Introduction to Brain and Behavior
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Lecture 01
A Brief History of Cognitive Neuroscience

Hello and welcome to the first lecture of the course Introduction to Brain and Behavior. I am Ark Verma I am a faculty at the department of Humanity and Social Sciences in IIT Kanpur also working with the interdisciplinary program of cognitive sciences at the institute. This course is supposed to be an introductory course in Cognitive Neuroscience and I have named it Introduction to Brain and Behavior so that it is very that what we basically going to do is to study the various ways in which the human brain interacts and modulates human behavior.

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Let us move on this will be the first week of the course and basically we will be covering some of the preliminary ideas that basically led us into the deeper investigations into understanding how various parts of the brain work together to form different mental functions.

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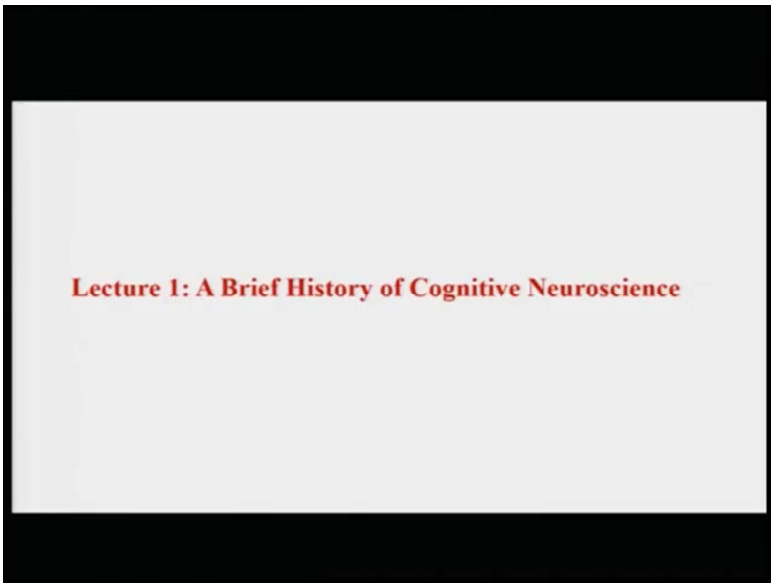

So let us begin with some very basic questions let us first go to a very brief history of how Cognitive Neuroscience as a field sort of develops. And how basically it evolves from the works of literatures and scientist who had worked in this area to setup some of the very basic understandings about how the human brain is related to human behavior.

Now it is often said that the human brain is one of the most fascinating organs on the face of this earth I remember in one of the lectures I attended as a student one of the faculty who was a visiting faculty from somewhere abroad. Actually told us that you know it was his background that he was mechanical engineer first and he you know he was doing well carrier with mechanical engineering. But, gradually over the course of years he discovered this particular faculty discovered that one of the most fascinating machines or one of the most fascinating organs that exist on the face of this earth or specimen of beautiful engineering was the human brain.

And that fascination basically took this mechanical engineer to study neuroscience and to basically become you know a Cognitive Neuroscientist perusing a PhD in that and also carrying out further research. That is also a partly one of the reasons that I am curious about understanding more and more about the human brain. Because it is particularly fascinating to me as well that this you know lump to mass which is hardly few grams few hundred grams and

forms a very small portion of the human body actually controls not only whatever this particular human body does. But practically everything that goes on in the world around as well.

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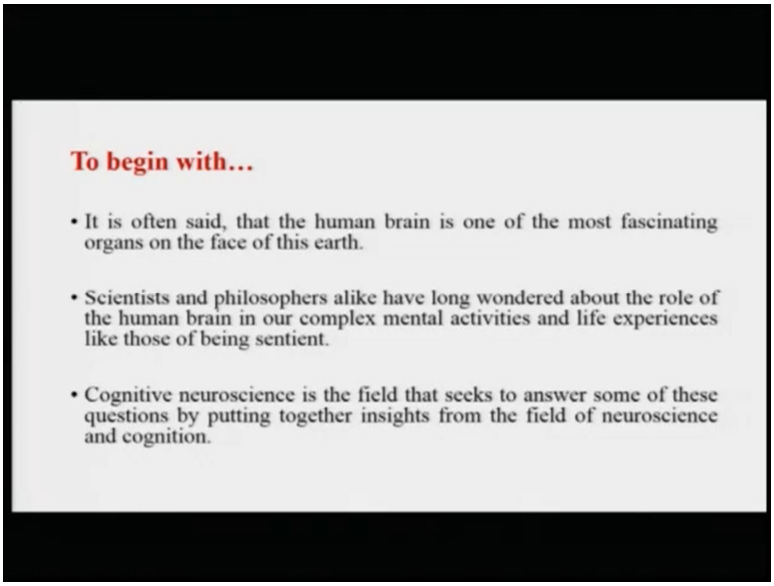

Scientist and philosophers have together wondered about the role of the human brain in complex mental activities and also, the life experiences of individuals like those of being sentient those of being able to perceive and to be able to sense the environment around us and also to create effect. So in that sense Cognitive Neuroscience is actually the field that seeks to answer some other questions by putting together the end sides from the fields mainly of neuroscience and cognition. But as we go ahead we will discover that is not only cognition or neuroscience that are contributing to insights that we will study in this course but there are several other fields as well.

