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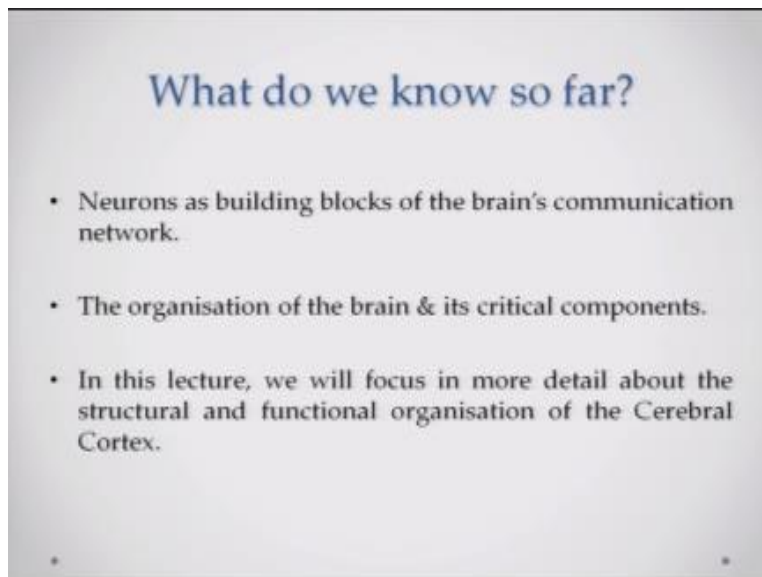
**Course Title
Basic Cognitive Processes**

**Lesson-10
The Cerebral Cortex**

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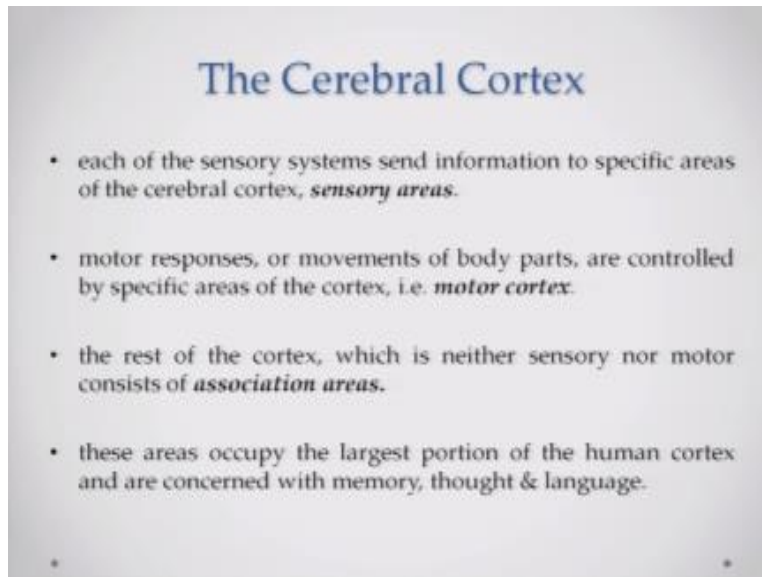
Hello and welcome to the course Basic Cognitive Processes! I am Doctor. Ark Verma from IIT Kanpur. The topic of today's lecture is: The Cerebral Cortex. Today we will take in more detail about the structural and the functional organization of the cerebral cortex.

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Last lecture if you remember we had talked about the organization of the brain and the basic communication processes that go on in the brain to lead particular kinds of processing of stimulus and resulting in behavior.

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Now the cerebral cortex basically can be said to have three specific kinds of areas so each of these sensory systems, the systems of vision, audition, etc all of them send information to the specific areas in the cerebral cortex which are the sensory areas. Motor responses or movements of body parts are basically are controlled by other specific areas of the cortex which are called the motor areas. Rest of the cortex basically which is neither sensory nor motor basically is a set of areas which are the association areas. These association areas basically acquire the largest portion of the cerebral cortex and these are the areas which is concerned with higher mental functions, which are like memory thought and language.

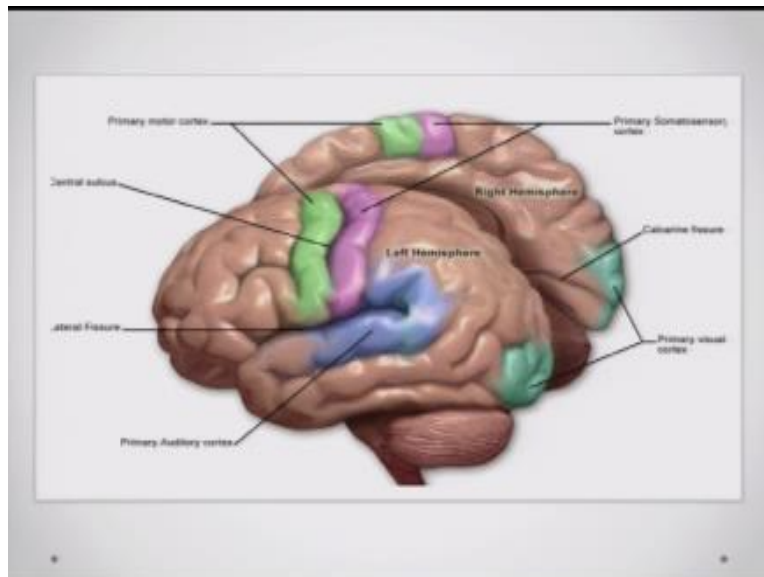
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- the cortex is composed of two hemispheres on the left & the right sides of the brain that are connected by corpus callosum.
- they are basically symmetrical, with a deep division, i.e. the longitudinal fissure, between them. & are referred to as the left and right hemispheres.
- each hemisphere is divided into 4 lobes:
 - the frontal
 - the parietal
 - the occipital &
 - the temporal lobes.

The cortex is composed of two hemispheres one on the left and one on the right and these are basically connected together by a bundle of axon fibers called the corpus callosum. These areas the two part of the brain the left and the right hemispheres are basically symmetrical and have a deep division wherein they are connected which division is called the longitudinal fissure. Each of these hemispheres is basically divided in to four lobes, the frontal, the parietal, the occipital and the temporal lobes.

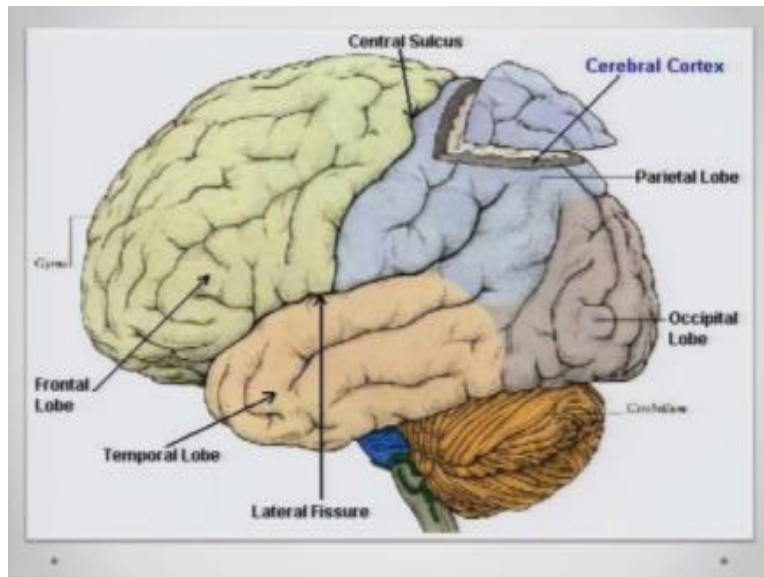
Both hemispheres contain homologues versions of these lobes. So the left and the left and the right hemisphere will both have the frontal lobe, the left and the right hemisphere will both have a temporal lobe and they both will have a parietal and an occipital lobe.

