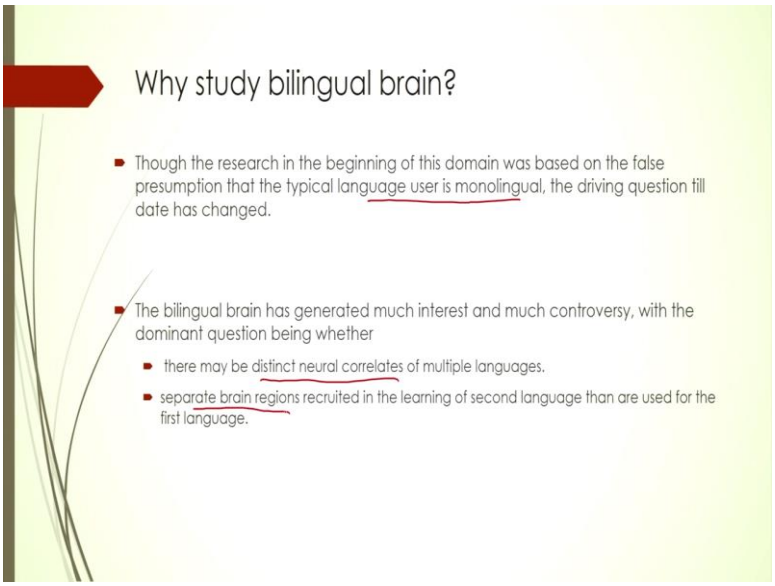
Bilingualism: A Cognitive and Psycholinguistic Perspective

Dr. Bidisha Som
Department of Humanities and Social Sciences
Indian Institute of Technology, Guwahati

Module - 04
Brain of a bilingual
Lecture - 09
Bilingual brain: neural representation of languages

Hello and welcome back. We will start with module 4 today.

(Refer Slide Time: 00:37)



This module deals with the bilingual brain, as in, the relationship of having learned two languages that is more than one language that is. So, if there is any distinct difference between a monolingual brain versus a bilingual brain. So, that is the primary motivating factor.

Now, even when understanding trying to understand the bilingual brain as in how a bilingual bilingual's brain functions in terms of language learning, in terms of language processing and many other factors, initially this field also was motivated by the monolingual brain as the standard, as the default thing to be noted.

So, as we have seen in the beginning, in the first second first and second modules, that there are lot of research in bilingualism bilingual language acquisition, bilingual language processing and all of that related area, have been motivated primarily in the

initial stages, primarily the motivation was to look at how a bilingual is different from a monolingual, that was how the study started. And the same happened with bilingual understanding trying to understand bilingual brain as well. So, this domain also was based on the presumption that typical language user is a monolingual, right.

So, that is; however, not anymore the case, and we now know that bilingual is a distinct kind of a language user and hence this is a domain of interest for its own sake, rather than comparing and contrasting it with the monolinguals. So, as a result of which, we have already seen 1960s onwards a lot of research has taken place in the field of bilingualism and the more the studies, the more the findings, the more also has been the controversy.

So, there is a lot of disagreement and lots of controversies in this domain. However, this is a very important domain of research within bilingualism as of today. Now, the main questions, the dominant questions that have been; that have been looked at in this domain are whether there are distinct neural correlates of multiple languages. Let me unpack this a little bit for you, before we go into the details.

What does distinct neural correlate mean? This means that, every language probably or that is the exactly the question does do multiple languages have distinct brain regions responsible for processing that particular language. So, is there a neural signature of one or two or three languages in the human brain?

So, does it basically mean that a monolingual's brain behaves differently compared to a bilinguals brain compared to a trilingual or a multilinguals brain. So, are there distinct neural correlates for different languages, that is the first one. And also, another important question that has been asked is that whether the learning of the second language use different brain regions?

Do we learn our first language and second language using the same brain regions or are there different regions? So, as we see that two primary questions with respect to bilingual brain have been the learning of second language and using of second language.

(Refer Slide Time: 04:08)

So, these are the two areas where we are trying to figure out the neural correlates. Now, keeping that in mind, we have more often than not these are the primary areas. There are some other related areas as well, but these are the primary areas when we look at bilingual brain.

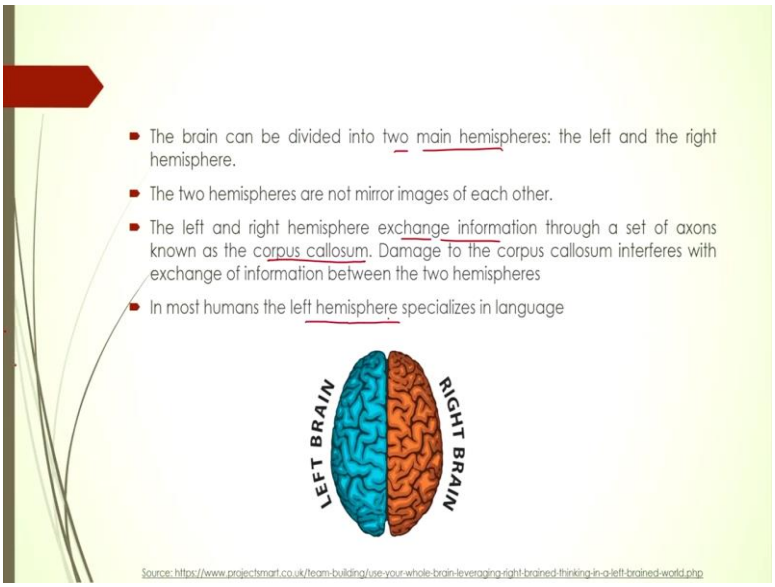
The first thing is the study of laterality, laterality as in where in the brain a particular function is located. This is this sounds simpler than it actually is as we will shortly see. Similarly, the allocation of cognitive resources; allocation of cognitive resources has to do with what kind how much of neural energy or let us say how what all kinds of cognitive apparatus, faculties like attention executive control are necessary for L1 versus L2.

How in other words, how much dependence does one's first language versus second language have on different kinds of cognitive resources? So, that is another interesting domain within this broad area and also language disorder has been a very important domain to study in this regard.

(Refer Slide Time: 05:18)

So, we will see them one by one, starting with laterality. Now, before we go into laterality with respect to bilingualism, let us understand what is laterality to start with. So, the first and foremost let us look at what is cerebral laterality.

(Refer Slide Time: 05:35)



Cerebral laterality is nothing but looking at the two hemispheres and in terms of the functions that they are known to serve. So, first thing first, the brain as all of us know is divided into two main hemispheres the left hemisphere and the right hemisphere. But

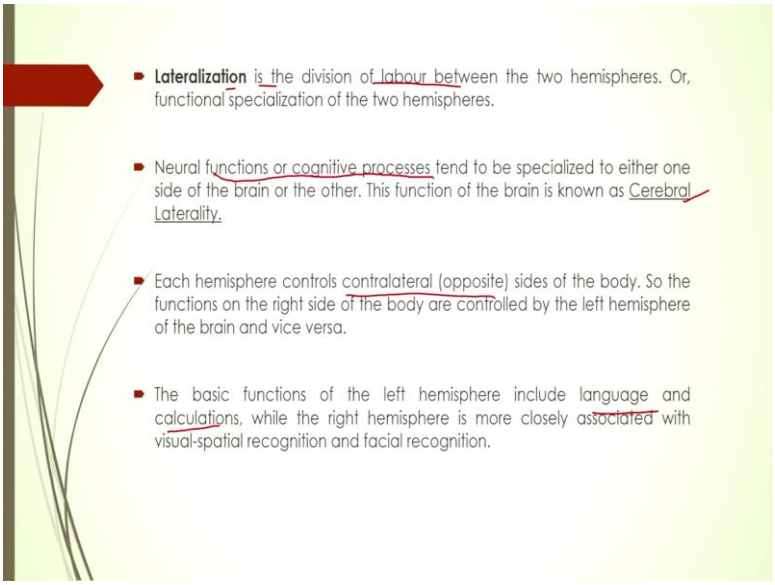
unlike many other paired organs in the human body, like many other paired body paired organs like kidneys and stuff the and the lungs and so on.

Human and the two hemispheres are not exactly a mirror image of each other. The two hemispheres are different and distinct in many ways ok. So, primary difference among them is the functional difference, the what is stored in which part of the brain. So, the, but nonetheless the two hemisphere all constantly talk to each other, they are always cooperating for carrying out most of the functions that we are that we know.

So, they exchange information through a set of axons, which is called the corpus callosum. So, that is corpus callosum is from is the is where is what is connects both the brains, both the parts of the brains ok. So, but otherwise there these are two distinct hemisphere. So, called damage to the corpus callosum interferes with the exchange of information as you would.

This is like a highway. So, there are two distinct parts of the brain and this highway connects one to other. And if in case there is some kind of damage that happens either through some kind of accident or through surgical processes, then there is a lack of communication between these two hemispheres. And in most humans left hemisphere specializes in language.

(Refer Slide Time: 07:19)

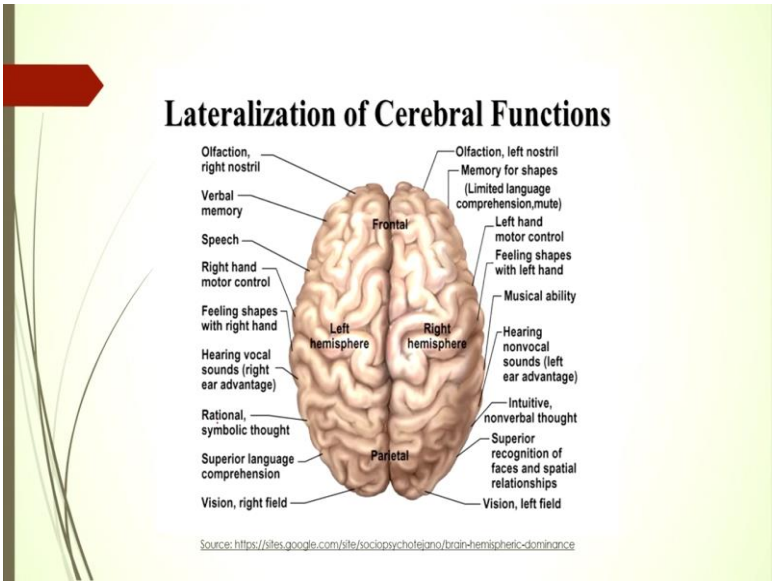


So, that is the very fundamental understanding as far as, cerebral laterality is concerned. Now, let us look at a little bit more in detail. So, lateralization can also be thought of in some sort of a division of labour. So, how each segment in the brain how each segment in the each of the hemispheres of the brain, are divided into in terms of the functions or cognitive processes as we will call them.

And this is what is technically called the cerebral laterality. So, which part of the brain is responsible for housing what kind of function. Now, before we get into further discussion one important thing about brain needs to be kept in mind. That is the contralateral control. So, left side of the brain controls the right side of the body and the right part of the brain controls the left side of the body.

This is one of the fundamental things to keep in mind whenever we study brain and it's functions with respect to whether language or any other functions. So, contralateral control mechanism is something that is a fundamental thing. Now, the basic function of the left hemisphere includes language we have already said that and calculations while the right hemisphere is used for visual spatial recognition.

(Refer Slide Time: 08:40)

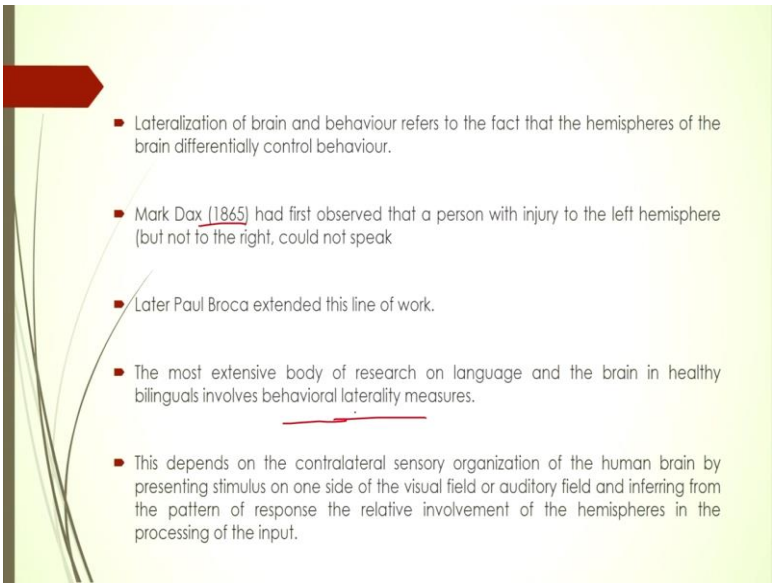


So, this is a sort of simplistic map for you to look at, the dependent on the right hemisphere or the left hemisphere you can see a list of a rough, broad list of functions that are how they are lateralized right. So, this is how it is.