So we will talk about various of these you know variety of these subjects that basically contributes toward the knowledge in this particular field.

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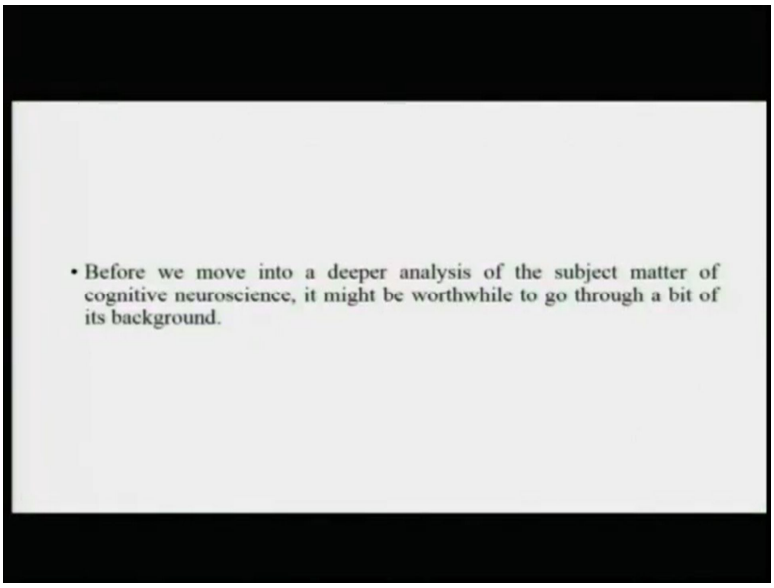

Now before we move into a slightly deeper analysis so this subject matter of cognitive neuroscience it might be worthwhile that we go through a little bit of history of cognitive neuroscience a little bit of its background. As to how the investigations how the basic findings came about.

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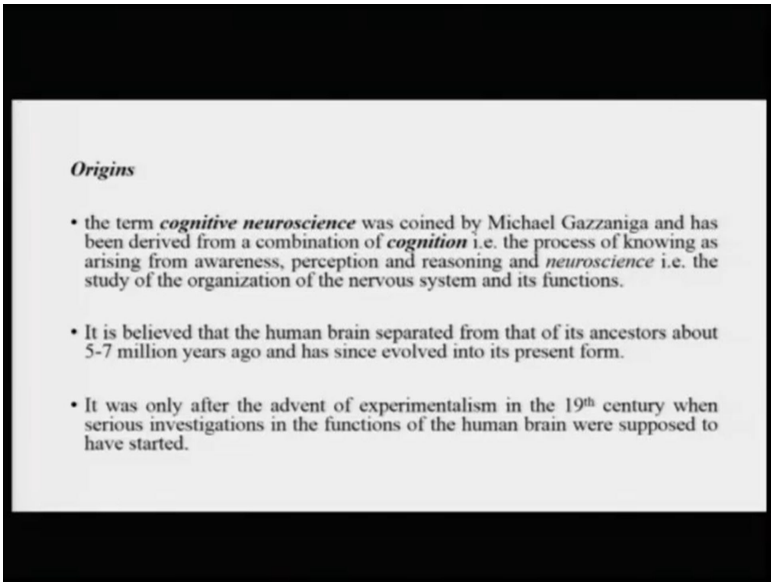

Now the term cognitive neuroscience is a fairly recent term and it was coined by Michael Gazzaniga and basically Michael Gazzaniga recounts this in his book which is also the main reference for this particular course the one called cognitive neuroscience. Is that this term was

thought of as a combination or though as being derived from two main terms one being cognition. And Cognition as a process of knowing which arises from awareness perception reasoning and so on. And neuroscience basically which is the study of the organization of the nervous system and its functions.

So Cognitive Neuroscience basically then can be seen as a combination of two field Cognition or cognitive sciences if you might you know extra (())(04:55) little bit further but cognition and Neuroscience primarily. Now it is believed that the human brain has you know human brain on course of evolutionary history separated from that of its ancestors that would have been Aps around 5 to 7 millions years ago. And it has from then on evolved to becoming or to being in its current form. So this is something rather fascinating that this that this organ that we you know we are endowed with basically is work of around 5 to 7 million years of evolution which has marked us as a you know homosapien as a species. Distinct and much more capable as compare to so many others species you know living on the face of the earth.

