

How The Brain Creates Mind
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Lecture – 14
Cognition and Emotions–4

Hello, and welcome again. I hope by now you would be feeling confident that we have been able to understand brain to some extent especially with the networks which we have talked about specially with the structures which MRI and pet scan and may be the functionality and rhythm and oscillations easy as discovered for us.

So, broadly you will not be wrong if you think you can grossly understand how the brain functions, but that is not the whole truth because, if you remember even we were talking about MRI and pet and they are lot of exploration of brain which we do apart from the postmortem or the autopsy, where we directly see the tissue, lot of it is indirect signal and lot of it is task driven. In the sense that we give a task a certain network or a certain area of brain gets activated then we change the task some other area.

So, this is not the full truth or if we take easy which may give you a signal from the whole brain, but then the easy cannot tell you where it where is it coming from. So, all the time we are struggling with this space or time differentiation, but when we are measuring or even from the given data if we are making network according to graph theory still we are focusing on a very small low dimension part of it.

What is the rest of the brain doing at that time? So, is it like that the certain network gets activated in a task and then you change the task, then some other network gets activated is there a switch in the brain which keeps doing all these it is very very unlikely, so the timescale problem. What are the other parts of brain doing? When, we are measuring a task dependent one type of activity or one type of network. Even, theoretically when we try to connect network still it is a very very limited thing because there is so much going on in the brain. So, our desire to have a single equation or set of equation is still not fulfilled that is the real problem because we do not have a supplementary area in brain

which will say ok fine this network task is done switch on to the other at the same time the whole brain is active.

What are the other parts doing when we are measuring the certain part this is one of the pressing challenges. So, today in this towards the last lectures of this week 3 module we will talk about one zone which still challenges us if, you look at your life we all think, we think and we all love to think that we think, but do we really think, we think whatever decision we have taken a very very rational decision and all of us are I mean that is one source of anxiety everybody wants to think logically and rationally and take rational decisions. If, everybody is doing rational decisions if the governments and the people in the individual life, within families, students, everybody is thinking rationally then why is so much disturbance; have you ever noticed, will do a small exercise if you just look at it.

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the power of the invisible?	
Danger	exploration
escape/fight	acceptance
Loss	Attraction

I have 6 words here and this 6 words they are not necessarily divided into two lines, just try to make three pairs out of it, just connect somebody just say danger attracts, but for most people danger will mean escape or flight or fight or flight loss eventually all losses you accept.

Now, exploration and attraction may give out together if, you are attracted towards something you will explore this is a logical rational brain which is telling you, but look at it. All rationality what is happening inside your rational thought process of matching these words, all rationality actually balls down to this basic emotions if there is a danger there is fear, if there is a loss there is grief and if you explore there is joy. So, underlying your seemingly normal emotions in the rational thinking are essentially these emotions, emotion is such a huge hidden world that it never comes to our notice.

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Darwin and emotion

- In 1872, Darwin wrote *The Expression of Emotions in Man and Animals*.
- This seminal work made apparent the absolute relevance of studying emotion in animal models.
- It also laid out the idea that autonomic responses are an intrinsic part of the emotional experience.



The slide features four illustrations arranged in a 2x2 grid. The top-left illustration shows a dog's head in profile, with its mouth open as if barking or howling. The top-right illustration shows a woman's face in profile, looking upwards with a serene expression. The bottom-left illustration shows a chimpanzee's head in profile, with its mouth open in a wide, toothy grin. The bottom-right illustration shows a man's face in a circular frame, smiling broadly.

Even Darwin, mentioned in 1872, that autonomic responses you remember we talked about the sympathetic and the parasympathetic systems which control your heart rate, your salivation your (Refer Time: 05:45) your skin resistance, your all that are controlled by your sympathetic and para sympathetic's, but they are actually intrinsic part of the emotional system.

Now, what happened in psychology as and if you can see Darwin said that peripheral skeletomotor and autonomic aspect of emotions they serve important functions in communication and in preparation for behavioral responses. So, behavioral responses we talked about fight or flight which is a universal thing. So, either in the face of stress you fight it out or you escape.

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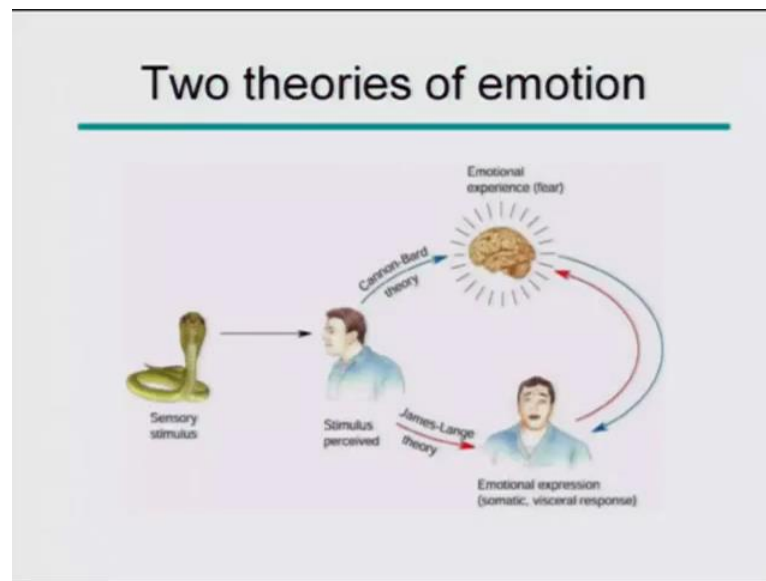
William James on emotion

- “What kind of emotion of fear would be left if the feeling neither of quickened heartbeats nor of shallow breathing, neither of trembling lips nor of weakened limbs, neither of goose-flesh nor of visceral stirrings, were present, it is quite impossible for me to think...I say that for us emotion dissociated from all bodily feeling is inconceivable.”

