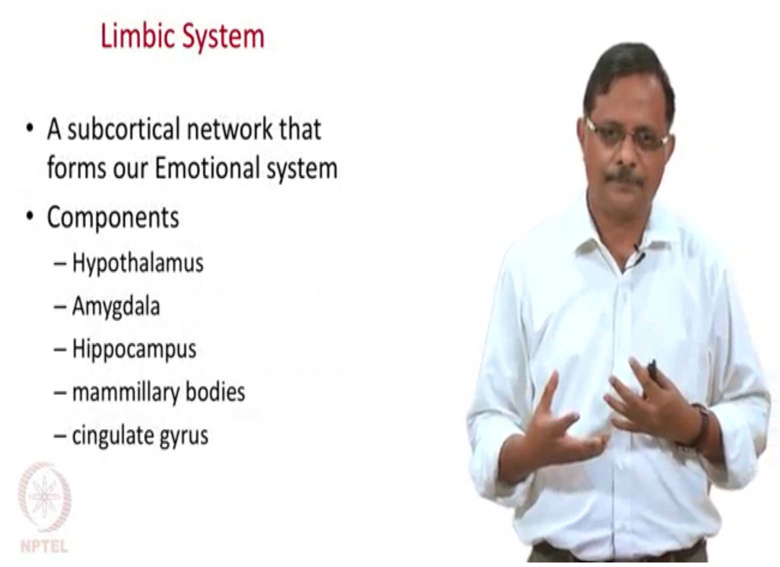

So, there are all these components, right all these brain structures within the sub cortex. Like you know hypothalamus amygdala, hippocampus, mammillary bodies and cingulate gyrus; which is actually a part of the cortex. All these brain regions form a network which is called a limbic system and this is the emotional part of the brain.

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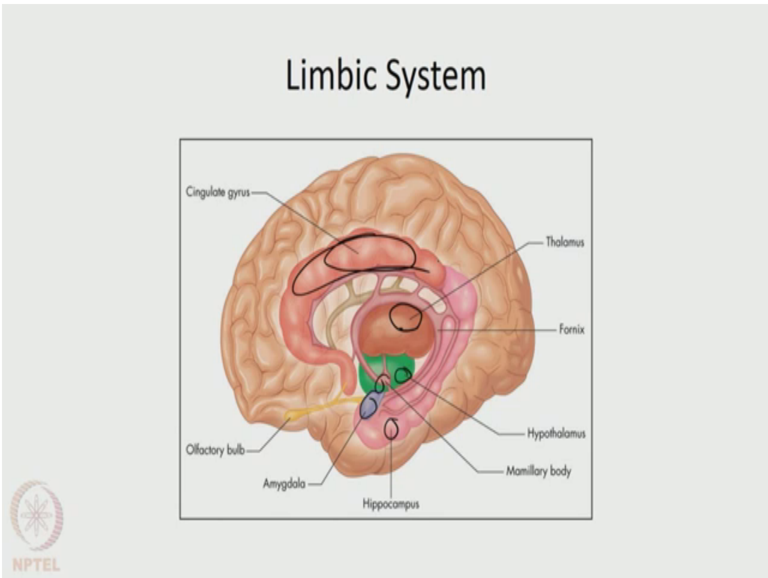

In this picture, you can see certain components of the limbic system. So, you see tholomus here, then hippocampus is here, amygdala is here and you have mammillary bodies, also here hypothalamus is here and the cingulate gyrus is this big region a cingulate gyrus, all these areas form a network, which is the limbic system and which is the emotional machinery of the brain.

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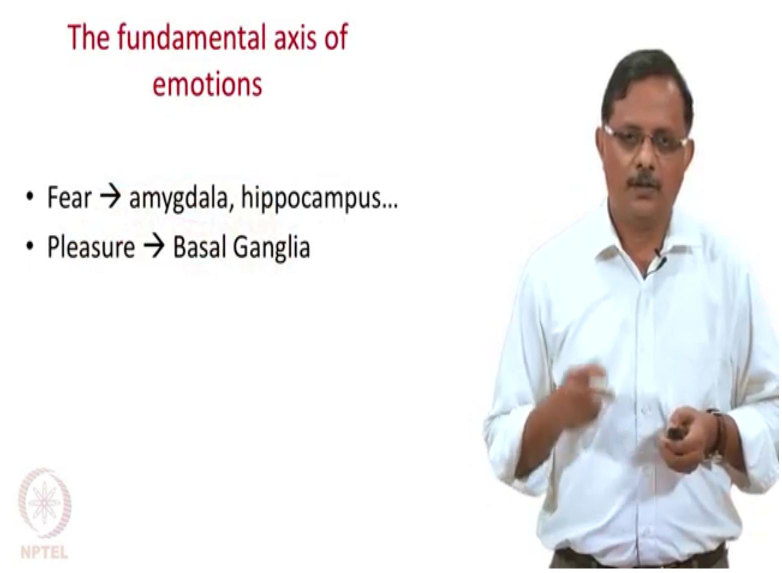

Now, let us look at 2 fundamental axis of emotions. So, there is fear which is processed by amygdala hippocampus and there is pleasure which is possessed by basal ganglia, which is a whole different circuit.