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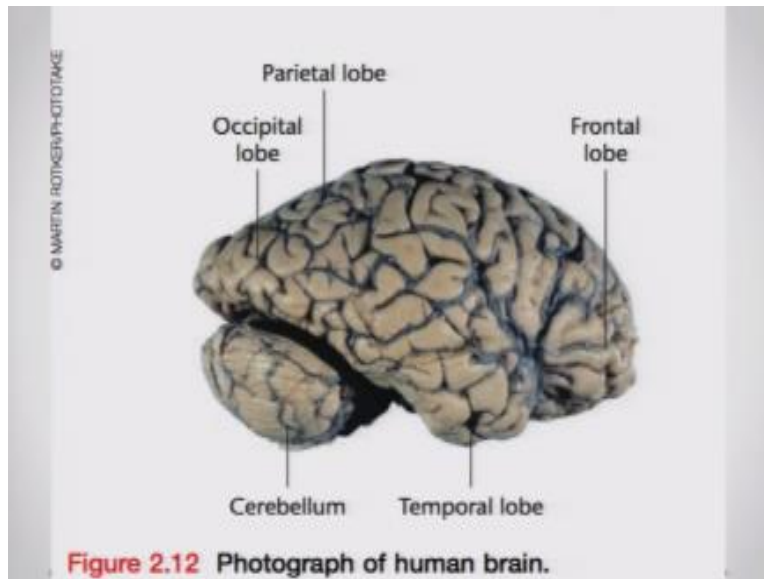
Here you can see in this figure that these are two parts of the brain which are the left and the right hemispheres. Both of these have the primary motor cortex, both of these have the primary somatic sensory cortex, both of these have the primary visual cortex and the auditory cortex.

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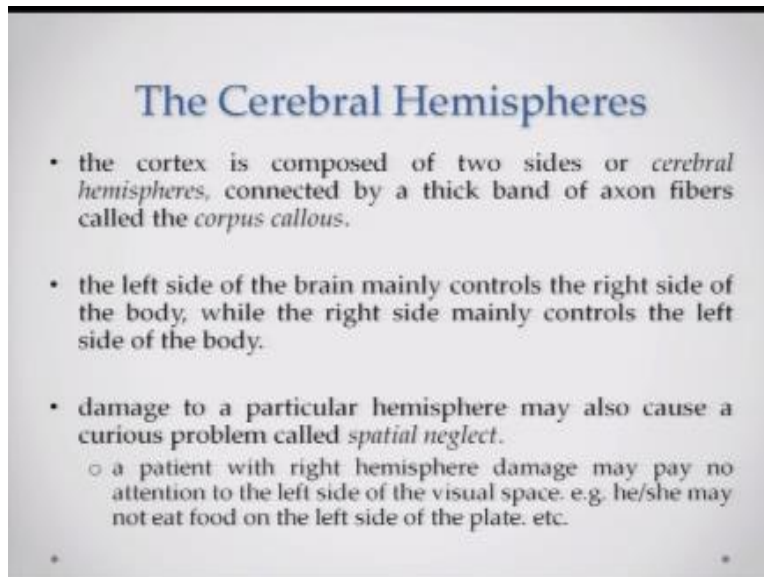
Here you can see in more detail that this is the layer of muscles which is called the tissue of the cerebral cortex. You will also see the division between the parietal lobe, the temporal lobe, and the occipital lobe.

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This is the real photograph of the human brain wherein you can more directly see where these each of these lobes are situated.

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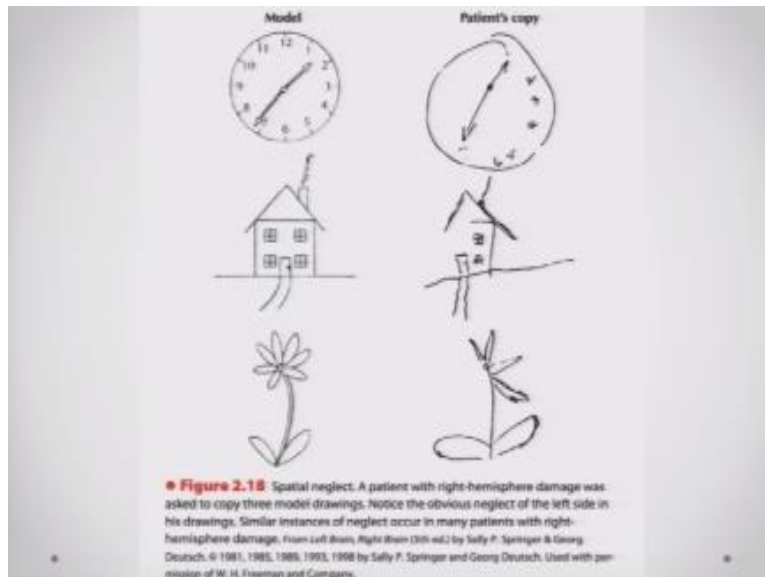


Now coming to the cerebral hemispheres, it can actually be seen to have these two sides which are the cerebral hemispheres, they are connected by this as I said thick band of fibers called the corpus callosum. The left side of the brain mainly controls the right side of the body while the right side of the brain mainly controls the left side of the body. This is basically the basic principles of the organizations in the human brain .

Now damaged to one side of the this vein, or damaged to one of the area of the left hemisphere or one of the areas in the right hemisphere may also cause curious problem which say for example spatial neglect. Spatial neglect is an interesting problem in a sense that a patient which say for example, a right hemisphere damage may end up in no tension at all to the left visual space, because that is what it was supposed to process.

Interesting things happen, say for example a patient who has a right spatial neglect or who has a right hemisphere damage and has left spatial neglect might not be able to pay any attention to, for example food on the left side of the plate or will not be able to comb the hair on the left side of the head and so on.

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Here is the demonstration of the kind of figures that these people come up with so on the left side you will see the model which these with the patient was asked to actually reproduce, and you can see that the patient actually produces the numbers on only one side of the clock or similarly makes only one side of the house or only makes only one side of the flower, this is basically I was referring to when I was talking about spatial neglect.

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- *Hemispheric Specialization*: the concept that the two cerebral hemispheres may be differently adept in the capabilities & functions. e.g. language, perception, music etc.
 - "Split Brains": patients who have gone a particular kind of surgery, wherein the corpus callosum is severed, usually done to control epileptic seizures.
 - the result is essentially a person with two brains in one body (Gazzaniga, 2005).
 - after the right & left brain are separated, each hemisphere will have its own separate perceptions, concepts & impulses to act.

An interesting concept that is very dominant concept in understanding, the brain is the concept of hemispheric specialization. Now the hemispheric specialization is basically a concept that the two cerebral hemispheres may be differently adept in their capabilities and functions, for example if you talk about mental functions like language or say for example perception or music or maths the idea that hemispheric specialization proposes is that one of the hemispheres is slightly better at say for example, language or music or some other abilities

An interesting scenario with respect to hemispheric specialization actually occurs with patients who have split brain. Split brain is basically the patient who is those who have undergone a particular kind of surgery wherein the corpus callosum is severed. So now it happens is the patients will have both side of the brain pretty much functioning normally, but just the fact that they are not connected to each other anymore.

Gazzaniga says that this kind of result often in a scenario where is essentially one person with two kinds of brains or two brains. After the right and the left brain are separated each of these hemispheres will have its own perception, will have its own concepts and impulses to act. And those will not be communicated to the other hemisphere in that sense not be integrated to lead to normal behavior.