This, he is a famous man William James just read this "what kind of emotions of fear would be left if the feeling neither of quickened heartbeats nor of shallow breathing, neither of trembling limbs nor of weakened limbs, neither of goose-flesh nor of visceral stirrings, were present, it is quite impossible for me to think".

So, what James was saying, if you do not have body symptoms of emotion that your heartbeat does not go fast, when you are anxious your tummy does not go butterflies, then what is emotion? William James was one of the pioneers of psychology.

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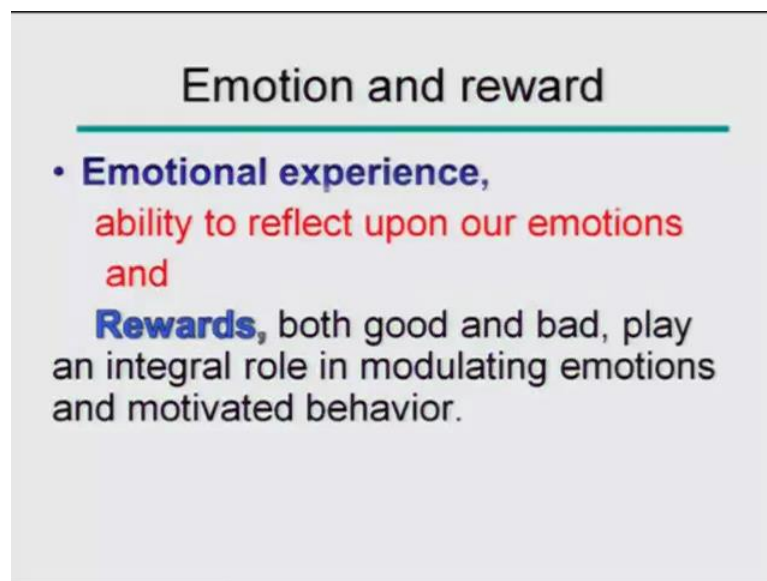


Now, William James this is around 1900, Once, he brought out this theory, emotions were almost pushed away from psychology because soon after that Freud came in and Freud said that all emotions are part of unconscious, suppression and repression and all those sense mechanism then Freud went out by the time behaviorism came in they said that everything there is no thought or emotion anything everything is a learned pattern Skinner and Pavlov and Thorndike. And the last to come was cognitive theory because the which is the cognition, that everything is thought rational thought and you can already train your mind so emotions were slightly pushed up, but then they have really bounced back in last 20 years. Specially, with the Neurosciences research and in fact, when we discussed we often think whether, Freud was right because we will talk, when we talk of consciousness we will be talking about this whole concept of unconscious and conscious.

So, essentially there are 2 theories, I have mentioned it briefly, that there is one thing called Cannon-Bard theory there is a stimulus, there is a snake here, your eyes see it Cannon-Bard theory says that you first experience fear it is the fear first in your mind and then you experience all these responses in your body trembling, a goose-flesh or heartbeat going fast whereas, the James-Lange theory says that "you perceive it first the bodily experience happens and then the emotional experience". So, irrespective of what theories correct because theories are often they try to explain and they are not the

ultimate answers you have a mental sense of emotion and you have a bodily sense imagine for example, anxiety just before going for exam or going to ask a kid before going for exam you may have a fear that you may be able to answer or not or not answer I have some apprehension in your head that is one part of it, but for some people palpitation may start or their mouth may get dry. So, that is a physical manifestation where as there is a mental psychic manifestation of anxiety.

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Emotion and reward

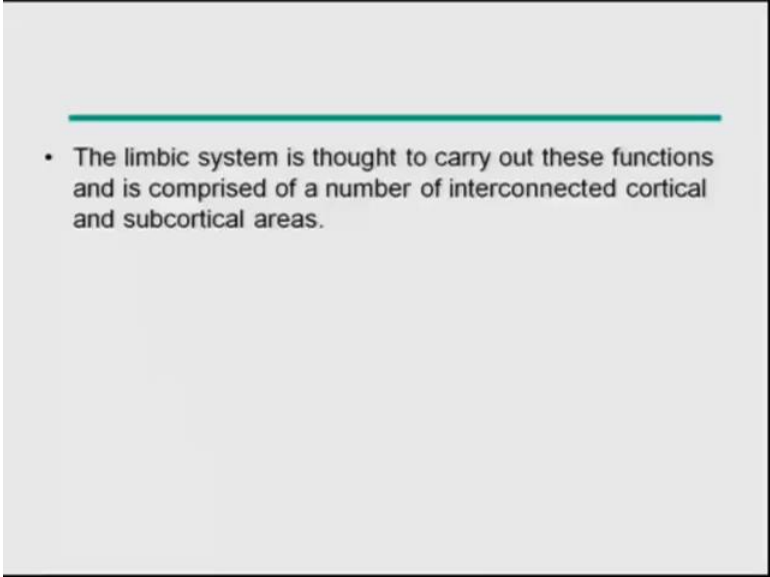
- **Emotional experience**,
ability to reflect upon our emotions
and
Rewards, both good and bad, play
an integral role in modulating emotions
and motivated behavior.

