Cognition and its Computation
Prof. Rajlakshmi Guha
Rekhi Centre of Excellence for the Science of Happiness
Indian Institute of Technology, Kharagpur

Lecture - 02
Historical Origin of Cognition Studies

Hello and welcome back to this course on Cognition and its computation. In this class, we are going to talk about how cognition the History of a Cognition Studies, how it has evolved across the years. We know that this our species of homo sapien sapiens has lived for 50 thousand years or more.

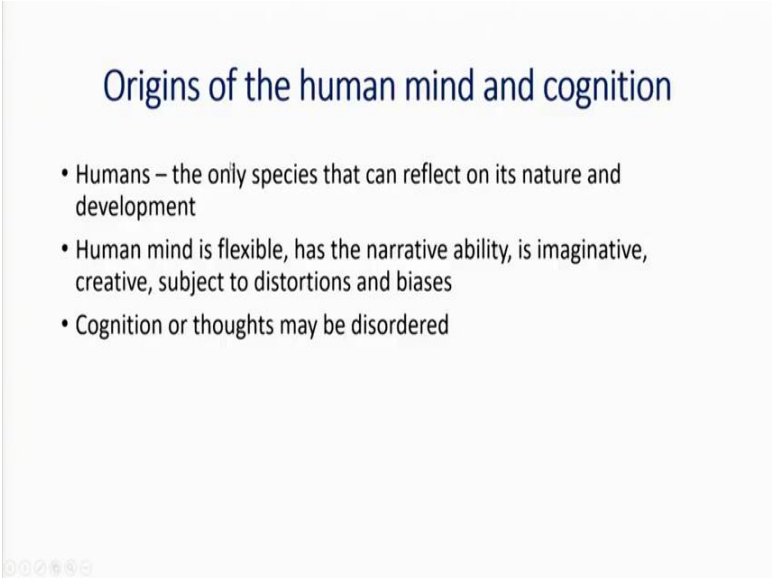
So, the current evolved species and we know how technology has evolved over this time. We see within a decade how rampantly technology has brought got a hold of our lives got a grasp over our lives in more ways and one specially during the Covid era.

Now, has that had an effect on the way we think? Has it affected the way we process information? So, over these years has our brain evolved has our thought processes has the basic single units of information processing has it evolved over time? And, along with it how have we started thinking how have we thought about from where these the origin of these thoughts.

So, to look into this how we have looked into cognition, how we have looked into you know the understanding of the mind where today we know that the brain is the biological substrate of the mind, but is this the way we thought from before? No. So, how did this come about, how has this progressed we are going to look at a timeline of events over the last couple of centuries to understand how our understanding, how the human understanding of its own thought, of its seat of the seat of its thought has evolved over time.

So, in this class we are going to look into the historical origins of cognition studies.

(Refer Slide Time: 02:44)



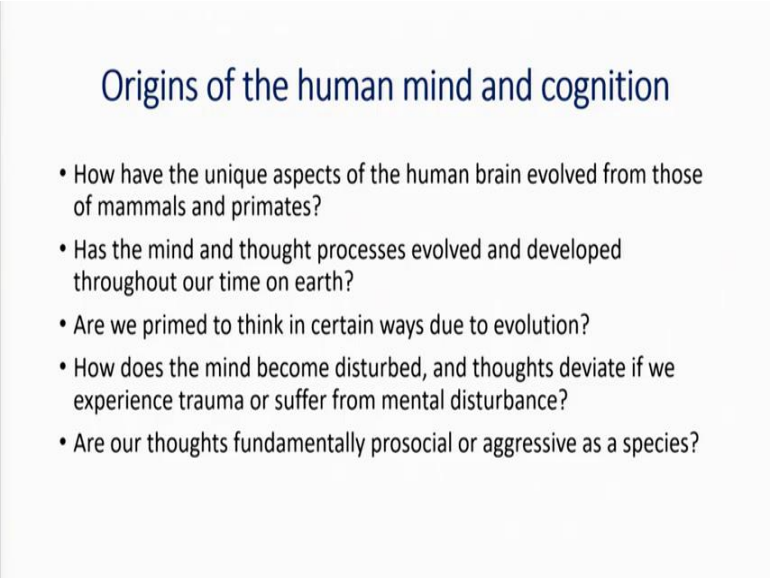
And, before we begin we must understand a few aspects about the human mind and cognition. We know that the humans are the only species that can reflect on its nature and development. Now, how can we say that? We are convinced about this today because we do not know a lot about the animal world.