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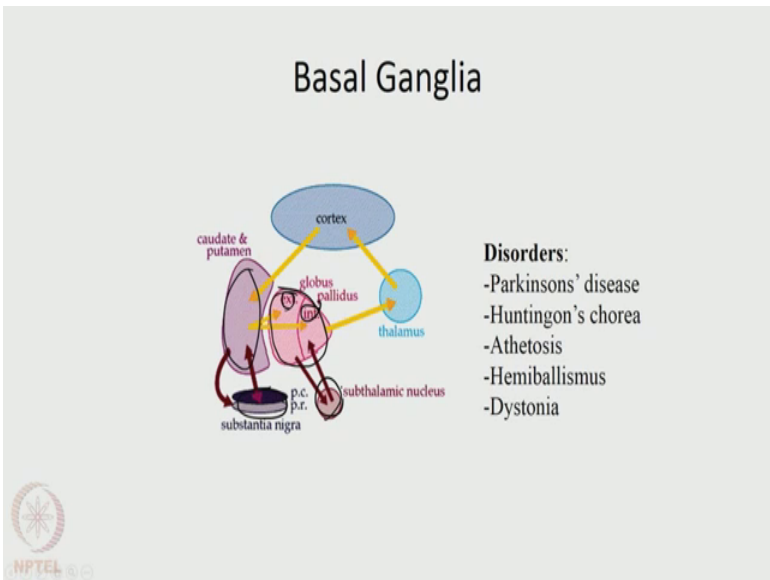

You can see in this picture basal ganglia, which is also a subcortical circuit right. Which consists of several nuclei, you can see some of them here in this picture. So, for example, there is the caudate and putamen and there is substantia nigra globus pallidus with it is 2 components; the external and the internal and the subthalamic nucleus right. So, the basal ganglia receives input from the cortex and sends output back to the cortex.

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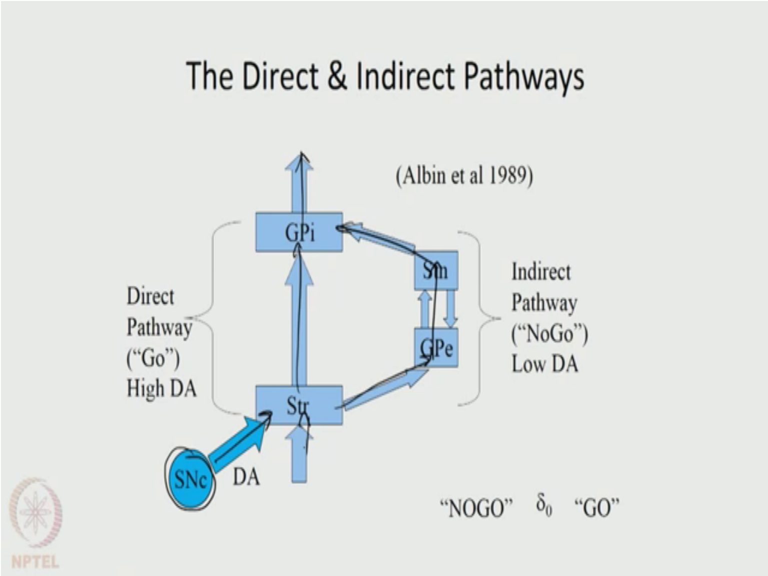

And this circuit has actually 2 pathways in it. So, the input on the cortex comes to one basal ganglia structure called a Striatum, which is this whole ,which show this whole region and the output from striatum goes directly to g p a and onwards back to the cortex, by a pathway which is called, the direct pathway. Then, the output from, so another output from striatum, goes to Gpe subthalamic nucleus is, s t n and then Gpi over a longer root, which is called indirect pathway. So, then there is this substantia nigra, which leaves a substance called dopamine, which acts on striatum and controls the flow of information from cortex and through the basal ganglia.

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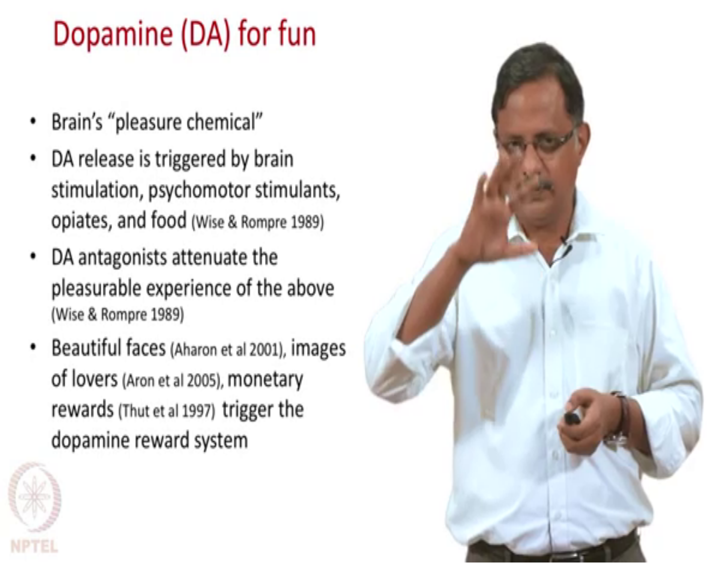

Now, this dopamine is a very important chemical, which coordinates activity of various nuclear in basal ganglia. It is, dopamine is called the brains pleasure chemical, because it is released when brain is stimulated, so for example, we talked about the pleasure centers in hypothalamus right. So, similarly the other pressure centers in for example, nucleus accumbens, if we simulate any of these pleasures in centers electrically right, that causes release of dopamine from substantia nigra. Or, if we take drugs right, drugs are opiates right, or even food because, food can be pleasurable. So, these kinds of stimuli cause a release of dopamine, from the dopamine centers then dopamine antagonists; that is, chemicals which attenuate, which counteract the effect of dopamine, can attenuate the pleasurable experience.