So, what is what are what are rewards, if remember I talked to you about dopamine and the reward and punishment system. So, what is an emotional experience? You may be thinking anything and thinking that fine rationally I am going to dry to from this place to that place and everything worked out wonderfully in your mind and suddenly something happens, somebody comes and bumps into your car. The first, reaction would be emotion, all rationality and thought would be go off will be off somewhere.

So, that is the power of emotion, but emotional experience if you look at it this is one feeling emotion, that suddenly you got angry or your heartbeat may or you may get fearful or after a bump which often I mean you see all neuroscience related to life, you talk about road rage. Road rage, is not a well thought of thing people start fighting and you often witness it on the news channel or you witness in the paper this is a sudden

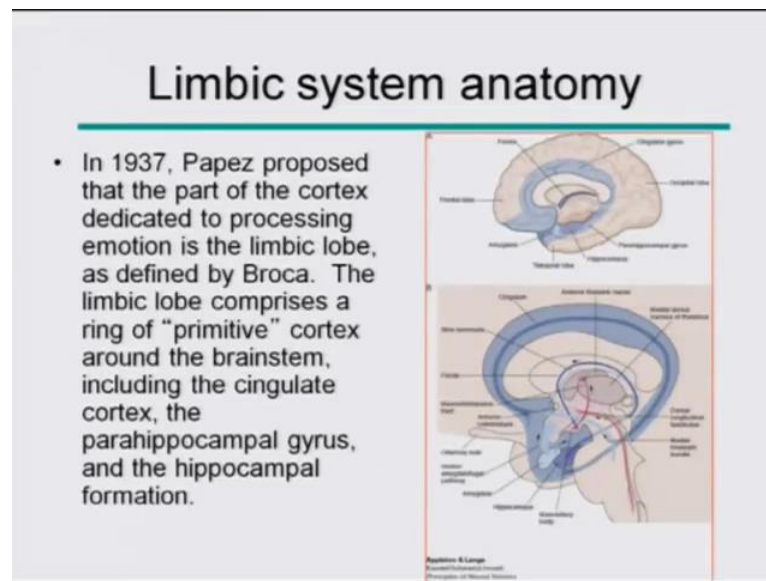
emotional search which comes, but after you have done an act either impulsively what is the emotional experience that is the ability to reflect up on our emotions and you have to decide whether this if act or a emotion, makes you feel good the chances are you will repeat it, but if you have gone on a back trip that will be not so good and you will probably the motivation to repeat or do will be less your motivation often comes from your emotions.

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- The limbic system is thought to carry out these functions and is comprised of a number of interconnected cortical and subcortical areas.

So, the part of the brain which actually does it is limbic system, I have not talked about limbic system I have just mentioned it briefly, in the last lecture called Papez circuit. And I had left it for this lecture it is comprised number of cortical and sub cortical areas. Cortical is you remember the cortex by now you are familiar with that sub cortical.

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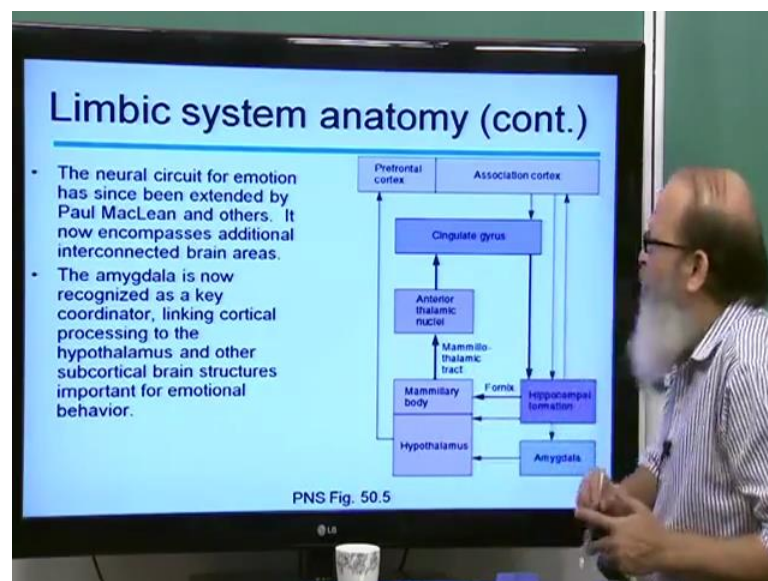
So, this is the anatomy of limbic system. The Papez circuit, which if you remembered I briefly mentioned this part of the cortex dedicated to processing emotion it comprises a ring of primitive cortex remember, I mentioned that it was a motor cortex which was developed in evolution and then the emotional cortex this is the emotional cortex which is present in mammals and lot of other animals in primates frontal lobe you know it very well. So, see this singular guidance which is around Corpus Callosum, Corpus Callosum, is the band of fibers, which unites two cerebral hemispheres in the center of the brain around it is singular guidance, temporal lobe, memory and sound and speech Etc. So, these are the actually biggest structure.