(Refer Slide Time: 09:00)

So, in terms of cerebral laterality we already know that the left hemisphere as far as language is concerned left hemisphere is the seat of language. In fact, it is so much so that it is said that we speak with our left hemisphere right.

(Refer Slide Time: 09:17)



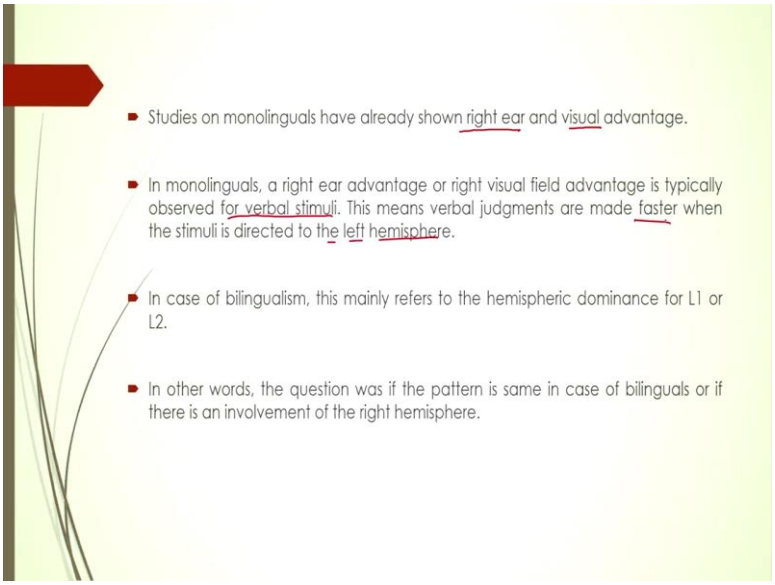
Now, let us next is behavioral laterality. Behavioral laterality as in when what kind what which part of the brain is responsible when any kind of behavioral output is to be given. So, various kinds of tasks have been used to find out the types of. So, how do we come to the cerebral laterality is through behavioral laterality.

We by giving various kinds of task to the human brain and seeing which part of the brain gets activated and how which are the neuronal networks that fire together is how we know where these functions are located right. So, these studies go back a little back in time.

So, one of the first to study this was Mark Dax in 1865 quite a long time back. He had observed for the first time that a person with injury to the left hemisphere could not speak. So, this there are many studies by Mark Dax, but unfortunately, he did not publish most of them. But he was the first person to mark that, that injury to left hemisphere has a result in language impairment.

Later Paul Broca extended this line of work and today if we say that we speak with left hemisphere it is credited mostly to Paul Broca, because of his work on the on aphasia. So, now the most extensive body of research on language and brain basically comes from behavioral laterality measures. So, we will discuss various measures like this one by one.

(Refer Slide Time: 10:48)



Some of these studies are called right visual field advantage, right ear advantage and so on. So, in case of both auditory and visual processing it has been studied on as it has been studied on monolinguals. We already know that that monolingual show a right ear and visual advantage. What it means is that right ear advantage is typically observed for verbal stimuli. Meaning the stimuli given to right ear will be processed better or faster or more accurately right.

The so, verbal judgments are made faster when the stimuli is left to the left hemisphere. So, as we said the left hemisphere controls everything that happens on the right side of the body and vice versa. So, any input coming from the right side of the of your sensory organs like eyes and ears are processed in the left hemisphere and that is what we are talking about here.

So, anything that is directed to your right ear any kind of verbal input given to the right ear or right visual field have been found to be processed faster. Any kind of judgment that and task that are given they are processed faster. Now, in case of bilinguals if we take this to bilingual the question becomes question turns slightly different. It turns slightly more tricky.

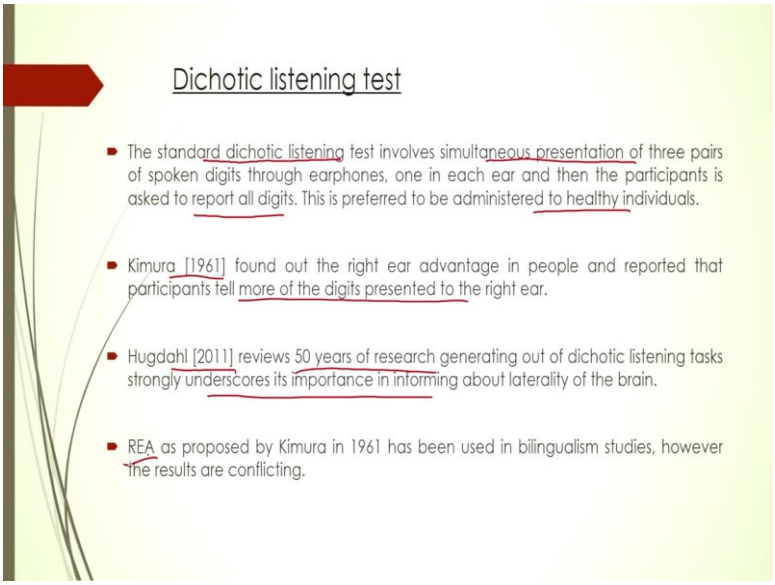
Now, we need to find out if there is a hemispheric dominance. So, we will right ear right ear and right visual field dominance will be found in case of bilinguals as well. Are they same for L1 and L2 or are there differences, these are the questions that we ask when the same question is asked for bilinguals.

(Refer Slide Time: 12:32)

So, whether the patterns are same or different between a bilingual and a monolingual with respect to these two things. So, how do we judge all of these? So, the this is what we will now see through three different types of tasks or tests, that are quite well known in this field of study. The first and foremost is dichotic listening task which takes us to

the right ear advantage domain, then right visual field advantage studies and dual task paradigm.

(Refer Slide Time: 12:57)



Dichotic listening task let us see what that basically is. So, a standard dichotic listening task in typical case, whether it is bilingual or monolingual does not really matter. It involves simultaneous presentation of three pairs of spoken digits. Basically, if you break it down to the details, both the ears get simultaneously some kind of auditory input right. So, simultaneous that is why it is very crucial.

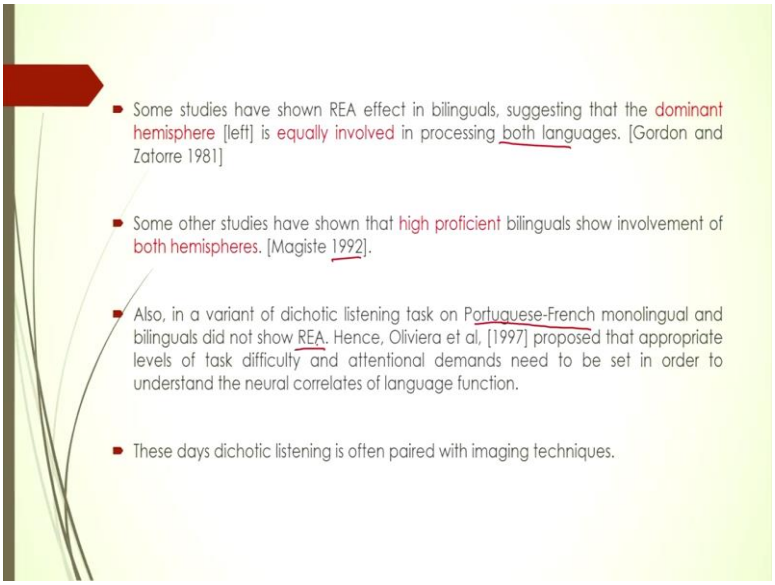
Now, through earphones so, a person subject is made to listen to digits by different kinds of digits and in 2 ears or sometimes other things also. And the typical task for the participant is to report all digits. That is very simple task. And this needs to be said this is preferred to be administered to healthy individuals because if you have hearing problems in either of the ears this the person will be unfit for taking this kind of a task.

Now, one of the earlier studies by Kimura 1961 found out for the first time that right ear advantage in people. Meaning if when simultaneously two different stimuli, auditory stimuli are given to both of the ears whatever you hear through your right ear will be processed better. As in you are more accurate, less mistakes, time is time taken is less and so on.

So, people tell more of the digits presented to the right ear. This is among the first findings in this domain. Later on, 2000 quite recent in terms of in comparison with Kimura, 2011 study reviews 50 years of research generating out of this dichotic listening task. This strongly underscores the importance of informing about laterality of the brain.

Basically, meaning that starting from Kimura 1961 there have been plethora of studies looking at the laterality measures through using dichotic listening task and it has been taken as one of the most important task and that is exactly what the 2011 review also suggests, that this is a quite reliable test. Now, the same Right Ear Advantage or we in short we call it REA this was proposed first by Kimura 1961. The same kind of studies have now been used on bilinguals as well.

(Refer Slide Time: 15:25)



So, many studies have found out that the same kind of right ear advantage exists for bilinguals as well. So, in bilingual's both languages the dominant hemisphere which is the left hemisphere in terms of language left hemisphere is dominant. So, in case of bilinguals also it was found that for both languages of the bilingual, the dominant hemisphere was responsible for processing, meaning there was right ear advantage for both of the languages of the bilingual.

So, this is very crucial finding. Some other studies have shown that proficiency also is a variable here. It cannot be taken as a you know blanket statement that for all bilinguals, we will see REA. In some cases, in fact, the proficiency of the bilinguals is a very

important factor. So, if they are high proficient bilinguals, then we will see the involvement of both hemispheres. This is also a very important finding.

Another study on dichotic listening task using Portuguese-French bilinguals as well as monolinguals they did not however, find the right ear advantage for these populations. So, basically, we see that there are also many other studies we did not include it, but just some representative studies we are talking about here.

Roughly, the finding is that in case of monolingual population right ear advantage is a common finding. But in case of bilinguals that finding sometimes is in tune with the earlier findings, but sometimes they do not find the advantage. Sometimes also it becomes a matter of proficiency in the L2, which could be a deciding factor.

So, keeping all of these in minds there have been demands of creating a general set of tasks that are equivalent, right. So, appropriate level of task difficulty is one very important marker in this case. So, there are two things that are coming out of the research in this domain. One is the proficiency level of the L2 and the task demands. So, different kinds of task demands might have different kinds of results.

So, what we need is there should be some amount of equivalence across tasks and also equivalence in terms of proficiency. So, in order to get better idea about what is happening in terms of the dichotic listening task and different brain region's activation these days dichotic listening task is also done along with some amount of imaging studies.

(Refer Slide Time: 18:06)

Imaging techniques as in brain imaging various kinds of brain imaging techniques are available these days. So, nowadays we the task they use both the listening task which is a behavioral task and the brain imaging technique. So, that is one. In terms of visual advantage, right visual field advantage these are the tasks that are typically asked in the experiments.

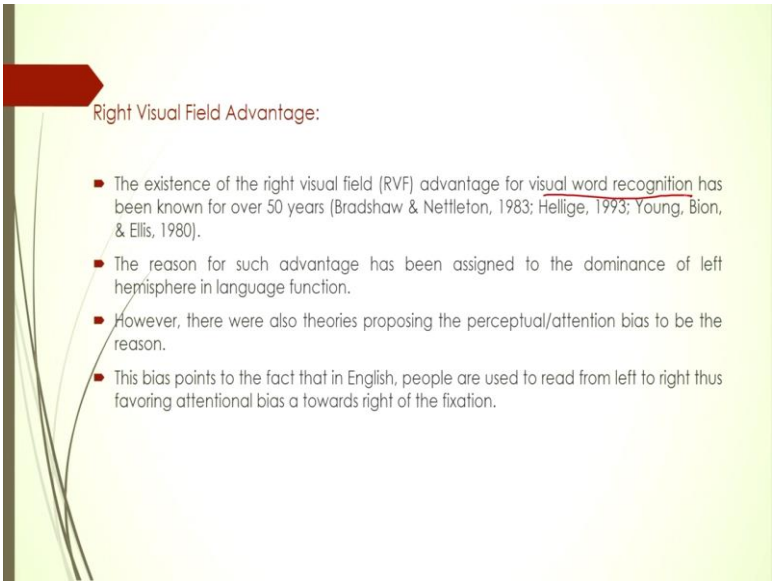
So, depending on which side of the visual field, typically there would be a computer screen and there is a fixation cross in the right in the middle and the display appears either on the right side of it or on the left side of it. So, that is how it is considered to be part of right visual field or left visual field, that is how it is done.

So, depending on where on the screen the stimulus is presented, we will take it as a right visual field presentation versus a left visual field stimulus and these are the kinds of task that are given. So, and how the performance on these task we will decide whether the which one which visual field has an advantage.