So, if you take, say if you eat, say a nice, as like a sweet, for example, which would normally release a dopamine and gives you a pleasurable experience. If you simultaneously take a dopamine antagonists, then your experience is somewhat attenuated it is not so much fun anymore. So, similarly people have studied and shown, that presentation of beautiful faces right, activates the same parts of the brain, which are activated when dopamine is released or emails of lovers. So, couples were made to participate in these studies and they were shown pictures of each other and their brains were scanned.

In f m r i and they were shown that the same reward system right, is activated because of by appearance of the lovers right of the spouse of a given individual. Or even presentation of monetary reward you give somebody cash right, you can see the rewards in the brain getting activated. So, reward system is basically brains you know underlying machinery, for processing pleasure are or positive stimuli ok.

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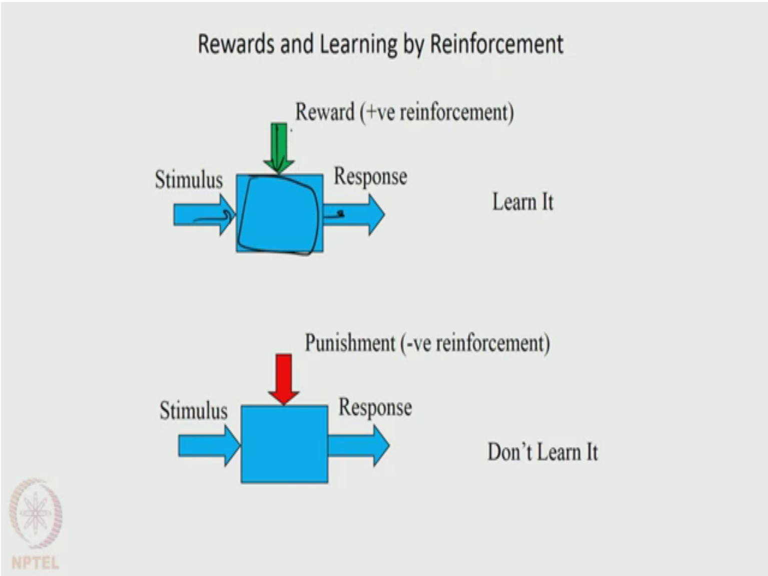

So these, so this machinery can be used for learning right, because very often, when you learn something, you are often learning a mapping between, stimulus and a response and if your response to the stimulus, gives a positive reward right, then next time around you tend to repeat that response to the stimulus right. So, which is called a reinforcement or learning by reinforcement, or for a given stimulus, if a response give rise to punishment, then next time around you try not to repeat that response for further stimulus.

So, this kind of a learning by reward and punishment is called reinforcement and basal ganglia is is plays a major role in this kind of, this form of learning. And that is because, if you look at the anatomical connectivity of basal ganglia it is located very strategically in the brain, there it receives the input from the sensory and motor cortex.

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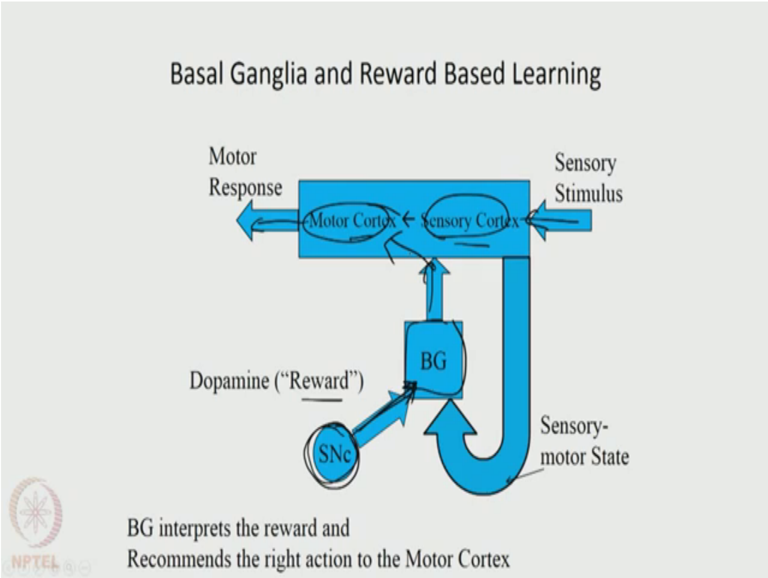

So, in this picture you can see that right, there is sensory cortex and motor cortex, that you receive input from the world in your sensory cortex and the, which is which sends information to the motor cortex, motor cortex in the sense commands which will make you move and act on the world. So, this information is sent to basal ganglia and basal ganglia also receives information from the substantia nigra, which sends information about the reward.

So, in this figure you can see that, so there is this box right, which combines 3 forms of information; the stimulus, the response and the reward. So, if you look at what basal ganglia is doing, it has information on the cortex about the stimulus and the response, it has information on substantia nigra about the reward. So, it is combining all these 3 and sending it back to the motor cortex and giving a recommendation about what is a good action to perform.