But, as of today we believe that we are the only species who has philosophical notions, philosophical ideas and that brings thoughts about who we are, how we have come into this world, what is our role in this world. And, our mind is flexible. It has the ability to narrate, it is imaginative, it is creative and along with it, it has the ability to create distortions and biases.

And, these aspects affect our processing of information; these aspects differentiate between one individual and the other; differentiates the thought processes of groups of individuals. And, also we have seen that cognition at large or thoughts at large can be disordered. Now, the disorder in the thought process need not be from a socio cultural perspective, but it can be or it has it may emanate from an error in the processing of information.

We will gradually see with time how when we move into the ideas of you know theories of memory studies, we will see how false impressions are created and you know the eyewitness testimony can be falsified without the intention of giving a false data.

(Refer Slide Time: 04:57)



So, now this these studies these thoughts of understanding human mind and cognition over the centuries we have these questions have been disturbing us. So, we try to understand how the unique aspects of the human brain have evolved from those of mammals and primates. And, there are researchers zillions of researchers in fact, who have studied how long?

Has the mind and thought processes been there in humans has it been in the same form as I was mentioning 50 thousand years ago or has it evolved over time? Are we primed to think in certain ways due to evolution? And how does the mind become disturbed, and do the thoughts deviate if we experience a post trauma or you know if we experience a trauma as in post traumatic stress disorder or suffer from any other mental disturbance – like a delusional disorder or if there are any other disturbances in the neurotransmitter system of the brain does it affect our thought processes.

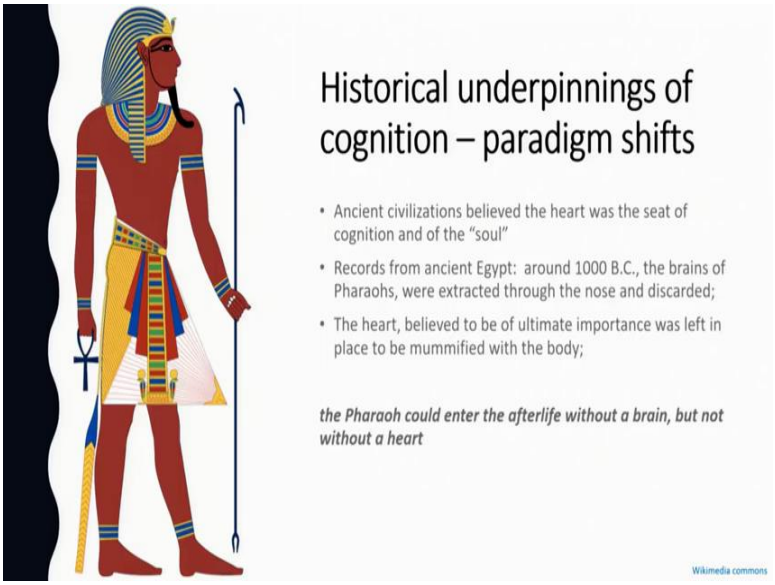
And, are our thoughts fundamentally pro-social or aggressive as a species? So, I was talking about biases and stereotypes in thought processes we understand from here we see how our you know thought processes differ in you know or I should say are each there is a group thing that develops it may be pro-social or aggressive in behaviour how have these developed over time.

Classic to understanding of this is provided by evolutionary biology where it is we will not be covering this within this syllabus but, I am too urge to inform you about this. So,

there is this concept of reciprocal pro-social behaviour or you know reciprocal altruism that has developed in our species in our genes. And, this I am not talking of humans per se, but this is a development that has happened over evolution in all the animal in the animal world to survive.

So, the idea of helping our kin or I helping others because expecting we are expecting that the others will be helping us in return. So, this has brought about prosocial behaviour. So, this is wonderfully studied in biological evolutionary biology and that itself has also a contribution to cognition studies.

(Refer Slide Time: 08:03)



But, we will go back further to let us see from how historical underpinnings to see the historical underpinnings of cognition and the paradigm shifts that have happened across centuries.