So, judging judgment of meaning, distinguishing between words and non-words, which is also called lexical decision task. We write it as LDT Lexical Decision Task. So, lexical decision task is a task where you see a string of letters, which may be a word in your language or may not be so, distinction between these two and the speed with which words can be read aloud and so many other things.

So, various kinds of tasks are given based on the display either in the right visual field or in the left visual field and the results are then taken into account.

(Refer Slide Time: 19:49)

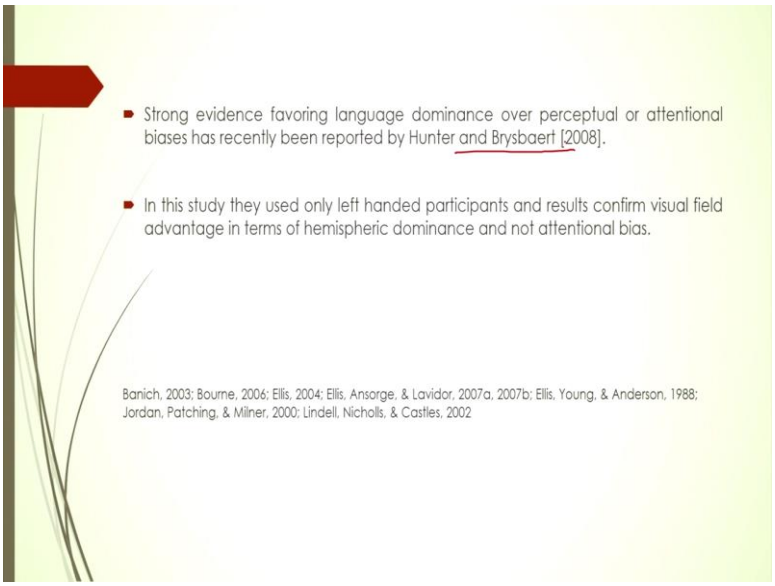


So, typical findings suggest that there is a right visual field advantage in case of word recognition, visual word recognition. So, LDT and various other task are done for visual word recognition, various kinds of comprehension tasks. So, this is already understood. This is already taken for granted that there exists an right visual field.

So, right REA and RVF both are established for monolingual population. Sometimes there are also controversies in this. Sometimes they it is said that the right visual field advantage may not be because of the behavioral laterality of the human brain, but because of some other kind of bias.

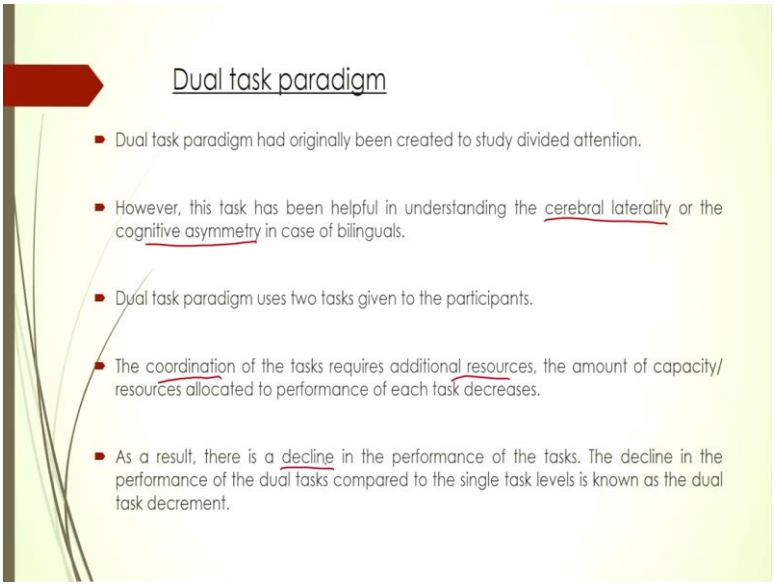
For one example, there are few studies that have claimed that in English language, for example, the right visual field advantage is seen because of the way the writing system in this language exists. So, in English we write from left to right. So, as a result of which light right visual field probably gets some kind of a biased attentional load.

(Refer Slide Time: 20:53)



So, that probably is at the core of why we have right visual field advantage. So, the to look into that issue, there was a recent study by Hunter and Brysbaert on attentional bias. So, evidence favoring language dominance over perceptual attention bias has been found out. So, this is another domain of study.

(Refer Slide Time: 21:14)



Similarly, there is dual task paradigm. Dual task paradigm is also a very important area that has been around for quite some time. The primary logic of dual task paradigm is, if we increase the cognitive load, if we increase the amount of work to be done, if we give

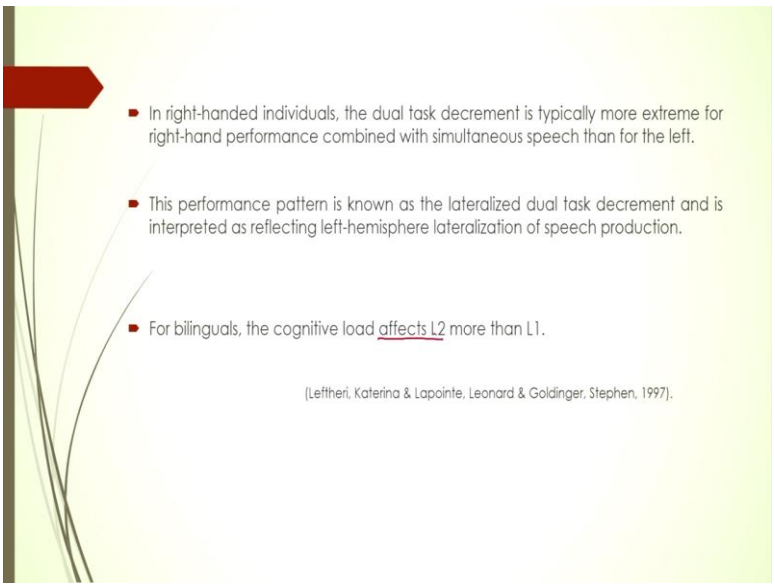
two task at the same time to the participant, how does the participant tackle it? That is what dual task paradigm is.

So, cognitive asymmetry is basically so, cerebral laterality or the cognitive asymmetry in case of bilinguals has been studied using dual task paradigm. So, dual task paradigm may, the participant is given two task at the same time. Some there have been studies comparing monolingual versus bilingual or bilinguals having different levels of proficiency and so on.

The results again in this also are varied. So, typically what happens when you have been given two task at the same time, we need to have a coordination. So, this as a result of which this coordination will need additional resources, additional resources in terms of attention and other capacities. So, the amount of capacity and resources allocated as a result will decrease.

So, basically if you the amount of attention and the amount of executive control that we will focus on one task, if the same person does two task at the same time, the allocation of cognitive resources will be decreasing. That is basically the finding. So, there is a decline in performance when two tasks are given.

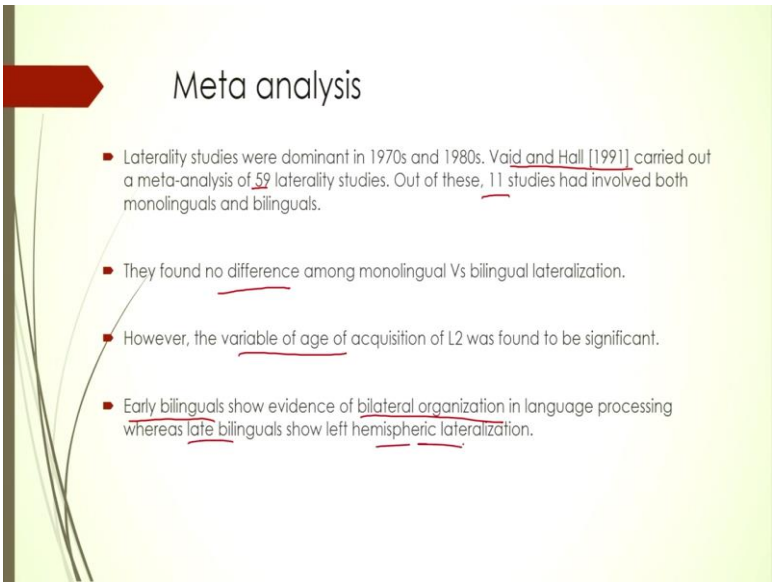
(Refer Slide Time: 22:51)



Primary finding in these cases is that for bilinguals, the cognitive load affects L2 more than L1. So, if you ask if you give two tasks at the same time to a bilingual, the second

language gets affected more as opposed to the first language. Language task we are we talking about language tasks here. However, dual task paradigm can use different types of task. It can be language related, it can be non-linguistic task as well but if it is a language task, L2 gets affected more.

(Refer Slide Time: 23:23)



As we go ahead with various other studies, we will see in most of these cases, various kinds of task conditions leads the mode effect on the L2 as opposed to L1. Now, there have been a lot of studies over all these years from starting from 1960s till today, there have been a lot of studies. So, there we need a meta-analysis to look at what is the overall picture. It is very difficult to quote each and every study. So, meta-analysis helps.

So, one such well-known meta-analysis came in 1991 by Vaid and Hull and they had a an analysis of 59 laterality studies as in 59 studies or research papers that looked at the laterality issues. And, but then the problem is not all of these laterality studies are based on bilinguals. So, we have seen that only 11 studies had involved bilinguals and monolinguals.

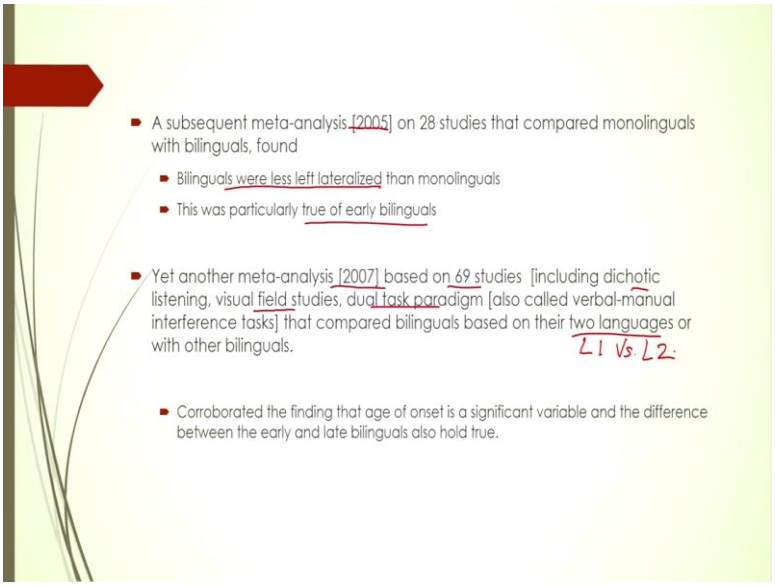
And they found no difference among bilinguals as this monolingual lateralization as in the language localization in the brain did not show much difference in terms of behavioral laterality. However, in some cases there was the variable of age of acquisition of L2 that was considered to be a significant factor. So, if your L2 acquisition age is

much later, if you learn the L2 later in life, there have been seen some kind of change, some kind of differences in the in those cases.

But overall, they did not find much problem. So, early bilinguals as per the study show evidence of bilateral organization, whereas late bilinguals show left hemispheric lateralization. What does this mean? If somebody has learned the L2 at an early age, the language localization will happen in both sides on both hemispheres.

So, the L2 is more globally present if the language acquisition is early as opposed to late. If you are learning the L2 late in life, then there will be left hemispheric lateralization.

(Refer Slide Time: 25:31)



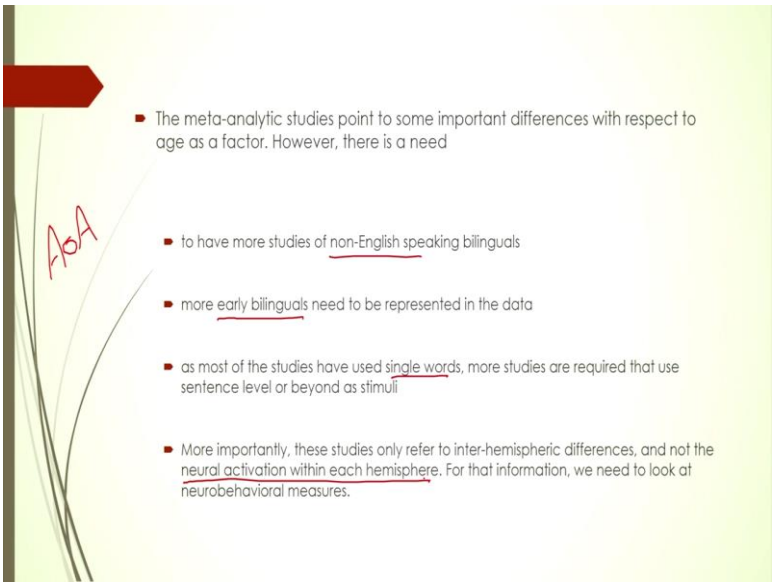
So, that is what the finding in 1991 study talked about. A more recent meta-analysis in 2005 that also compared monolinguals with bilinguals. And that and they found that bilinguals were less left lateralized that monolinguals than monolinguals, which is a similar finding as the 91 finding. So, bilinguals are likely to be more bilaterally organized.