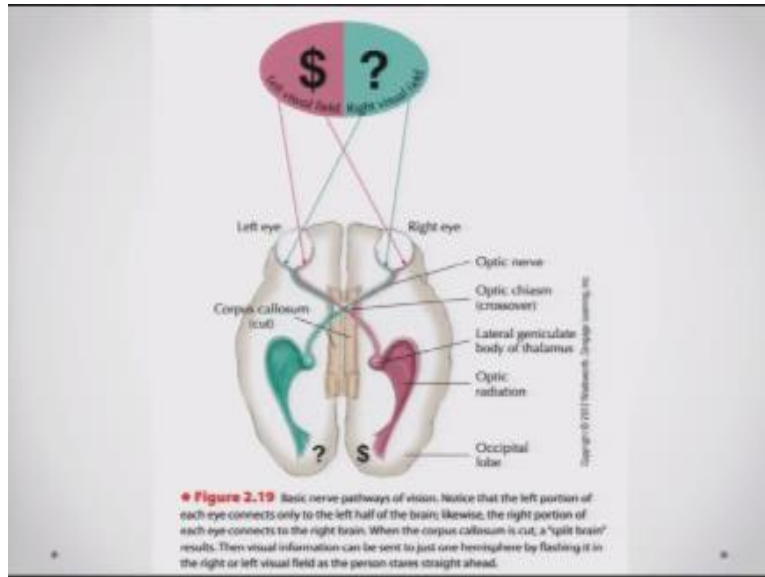
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- Interesting scenarios get created with split brain patients: for e.g. when one split brain patient dressed himself, he sometimes pulled his pants up with one hand (that side of his brain wanted to get dressed) & pulled down with the other (while this side did not).
 - Split brain patients are easiest to see in specialised testing, e.g. we flash a \$ sign to the right brain and a ? mark to the left brain of a patient named Tom.
 - Next, Tom is asked to draw what he saw, using his left hand, out of sight.
 - Tom's left hand draws a \$ sign.
 - If Tom, is then asked to point with his right hand to a picture of what his hidden left hand drew, he will point to a question mark (Sperry, 1968).

An example could be , that if you really want to test how the behavior of the split brain patients is , so one of the experiment one could do is you could flash the dollar sign to the right brain and question mark sign to the left brain of a patient let us say named Tom, then we ask Tom to draw what you saw using his left hand while the left hand is out of sight, so you can actually cover the left hand you can ask him to draw with his left hand whatever he saw or he is seeing.

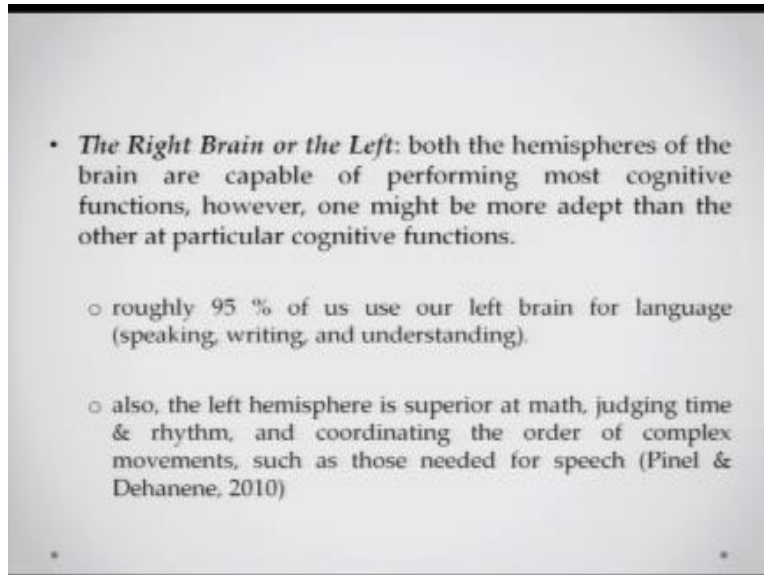
You will find it on the left hand of Tom will end up drawing a dollar sign which is basically flash to the right brain. Because your right brain controls the left hand and in that sense the from the left hand this person draws the dollar sign. Now intentionally if you ask him to point out with his right hand to a picture of what is written what the left hand might have drawn Tm would point out to the question mark. Because now he is using his right hand he is basically going to point out at something which the left brain has seen which is basically a question mark.

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So you see that the perception of the two visual stimuli that we presented to the left and the right brains is so disconnected that one of the hemispheres does not really know what the other hemisphere has actually seen or experienced. This is basically a representation of the scenario that we were talking about so you present the dollar sign in the left visual field which has to be seen by the right hemisphere and the question mark sign to the right visual field which has to be seen by the left hemisphere. This is pretty much what we were talking about right now.

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Now in this whole point of this hemispheric specialization let us talk about what is the unique abilities of each of these two hemispheres. Now I use the word unique which will actually not apply here because we say both the hemispheres of the brain are capable of doing or performing most cognitive functions the only difference will be more adept and it is the matter of degree actually one might be more adept one particular cognitive function while the other will be less adept. So it is not that the right hemisphere does not process any language at all and left hemisphere processes all the language it is that the left hemisphere language process better in some components while the right hemisphere might process language in some other components.

Now, so as I was talking about language, roughly 95% of us use our left brain for language say for example speaking language, writing language or understanding language. Also the left hemisphere is found to be superior at abilities like maths judging time and rhythm and also coordinating the order of complex movements, for example if you have to do a highly dexterous task which was in the use of your fingers and fine motor movements.

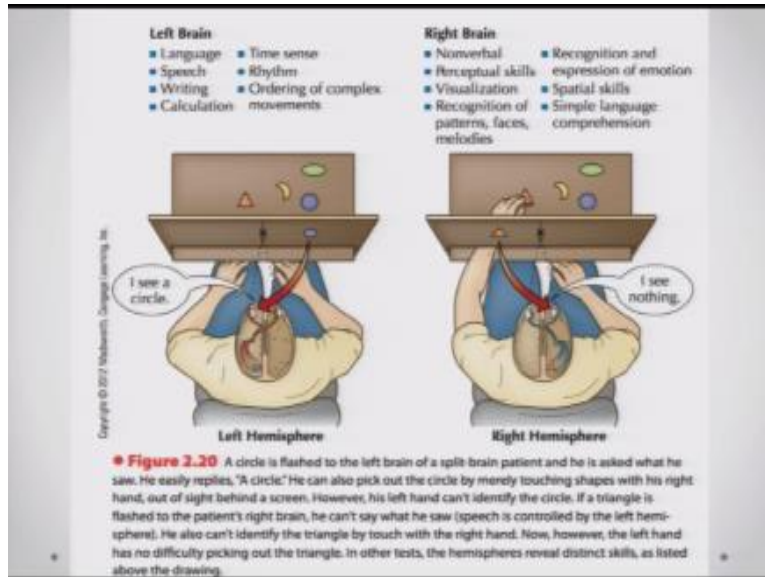
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- in contrast, the right hemisphere can produce only the simplest language & numbers.
- however, the right brain is good at perceptual skills, such as recognising patterns, faces & melodies; putting together a puzzle, or drawing a picture.
- the right hemisphere also helps one express emotions & detect the emotions that the other people are feeling.
- also, the right hemisphere of the brain is superior at some aspects of understanding language for e.g. understanding jokes, irony, sarcasm, implications and other nuances of language.

In contrast the right hemisphere can produce only simplest language and numbers. However the right hemisphere is good at other things, say for example perceptual skills, recognizing patterns, recognizing faces, understanding music, drawing a picture those kind of thing the right hemisphere is supposed to be better at, I am not saying it exclusively does it again I am saying it is better at doing this. The right hemisphere also helps one express emotion and deduces emotions that the other people are feeling.