Now there has been interest in studying about the brain from very long, I remember teaching in a course of introduction to phycology that it was you know hypocrites who first sought of made the link between the functioning of the brain and human behavior. And he said that it brain must be the seed of all human behavior and there are several other Greek philosopher after that who kind of talk a little bit about the relationship between the brain and the mind. And the you know the relationship between say for example how the two interact you know to reach to this you know sought of very interesting combination of mass neural matter of physical substance and made a physical substance that is our behavior.

So there has been interest in how the human brains functions from a very long time philosophers have talked about it, biologist have been interested in it. But Gazzaniga sought of notes that it is only after the advent of experimentalism which is around end of the 18 century beginning of the 19 century when serious investigations into the functioning of the human brain formally started. Where people actually started studying about the human brain and basically started correlating the patterns of deficit or the changes in the brain activity. And as they were related to different aspects of human behavior.

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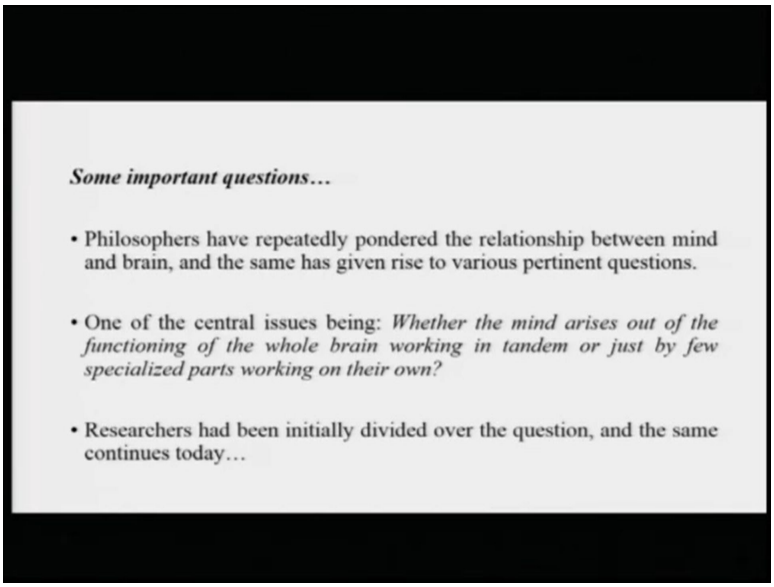

There have been likewise some important questions that people have asked over the years and one of the very important question one of the central issues in this has been this aspect of whether this metaphysical thing that we call our mind arises out the functioning of the whole brain. Or it basically it is just a few very important areas of this brain which is the physical part that give rise to what we call mind. The relationship between mind and brain is fairly well discussed theme and it will keep coming and going throughout the course of this semester. So or throughout the course of this course. I would like you to sort of make some notes in the end. And at some point in time we will suddenly take out time and really look at the relationship between mind and brain from the philosophical prospective.

But for now let us focus on a specific question and the question being that whether it is the whole brain that functions together to leds to what we call the mind. Or it is just a few areas in the human brain that leds to what is called the mind. So this been a very important question and researches have sort of pondered about it worked to sort out systematically uncover this particular question.

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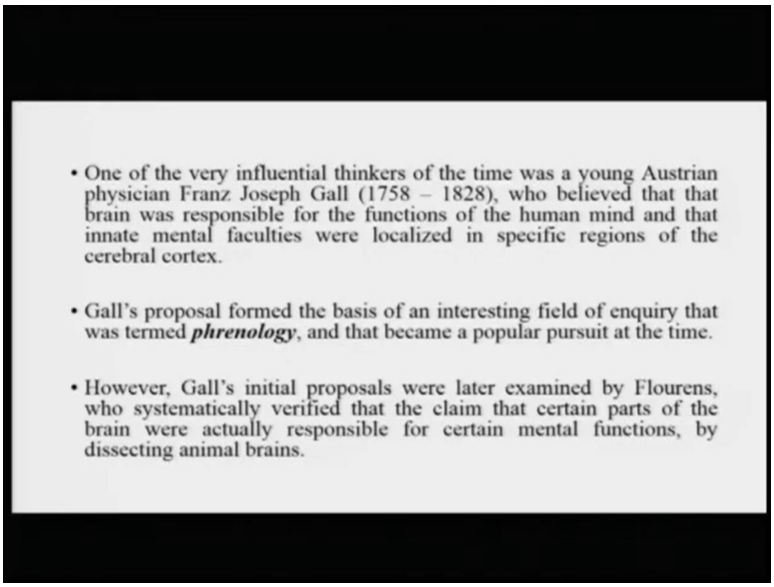

Now in this area there have been several very influential thing thinkers and researchers. But well the more famous one of them is this Austrian physician called Franz Joseph Gall and Gall basically believed that it is the human brain that is responsible for the functioning of the human mind.