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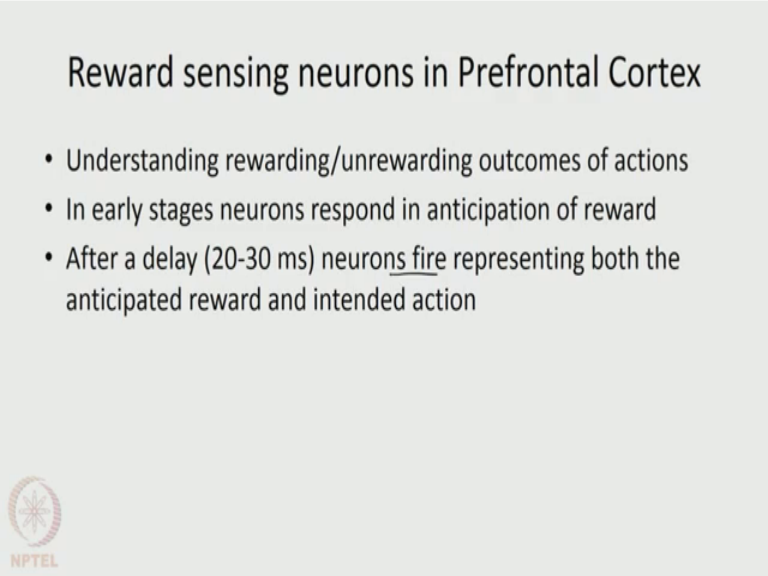

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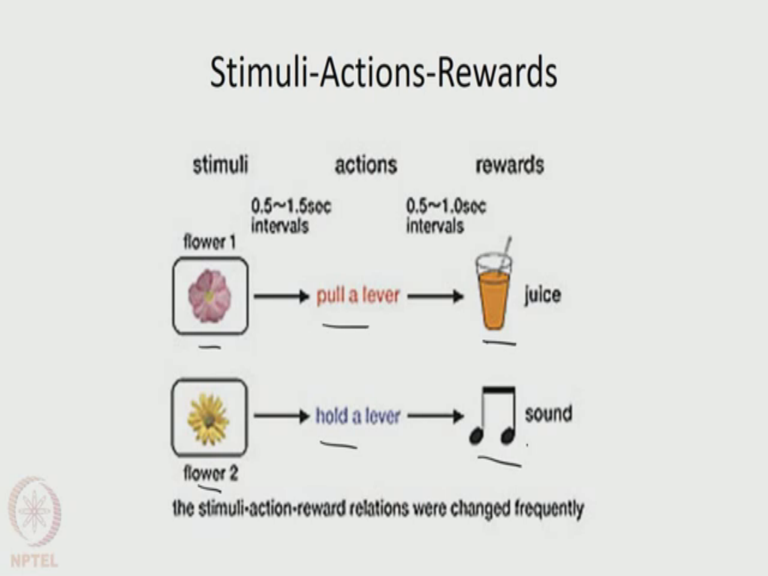

So, there are also a reward sensing neurons in prefrontal. So, in addition to basal ganglia there are other parts of the brain, which also process reward or pleasurable experience. So, in this experiments, the subject is shown a flower, whereas which is the stimulus, in response to that it is expected to pull a lever or perform an action, when that action is performed, it is given a reward like juice. And then there is another stimulus, which is another flower, yellow flower. And in response to that, it has to hold a, if it holds a lever, that gives a, it is given a neutrals, as you know outcome, like the song.

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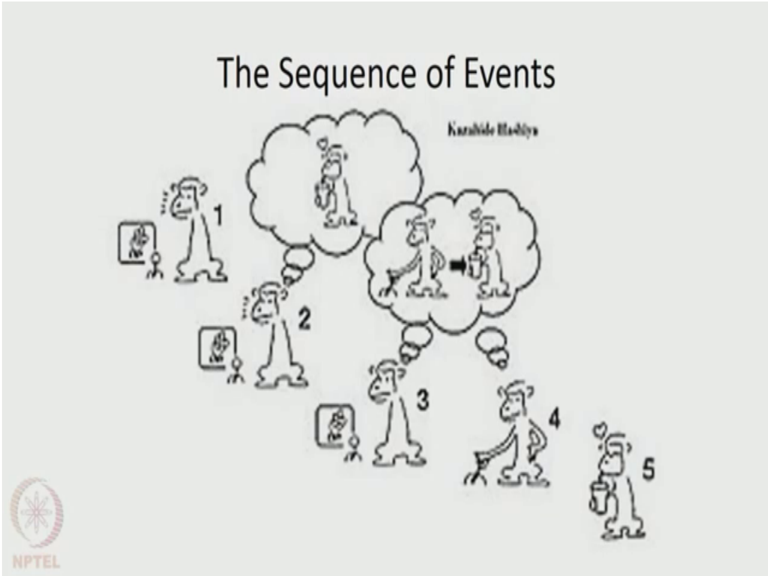

So, when they presented this and the animal is trained on this kind of a task repeatedly, what was found is in early stages, it only knows about the reward right, and lesions neurons were able to learn responds to reward and the internal action. So, nearly says neurons respond to the anticipation of reward right, that it is going to get a juice or something like that, but after it delay neurons firing, that represented both anticipated reward and intended action. So, basically the animal is the, neural firing indicates that the animal things that, if it perform this action then it is followed by a reward right, because it is seeing this kind of a particular stimuli.