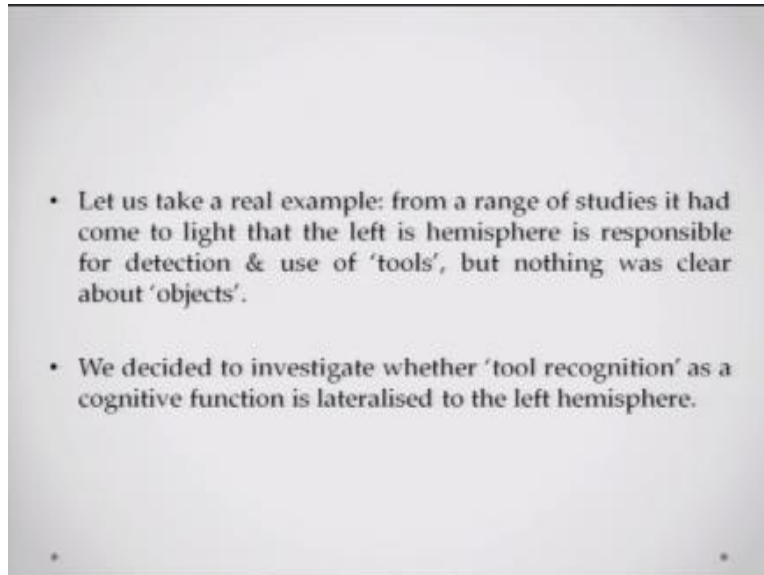
Finally the right hemisphere is more superior at some of the aspect of understanding language say for example understanding jokes, irony, metaphors, and those kinds of aspects.

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So in this figure see a slight comparative of what the left brain and the right brain might be able to do, it is basically not supposed to be taken too seriously because both of the parts of the brain do each of these things it is just by degree that say for example the right hemisphere is much better in non verbal skills whereas the left hemisphere is better in language related verbal skills.

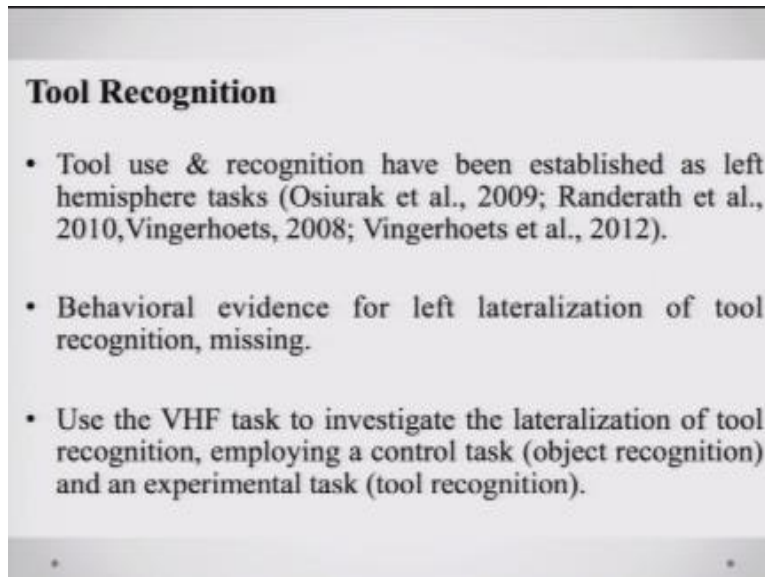
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Now let us take an example from one of the range of studies that I personally did and basically wherein we were trying to see whether the left hemisphere involved in the deduction and use of tools but that kind of scenario. What are tools? Tools are those objects that we use in our hands to achieve certain things, for example hammer, ruler, things that we can actually pick up from our hand and use to create particular kinds of affair.

So it is basically know, that it was already in the literature that the left hemisphere is involved in using and manipulating tools, while the right hemisphere is not or right hemisphere is not involved directly the using the manipulation of tools. Less was known about the other objects say for example what happens with other objects like, things that you do not use as tools there is no clear indication of that.

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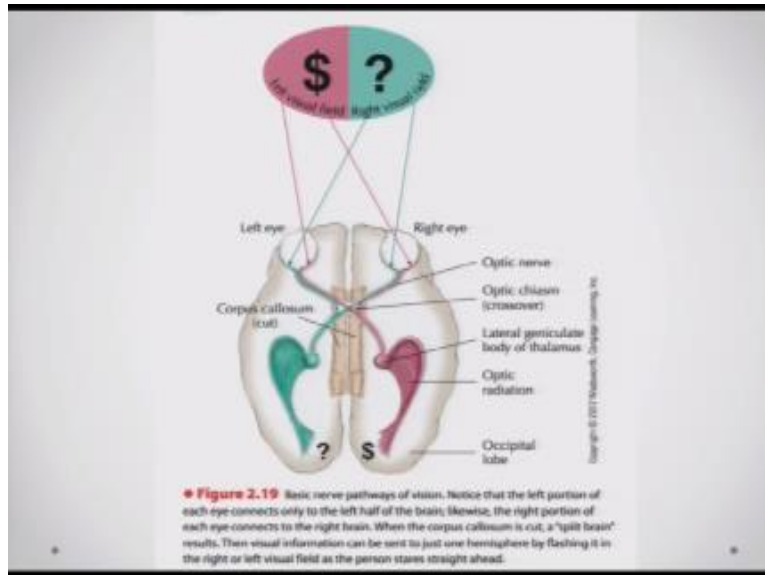


Tool Recognition

- Tool use & recognition have been established as left hemisphere tasks (Osiurak et al., 2009; Randerath et al., 2010, Vingerhoets, 2008; Vingerhoets et al., 2012).
- Behavioral evidence for left lateralization of tool recognition, missing.
- Use the VHF task to investigate the lateralization of tool recognition, employing a control task (object recognition) and an experimental task (tool recognition).

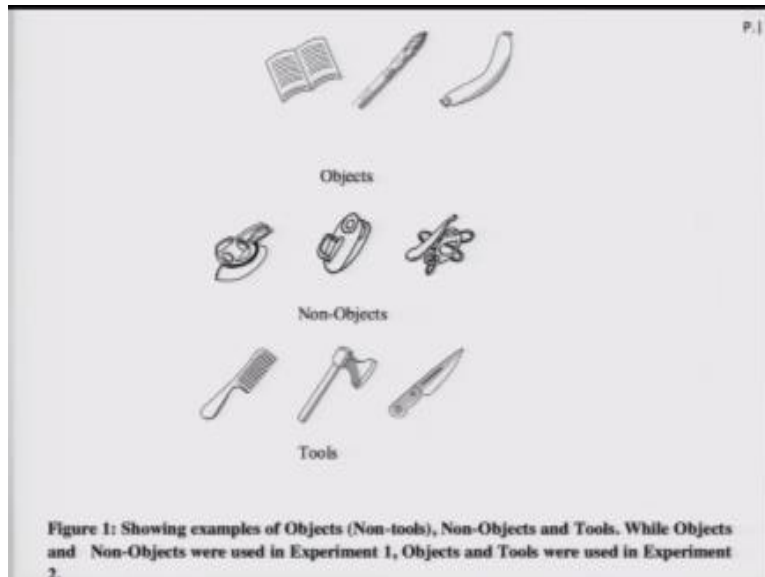
So we wanted to actually compare this and this was there, so we actually created a task which was called a visual half field task which was basically was specifically designed to investigate whether tool recognition is lateralized that is processed laterally by the left hemisphere or not.