And he basically says that the human mind is composed of these innate you know mental faculties he almost he basically draws a sort of a map he draws a sort of map on this skull and say that this region of this edible cortex, this region of the skull is corresponding to this mental faculty of the individual. Say for example this area is responsible for the imagination, this area is responsible for mathematical ability for reasoning for logic, for music ability for aesthetic sense, etcetera, etcetera.

So Franz Joseph Gall was only the first person who sort of believed and draw a direct coordinate direct correlation between physical human brain and the metaphysical mental abilities that human beings possess. Gall's proposal basically form the basis of interesting field of enquiry which was later termed Phrenology and became a very popular pursued at that time. It is said Gall and some of his collaborators actually travelled around the globe or travelled around the Europe at that time. Probably basically studying people skull studying peoples brain and scribing the presence or absence of particular mental abilities in these individuals on the basis of whatever conclusions they could derive from their skulls.

I remember one of things that is very interesting is that Gall and his collaborators actually believed was the fact that the area of the brain which was more highlighted visible in a person. Or basically leds to the presence of a particular of that particular ability of which this area is actually responsible for. So it was almost interesting idea at that point in time and a lot of people bought it and it became fairly popular. Napoleon Bonaparte at that time basically assigned Marie Jean Pierre Flourens who was another scientist in France at that time. To systematically verify what Gall was claiming and Flourens basically studied the brains of many animal and he dissected these animal brain. And he destroyed some of these animal brains to see what corresponding changes in human in their behavior it was causing.

And after this systematically studied systemically study Flourens actually verify the claim that yes indeed certain parts of the brain were actually responsible for certain mental functions. So in some sense although Galls idea would have seemed almost fantastical to researchers at that time. It could be verified very soon that yes there is direct correlation between areas of the brain and you know several aspects of you know behavior of organism. Mainly Flouren's work focused on animal brains but the same could be extrapolated to understand yes there should be or could be a relationship between you know different parts of the human brain and different aspects of human behavior as well.

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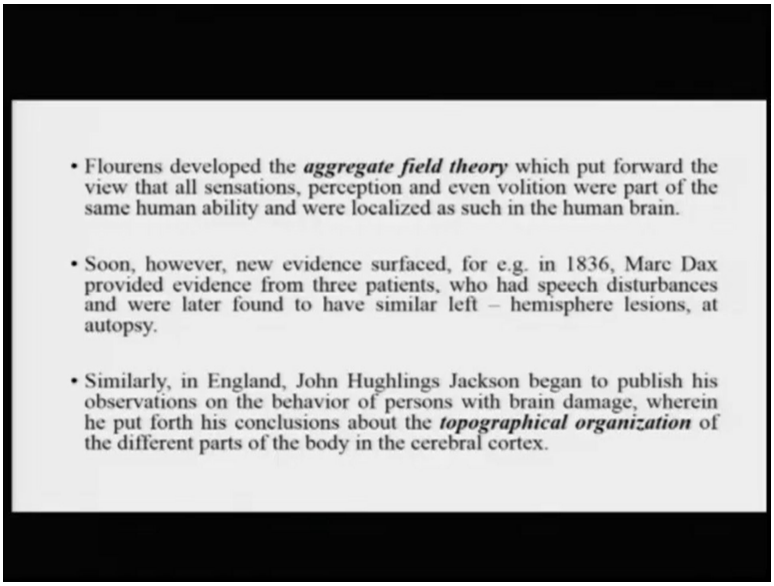

Now Flourens basically on the basis of this work came up with what is called the aggregate field theory which put forward the view that all sensations, perception and even aspects of volition were part of the same human ability. And that they were all localized as such in a same area in one area of the human brain. Now this could probably have been because while Florence was able to correlated simple mental functions with specific areas of the brain. Say for example if this particular area is damaged vision is compromised, if this particular area is damaged audition is compromised but he could not really link together different areas of the brain which would together give rise to more complicated abilities such as reasoning or perception or volition.

So it is sort of you know combined all of this together and said, it is quite possible that all of these areas or all of these mental functions are inseparable from each other and hence the area of the brain or the part of the brain is also together responsible for these kind of mental functions. But again new evidence keeps coming in science, and in around 1836 Marc Dax provided evidence from three patients.