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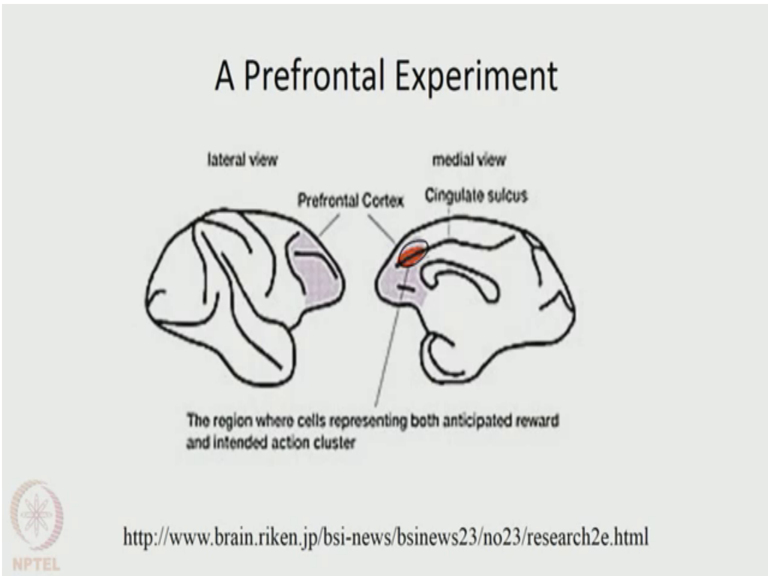

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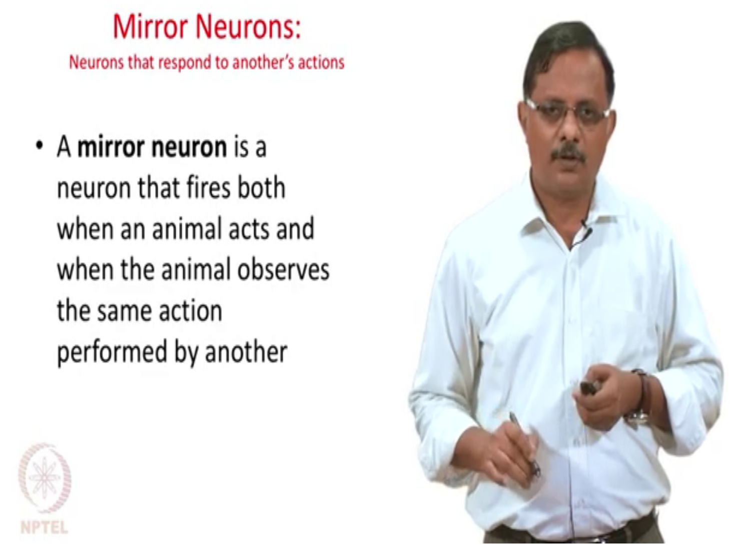

These kinds of neurons were found in prefrontal cortex right, particularly in this cingulate Sulcus. Let us look at one more element of neurobiology, which has something to, which will find the link to our outline of theory of emotions which has it is roots in neurobiology. So, there is this neurons called mirror neurons right, which fire when both, when animal acts or performs an action or when it sees another animal right, performing the same action ok. So, it fires when both animal acts and the animal observes the same action performed by another animal.

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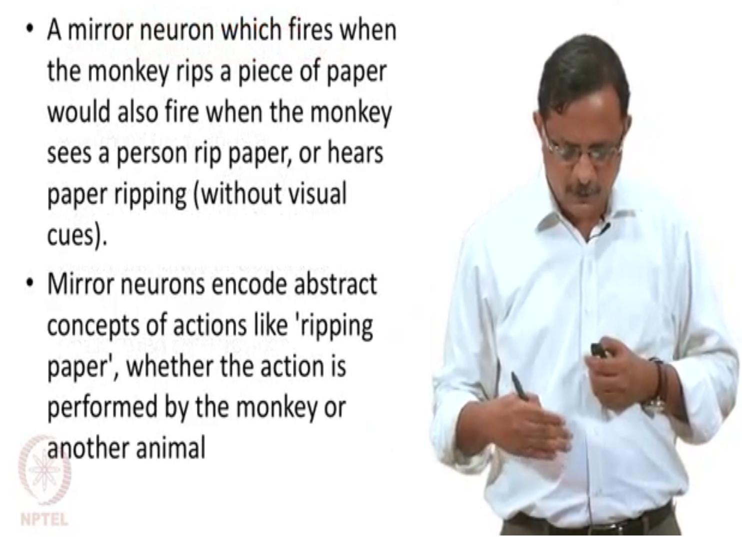

So, for example, right this is mirror neurons responds when a monkey rips a piece of paper right, and the same neuron will respond, when a monkey sees a person ripping a piece of paper or even when it hears right, or you know auditorily right, the sound of paper getting ripped; that means, a mirror neurons has to encode abstract concepts of actions like ripping paper, the action could be performed by the animal itself or some other animal, now it is been thought.