There is a ring in the deep brain inside it goes, like you take it the brain is this way it is like this central if you take two hemisphere in the center there is a ring like this on both sides and these are the structure Thalamus is the very very important structure because Thalamus if you remember is the relay center nothing goes to the cortex nothing comes from the cortex and Thalamo cortical connections keep you conscious and integrates information Etc. Etc, you would have heard of in the popular press also this is the structure which has been most often implicated in fear and in rage and anger hippocampus is a structure which is involved in memory.

So, memory and emotion will not go separate because if you do not have a memory of something you will not bother that is why small kids are not afraid of fire or dogs or any because they have no memory they will just so once they go and a dog bites that memory will. So, memory does not have only a verbal component. Memory also has a component of emotion. So, when your memory is get activated, when you see something and you recall your memory and your memory compares present stimulus with the past one it is actually not only evaluating on the facial features or bodily or it is comparing that on the emotional contact.

So, often you will wonder the why am I getting, why am I remembering all these things you are remembering because your brain is remembering all that and hippo-campus they are all the short term memory if you remember last time we talked about it the long term potentiation hippo-campus happens to be there. So, this is just a simpler representation.

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If you remember, last time I was telling you that whether the cortex is involved in emotion and all for a long time we thought it is not involved it is the thinking part of the brain, but all injuries to cortex bring a lot of emotional changes. So, the prefrontal cortex which is actually a the center in the brain on the left side (Refer Time: 15:09) lateral and lateromedial which controls abstractions, judgment your differentiation between stimuli,

taking a decision finally, is a part of not exactly limbic system, but part of the emotional brain the association cortex, the primary cortex of movement, primary cortex of sensation, and the association cortex mind you have a mind because everything gets associated in those.

So, these association areas are between the frontal lobe, the temporal lobe, the parital lobe, cingulate gyros, satisfies a ring thalamus we all know this hypothalamus. Hypothalamus, is a small body deep inside the brain which controls sleep, sex, hunger thirst, all your body chemistry is regulated and hypothalamus sense actually the chemicals to control the neurotransmitters and the neurotransmitters control the hormones, and the hormones rest of the body. So, hypothalamus is such a beautifully connected chemical system.

So, the nerves control the movement in sensation, but hypothalamus through chemical messenger actually controls the secretion of controlling hormones, which controlling hormones again come through the blood to the end organs like thyroid like adrenal, like pancreas, the secretion of the chemicals from there finally, controls the rest of the body metabolism. So, some intelligent people know that man, is a slave of hypothalamus because if hypothalamus shouts thirst you have to give it water, or if it shouts sleeps. So, the part of hypothalamus controls the circadian rhythm so when we talk of sleep we will talk about it hippo-campus memory and amygdala, is the most important structure of the fear and rage. So, you may be wondering what is the big deal about it when we know so much about the network, we know about the areas of the brain, and we know this that these parts are controlling why cannot we fit in together I will come to the towards the end, why cannot we fit in together.

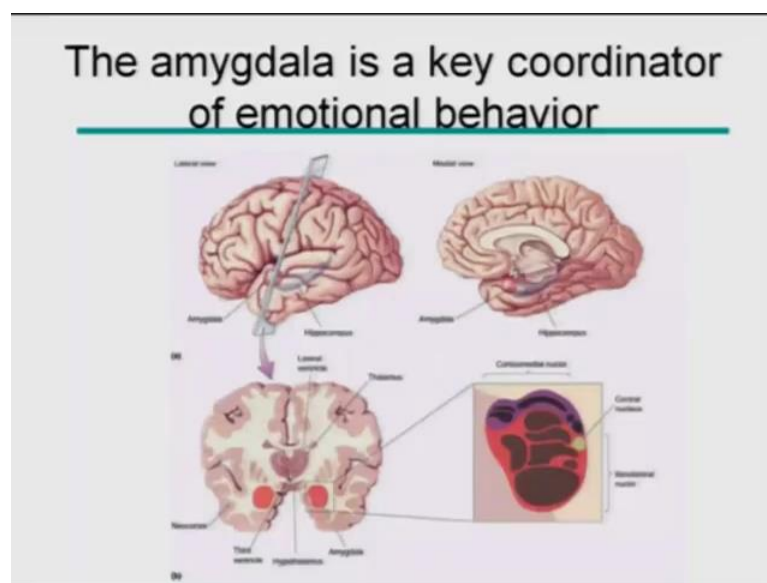
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What triggers the hypothalamus (and other brain areas) to modulate emotional behavior?