All three of these patients had certain difficulties with respect to producing speech with producing language and later were found to have similar lesions in the left hemisphere of the respective brains. So automatically by this time evidence is started coming in that yes specific areas of the brain may be related to specific mental functions. Around the same time John Hughlings Jackson in England started publishing some of his findings where he basically talks about their representation of the various parts of the body in the human brain which is later referred to as the topographical organization of the brain.

Basically showing that, let us say that the palm is represented in this particular area of the brain, and then the neck and then the arms and etcetera are represented in these these areas of the brain. So this we will talk about the topographical organization and etcetera later. But the idea was what you have to focus is, the idea was that much of this evidence had started coming in around the 18^{th} and 19^{th} century onwards.

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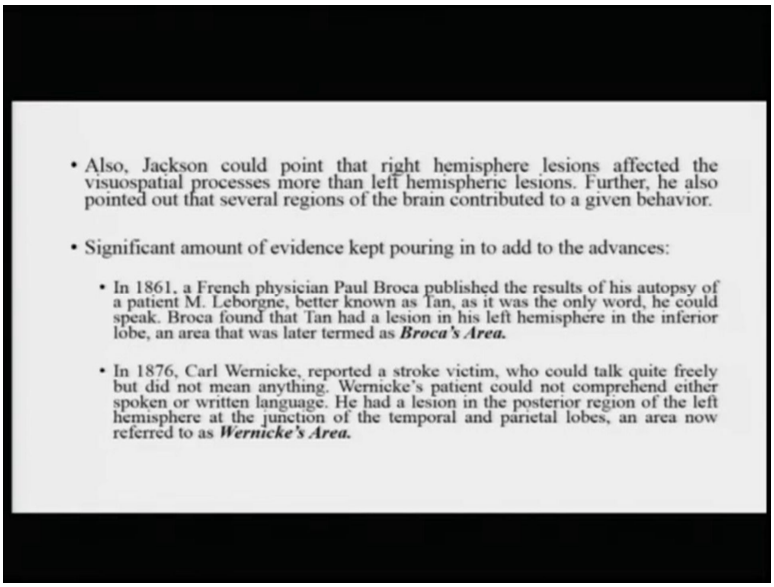

Jackson could also point out that lesions in the right hemisphere of the brain were more responsible for disturbances in visual special processes as supposed to lesions in the left hemisphere of the brain. Similarly two more two very significant discovery came through in 1861 and 1876 respectively. In 1861, French physician called Paul Broca published his results of his autopsy of a patient called M. Leborgne who is also know an Tan, because Tan is the only word this person could speak.

Tan's brain was taken for autopsy soon after he died and it was found that Tan has a major lesion in the lower portion of the left front lobe in the inferior left front lobe that is what it is called. And this region was later held responsible for the speech disturbances that Tan was experiencing and because this was discovered by Paul Broca, this region later came to be known as Broca's area. We will talk about Broca's area and speech disturbances in much detail moving further.

But let us move to the next finding and next finding came up in 1876, a few years later by Carl Wernicke who was also a physician. And Carl Wernicke basically reported a stroke victim who could talk quite freely but did not really mean much. So he could say a lot of things without meaning so much. Part of the reason of that could be that, he had lost the ability to comprehend language both in the written and in the spoken form.

Wernicke's patient was also later taken for autopsy and it was discovered that this patient had a very significant lesion in the left hemisphere of the brain. But more towards the junction or the

temporal and parietal cortex which is somewhere here. So this area also came to be known as Wernicke's area, and the disease basically later was referred to as Wernicke's (())(16:39).. So these two findings were very significant in the seam of things. And basically what they did was, they contributed to the growing belief that yes different areas of the brain could be linked with different mental functions in a more coordinated in a more systematic sort of a fashion.

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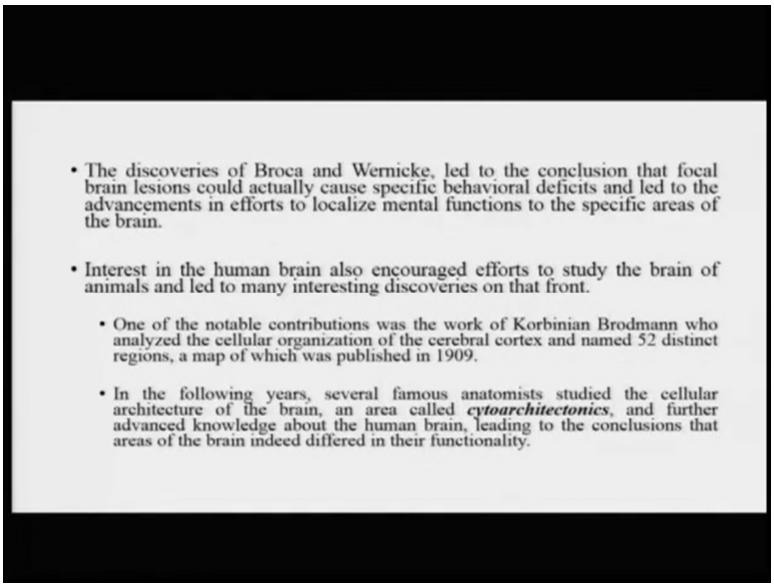