So since, the neurons respond the same way, this mirror neurons responds same way, whether this action is performed by yourself or somebody else. People propose that this system, this mirror neuron system is necessary for imitation or imitation learning and imitation learning is found in very small animals for example, you see in this picture.

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A person is taking his tongue out and the little monkey cub, is able to imitate him by sticking it is tongue out. So, mirror neurons, so it is not just a, motor function which mirror neurons reflect, they also are found to reflect emotion.

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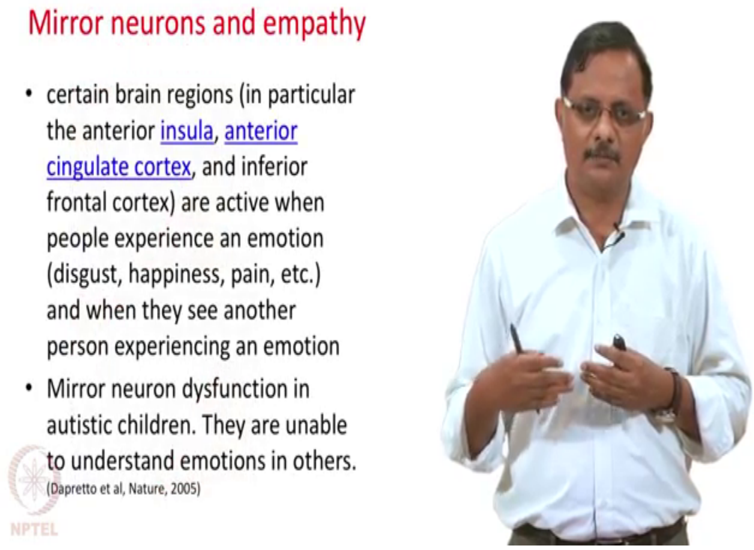

For examples, there are certain brain regions like, anterior insula and anterior cingulate cortex and inferior frontal cortex, they are active and people experience an emotion like disgust, happiness, etcetera and they are also active when they see somebody else, experiencing the same emotion. So, which means there is a mirror neuron system for emotions and it turns out that mirror neuron dysfunction happens in autistic children.

And therefore, they have trouble understanding emotions in others and not only that or some other situation are thought to have the problem of a theory of mind, they do not seem to have what is called theory of mind, but is the understanding that this has, they have a self or a sense of self, others also have a sense of self. So, some autistic children seem to have trouble with having a theory of mind, because there is a problem with their mirror neuron system.

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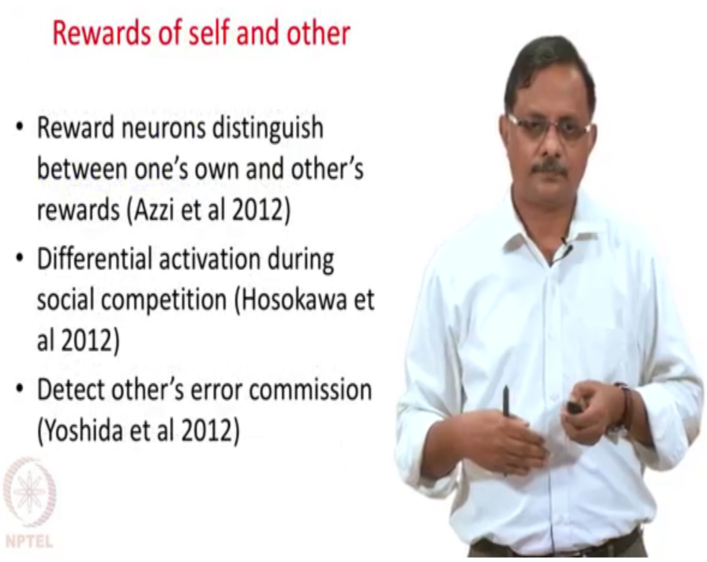

Again there are reward neurons, which distinguish between ones own and others rewards. So, whether you get a reward all right, or somebody else gets a reward. There should be neurons, brain should be able to distinguish between these 2, otherwise you know, you cannot really operate in the real world, because if somebody else gets a reward and if you think you have got a reward, then you know you will get into troubles of you know, decision making.

So, similarly people found differential activation of the brain during social competition. So, when you are competing with somebody, when somebody else is winning, the brain should respond to it in one way and when you are winning, you should respond differently, otherwise you will not be able to compete. So, brain actually shows that kind of a differential activation. So, similarly when somebody else performs a error, as suppose you performing an error right, different brain errors are distinct between these 2 cases. So, to summarize some of the ideas that we have looked at, so we reviewed some of the observations from neuroscience alright, which have relevance to emotion processing.