- Emotionally significant stimuli be recognized
- Reward information

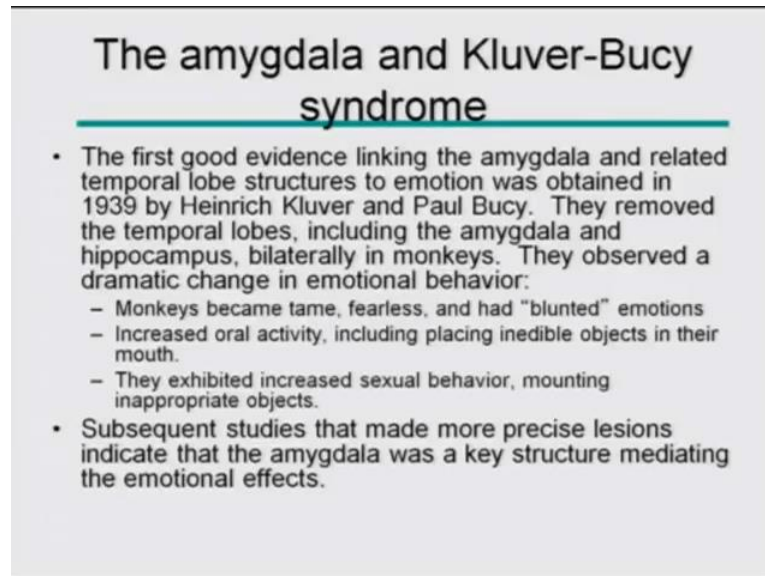
To what triggers the hypothalamus emotionally significant stimuli there may be 10 things in your environment, but not all of them will be important for you, you will only react or pay attention to what is emotionally significant. So, you may have your father standing there and, you may have a stranger the chances are first thing you will pay attention is to your father.

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So, as I said amygdala, is the key coordinator in the development of amygdala if you look at it this is here, here at the somehow over years amygdala does not work in solution, but probably amygdala is the place which triggers, which actually triggers the response of fear and rage.

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The amygdala and Kluver-Bucy syndrome

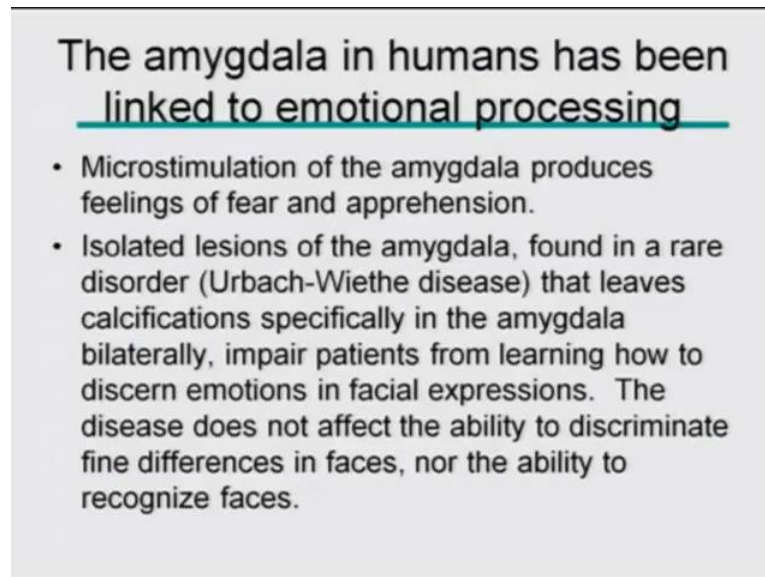
- The first good evidence linking the amygdala and related temporal lobe structures to emotion was obtained in 1939 by Heinrich Kluver and Paul Bucy. They removed the temporal lobes, including the amygdala and hippocampus, bilaterally in monkeys. They observed a dramatic change in emotional behavior:
 - Monkeys became tame, fearless, and had "blunted" emotions
 - Increased oral activity, including placing inedible objects in their mouth.
 - They exhibited increased sexual behavior, mounting inappropriate objects.
- Subsequent studies that made more precise lesions indicate that the amygdala was a key structure mediating the emotional effects.

But there is one something called Kluver-Bucy syndrome I mentioned it briefly, if you remove the amygdala and hippo-campus of both sides in monkeys, monkeys become tame or fearless, non emotional "blunted" emotion you do not express and we find this "blunted" emotions in some of the illness like where (Refer Time: 18:42) where we have lot of negative symptoms.

They will have increased oral activity; they will put everything to the mouth including placing inedible objects in their mouth and the sexual behavior increases like mounting inappropriate objects. So, lot of the stuff was gone in this hippo-campus was gone in this temporal lobe was gone and (Refer Time: 19:07) tips of temporal lobe we have gone. So, these were the memories stuff an amygdala which increases the fear response. So, this is called the Kluver-Bucy syndrome it is very rare and then they went on to make precise lesions make a region in temporal lobe, then make a region in hippo-campus. So, that indicated it was amygdala is actually the key code in like, Thalamus, is the key

coordinator for integrating information the sensory and motor the emotion center the emotion coordination is with amygdala and it has been linked to emotional processing.

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The amygdala in humans has been linked to emotional processing

- Microstimulation of the amygdala produces feelings of fear and apprehension.
- Isolated lesions of the amygdala, found in a rare disorder (Urbach-Wiethe disease) that leaves calcifications specifically in the amygdala bilaterally, impair patients from learning how to discern emotions in facial expressions. The disease does not affect the ability to discriminate fine differences in faces, nor the ability to recognize faces.