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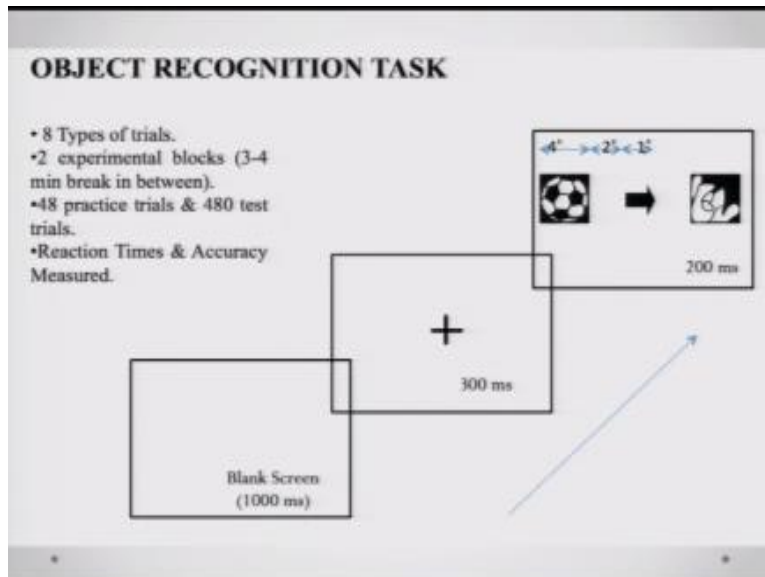
So we had a scenario pretty much similar to the one which we saw so we present something in the left visual field and we expected to be processed by the right hemisphere we present something to the right visual field and then we expected to be processed by the left hemisphere.

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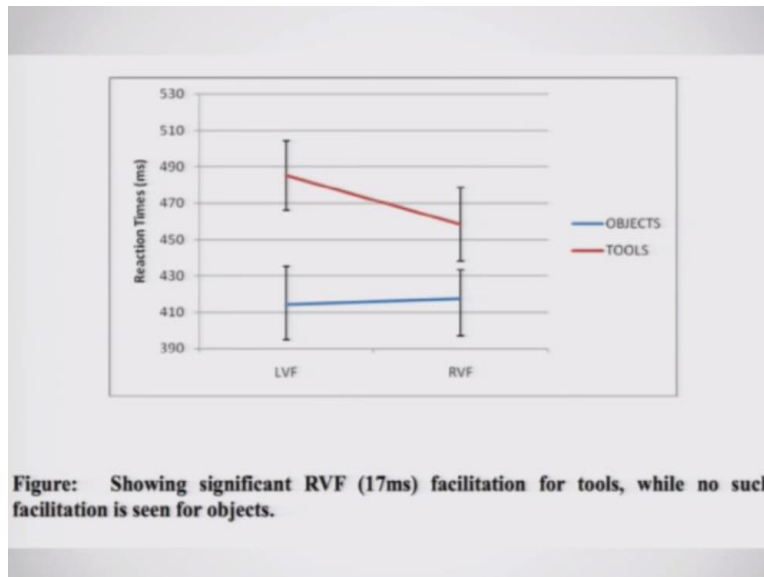
So these are the kind of stimuli which we use so on the top you can see objects which are not tools and the bottom you can see objects which are tools which I actually refer to earlier and middle we also had a comparison with things called non objects, these are just random shapes which can be considered as objects but they are not.

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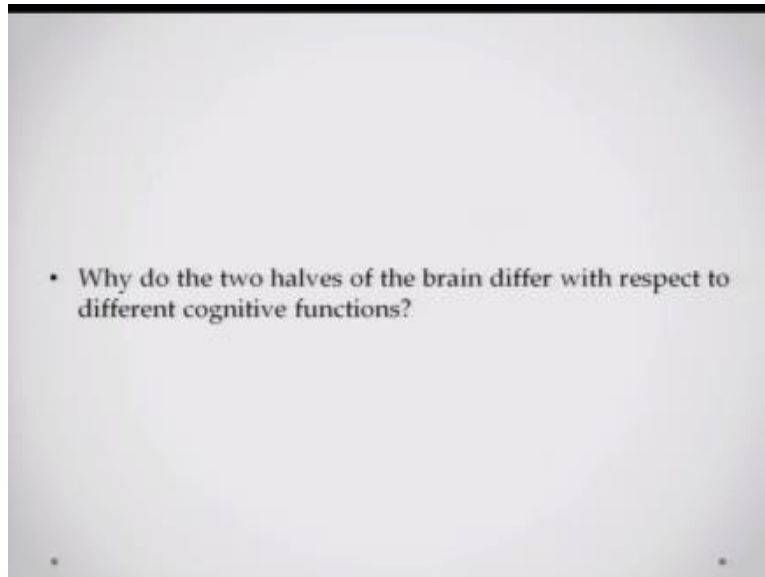
So had two kinds of task we had an object recognition task in which the participants had to tell us whether what he or she was seeing as pointed by an arrow was an object or not an object this was basically done as the control to see whether objects on the whole are lateralized towards the left or the right hemisphere or not. The second was the critical task the tool recognition task the participants had to tell that the stimuli pointed towards by the arrow was a tool or not a tool. Very simple decision Yes No kinds of decisions.

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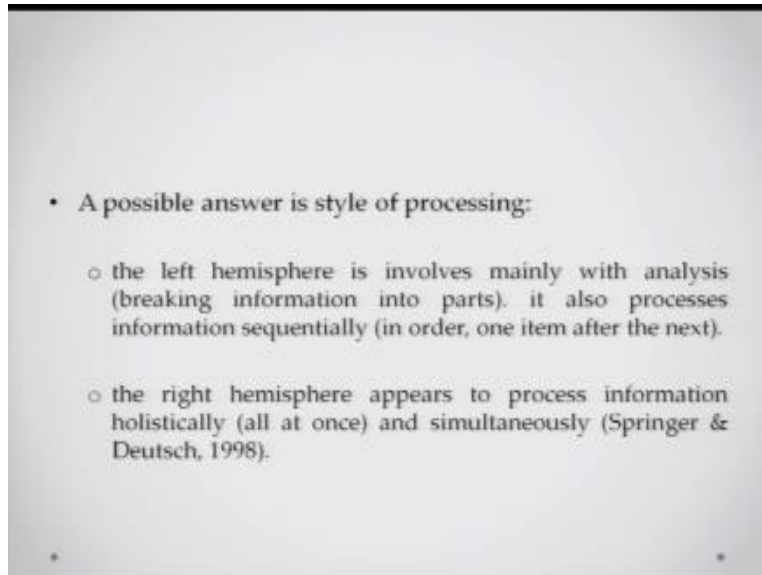
What we found here was indeed recognized faster in a more accurate fraction by in the right visual field which if you remember this process by the left, so in that sense it kind of you know conformed our hypothesis or for the fact left involved in the processing of tools.

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Why should this happen the you know two half of the brain differ with respect to this coactive functions this is something which is you know very dominative area in the field of cognitive psychology research something that keeps getting asked again and again there are certain theory's about this but are the permanent theory.

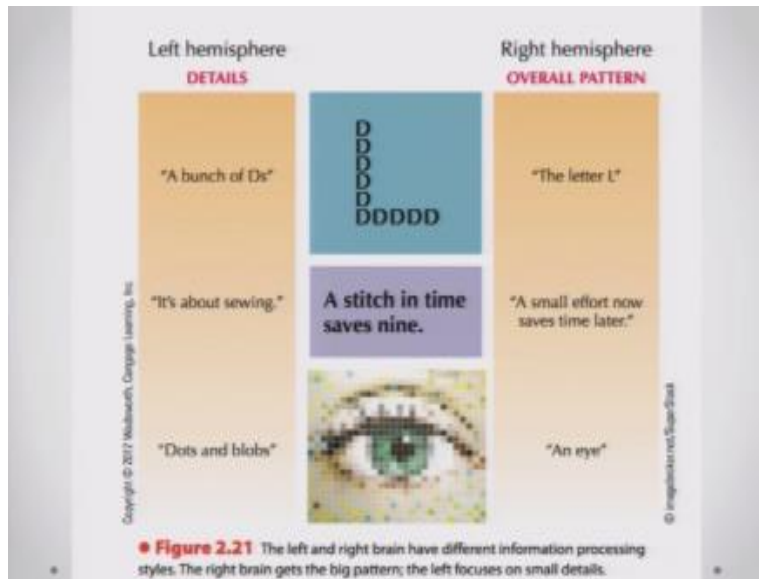
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Is basically it talks about the style of processing so particular cognitive function or particular stimuli involve particular kind style of processing and what we can say is that one hemisphere involve n one kind of processing while the other hemisphere involves in another kind of processing and it is with respect in different style of processing that basically makes one hemisphere at dept at with processing a particular.