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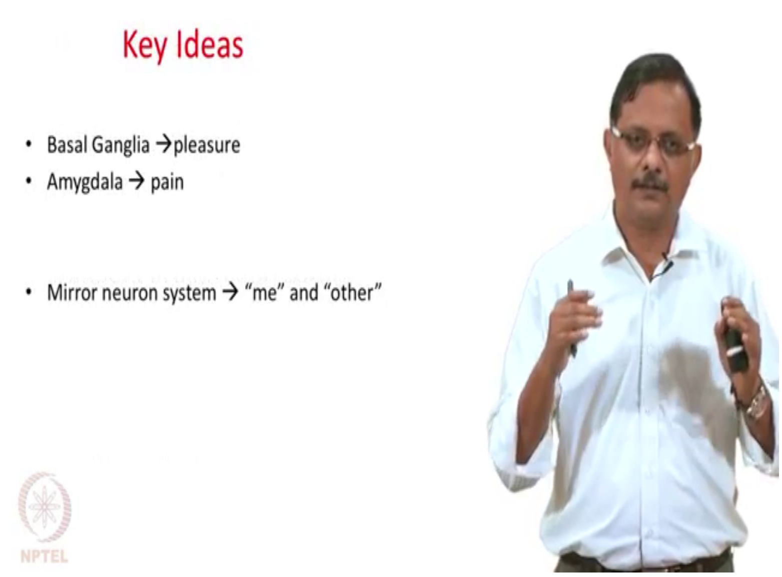

So, main ideas are that basal ganglia process, pleasure and amygdala processes, pain or aversive stimuli, which gives rise to fear, then the other idea from neuroscience which we invoke is the mirror neuron system, which can distinguish between something happening to me and something happening to other.

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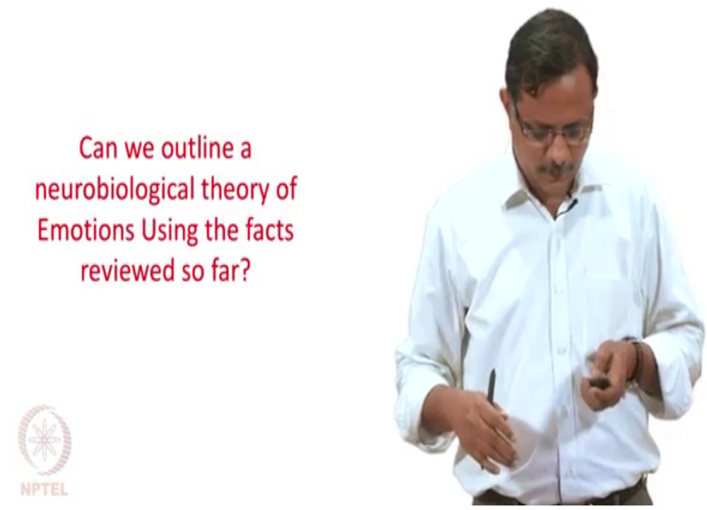

So, with this we will give a quick outline of a neurobiological theory of emotion, but let me say straight away that, we still do not have actually a comprehensive theory of emotion. So, I think here we, in the lecture, we are trying to put together ideas from many sources and trying to give a, kind of a cartoon picture of how emotions have work in the brain.

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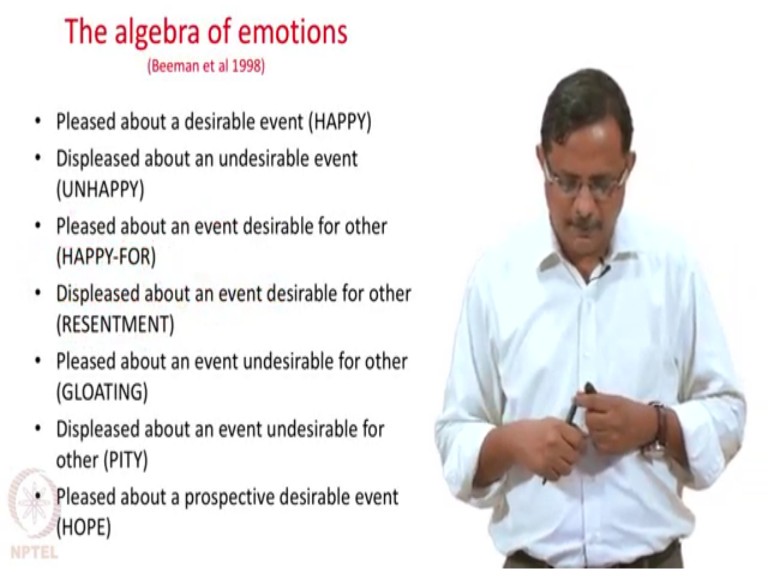

So, this is interesting paper by Beeman Et Al right, where they have tried to reduce a lot of emotions to certain fundamental dimensions right. For example, happiness that defined as, being pleased about a desirable event. And unhappy is defined as, displeased about an undesirable event or happy for is defined as, pleased about a event desirable for another or if you go down the list right, pity is displaced about an event undesirable for another. So, something that is undesirable for somebody else, has happened and I am not happy about it and that is what is called pity.

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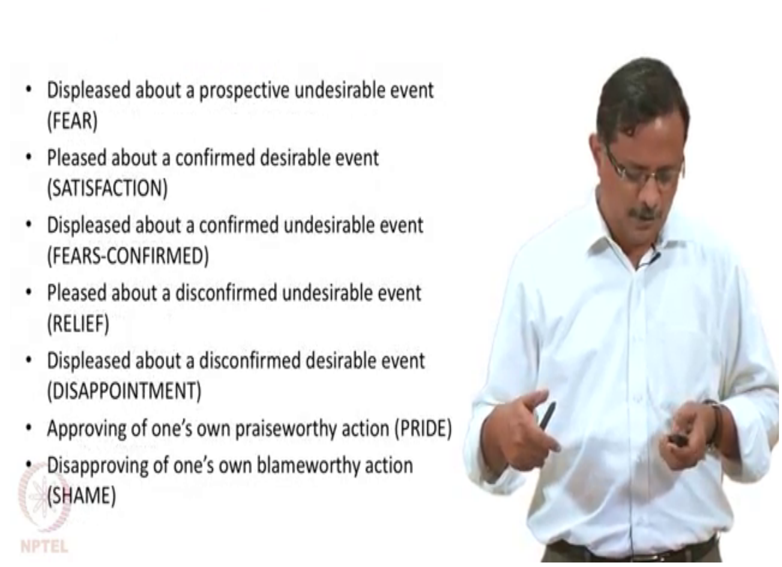