If, you stimulate it without any external stimuli just sort of may be electro stimulation or or a chemical stimulation the feeling of fear and apprehension automatically comes in and you read this lesions of amygdala is a rare decease like Urbach-Wiethe the calcium deposits they, impair patient - patient after that cannot find out emotions in the facial expressions already if you if you remember organ which we talked about insulla where neurons are they will actually look at facial expressions and, but automatically it does not reach insulla, Insulla, has does not have a separate eye to look at it. It is the same information.

Now you look at the complexity of the whole thing I am sure you will be able to understand what I am saying you same stimulus from eye comes in a discrete feature extraction it goes to the it reaches the mirror neuron the mirror neuron also fills the same thing like what you have mirror neurons will not feel anything unless that descending emotions happen in amygdala and the Papez circuit. Because, Papez circuit will compare same expression with the previous memory and that will be conveyed to the higher centers.

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The amygdala in humans has been linked to emotional processing (2)

- Imaging studies have revealed that the amygdala is activated differentially by emotional facial expressions.
- Other functional imaging studies have shown the amygdala to respond to emotionally arousing stimuli.



PNS, Fig. 50-6

Imaging have has revealed this is what I was saying. So, it is the amygdala actually which response through facial expressions first and then the once the emotional thing has filtered then, neurons can feel it at the higher center that this person is sad because, what does sad mean? Sad is a meaning given to a certain emotional state. What is happiness? Happiness is a meaning given by the higher context was certain types of set of the physical and mental state that basic processing the basic set of information is there is with the limbic system, meaning may be given by the higher center later on there is a process there is a same set of information.

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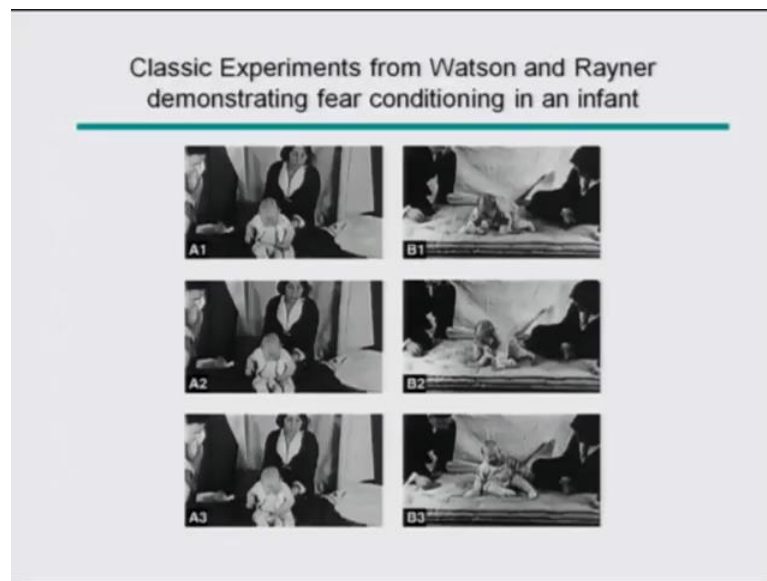
Fear conditioning is a tool for investigating neural substrates of emotion.

- Fear conditioning is a process in which a neutral stimulus (conditioned stimulus, CS) is paired with an aversive stimulus (unconditioned stimulus, US), so that the CS comes to predict an aversive outcome, eliciting fear behaviors even in the absence of the US.
- Fear conditioning can be found in a large range of animals, from rodents to rabbits to humans.
- As early as the 1920s, fear conditioning was demonstrated in infants. A white rat presented to an infant does not innately elicit fear, but pairing the rat with an aversive noise, produces crying and attempts to crawl away, even when the rat was presented without the noise.

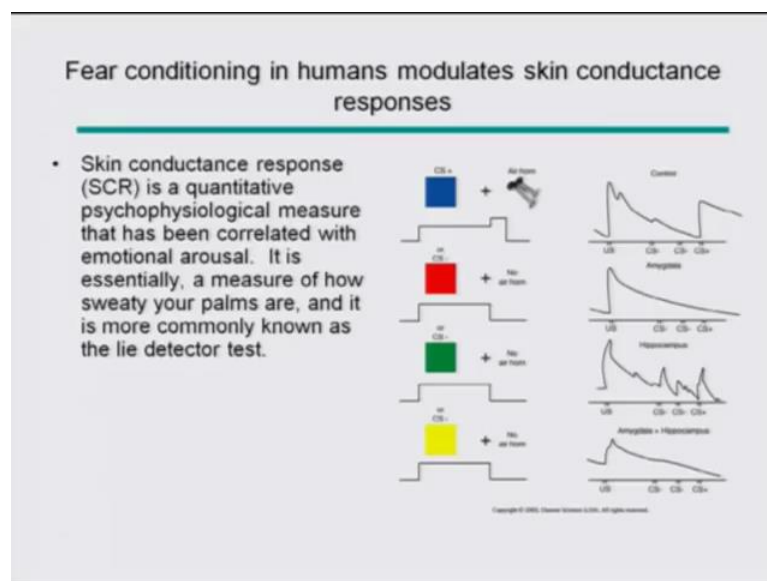
Fear condition you remember we talked about the problem in the experiment condition stimuli.