So, if you look at the ancient world, if you look at a pharaohs and you know around 1000 BC the records from ancient Egypt you will see that you know especially from most from the sarcophagus that have been excavated, we have found that the brains of the pharaohs were extracted through the nose and discarded.

So, the Egyptians, the ancient Egyptians they felt that the brain was an irrelevant organ that wasn't required, the heart was the seat of information, the heart was the seat of knowledge. The heart was more important because it helped us to survive. And, so, the

Egyptians even when they mummified and you know maintain they kept things in the sarcophagus we have found that they would discard the brain. So, this idea about the brain being the seat of cognition the brain being an important organ wasn't believed even in the ancient century.

So, they were they thought that you know it was the ultimate organ was the heart and that is why they mummified when they mummified the body they kept the heart, but not the brain. So, the pharaoh could enter the afterlife without a brain, but not without a heart.

So, it is important, in fact, if you see images of Anubis that is one of the Egyptian Gods. There is a wonderful picture of the Anubis holding a scale a balancing scale with the heart on one end of the scale and truth on the other end of the scale and he balances it. So, this is the in the gates where you know to enter the other world one has to.

So, the he the individual is evaluated on the basis of the heart which is again a very important organ as the Egyptians would see, but the brain was not given much importance.

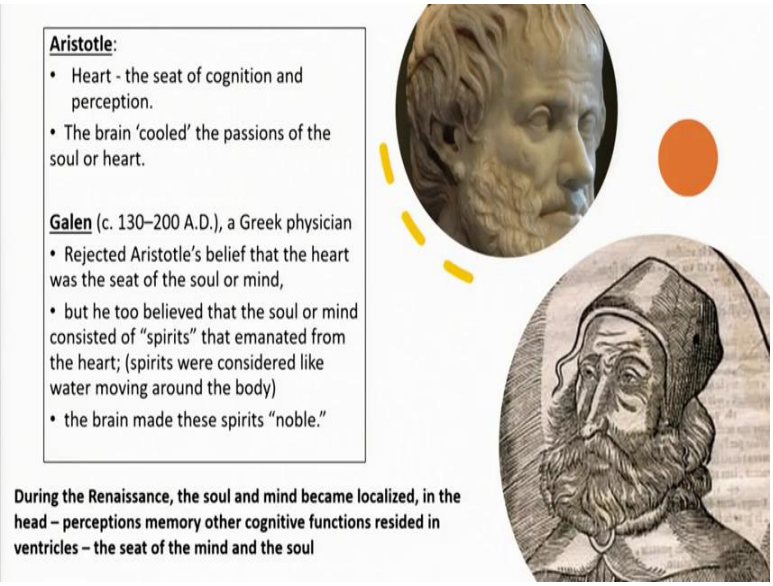
(Refer Slide Time: 10:40)

So, now we move on from there to the other civilizations. Now, if we look at our Indian civilizations, these are old Sanskrit texts and if you look at Mesopotamian civilizations or Chinese civilizations you will see that the heart again is considered the seat of

intellect, memory, emotions, thoughts, attention. So, all these important cognitive functions as we would say were by the heart were controlled by the heart and that is what the ancient civilizations thought.

And, primarily, what in the heart? It was the spirit of the soul of the individual that controlled these factors these cognitive functions and not the brain. So, the idea about the brain being important developed much later the idea about brain being important in thoughts and in mind came much later.

(Refer Slide Time: 11:44)



Now, we come into more recent times and if you look at famous philosophers like Aristotle, Aristotle too believed that the heart was the seat of cognition and perception and the brain cooled the passions of the soul or heart. So, he added the responsibilities of the brain being the you know it is more like a cooling center or an or a conditioner that would calm the individual down from the passions of the soul or the heart.

Galen between 130 to 200 AD was a Greek physician who rejected Aristotle's belief that the heart was the seat of the soul of the mind and in fact, Galen is one of the first people who rejected the idea of heart being the seat of cognition. But, he too believed that the soul or the mind consisted of spirits and this emanated from the heart.