Bilingual and then that L2 is more bilaterally present than L1. That is what is. So, bilinguals are less left lateralized. And this is also true of early bilinguals. This is what the earlier finding also talked about. A few couple of years later another study looked at 69 studies including all different kinds of behavioral laterality tasks like dichotic listening, like visual field, dual task, all of these major task paradigms.

And they looked at and there is the comparison was based on two languages or as in L1 and L2, the two their two languages and as in L1 versus their L2 or with other bilinguals. So, that was the change that this meta-analysis looked at, compared to the earlier ones. This also this study also corroborated the earlier finding that age seems to be a very important factor.

Very important variable and that could decide the localization of the language as opposed to. So, L1 is that as far as L1 is concerned, the there is hardly any controversy. L1 is left lateralized, as in the left hemisphere houses our first language. But L2 might be, there might be lot of variation across population depending on where in the brain L2 is localized. It can be in both the hemispheres; it can be in one single hemisphere. The reason the of this variability is, one reason is age.

(Refer Slide Time: 27:35)



So, the age of acquisition, age of acquisition is written like this. In a in the literature, in this literature we write like this AoA, A capital o small A capital again. So, as we just said that age seems to be an important predictor. However, these studies are of a particular type. So, there are not too many types of bilinguals that are represented, not too many L2s are represented and so on.

So, one of the suggestions in this regard that has been that has come out is that more non-English speakers should be taken into account. So, English either an L2 or an L1 is of

course, a very important source of data, but more different kinds of populations need to be studied. More early bilinguals also need to be represented in the data and so on.

So, other domains that need to be looked at as per the suggestions of most many researchers is that typically we have used single words in the in this kind of judgment task. So, there should be every level of language should be represented. So, word level is a very at a very rudimentary level. So, why not look at the sentence level and beyond as well.

So, paragraphs, how do you process paragraphs and so on. So, another important as neuroscience has taken giant leaps in the last couple of decades. Another important question that has been asked is why look at a bigger picture of lateralization only. Why not look at distinct possibilities within each hemisphere? That suggestion has also come up.

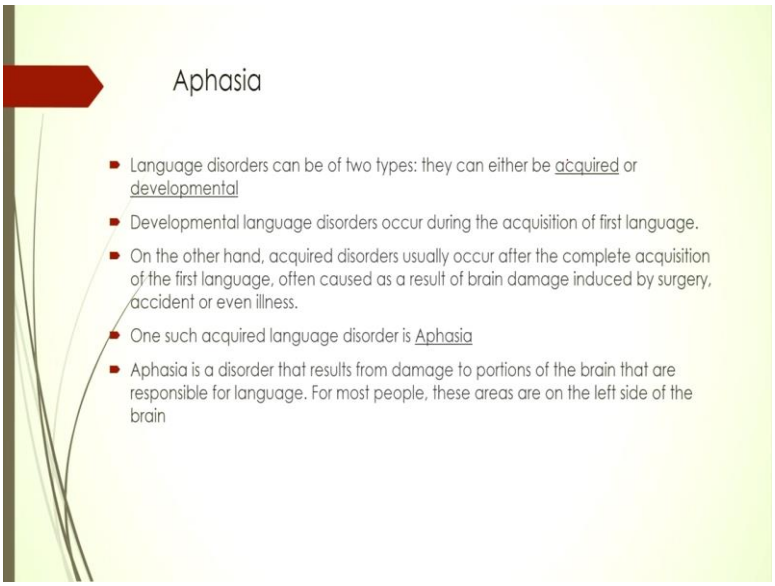
So, neural activation within each hemisphere not only we should look at different kinds of bilingual population non-English included. We have also should look at early bilinguals. So, should we need more data on early bilinguals from across different kinds of diverse backgrounds. Thirdly, we need more and more input of language types of language use beyond single word and, last but not the least, neural activation within each hemisphere also should be a matter of concern. It is not a there should there could be differences even at that level.

(Refer Slide Time: 29:54)

So, these are the things that are in there in terms of behavioral laterality studies and things where they stand today. Another important domain of study with respect to organization of the two languages in the brain of a bilingual is has come from the aphasia data, data from aphasia and epileptic patients.

In fact, aphasia is a language disorder as many of you might be knowing and electrophysiological data also have come from another type of patients, epilepsy patients, ok. So, a lot of this data have come from epileptic patients. O 2 kinds of patients data have informed us about how the bilinguals two languages could be organized in the brain. So, this data is not any task data, but simply patient's data.

(Refer Slide Time: 30:45)



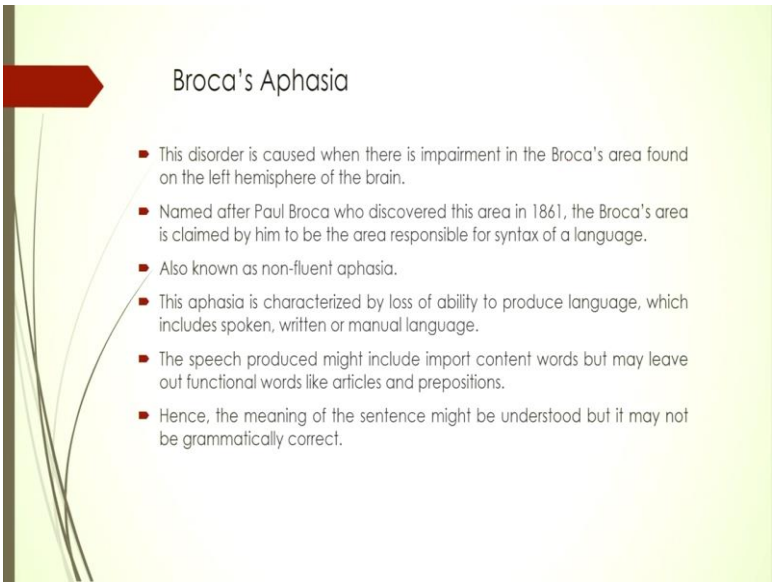
Now, aphasia as many of you might already be knowing, aphasia are a kind of a language disorder. There are two kinds of aphasia; one is called acquired, another is developmental. Developmental language disorders can be of two types developmental and acquired. Aphasia is one of the acquired language disorders, right.

So, aphasia occurs when the for various reasons, one there could be a brain injury, there could be a stroke, there could be you know hemorrhage and various kinds of things that lead to aphasia. So, damage to the those part of the brain that are responsible for language functions, results in aphasia.

(Refer Slide Time: 30:32)

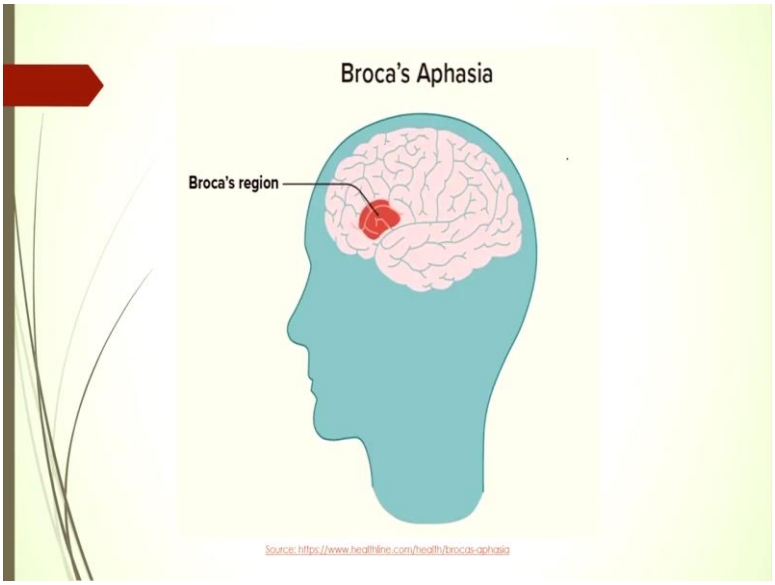
Aphasia are of two types, 3 types.

(Refer Slide Time: 31:33)



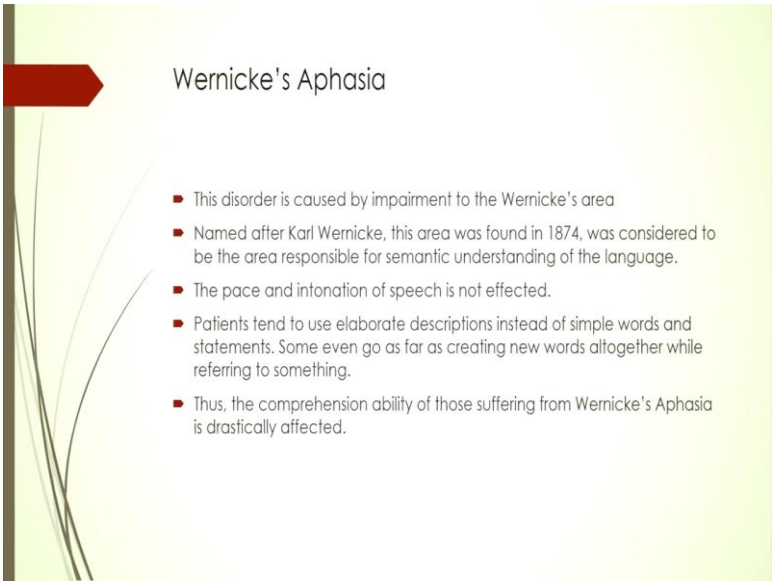
In fact, now there are many other types also, but primarily when you talk about aphasia we talk about Broca's aphasia, Wernicke's aphasia, and global aphasia. So, this part is just for you to all of you to brush up the what is what kind of aphasia exist.

(Refer Slide Time: 31:50)



And what part of brain is responsible, where do we need the problem to happen in order to in order for us to have Broca's aphasia.

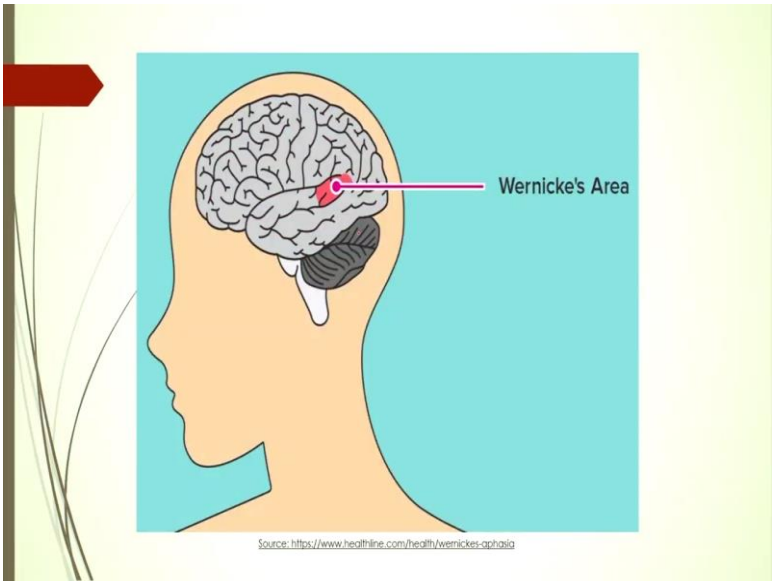
(Refer Slide Time: 32:06)



So, this is the Broca's area in the brain. So, any kind of damage to this particular brain area will lead to Broca's aphasia. Similarly, Wernicke’s aphasia, Wernicke’s aphasia is also called the fluent aphasia, as opposed to Broca's aphasia. Broca's aphasia is non-fluent aphasia, because in this aphasia there is a lot of difficulty in speaking.

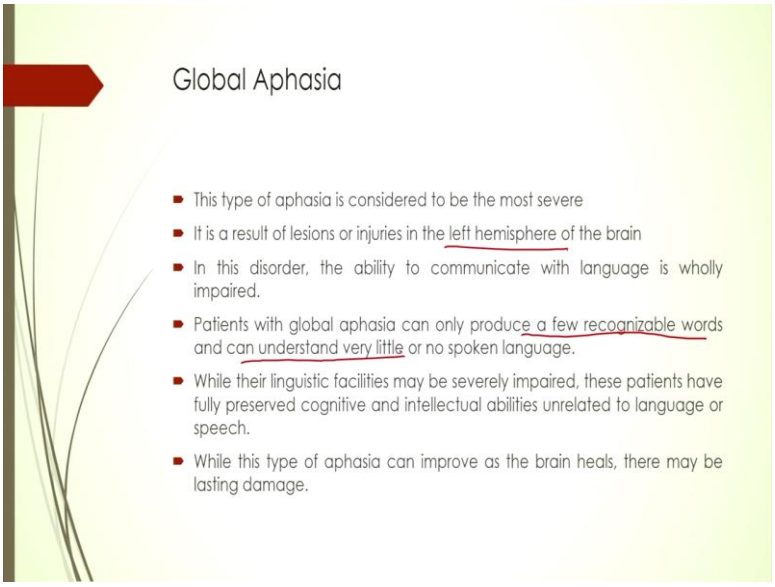
Production gets heavily disturbed. In case of Wernicke's aphasia, however, production is not disturbed, but understanding is disturbed. So, semantics will be absent.