For example the left hemisphere so involved in mainly analysis and braking down of u know larger sunk system into much smaller part and it is also involved in processing information rather sequence so all those steamily that need to be process sequence or that need to be broken down in more u know smaller components will evenly processed better by the left hemisphere and all those stimuli that need to be process holistically will then better be processed by the right this is one of the common theory that exists let us see

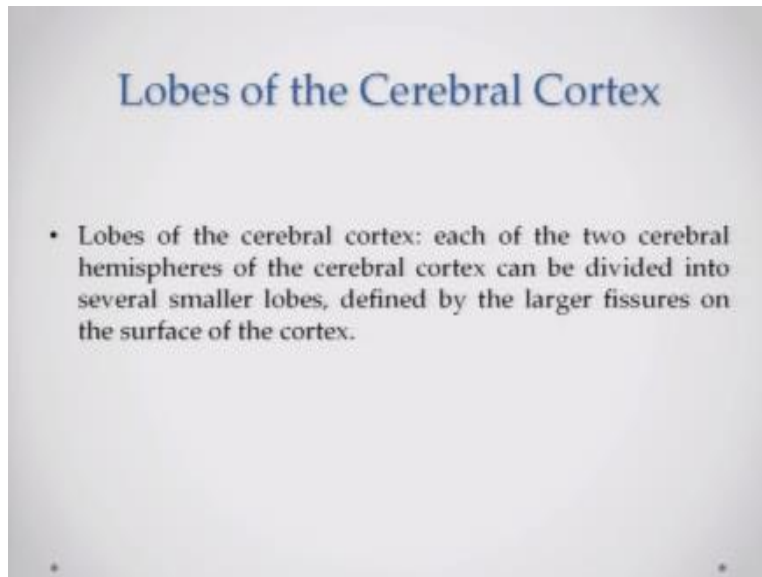
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For example here if you see that there is an L is formed being formed by a bunch of bees look at the same kind of similes the left hemispheres because it start break it down into components will tell you that there is a bunch of bees the right hemisphere on the other hand which has to look at the particular stimuli holistically will tell that it is just the later L. now you are seeing that is one stimulus that is being looked at differently by the two hemispheres depending on the style of processing that each of these hemispheres bring in.

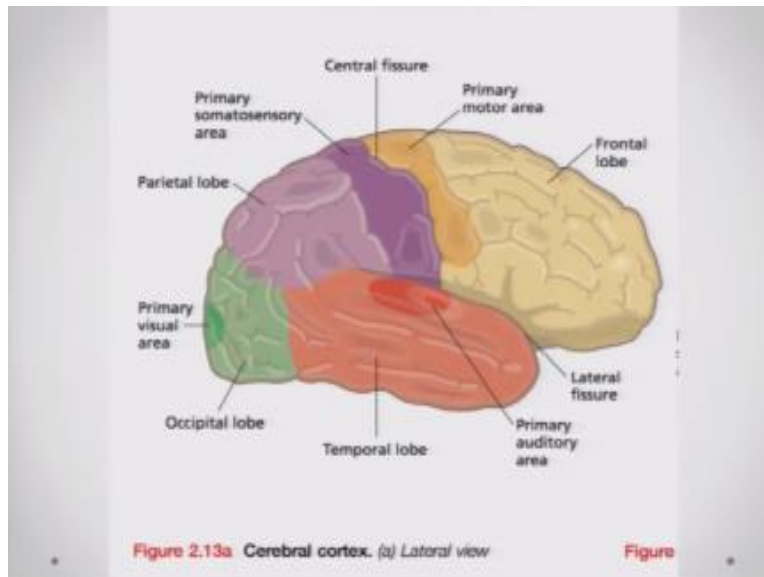
This is pretty much what the one of the basic explanations of hemispheric specializations, is put forward. Obviously there are other theories as well but this is something which is commonly put forward.

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Now let us move towards the lobes of the cerebral cortex we talked about the frontal, the temporal, the parietal and the occipital lobes, let us talk about these lobes in a bit detail. Now these lobes are the cerebral cortex basically can be divided into several smaller lobes, which are the lobes we actually talked about.

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Now let us look at this figure you can see very clearly the parietal lobe, the frontal lobe, the occipital and the temporal lobes. And you can also see that there are these areas the somatic sensory area. The primary motor area and the visual area which are actually lying in each of these lobes.

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- *The Frontal Lobes*: the frontal lobes are associated with higher mental abilities and play a role in your sense of self.
 - also responsible for the control of movements. an arch of tissue at the rear of the frontal lobes, called the *primary motor cortex*, directs the body's muscles.
 - the *homunculus map* represents the *dexterity* of the body areas, not their size.
 - the motor cortex is one brain area that contains *mirror neurons*, those neurons which become active when we perform an action and when we merely observe someone else carrying out the same action.

Now let us talk about what the frontal lobes do. The frontal lobes basically are associated with higher mental abilities and they play a role in your senses of self say for example that a idea I am somebody and these are my characteristics this is my behavior this is how I decide, this is my style of thinking all of this basically is and the sense of memory and that because memory provides you the sense of continuity that I am this person five years ago and five years hence I will be the same person is basically done by the frontal lobes.

The frontal lobes are also important for movements and arch of tissue basically near the rear of the frontal lobes is called the primary motor cortex, you can see it right here is basically called the motor cortex, it is basically for controlling and directing various kinds of movement that the body makes there is this area in this primary somatic and this area is called a primary somatic cortex which is the homunculus map which represents the dexterity of the body with respect to different areas of the body.

I will show you the homunculus map in a while. The motor cortex again the part of the frontal lobes is the one area that also is supposed to contain things and special set of neurons called the mirror neurons these are the neurons which are basically which become active whenever you are performing a particular

action or even when you are seeing somebody perform a particular action so mirror neurons help you mimic and learn the same kind of action that you are observing at any point of time.

There are lots of theories that tell us about the mirror neurons are very important for things like language and social behavior and so on. That is also one of the reason you can say that the frontal lobes are involved in kind of behavior that I mentioned

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Here you can see the homunculus map you can see the amount of neural tissue that is allocated to the processing different parts of the brain is shown here you can see there is a large amount of neural tissue allocated at the face where there is relatively less amount of neural tissue allotted to, for example the trunk, the neck, the head etc.

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- the rest of the frontal lobes are often referred to as *frontal association areas*. i.e. only a small portion of the cerebral cortex directly controls the body or receives information from the senses;
- the surrounding areas called the *association areas (association cortex)* combine & process information. e.g. if you see a rose, the association areas will help you connect your primary sensory impressions with memories, so that you can recognise & name it.
- some association areas also contribute to the higher mental abilities, such as language. e.g. a person with damage to association areas in the left hemisphere may suffer *aphasia*, i.e. an impaired ability to use language (speak). e.g. Broca's aphasia.

The rest of the frontal lobes are basically are referred to as the frontal associational areas that is only a small portion of the cerebral cortex which is directly controlling the body or receiving the information from the senses. The surrounding areas are called association areas which combine in process information.

For example if you see a rose the association areas will help you connect your primary sensory impressions with the memories you would have of the rose you will get those sensory impressions about the touch about the smell and the color of the rose, but the association areas will actually help you integrate your experience of the rose with an experience that you might have had earlier. You would come across rose the first time, the second or tenth time every time you see the see he rose you actually get connected to whatever your previous experience was.