The discovery is as I was saying the discoveries of Broca and Wernicke led to the conclusion that focal brain lesions could actually cause specific behavioral deficits and basically and these two discoveries led to the advancements in the effort of different scientist who basically now wanted to localize which area of the brain is responsible for what functions. So a lot of research sort of was fueled by this idea.

Similarly, you know these findings that were coming with respect to human brain encourage a of of people to look into different kinds of animal models to look into animal brains. And also start coming up with different kinds of methods in genius ways in which the structure of the human brain could be studied. One of the very significant contributions in this area was then made by a person called Korbinian Brodmann, who analyze the cellular architecture of this cerebral cortex or the human cerebral cortex and named 52 distinct regions.

So later in later parts of the course when I am telling you this is Brodmann's Area 43 or this is Brodmann's Area 17, this is basically derived from Korbinian Brodmann's map of the human

brain which basically has around 52 distinct regions. Different people you know different scientist you came later have also sort of sub divided these regions into more specific names into more specific functionalities although.

But this was again very very important work at its time. Following from Brodmann's work and there were several other anatomist who were working at a time. Area of investigation developed which was called cytoarchitectonics, which is basically more concerned with understanding the cellular architecture of the human brain. So basically saying which areas of the brain have what kind of cellular organizations, which kind of cells in what area and how are they organized?

So this is basically the field of cytoarchitectonics, which actually contributed a lot to our current understanding of how the human brain is organized.

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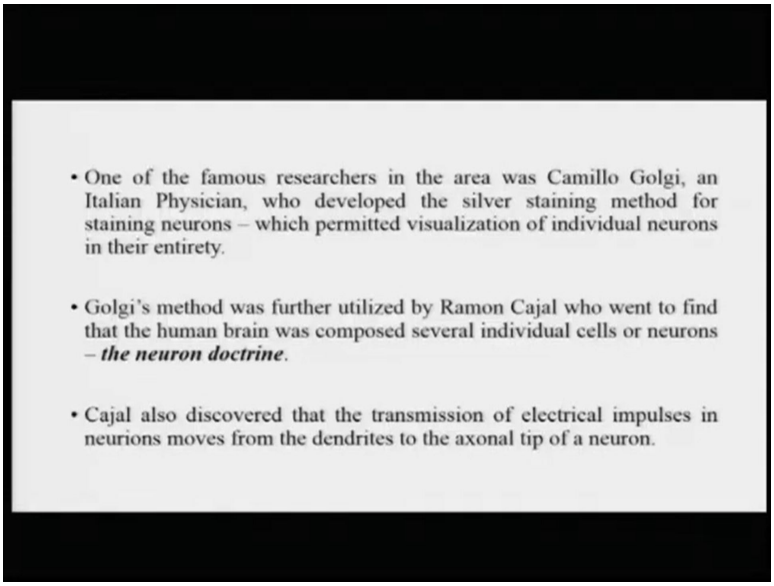

Again moving further one of the many famous researches in this area of cytoarchitectonics and neuroscience broadly was Camillo Golgi and Camillo Golgi was an Italian physician who developed a particular method referred to as the silver staining method for staining individual neurons.

And this was very revolutionary at the time, because what it allowed was, it could it allowed scientists and researchers to visualize an entire neuron. So from where does it start till where does its connections go and this is very fascinating for the scientist at that time? Basically allowing them to look at where are these specific neurons? And this sort of again was further

used by another you know very fascinating scientist called Ramon Cajal, and Ramon Cajal basically used Golgi's method to study the different kinds of neurons in the human brains the different neurons in the human brain.

And he basically that led to the formation of what is referred to as the neuron doctrine. The neuron doctrine basically you know won Ramon Cajal his noble prize also. And basically it is one that is concerned with the idea that the human brain is composed of you know several individual cells called neurons, and it is the organization of this several individual cells. I am sure I might have mentioned things of the earlier in a different course that I have taken that it is almost around 1.3 billion neurons that are there in the human brain.