(Refer Slide Time: 32:32)



So, this is the Wernicke's area. Any kind of damage to this particular brain region leads to Wernicke's area.

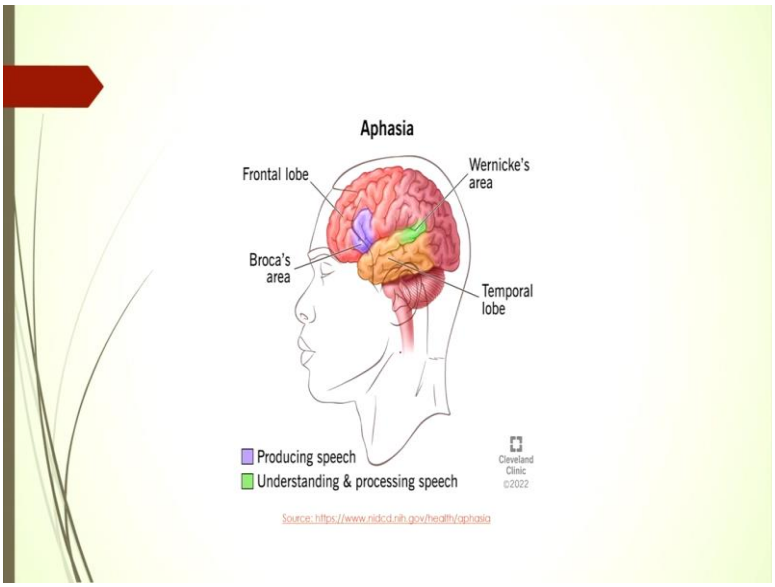
(Refer Slide Time: 32:39)



Similarly, there is a global aphasia. Now, this is a this is the most severe type of aphasia. This typically happens as a result of injuries in the left hemisphere of the brain, but the injury needs to more widespread than either Broca's or Wernicke's aphasia. So, in this

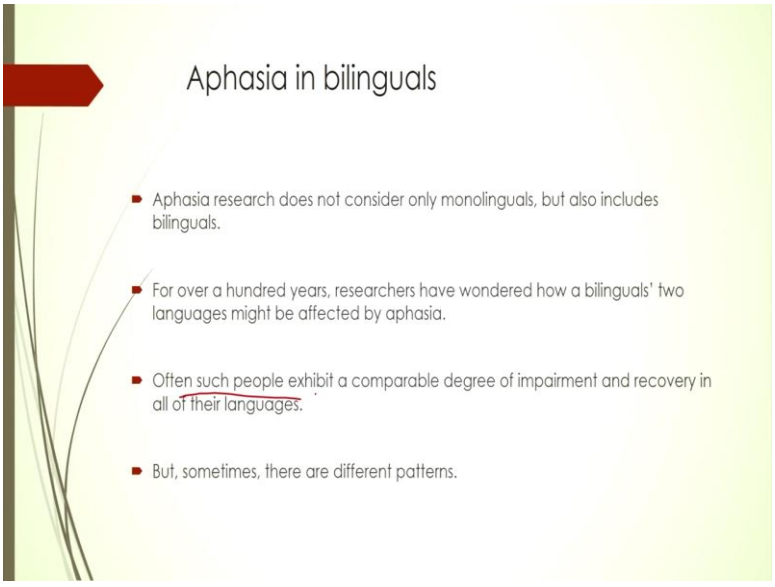
case there will be a severe. So, they can only produce a very few words. So, production is affected or can understand very little. So, this is sort of a combination of Broca's and Wernicke's aphasia. They can speak very little, they can understand very little also.

(Refer Slide Time: 33:14)



So, this is what aphasia is all about. So, this is just a representative map for you to remember what which are the brain areas are responsible.

(Refer Slide Time: 33:22)



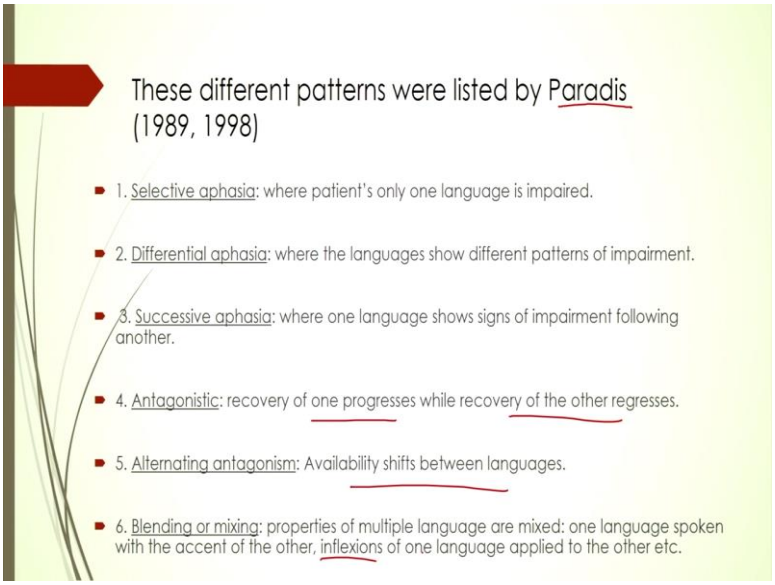
Now, in terms of aphasia and bilingualism there have been some reports. There are, but the number of bilinguals in, the data of bilingual aphasics, is far less as opposed to

monolingual aphasics, but nonetheless that exits some data. And based on that data we will see what it says about bilinguals. So, the primary question about aphasia patients in bilinguals or bilingual aphasics is that how the two languages might be affected.

Do they get affected similarly or do they get affected differently? That is the question that have been asked. So, in some cases, there is a lot of variability in this fine in the data in this domain and some such people often such people exhibit a comparable degree of impairment meaning that a bilingual's both languages could be affected similarly.

And if they are affected similarly, the recovery also is similar; that is a one side of the finding, but some other cases also show there are different patterns. So, both languages do not get affected in the same way. So, two kinds of findings have been reported in the literature. One group say that there are similar kind of problems and similar recovery pattern. The others other finding suggest that there are differences and those differences lead to various kinds of patterns that is not a single pattern.

(Refer Slide Time: 34:55)



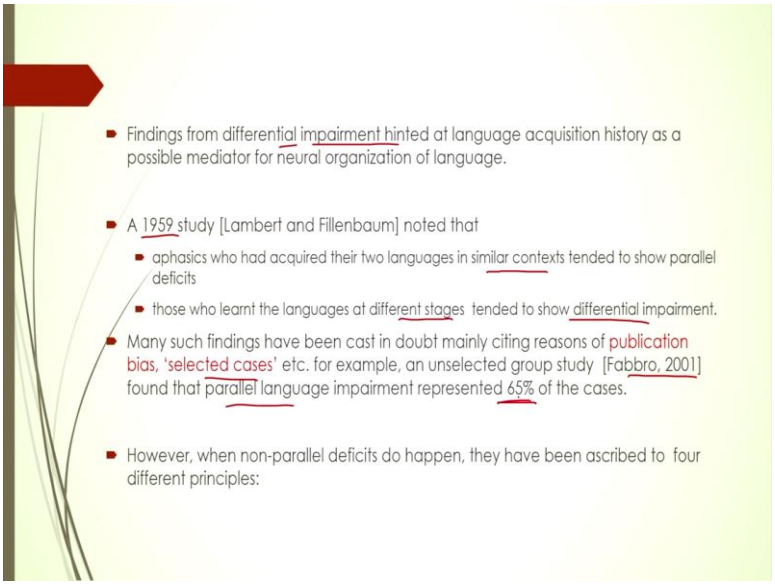
And so, we need to look at all these different types of patterns right. So, when there are differences, these are the kind of differences that Paradis collected and put them together. So, 1 is called selective aphasia. In case of selective aphasia, patient's only one language is impaired. So, a bilinguals speaking L1 and L2 let us say only the L1 gets affected or only the L2 gets affected that is selective aphasia.

Differentially aphasia is both languages get affected, but there are different degrees of impairment. So, one language getting affected more compared to the other. Successive aphasia has also been reported in the literature, where one language gets affected first and then the other language gets affected. So, you will lose capacity to speak in L1 first or L2 first and then the other one follows that is another.

Antagonistic aphasia has also been reported. This is rather different type where recovery of one progresses. while recovery of the other regresses. So, as one gets better the other language gets worse that has also been. So, there is an opposite pattern between L1 and L2 in terms of recovery. Then there is alternative antagonism also.

So, availability shifts between language, sometimes this language is available, sometimes the other one and blending or mixing. So, properties of multiple languages are mixed. So, one property of this language gets attached to another property of another language and so on. So, it inflexions could be of one language could be used for and do it root word of another and so on. So, various patterns do exist.

(Refer Slide Time: 36:37)



So, there are findings from differential impairment hints at language acquisition history as a possible mediator. So, there when there are differences, in many cases there are no differences. When there are differences, there are these kind of different patterns and one possible reason for these different patterns is that has been put forward is the language acquisition history.

As in when in at what age the second language was acquired and because that is taken as a very important predictor of the neural organization. If you just as we have seen the with the studies with behavioral laterality that early bilinguals show a very different pattern of lateralization as opposed to late bilingual.

Similar kind of thesis have been proposed for aphasic data as well. A rather old study 1959 study had proposed that they found that the bilinguals who had acquired their two language in similar context tended to show similar kind of deficit, parallel deficit so, if for example, if we go back to our simultaneous bilingualism.

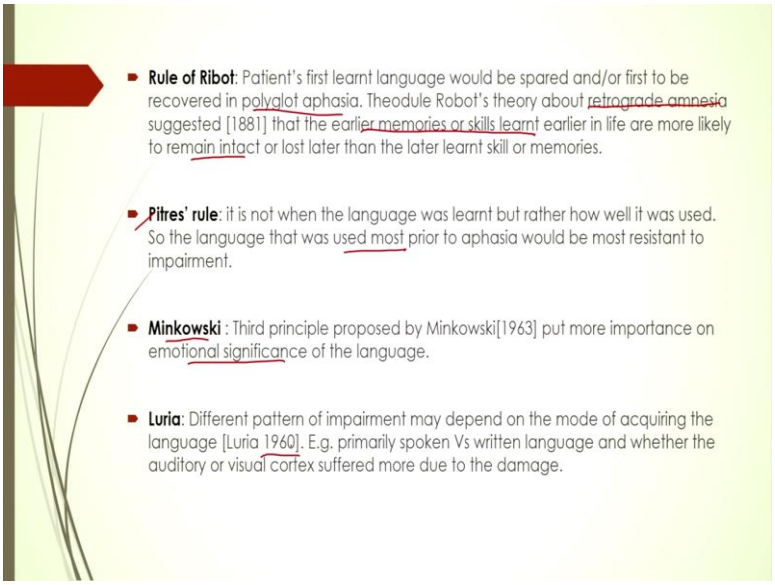
So, if a simultaneous bilingual is affected by aphasia chances are higher that both of his languages will be equally affected or parallelly affected that is why they mean that the similar context learning the languages in similar context may lead to similar patterns of deficit.

And then those who learn the language in different stages, tended to show different impairment. There are various kinds of theories that have been given. However, a recent comparatively recent study by Franco Fabbro in 2001 has severely criticized such findings and cast a lot of doubt. There has there are many reasons that he has said that the data probably has some issues.

Couple of reasons he has put forward one of them is publication bias. Publication bias is a bias that exists for publishing certain kind of result and ignoring the other kind of result. So, he says that publication bias has worked here in order to highlight the differences and also selected cases. So, the subjects so, the studies that were selected there was not a it was not a random general study.

So, for example, an unselected group study by him by his group found that parallel language impairment represented 65 percent of the case. So, his study which shows that in 65 percent that is majority of the cases parallel impairment happens. In any case, since we have the data for both parallel and non-parallel impairment there have been various study various theories that have been put forward as to understand, to answer ,to justify as to what probably is the reason.