So some association areas they also contribute to the higher mental processes abilities like languages, for example if you want to write a poetry, if you want to describe something verbally those kind of processes are also sometimes done by these different association areas. One of the example could be, a damage to the association areas on the left hemisphere may lead to a particular kind of a disorder called aphasia, which is basically an impaired ability to speak language.

One of the kinds of aphasia is called Broca's aphasia wherein the person actually cannot produce normal speech. The speech will be very jittery it will have ungrammatical sequences and the like.

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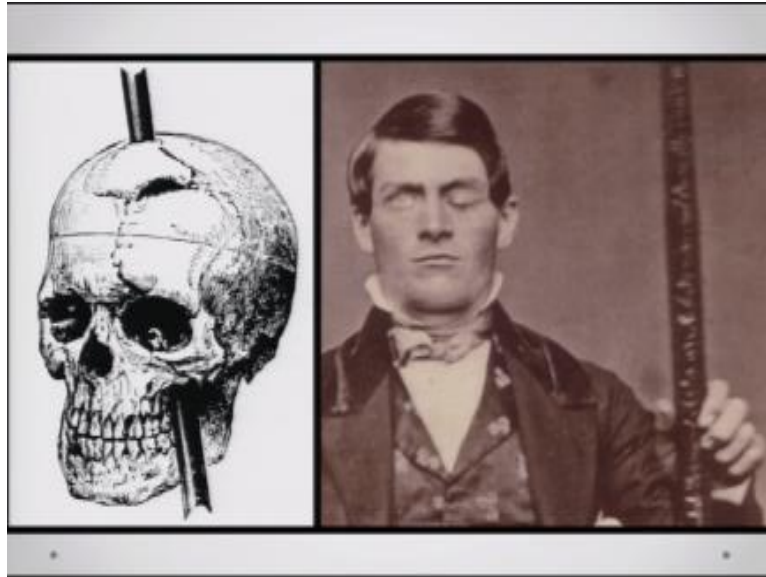
Here you can see the sample of somebody's brain wherein there is this damage on the frontal part of the brain which is basically the Broca's area. Damaged to this part are actually leads to what I was talking about Broca's aphasia

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- the very front of the frontal association region is known as the *prefrontal area (prefrontal cortex)*.
- this part of the brain is related to more complex behaviours (Banich & Compton, 2011).
- remember Phineas Gage?
 - if frontal lobes are damaged, a patients personality & emotional life may change dramatically. reasoning or planning may also be affected.
 - reduced frontal lobe function may also lead to greater impulsivity, including risk for drug addiction etc.

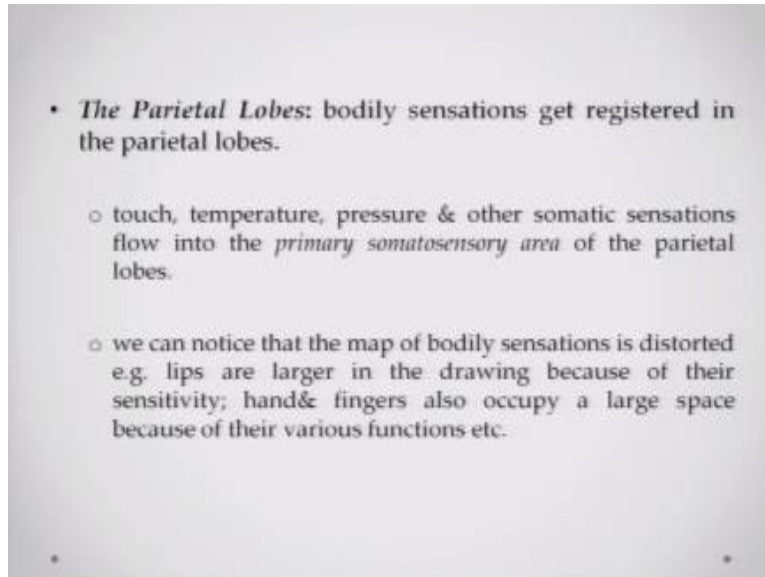
Now the very front of the frontal association region is the most anterior region is called pre frontal area or the prefrontal cortex. This part of the brain is related to more complex behavior like thinking, personality somebody being more sociable less sociable, irritable, or say for example civil behavior those kind of things. If some of you being students of psychology you would remember a patient named Phineas Gage.

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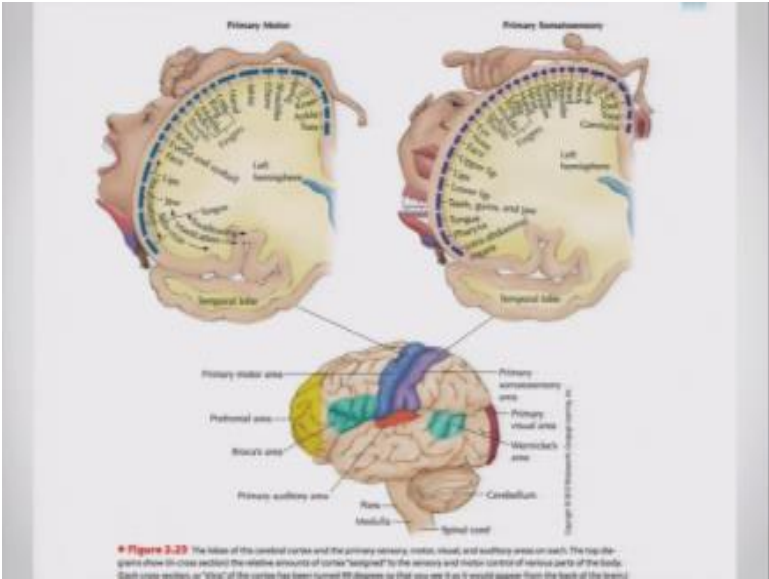
Phineas Gage was basically a railroad worker and in one of this accident he had a iron rod actually passing towards the front portion of his skull. After this accident happened the personality everything remained rather same but the personality of Phineas Gage changed considerably he began abusing people, speaking of profanities and he became less and less for civil person. So that is how you can actually link social behavior to the frontal lobes.

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Coming to the parietal lobes, the parietal lobes register all these bodily sensations that are received from the sensory areas of the body, touch, temperature, pressure other somatic sensations basically flow into this area called the primary somato sensory area, which is there in the parietal lobes. We also notice the map of homunculus map that the map of bodily sensations is distorted, lips are larger in the drawing because of their higher sensitivity hands and fingers also occupy a large space because of their various functions.

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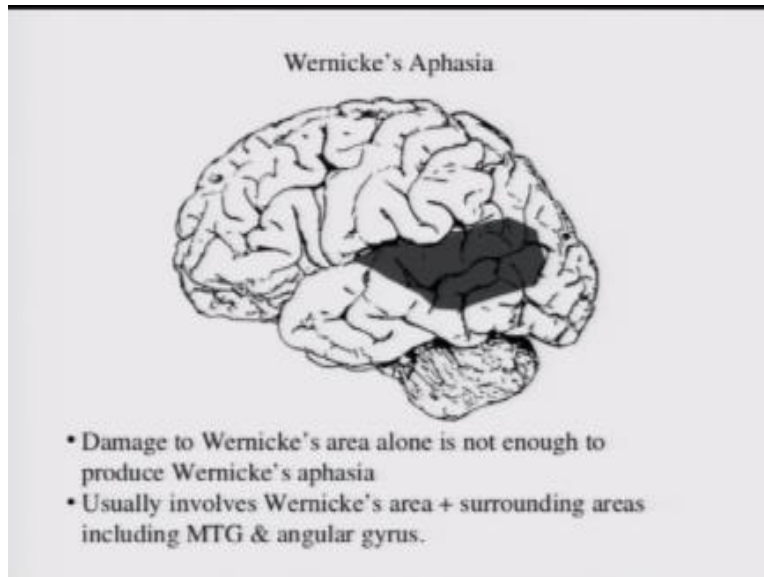
Here you can see that.