So, all these conditioning and of fear and any other symptom for that matter is there is all animals number one and lot of animal experiments have been gone this is a very very common psychological thing which we find.

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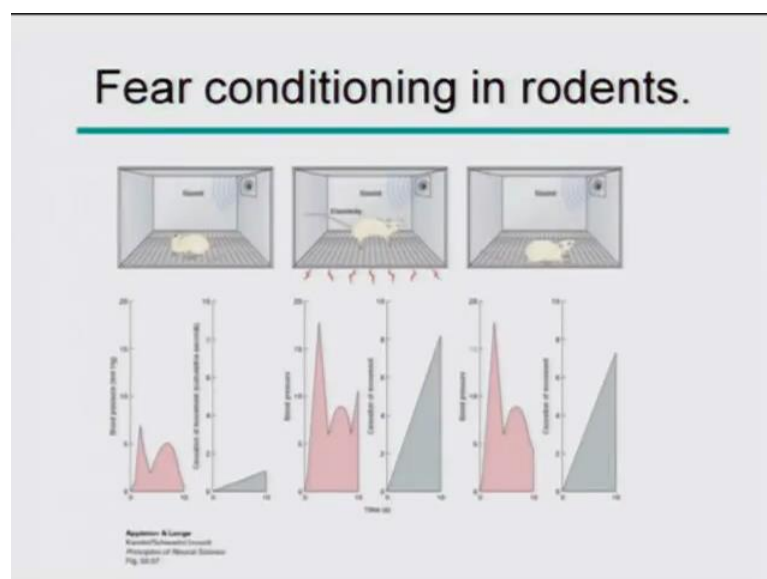
So, this is the type of fear conditioning it do which is very very unethical these days nobody will listen, but there is something called skin conductance. Skin conductance or galvanic skin conditions is a psycho physiological measure you already have some current or resistance in it this varies because there is a lot of blood flows which happens and as the blood flows happens the different physiological condition in fear and anxiety

these are the basics of what you call this is one of the parameters of live detector machines.

The other parameters like heart rate, like people retaliation, all of this put together they are assumed that if you are not speaking a lie, your emotional will be less, if you are speaking the truth, but once if you are speaking a lie then your mind knows deeper that there is something else there will be a conflict situation in the brain. So, brain keeps passing through this bifurcations of decision all the time, in all movements these are the big questions which will talk when we start the fourth week lecture the this whole diversion, bifurcation, then the conflicts that raises your emotional arousability, because in the situation of conflictive your mind is not clear what is happening and it does not what ambiguity.

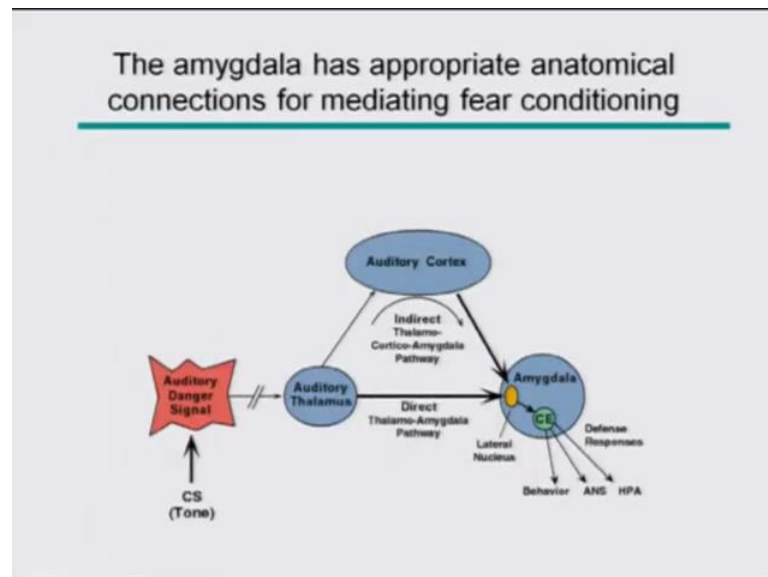
So, it does not know which way it is going to head that changes the galvanic (Refer Time: 24:23) you may not realize it because these are all under deep control of parasympathetic and sympathetic. The parasympathetic uses a style Colin and sympathetic uses nor (Refer Time: 24:35). So, now, you can, you can ask me whether. So, what is so mysterious about emotions? Like, we have defined network and we have task based imaging. So, we do task based emotional measurement also.

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This is the type of stuff which they do for fear conditioning is a graph which you can see.