(Refer Slide Time: 39:33)



These four are most important theoretical standpoint to try and understand what is happening. So, one is called the rule of Ribot. So, Ribot is well known for his study on retrograde amnesia. So, in case of amnesia, he found out that not all kinds of memory are lost. Certain memories that have been created earlier, some skills that whether that you have learnt earlier are more difficult to lose and the skills that are learnt later,so that they are easily lost.

So, the earlier memories or skills earlier they are more likely to remain intact. So, this is this his theory was with respect to memory you know in terms of amnesia. So, taking that theory to language, in case of language disorder the idea is that if the language that you have learnt first, in the first part of your life will remain intact it will get less affected by aphasia, as opposed to a language that is learnt later.

So, again age becomes age of acquisition becomes a very important marker, a very important variable to make sense of what is happening. So, this is about rule of Ribot to understand polyglot aphasia. Polyglot aphasia that affects bilinguals or multi-linguals. Another important rule that have also been proposed is called Pitre's rule. Now, here this rule says that it is not so much about the age of acquisition of the second language, but however, how well it was used.

So, are you using your L2 sporadically or do you use your L2 most of the time, that will beside how much it will get affected. So, language that was used most, prior to aphasia

would be most resistant to impairment. This is what the this rule says. So, as opposed to Ribot say Ribot's idea, its age of acquisition as an important factor. Pitres rule takes the used factor, usage of the language as an important factor as a resistance through aphasia.

Third principle was put forward by Minkowski, gives more importance to emotional significance of the language. This theory actually goes back a long time this. In fact, at there was a time when we the differentiation between L1 and L2 was that L1 is the language of emotion. L1 is you know when you really need to use a language for emotional purposes, this is L1 is what.

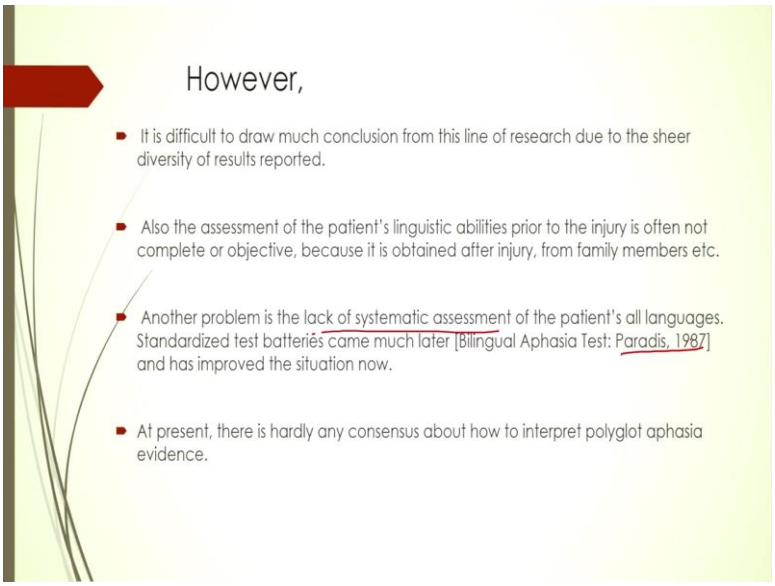
So, this is basically the emotional valence of language that Minkowski talks about. So, the language that is more connected to emotion is the one that is more resistant to being lost, due to aphasia. And then we also have Luria. Luria's theory is more dependent on the mode of acquisition of the language, rather than age or you know usage or emotion.

He says that most important thing is which is the mode in through which the language was learnt? Was it visual mode or was it auditory mode? What he basically means is that often what happens in the in childhood, the first language is learnt not so much through teaching or through using books or some such other things, but more in the social domain by listening to other people.

So, that is dependent on the auditory vocal loop. On the other hand, often the second language is learnt through visual mode so, using books and various visual medium. So, that is exactly what he brings to focus.

He said if the visual cortex gets affected because of the stroke or the head injury, then the language that was based on visual input will be lost as opposed to the other kind of thing. So, there are these kind of four main theories that have been put forward to, in order to understand how the how aphasia of any kind may affect L1 versus L2 that is our aphasia data.

(Refer Slide Time: 43:41)



But the problem here is that because the data is so varied, there is so much of difference across studies, across population that very difficult to really come to a conclusion as to what has what really has happened. There are many factors as in when the there is an patient which suffering from aphasia. By the time that person goes to goes for medical intervention, there are a lot of there lot of tasks that the person is put through.

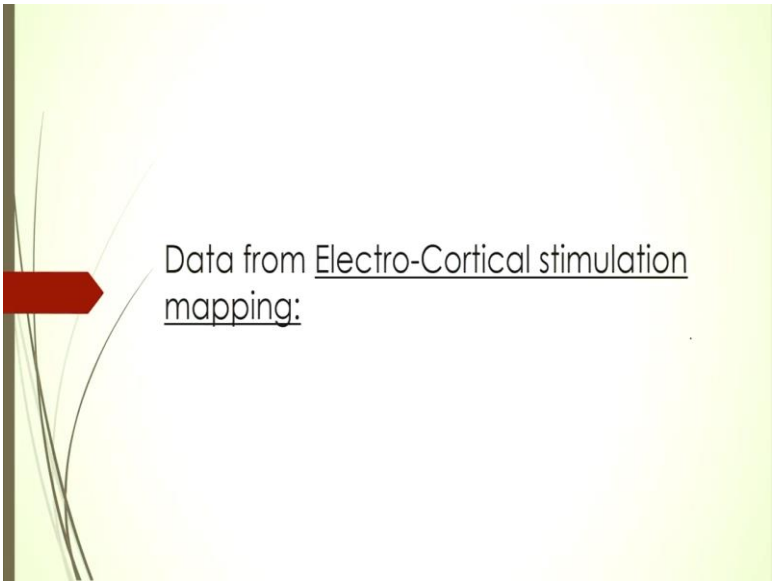
Many kinds of linguistic task also, to see what kind of language function has been affected. Now, one important aspect in this profiling of the patient is knowing about the language competence of the person *before* the problem happened before he became an aphasic patient. So, that also is also very crucial data source. Now, this data of course, is collected either from the patient or from the patient's family members, other close associates and so on.

So, this data is often that they need to be taken with a pinch of salt. Nobody, no family member will say his L2 performance was not very good before. They it is not a, to put it very bluntly, the data is not often very reliable. Another problem that many researchers have been talking about is lack of systematic assessment of the patient's all languages.

So, there needs to be a very thorough analysis of the patient's impairment in all the languages that he knows. And because this kind of standardized test batteries came much later, the earlier studies have been that is why cast in doubt. So, this in fact, this is this came in as late as '87; Paradis is credited with creating the bilingual aphasia test which is

used now for assessment of a bilingual's both languages or a multi-lingual's all the languages. So, the data before this hence has some issues.

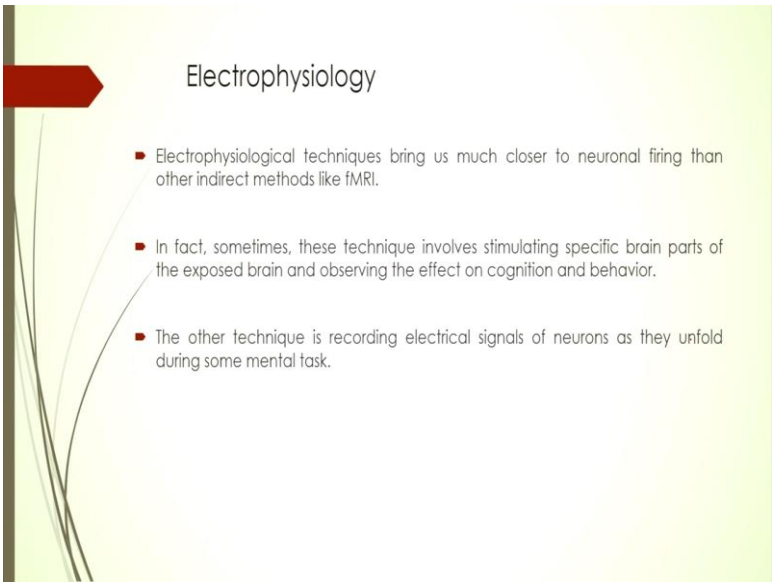
(Refer Slide Time: 45:46)



So, as a result not much of consensus as to how to interpret the data, because of the varied possibilities however, we must keep in mind that both possibilities exist, that bilinguals L2 may be affected just as the L1 does or there might be differences.

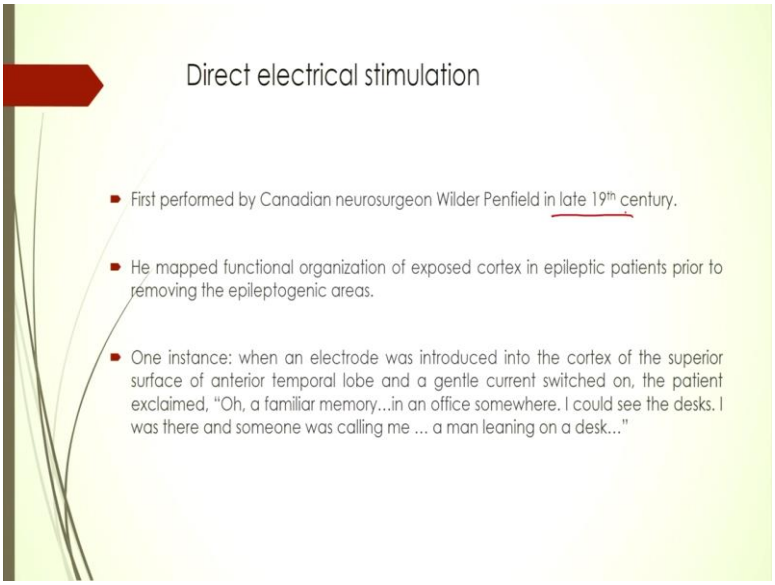
Another set of data that we have in terms of a bilingual and the laterality, the bilingual second language organization in the brain, that data comes from electro-cortical stimulation mapping. Now, this is basically a test that is done before epileptic surgery.

(Refer Slide Time: 46:26)



Before we go there let us just to give you a brief idea about the different kinds of brain mapping methods which are not in which are direct methods. So, there are different kinds of machines that are used for collecting information about the neural activity using different kinds of. So, there could be you know outside the brain there could be so, so intracranial versus extracranial kind of mapping. So, electrophysiology is basically what?

(Refer Slide Time: 46:52)



So, direct electrical stimulation is one such method, that uses direct electrical stimulation of the open head, open head as in the cortex. So, this was first performed by Wilder

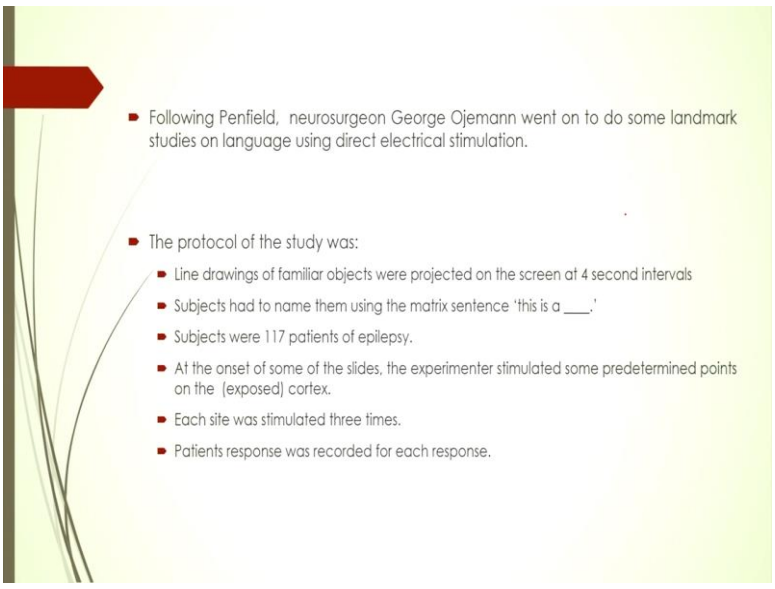
Penfield. He in the late 19th century it really goes back a lot of time. So, what happened is this the history goes back to basically the treatment of epilepsy.

When all when the epileptic person needs to get a surgery done in order to for his as that as a treatment to get rid of the seizures, typical procedure involves a opening up the head opening up the skull in that region the epileptic region of the brain and then a small electrode is connected to the surface of the brain and mild, very mild, minute amount of current is passed through.

In order to check which because epileptic surgery includes removing brain parts surgically. So, certain part of the brain will be removed in order to help the patient. So, in that case while removing those areas it is always taken in taken care of that the regions responsible for other functions should not get affected other functions include language function.

So, that is exactly why this task is done. So, direct electrical stimulation is typically a part of epileptic surgery to check for language areas in the brain. So, this is the history of course, goes back one you can read up just this will give you a brief idea about how the field came to being.