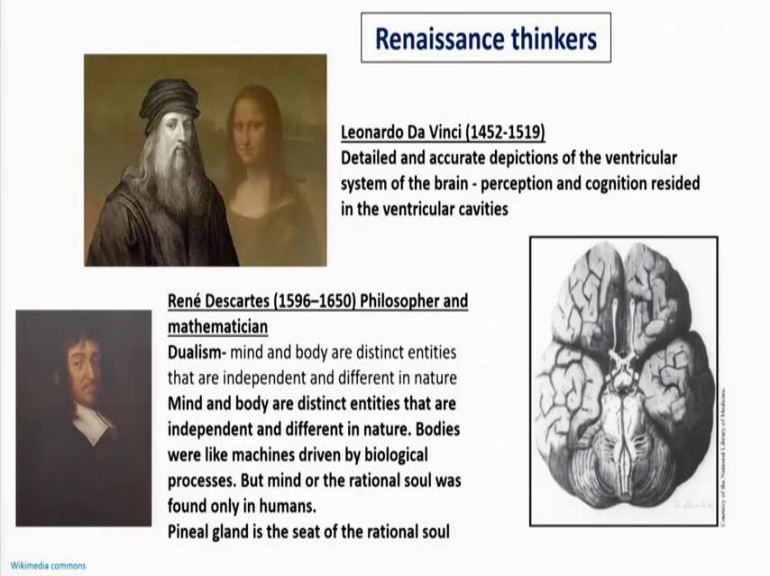
So, the source was the same and the spirits were more like a fluid moving in you know like in a watery motion moving around the body. So, it was could move around across

the body and these the spirit controlled the mind. So, the brain was made up made the brain made these spirits noble. So, whether it would be a good spirit or a bad spirit that is where the brain came in.

So, this idea about the soul and mind this was emerging during the Renaissance period and it became the soul and mind gradually they became localized in the head. And, when we talk of the head, it is about perceptions, memory and other cognitive functions.

They came to be believed there as to be residing in the ventricles and that was supposed to be because at this point in time people were people thought that like because the spirit flowed across the body so, there must be some mechanism for the flow from the head to the rest of the body and the ventricles were considered as holes in the head that made this flow of information easier. So, that is why the ventricles were responsible for cognitive functions, but at least it came to be localized in the head.

(Refer Slide Time: 14:37)



Now, let us look at some Renaissance thinkers and the most prominent among the renaissance thinkers is Leonardo Da Vinci who was there in the 15th and 16th century and he gave us detailed and accurate depictions of the ventricular systems of the brain. And, he showed us he gave us anatomical images of the cavities ventricular cavities and believed he too believe that the perception and cognition presided in these ventricular cavities.

Next came we cannot when we talk about the mind, the body, the soul cognition we cannot do away without talking about Rene Descartes. Rene Descartes was a philosopher and mathematician in the between 1596 and 1650. And, we are all familiar with Descartes' idea of dualism or he said that mind and the body are distinct independent entities that are independent and different in nature.

So, bodies were like machines. They were driven by biological processes, but the mind which he also termed as the rational soul because the mind is the functioning of the mind as per Descartes was to take rational decisions. So, that is why he called it the rational soul was only found in humans. It is more like the idea of logic where he believed that you know for logical thinking processes for rational decision making the soul was important.

And, the this idea of dualism mind body dualism was propagated by many scientists and researchers of this century and like Descartes many people believe that the mind and body were separate entities. Descartes moved ahead of that. Descartes felt that it was they did connect with each other.

So, there is in fact, some of the researchers during this period also believed that the mind and body worked in unison because god started the mechanism, the time frame together when the child when an individual was born. So, you have the body functioning along the timeline of the lifetime and at the same time the as per the clock the brain the mind functioning so, these were separate entities.

Descartes was a little different and Descartes from these philosophers and Descartes said that know the mind and body are connected at a point in the body in the machine and from there must be some organ in the body from where they connect to each other and this organ he identified as the pineal gland.

So, the pineal gland, why the pineal gland? Because the pineal gland or the pineal gland as many people say is the seat of it is a single is a single structure Descartes realized that for all the other structures they occur in pairs in the human body they occur in pairs.