Or similarly, if you look at some of the other examples, fear is being displaced about a prospective undesirable event. So, something undesirable is going to happen and I am not happy about it, or if you look at shame; disapproving of ones own blameworthy action or pride is approving of ones own praise worthy action and so on, and so forth.

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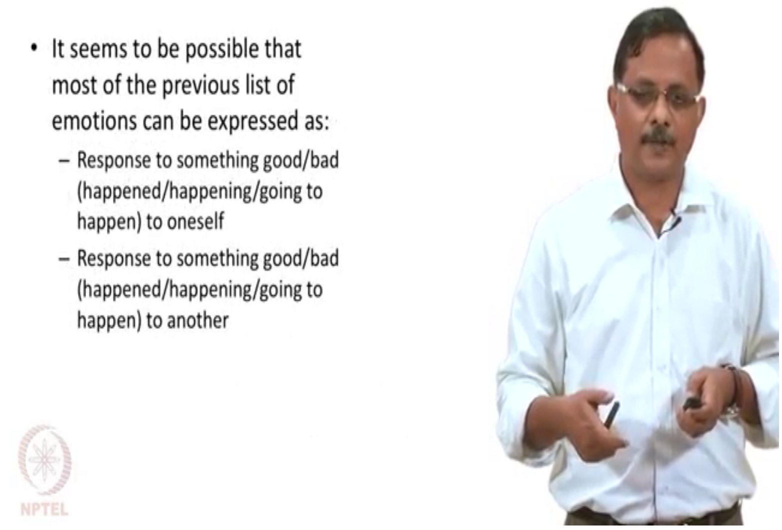

So, the way of defining emotions, basically as is reducing emotions to certain basic dimension. So, most of the previously list of emotions can be expressed as response something good or bad. That has already happened or is currently happening or going to happen right, in prospectively to oneself or all these things to somebody this. So, if you look at all that we are covered in you know, in terms of neurobiological substrates of emotion, we have seen that the brain areas which tell you whether something good or bad is happening all right, and their brain areas which tell you whether something is happening to you or to somebody else and I have not covered in this lecture, but there are also brain errors which brain signals which can tell you about what is going to happen in future, as supposed to what has already happened in the past.

So, if we combine these ideas you kind of see an outline of neurobiological theory of emotion. So I now, let us make a summary of what we discussed so far in this lecture.

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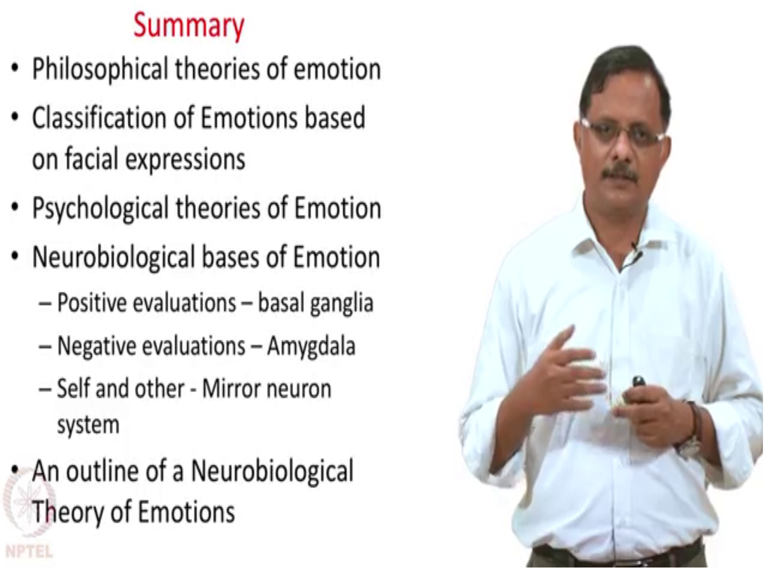

So, we are presented, we have begin the discussion with philosophical theories of emotion. We discuss ideas from both, Indian philosophy and western philosophy. Then we talked about classification of emotions based on facial expressions. We are starting with Darvin and right and others, Paul Ekman and others. So, then we talked about psychological theories of emotion right, the James Lange theory and you know Cannon Bard theory and so and so on.

Then we talked about neurological basis of emotion like, that positive evaluations are done by basal ganglia, which is pleasure. Negative evaluations, that is pain or fear is done by amygdala and finally, a distinction between self and other is done by the mirror neuron system.

So, finally, we have put all these ideas together and proposed a kind of a neurobiological theory of emotions. Like again let me repeat that, we still do not have a comprehensive theory of emotions, but I think there are of pieces of necessary ideas to build this kind of a theory, these ideas can be borrowed from psychology and neuroscience and so on right. And this is all kind of something that is left for future research.

Thank you.