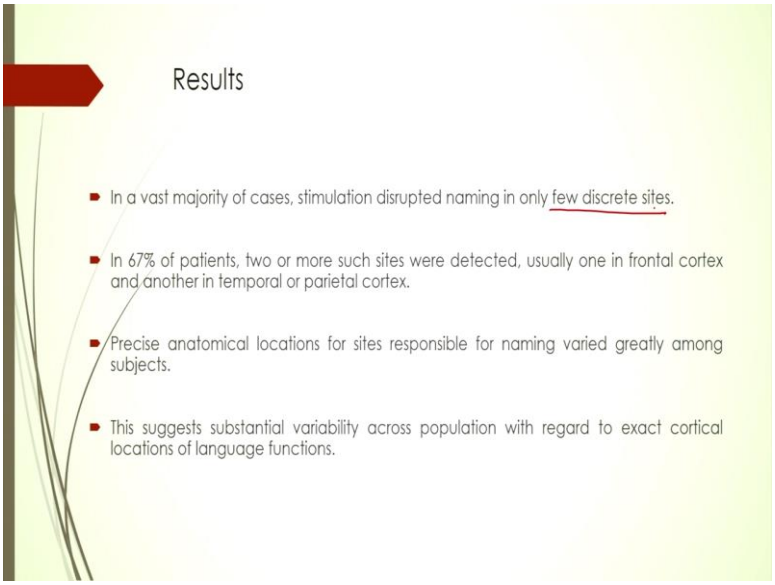
(Refer Slide Time: 48:26)



So, there were lots of studies after Penfield lots of other people also studied and basically the outcome of these studies was in the initial days it was to know the brain areas for

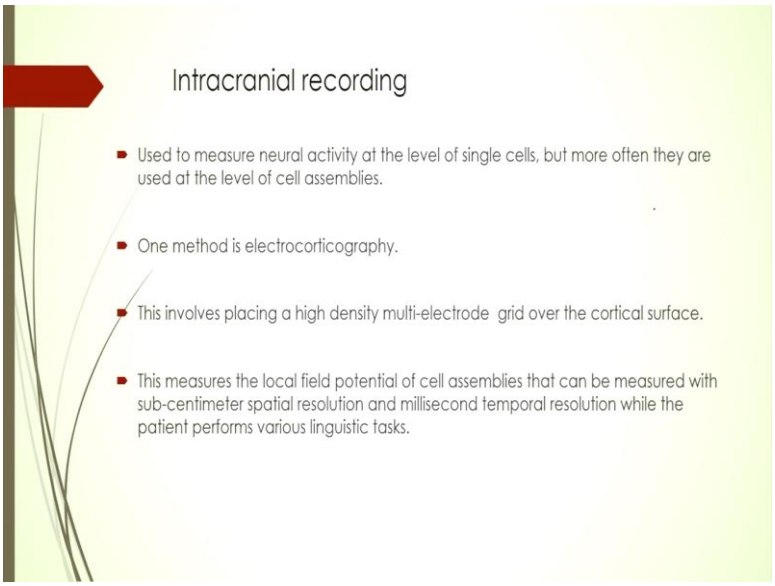
language functions. So, which part of the brain is responsible for processing what language?

(Refer Slide Time: 48:45)



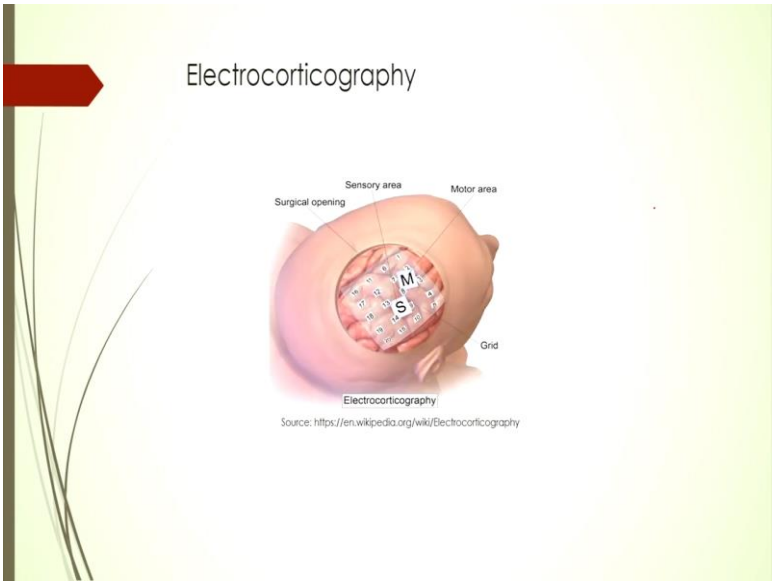
So, often there was no focus on bilinguals or monolinguals or anything; patients do not come in that kind of format. So, typical findings would be there would be more monolinguals than bilinguals, the data is such. So, basically basic findings were that there are few discrete sites in the brain that are responsible for naming and so on.

(Refer Slide Time: 49:08)



And also there were lots of individual differences that was found out during this kind of studies.

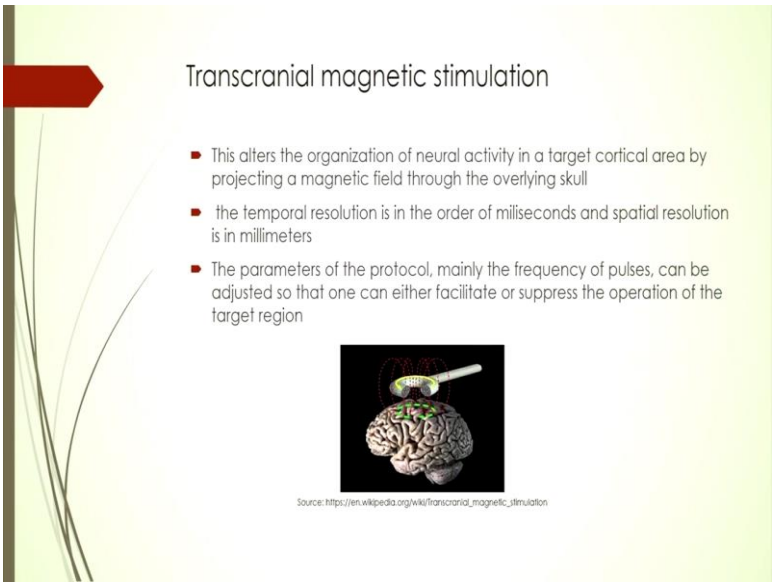
(Refer Slide Time: 49:13)



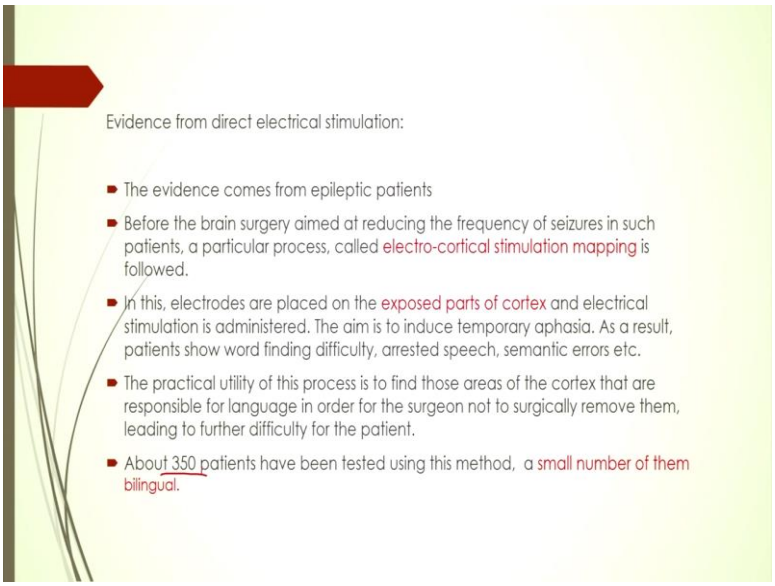
This is how the open brain looks and so on.

(Refer Slide Time: 49:15)

(Refer Slide Time: 49:16)

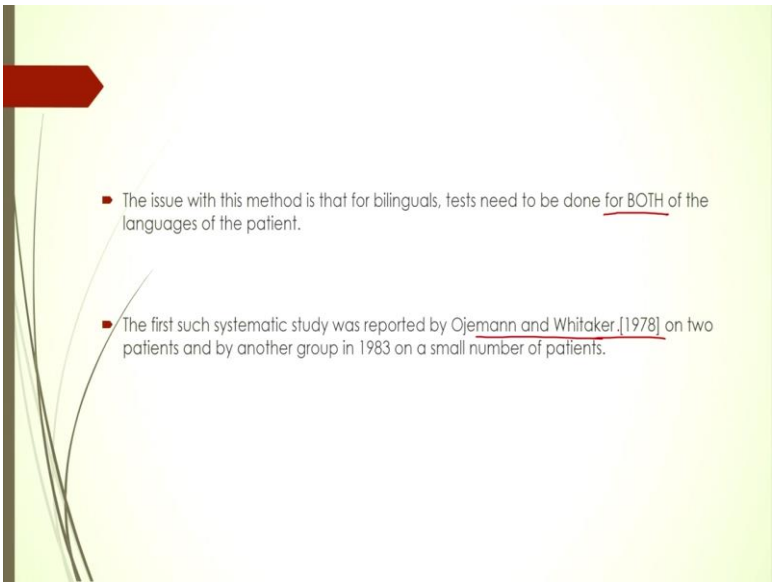


(Refer Slide Time: 49:17)



So, these are various types of brain imaging techniques. Now, what does the evidence from direct electrical stimulation of epileptic patients tell us? That there are lots of different brain regions we came to know about. And there are lot of data in one study they talked they have mentioned 350 patients' data, but the thing is that entire data set only had a very few bilinguals.

(Refer Slide Time: 49:44)



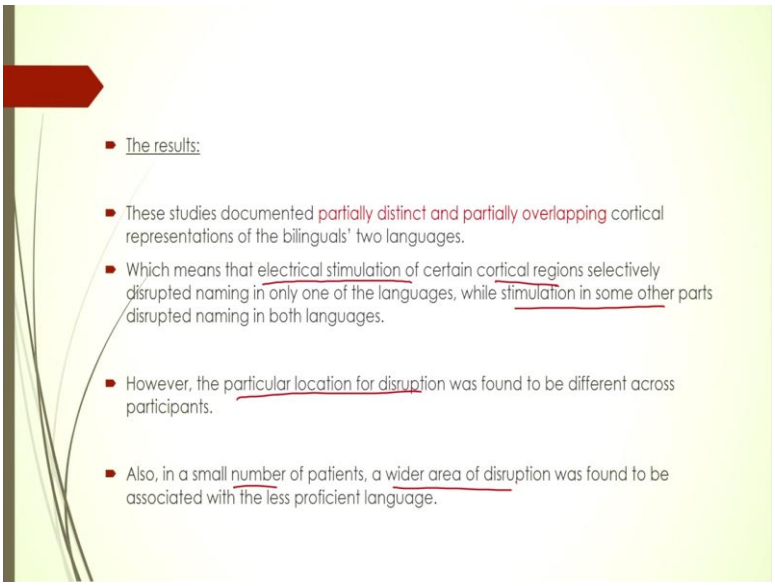
So, in case of bilinguals, however, the data is because it is where data is less. So, the picture is not very clear and the studies are also not conducted very systematically as we have mentioned in the previous task. These epileptic surgeries have been going on for a very long time, going back to late 19th century. However, the test batteries were created only towards the end of 20th century.

So, the large amount of data that are presented, that are mentioned that exist in the literature are they do not have that systematic test batteries used, right. So, a lot of subjectivity could probably creep in. So, and another thing is, the data does not have too many bilingual patients mentioned.

There are also other issues that have been mentioned by various researchers that tests need to be done for both of the languages of the patients which often were not used. But nonetheless, there have been some systematic studies on bilingual patients with in this kind of studies.

So, one of them was the 1978 study by Whitaker and his group on two patients and by another group in on a small number of patients, because there are not too many bilingual patients in this domain that have been reported.

(Refer Slide Time: 50:56)



So, this studies these later studies they reported some partially distinct and some cases partially overlapping areas for the bilingual's two languages. So, the monolingual's data we already know which are the areas in the brain that are responsible for language. However, there are lots of differences across patients.

In case of bilingual the findings the later systematic studies revealed that there are some cases they have found overlapping areas, some cases they have found distinct areas. What does this basically mean? That in some cases the L1 and L2 were found to be placed in distinct areas in the brain, but in some cases, they were overlaps. So, in the same area you could find both L1 and L2.