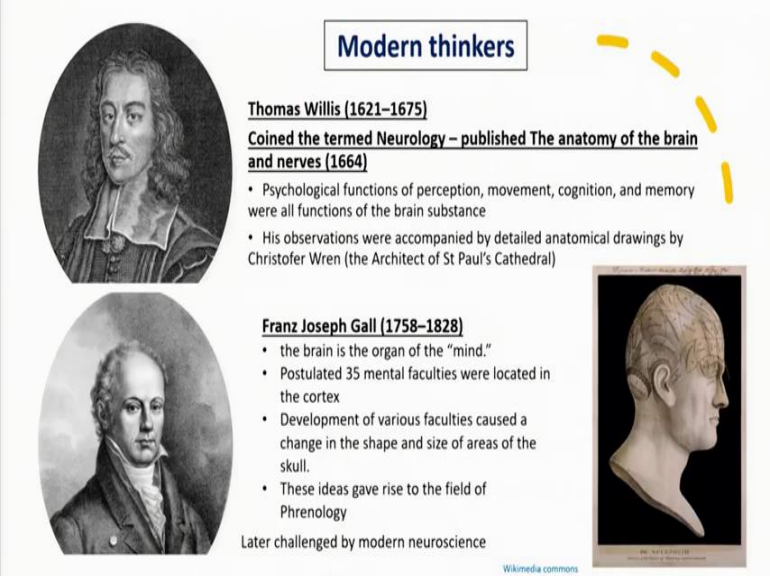
So, they must be for the some structure a single structure through which the inter the you know the information is travelling from the mind to the brain to the body for the body to

carry out the biological functioning or for the body to execute the action and, descartes pointed it out as the pineal gland.

The interesting thing about the pineal gland as we know today is that it is very important for it is far from determining the cognitive activities of the brain of the body, but the primary function of the pineal gland is to secrete melatonin in the brain and it is responsible for sleep wake cycles.

But, this we cannot completely do away with this theory of dualism because at least in this was the first theory of its kind where it brought together the ideas about the mind and body having a relationship ok.

(Refer Slide Time: 19:43)



Then we come to the modern thinkers and further from Da Vinci and Descartes we move into Thomas Willis and he has coined the term neurology. He published the book in the anatomy of the brain and nerves in 1664. And, Thomas Willis he said he was the first one to talk about brain substance and he said that these psychological functions of perception, movement, cognition, memory, decision making –these were all functions of the brain substance.

And, what he did was the he was a part of an Oxford group of educationists at that point and along with him there was John Locke, there was Christopher Wren and you know

these Christopher Wren in fact, was an architect and he was the architect of the Saint Paul's Cathedral.

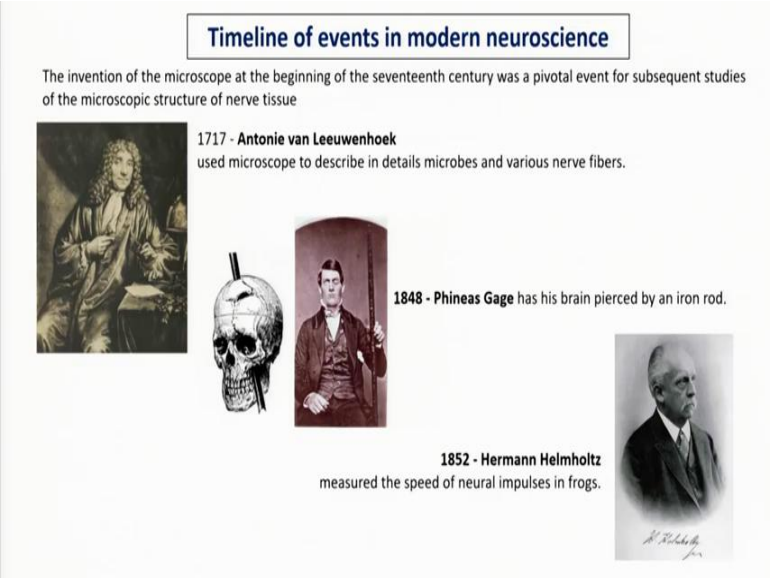
But, he was he has given us beautiful anatomical drawings of the human body and with the accompaniment of these anatomical drawings, Thomas Willis spoke about the brain functions and you know these the brain being responsible for the brain and the nerves being responsible for psychological functions of cognition.