So you know the human brain is composed of billions of these individual neurons and it is a combination of these which basically you know causes the functioning of this organ. Now Cajal also in addition discovered that the transmission of electrical impulses in these neurons moves from the dendrites of a neuron to the axonal tip of the neuron. So it is basically how these neurons get connected with each other. So this is also fairly interesting to sort of note.

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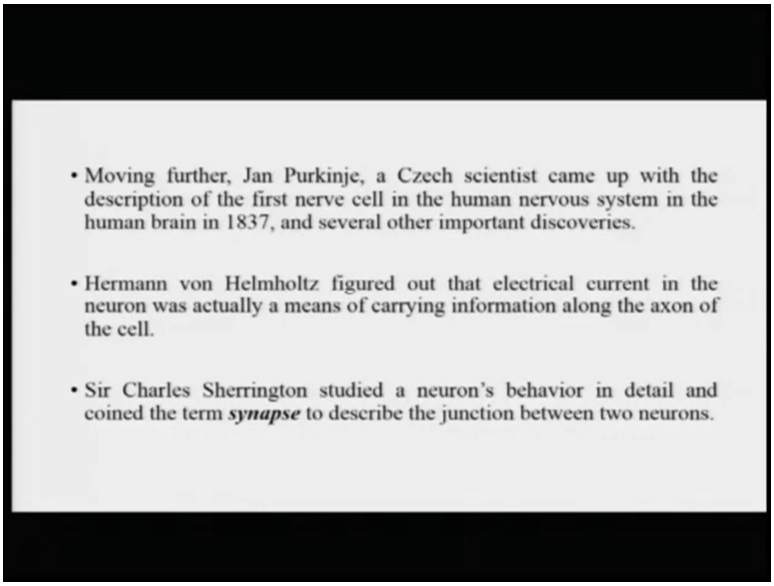

Now if we move further, there are other more notable contributions that were made, for example, that of a Jan Purkinje, a Czech scientist who came up with the description the first nerve cell in the human system in around 1837. And also contributed to several other discoveries which sort of obviously advanced the field or advanced the given knowledge at the time.

Similarly Hermann von Helmholtz found out that electrical current that is basically passing through the neuron, these neural these electrical impulses are not only just by products of cellular activity but actually are means of carrying information from one neuron to the other. So these were some of the very basic description some of the discoveries that were setting the ground for understanding and investigating the functioning of the human brain.

Similarly we can also you know talk about Sir Charles Sherrington's work, who studied neuron's behavior in a lot of detail and basically coined the term called synapse, which is used to describe the junction between two neurons. So I was talking about how the neurons are connected with each other. And this basically junction between the two neurons has been termed as synapse and basically which is used to pass on message or the electrical impulse from one neuron to the other.

We will again as I am as I am saying that we will again talk about synapse and other things in much detail as we move further.

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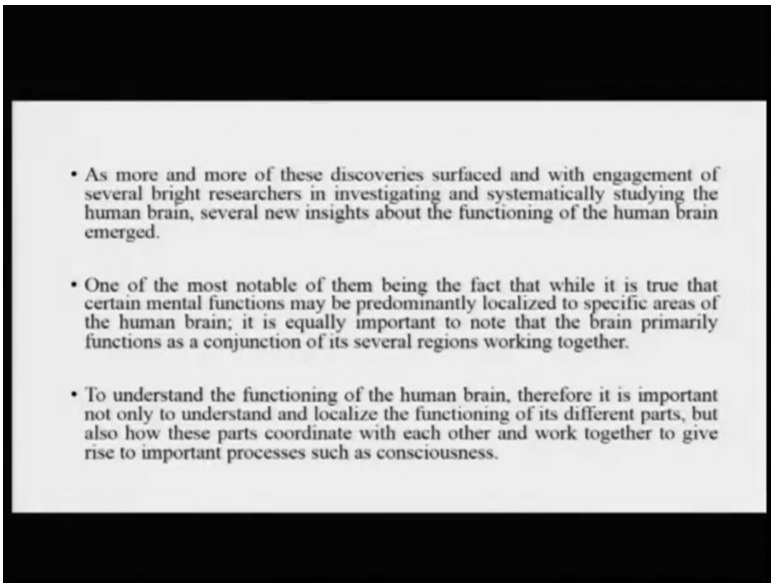

Now as more and more of these discoveries were coming up, and we have seen that some of the more notable contributions are coming in the 19th century and mid of the 19th century around that time. A lot of very bright researchers were engaged in studying the human brain and this became a fascination of almost all the neuroscientist and people who were otherwise from different fields were otherwise interested in the human brain.

Several new insights about the functioning of the human brain started coming up. One of the most notable of them being that while it is true that certain mental functions are predominantly localized to certain regions of the brain. So for example, speech production may be localized to the left inferior frontal cortex, or speech comprehension is basically more localized to the junction of the temporal and parietal cortexes in the left or in the left hemisphere.