In terms of the experiments what this basically means is that the electrical stimulation of certain cortical regions selectively disrupted naming. Typically, they will have their naming of words naming, the then digit naming and so on. So, in some cases if the there was an electric current passed so, only naming in only one language got affected, but not in the other language, which means there are distinct areas for naming in both languages, right.

While in other cases while stimulation in some other parts showed that both languages were affected while they were trying to name. However, again particular location per disruption was found to be different for different participants. So, basically across

participants, there is a lot of diverse findings. So, there is lot of variability across patients.

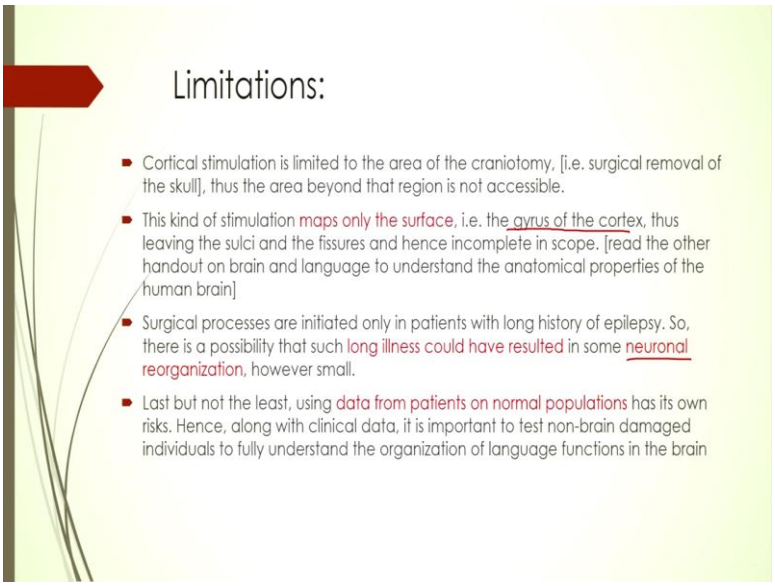
Another, in a small number of patients, they also found a wider area of disruption for the less proficient language meaning the less proficient language was much more widely represented as opposed to the more proficient language. This takes us back to the older finding that L2 is globally present L1 is present only in the left hemisphere. So, this is also similar finding.

(Refer Slide Time: 53:07)

Some recent studies also have these are comparatively recent 2002 and 4 that distinct cortical modules exist for different languages and also electrical stimulation to specific areas they found to be responsible for errors either in L1 or L2. So, there are distinct areas that I have been talking. So, a lot of studies, the gist of the matter is, that a lot of studies have found out distinct cortical regions that are devoted to either L1 or L2.

However, there are also some findings that do talk about overlapping areas, but largely the finding is that L2 is globally represented versus L1 which is left lateralized, right as a result of which possibility exist that L2 and L1 will have different sort of representation.

(Refer Slide Time: 53:55)



But this kind of studies also come with their own limitations. There are quite a few questions that have been raised. One is that this electrical stimulation study is never carried out a normal population. Nobody it is not a fun thing. It is used only with epileptic patients. Now, with epileptic patients also this is a very tiny area of the brain that is exposed where this entire experimentation goes on.

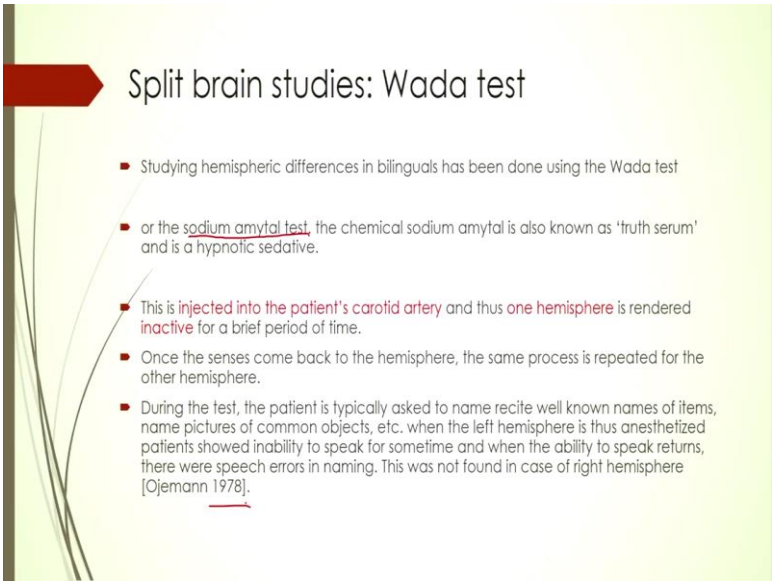
Then how can this be taken as a representative sample for everybody? That is the question that have been asked. So, because this is only the surface, that too a very small area of the surface, that is checked in fact, the gyrus of the cortex that is the top part of the cortex not the lower part that gets studied.

So, the this is very limited in scope, in terms of giving us the full picture, because it is not only the gyrus, but also the sulcus and various sub cortical regions which are also responsible for language function, be it L1 or L2. So, that is one problem with this kind of studies. Similarly, there is this the other factor that has been pointed out is that epileptic surgery takes place only when the per patient has been suffering for years.

So, it is not a first level of treatment. This is the last level of treatment, which means the this person has been unwell for a very long time. So, what if the long period of illness has already reorganized the cortical areas, already reorganized the neuronal organization. How what about the neuronal organization and getting reorganized because of the illness, that is also a possibility.

And then also the because of data come from patients, namely the epileptic patients, that is always some you know 'if' the about using this data on normal population. So, data from patients and extrapolating that data to normal population has always been a tricky affair, whether it is a physics or it is epileptic patients. Nonetheless, they are important source of data for us to take the field ahead; however, this kind of limitations do exist.

(Refer Slide Time: 56:13)



Another domain of studies that have informed bilingual language organization in the brain is what is called the Wada test or this is also called split brain studies. In this study what happens is that the primary idea is to check the functioning of each hemisphere alone. So, you know individually, if you can you look at only the working of the left hemisphere whether right hemisphere is not active, something of that.

So, that to do that of course, there is if the corpus callosum is cut in some way then that will happen, but artificially in the in laboratory setup this has been also done, by using what is called the Wada test. So, what happens in Wada test this is also called sodium amytal test. Sodium amytal is a chemical it is called 'truth serum' for I do not know which reason and this is actually a sedative a hypnotic sedative. Now, this study involves injecting this particular chemical in the carotid artery.

Now, carotid artery' as we as all of us know' carries blood this is the main source of blood flow to the brain. So, we have the two carotid arteries taking blood to the two parts of the two sides of the brain. So, right hemisphere and the left hemisphere. So, if you

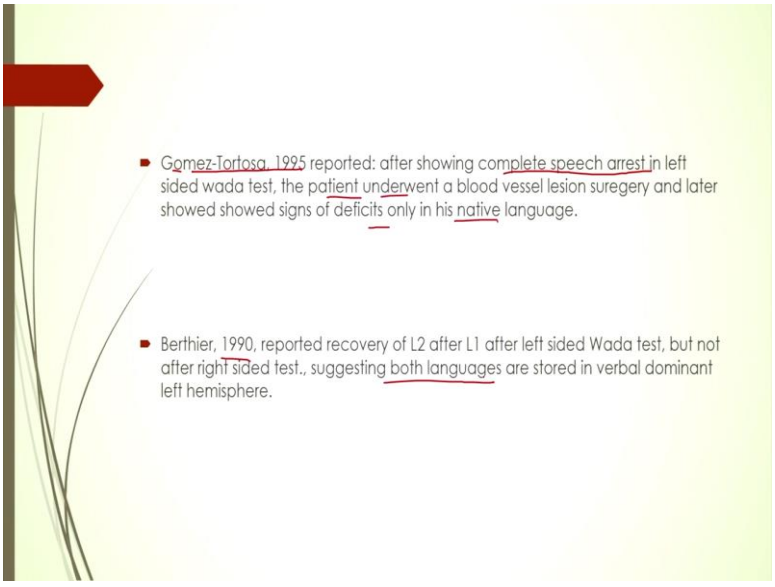
inject sodium amytal in right carotid artery, the right brain sleeps if you do it to the left carotid artery the left brain sleeps.

Now, using this there have been some studies that looked into the organization of L1 versus L2 in the human brain. So, one hemisphere is put to sleep by using this and then certain kinds of linguistic tasks are given to the person. This is not harmful, the person does not really suffer than this last for a very short time. So, that disclaimer is important.

So, while one brain one part of the brain sleeps, the person is put asked to carry out certain task in language in both L1 and L2. So, the once the first they will put the left hemisphere to sleep and some task and then right hemisphere and then some task and so on.

So, typical findings have found out that when the left brain sleeps, the language functions decline. When the left brain is put to you know when the left brain is inactive, the language functions are and then people gradually become unable to speak. But when right hemisphere is put to sleep this thing does not happen.

(Refer Slide Time: 58:40)



So, this kind of findings have been reported from 1970s and 80s. Now, in case of bilinguals, this study this kind of task have been carried out for bilinguals also and they show that in a particular study in by Gomez in 1995 they show complete speech arrest in

left sided Wada test. So, when the left hemisphere is put to sleep, when the left hemisphere is inactive, people and the participants stopped talking all together.

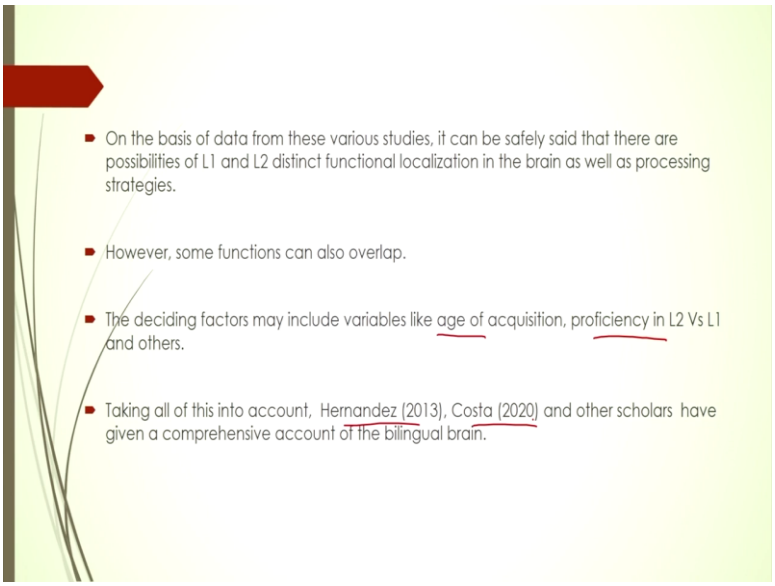
There was no complete speech arrest this is called complete speech arrest, the person stop speaking altogether. Later this person this particular patient had undergone blood vessel lesion surgery and later on showed signs of deficit only in his native language. After the surgery when there was some amount of probably some removal of brain areas and the brain parts in this in the study in this surgery and then they he showed deficits only in his native language, which is L1.

Another study in 1990 reported recovery of L2 after L1 after left sided Wada test, but not after right sided test. So, basically there are different kinds of findings, but in this through studies they have showed that left hemisphere is responsible for. So, the dominant hemisphere is responsible for both L1 and L2.

There are some other studies who have found that L2 is more globally present using Wada test as well. However, there are differences as we said already, we have seen that there are these differences across population. Now, basically often this in this kind of studies they have initial cases they have used patients and patients you cannot choose to have them as bilingual or high proficient bilingual versus low proficient bilingual.

So, those parameters cannot be checked, but the data that exists there is some amount of variability. So, in terms of which brain region dominant finding is left hemispheric lateralization for both languages.

(Refer Slide Time: 60:46)



So, on the basis of data from all of these studies different studies, we can safely say that there are possibilities that have been indicated by whether it is behavioral laterality task, Wada task or different kinds of various other kinds of task, that there exists a possibility that L1 and L2 are differently represented in the brain and there could also be some overlapping regions.

So, to take care of these, there are many parameters what might be the reason for differences when they exist and what are the areas where we find a overlapping. So, this needs further study, further study with respect to normal, typical population not patient data.

So, this is this kind of historical background tells us that these are the things that need to be taken into account and the deciding factors are also seem to be the age of acquisition, proficiency in L1 versus L2 and many other control measures like proficiency in terms of executive functions and attention allocation, cognitive load and so on.

So, there are many factors that are now being looked at and taking care of all of these accounts, there are the Hernandez 2013 and Costa 2020 have taken into or taken all of these into account, and have given a very comprehensive analysis and account of the bilingual brain and that is what we will discuss in the next segment.

But as of now the older data suggests that there are a possibility, there are possibilities of variability across language L1 and L2, in terms of the bilingual brain in terms of various task conditions. Now, we will look at the a picture as it stands today in the next segment.

Thank you.