So, next came in Franz Joseph Gall. We cannot do away with Gall. Again, Gall in was the most prominent biologist or physiologist I must say during the 17th, late 18th century and he identified the brain as the organ of the mind. And he spoke about 35 mental faculties that were located in the cortex. So, Gall's ideas gave the gave rise to the field of phrenology that is that there are definite areas of the brain that are important for definite mental faculty.

So, if and this if that faculty was working well then there would be a change in the structure of the skull. So, today we shape and size of the skull. So, today we know that phrenology is not scientific and we would we have discarded the idea of the skull being changing in its shape and structure, shape and size shape and structure because of the active you know functioning of certain mental faculties.

But, phrenology as science developed in this century in the 18th century and was very very prominent, but it was later challenged by modern neuroscience of course. But, this has given us the idea that you can actually localize brain activity, you can localize brain functions.

(Refer Slide Time: 23:27)



So, we move on from Gall to the recent neuroscience or the modern neuroscience and a modern neuroscience has developed with the help of the advancement of various tools. And, along one of the major important instruments that has helped in the understanding of the brain from the you know or scientists trying to understand the different areas within the biological structures that are responsible for cognition.

The was improved or became more advanced due to the invention of the microscope at the beginning of the 17th century and this was a pivotal event because it helped with the subsequent studies of the structure of the nerve tissue. And, Antonie Van Leeuwenhoek used the microscope to describe in details microbes and various nerve fibers. In fact, Leeuwenhoek is known as the first microscopist or the microbiologist during the time.

And, he along with studying microbes, he also studied various nerve fibers in frogs and other animals. And, after this again a very important event that came that is important for the understanding of personality and how the personality and the thought functions are embedded in different areas of the brain, the study of Phineas Gage is very important.

In 1848, Phineas Gage a construction engineer had during one of his work periods in the railway tracks had an iron rod that pierced his face and so, it entered over here and went out from here. So, this is an image that is gives us a demonstration of from where the iron rod entered and it came out from here. And, Phineas Gage did not survive the incident. He was conscious for a while and then he was taken to the hospital.

And, after several surgeries, he returned as a normal individual and he carried on with his regular activity. So, when I say returned as a normal I mean that there was no disturbance in his visual process of course, his one of his eyes got damaged because of the injury, but he lost one of his eyes, but otherwise there was no problem with his speech, with his movement, with his perceptions, with his other information processing ability.

But, what gradually what people started noticing is that Phineas Gage had changed as an individual. So, he did not behave the way he used to do earlier and this brought about an understanding of the importance of different areas of the brain and this was the first time that people understood that the frontal lobe that is the frontal area of the brain is important for behaviour, is important for personality, is important for decision making.

So, this and later on so, Phineas Gage was looked at by his friends as an entirely different person. So, even when his other functionalities, his motor functions, his other information processing abilities were the same were not affected, but they had something had happened in the individual. So, this accident of Phineas Gage is a very important event in the timeline of modern neuroscience and modern cognition because it tells us it gave rise to the study of the frontal lobe or the frontal areas of the brain. So, earlier it was known as a sleeping area.

Now, then again in 1852 we must talk about Hermann Helmholtz and he studied the speed of neural impulses in frogs. Now, you may be thinking that this is moving far away from cognition, so, what exactly are we talking of? We talking of Leeuwenhoek and microbes and nerve fibres; and here we are talking about neural impulses in frogs – how is this related to cognition?

If you think about cognition to as we see it today, we must and it is again how do we see it today? We see it as emerging from different neuronal activity or synaptic activity and different circuits that are creating associations within the brain that gives rise to different kinds of cognitive functions.

Now, to understand this how this came about we must see how it developed in other you know how these studies developed over time earlier in you know in animals and that is how we have transferred or translated these into other studies in humans.

(Refer Slide Time: 29:18)

Again one of the very important studies during in the events of modern neuroscience is Broca's work. So, Broca showed us how there were specific areas in the brain and in fact, I must also mention about one very important individual whose you know whose injury was important in the study of modern cognition modern neuroscience.

He is known by the initials of HM and we have seen that his you know due to epilepsy a certain area of the brain had to be surgically removed and that affected his memory. We are going to talk about HM more he it was hippocampus and we are going to talk more about HM in a later part of the you know of the course.

But, here again I must come back to Broca and in 1861 he described the neural localization of language. Today we know about the Broca's area, we know about following which we know about the Wernicke's area and the Gashwins area and this work of localization of pinpointing a specific area for language production was first done by Broca.