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- *The Temporal Lobes:* the temporal lobes are located on each side of the brain.
 - auditory information projects directly to the primary auditory area, making it the main site where hearing is first registered.
 - an association area, called *Wernicke's area*, lies on the left temporal lobe (for 5% of the people on the right). Wernicke's area also functions as a language site.
 - damage to the Wernicke's area leads to *receptive aphasia*, i.e. a person can hear speech but has difficulty understanding the meaning of words.

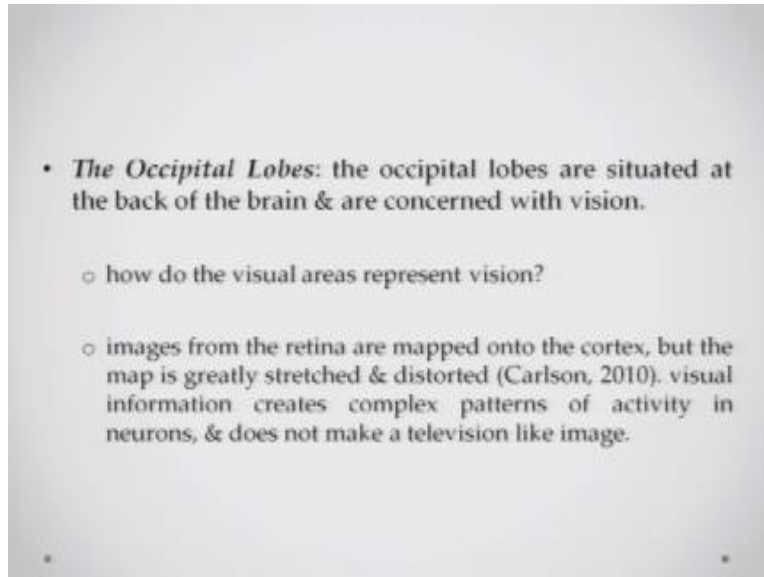
Coming to the temporal lobes, the temporal lobes are basically located on each side of the brain right above your ear. The auditory information projects directly to the primary auditory area which is there in the temporal lobe, making it the main site where hearing is first registered. An association area in the temporal lobe is called the Wernicke's area which is on the temporal lobe and is basically acting as the language site. This is the area which basically helps you comprehend whatever language you are hearing. Damage to this kind of area the Wernicke's area basically leads to receptive aphasia which is a way to say that you will not be able to understand any language.

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Here you can see the areas damaged which leads to the Wernicke's aphasia or the receptive aphasia.

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Coming to the occipital lobes, they are at the back of the brain and are concerned with vision. How do the visual areas represents vision is one the questions that is asked much in cognitive psychology. So images basically are trapped from the retina to the cortex, but the map is rather stretched and greatly distorted because you will have to convert the dimensionality as well. The visual information areas are basically creates complex patterns of activity of neurons and does not really send you a television like image rather a two dimensional distorted kind of image.

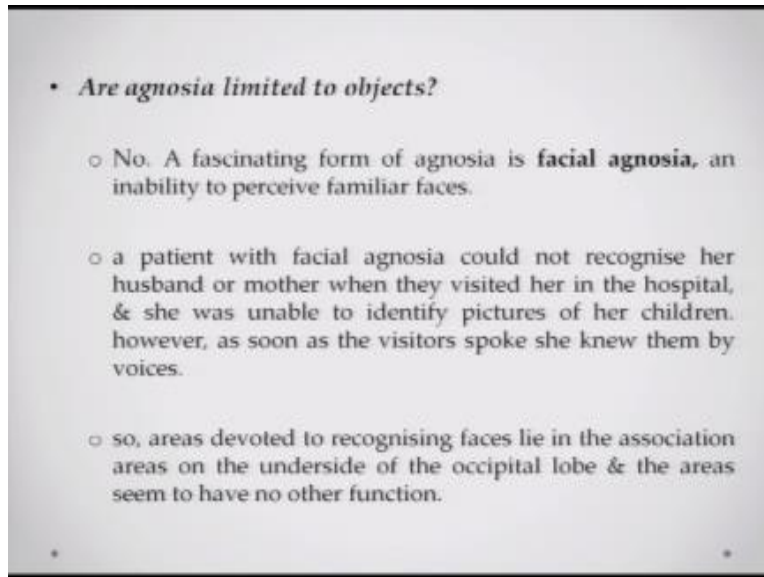
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- an interesting result of brain injury is **visual agnosia**, an inability to identify seen objects.
- visual agnosia is often caused by damage to the association areas on the occipital lobes (Farah, 2004). often called **mind blindness**.
 - for e.g. if we show Alice, an agnosia patient, a candle, she can see it & describe it as "a long narrow object, that tapers at the top." Alice may also be able to draw the candle, but not name it.
 - however, if she is allowed to touch the candle, she will be able to name it.
 - In short, Alice can still see color, size, shape etc. but can't form the associations necessary to perceive the meanings of objects.

An interesting result of injury to the visual cortex or occipital lobes leads to something called visual agnosia, which is the inability to identify then seen objects. This also refers to sometimes as mind blindness, for example if you show Alice who is an agnosia patient an object you show a candle she can see it she will describe it as a long and narrow object, but she will not remember the name of the object. Because the information link between the occipital lobe to the higher associational area is somehow damaged.

In short Alice will be able to see the colors eye shape etc, but will not be able to form associations of this visual percepts to the memory and other higher centers of knowledge.

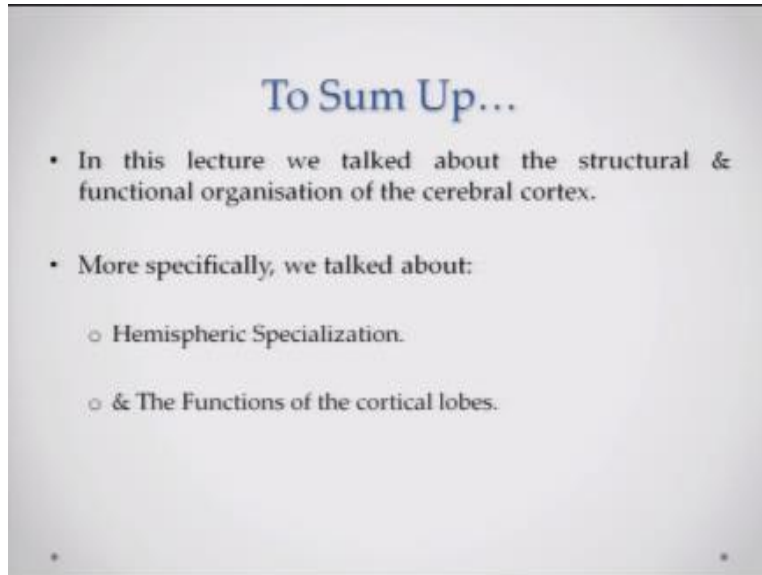
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Is agnosia limited to objects only? No agnosia can also happen for faces, for example there are variety of agnosia called facial agnosia, which is people's ability to perceive familiar faces, say for example somebody who has an injury in the occipital area the area which is responsible for perception of faces might suffer something called facial agnosia wherein the patient will not be able to recognize the faces that he had otherwise known, see one of these patients will not be able to recognize the face of her husband or mother when they visited her in hospital. She is not been able to identify the picture of her children, however as soon as they visited speaking she could recognize each of them because the auditory link was still intact.

So these areas devoted to recognizing faces lie in the association areas on the underside of the occipital lobes and the seemed to have no other function other than associating this visual input to other higher areas.

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To sum up in this lecture we talked about the structural and functional organizations of the cerebral cortex we talked about hemispheric specialization and we also talked about the structural and functional details of the other areas of the cerebral cortex which are the cortical lobes. Thank you!

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