So while it you know these things are sort of you know ascertained and can be stated, but it is also very very important that you understand the function of the brain, not in its parts but in totality. And basically all sorts of human behavior any human behavior that we talk about basically it has to be understood as a result of the combination of different working parts of the human brain. So to understand the functioning of the human brain, it sort of became clear by around end of the 19^{th} century onwards that it is very important not only to understand and localize the functioning of the different parts of the brain, but also how these parts coordinate with each other and worked together to give you know rise to the overall broader or higher advanced mental functions that we have talked about, such as, thinking, reason and decision making, language, and so on.

So this is pretty much the story that I sort of wanted to tell you in today's lecture. We sort of take things a little bit slow to begin with, but I hope I have highlighted some of the basic discoveries I have sort of given you a bit of a peak into you know some of these very notable discoveries that happened, that sort of set the ground for investigation into the functions of the human brain and its relation to human behavior.

So I will sort of try and conclude now and the give you the take home message for today's lecture.

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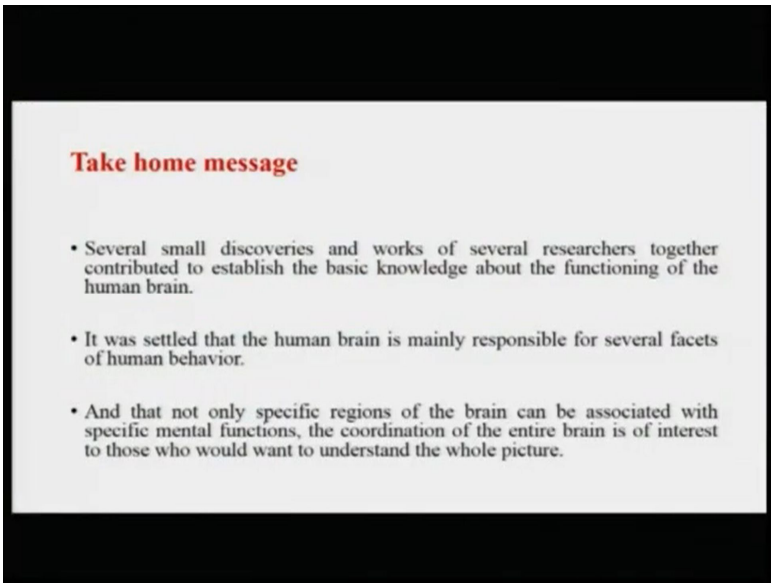

And this take home message is very simple, it is basically that yes, it has been established throughout various experiments and through you know years and years of research that the human brain is the one responsible for all sorts of human behavior. But basically it is very very important to study and understand not only you know the specific parts of the human brain which are responsible for specific mental functions.

But more importantly, to try and understand how the different parts of the brain work together to give rise to more advanced cognitive processes.

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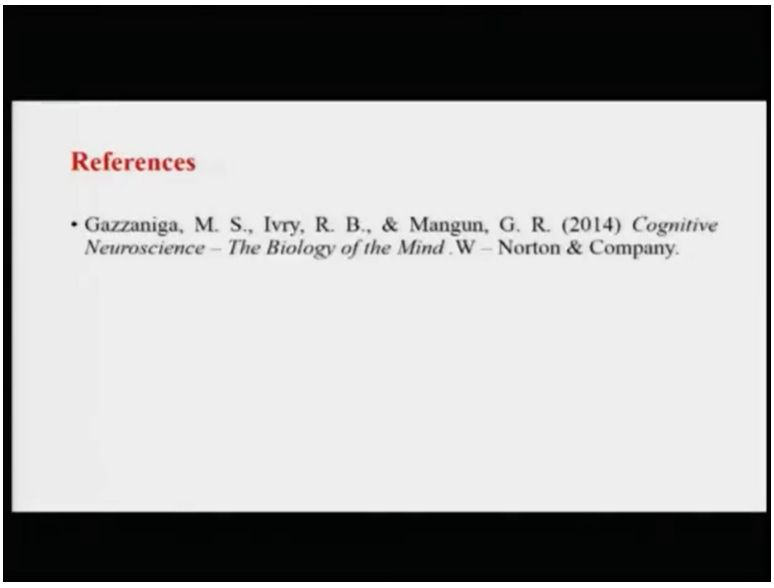

So with this I will sort of conclude this lecture of today and these are the references. Mainly I will be following Gazzaniga's book, Cognitive Neuroscience – the Biology of the Mind for this particular course. And I wish you good luck for this course and we will meet in the next lecture. Thank you.