So, this showed that there are areas within an anatomical structure in the human body that is responsible for a psychological function. Before modern neuroscience we knew that it thoughts were you know spread across the body or thoughts were spread emanated from the heart, but now we are talking of specific areas. And, this advancement of our understanding of the specific anatomical structures and anatomical units, microscopic

units that were responsible gives us a better understanding of the mind and the human brain and the thoughts of cognition.

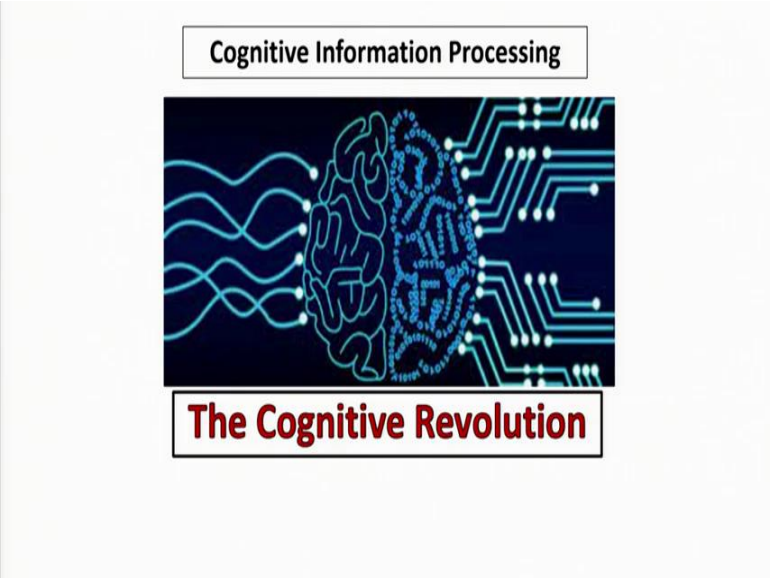
In 18 9 89 Cajal he was a Spanish biologist Cajal argued that a nerve cells are separate elements. So, now, from the anatomical structure, we have moved to nerve cells and he with Golgis' nerve net hypothesis. In fact, Golgi created a stain by which a Golgi behaved that all the neurons or the single units of information processing were connected with each other, but Cajal contradicted this idea and he thought that there must be a space between two neurons.

And Cajal was proved right Cajal was proved right in 1889 and he used Golgi stains this by using a better improved microscope he showed that there is a space between two neurons and the neurons are not directly connected to each other, but there is a gap or the synapse that separates the nerve cells and information travels through this synaptic cleft.

So, both of them were of course, given the Nobel Prize for their discoveries and this is a very important event for the history of modern neuroscience and modern cognition studies. Along with it so, starting from the 1920s and onwards we have had enormous development in the in mechanization and this has the engineering sciences, the computational sciences.

They have come up with further advancements and improved instruments to understand minute units of the nervous system. And, the EEG developed during the 1920s; the CT scan in the 70s; PET and MRIs in the 80s and FMRIs in the 90s has given us much better understanding about the functionality of the brain.

(Refer Slide Time: 34:22)



Of course, when we talk of so, this basically gives us an idea about you know how cognition studies have approached or rather how researchers has approached cognition across the century. I must admit that in this session that we today I spoke about Cajal, I spoke about Broca, I spoke about Descartes and primarily directed the orientation of cognition studies towards biological substrates of the mind.

There is another aspect of cognition that is has been studied by Locke, has been studied by other philosophers and you know we have we are not talking of this today because we will be trying to understand the computational aspects towards cognition. So, to understand cognition from observable scientific facts, we are moving or we are orienting our thought process to neuroscience.

So, you might be wondering why I haven't covered most of the other philosophers or moved towards psychological thoughts on cognition. But, we will be talking about the cognitive revolution in the next class and there we will be talking about the different fields of study that have made cognition studies and eclectic approach.

So, again to end this lecture, I must admit that our approach in this whole course will be directing or orienting towards neuroscience, towards the psychological aspects, towards the behavioural and thought functions of that are expressed and that are observable and getting to the underlying roots of these functions through biological substrates and computation.

So, thank you, meet you in the next class.