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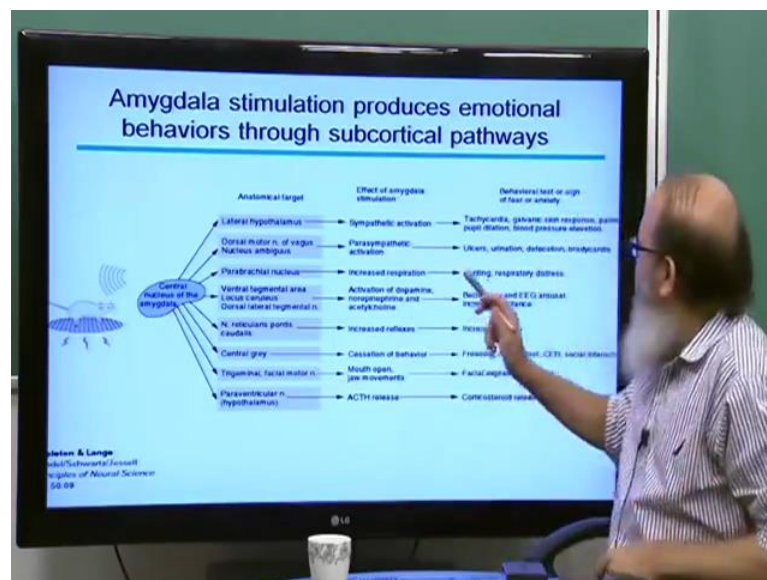
Why is amygdala so important? Like, hypothalamus is important like a small peanut amygdala.

Now, you go back to talking about networks what is the point of network developing through habient rule or non habient rule, firing together, presenaptic, prosenaptic, to form connection it is all about connection. Amygdala is sitting at a place where it has connection with the thalamus. So, there are direct thalamo amygdala now once you have a connection with thalamus thalamus is already a point of relay of information. So, suppose for example, you get auditory danger signal or it is thalamus it goes to auditory cortex and temporal lobe is auditory cortex. Amygdala is a part of that Papez circuit with it. So, it is very easy to make amygdala as a seperate coordination center for emotion.

So, maybe it is like this if you try to look at it thalamus is the integration center for all the sensory and motor and the level of conscious the oscillation, the bind and all that if amygdala had been mixed with thalamus everything would have really got jumbled up it is just at some distance separated simultaneously 2 things are happening 1 evaluation of the sensory thing physical properties and a, evaluation of the stimulus on emotional

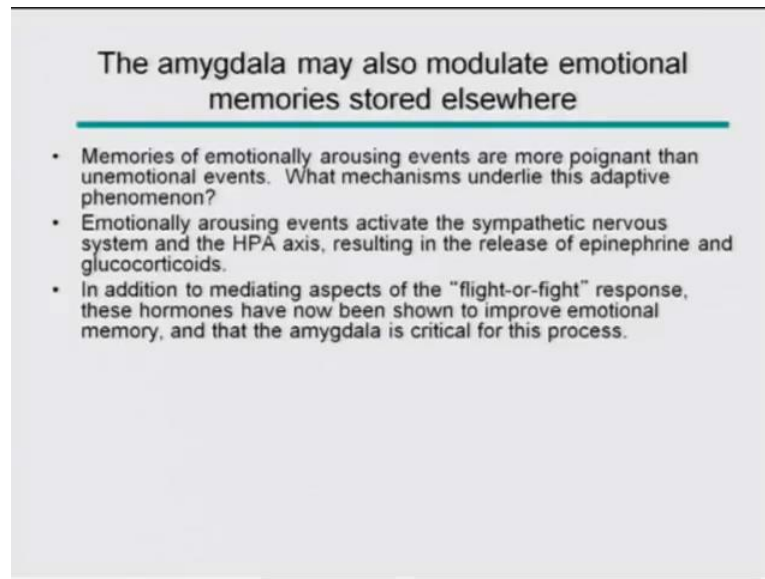
properties these 2 things together decide a relevant hierarchy on the basis of which the higher conscious brain can decide whether you want to act on it or ignore it and that is why amygdala actually see.

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Now, now it will become clear to you so this is amygdala see the type of connections hypothalamus, sympathetic that is a (Refer Time: 27:15) tachycardia, faster heart beat, pupil dilatation, blood pressure goes up, galvanic response, parasympathetic through vagus nerve which comes here, ulcers, urination, defecation. VTA, Ventral Tegmental Area is very very important activation of dopamine, behavioral and EEG arousal increase in startle. So, with there is a small thing, the small economy connections all over this whole body thing is managed.

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The amygdala may also modulate emotional memories stored elsewhere

- Memories of emotionally arousing events are more poignant than unemotional events. What mechanisms underlie this adaptive phenomenon?
- Emotionally arousing events activate the sympathetic nervous system and the HPA axis, resulting in the release of epinephrine and glucocorticoids.
- In addition to mediating aspects of the "flight-or-fight" response, these hormones have now been shown to improve emotional memory, and that the amygdala is critical for this process.

This is important I said hippo-campus is involved in the memory thing amygdala they also modulate emotional memories to store elsewhere. Now, how does it do it? And why should it do it? Because, if what mechanism if this arousing events activate the sympathetic nervous system and the hypothalamus (Refer Time: 28:16) axis which is this controls the hormones, which results in the release of epinephrine.

So, this fight or flight to be managed now for absolutely new emotion or new memory thing which does not have a memory, what is amygdala going to compare? And what is the mind going to compare? The mind has to compare any stimulus on it is perceived set thing in the past and based on that emotional memories mind will decide what to do and how are you going to act on it. So, amygdala is the hero of the emotional world. We have also seen that once you give lesion destroy a bit of amygdala this memory enhancing functions are gone whether it is a physical injury or it is a chemical injury.

So, we will talk about this in the next lecture, which will be the last lecture of third week, and we will talk more about emotion.

Thank you.