Bilingualism: A Cognitive and Psycholinguistic Perspective
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Module - 04
Part - 02
Lecture - 10
Data from processing studies on bilingual representation in brain

Hello and welcome back. We are in module 4. Today, we will start with part 2, 2nd part of module 4.

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So, so far, we have looked at data from aphasia and epileptic patients and the data so far has told us that the there is a possibility that the L1, first language and the second language of a person might be represented differently in the human brain. So, various or kinds of data have been discussed. So, this is all in the background, that is what we discussed till the last part.

So, today we will move forward and look at where the current state of the affair is and what we know today. So, starting from the background of aphasia and epileptic patient's data, now we move on to experimental, processing data from the processing studies in recent times and what this points towards. So, this entire part will be discussed in terms of data that have taken three important variables into consideration. These three variables are age of acquisition, proficiency and the control mechanisms.

Now, these three are important aspects, we have already seen that age of acquisition plays an important role in terms of how the second language proficiency builds up. So, they are connected, proficiency and age are connected and also how age of acquisition also change turns into whether it is a simultaneous bilingual or somebody becomes a successive bilingual and what are the repercussions.

So, as a result of which, the data existing data already points towards the fact that these probably are important variables to take into account while we look at the representation of language in the human brain, different languages in the human brain of a bilingual.

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So, let us start with the first and most important one, age of acquisition.

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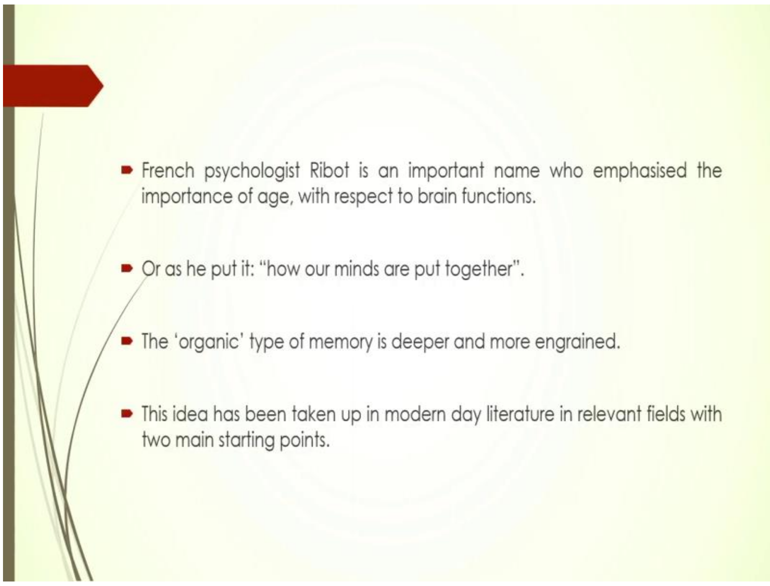

Now, if you remember we have already looked at aphasia data and how rule of Ribot says that the language that is learnt first which is the language learnt in infancy that is the first language will be less affected as opposed to the second language, which is learnt later in life, because the Ribot's rule says that the any memory that is earlier that is connected to infancy will be more resistant to any kind of damages.

So, as a result we will discuss Ribot again here because of the way his theories have had a very great impact on all these connected areas. So, the French psychologist Ribot and he how he basically put the aspect of age into consideration, so he basically said how our minds are put together is a factor of age. It is not it because the brain develops over a period of time and through different stages and hence it needs to be taken into account.

So, the first part of the life's journey is when the brain development happens very quickly. There are dramatic changes that happen at that time and the memories of connected collected during that time are what is he calls 'organic memory'. So, this idea has been taken up in modern day literature to look at if the relevant literature has and does point to the same aspect as he said.

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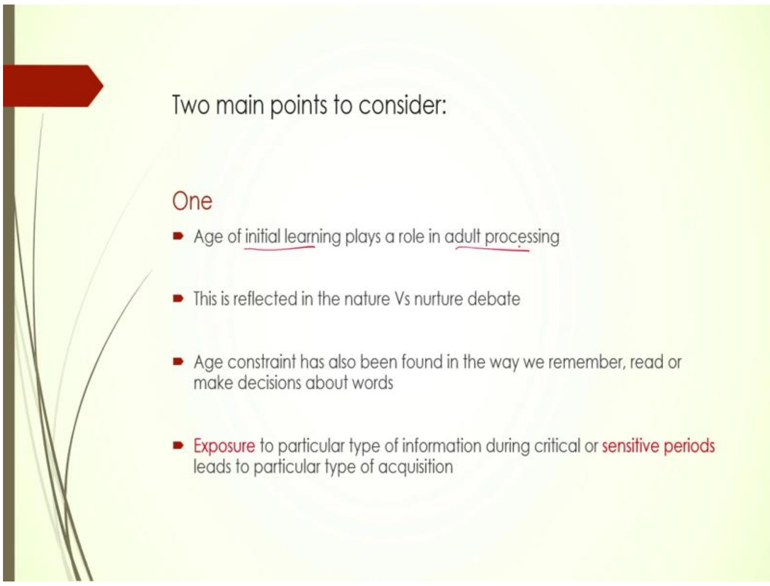

So, there are basically two things to keep in mind when we take Ribot's rule to understand language lateralization in the bilingual brain. One is that age of initial learning plays a very important role in adult processing. So, how and what we acquire in our childhood plays a very important role in our adulthood.

This is almost common sense. We know that the kind of exposure that one might have or not have in early childhood will shape the person as they are. That is why do we say that depending on the kind of exposure the child has had, it will help him or her tackle things better in life later on.

So, this is basically where it all boils down to. So, the kind of training, the kind of exposure the person has had in the initial stages of life, will make him will reflect in the processing of any kind of information, language included, later in life. That is the first part of the story.

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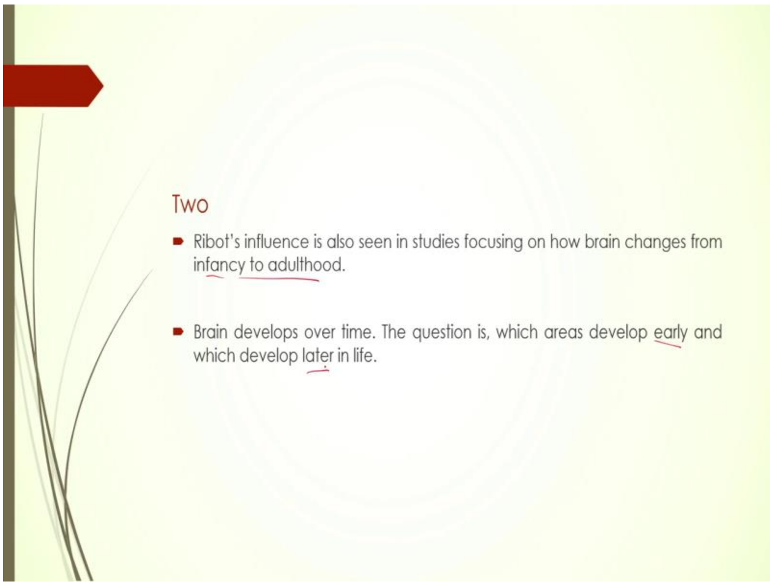

Second part is that, which is also connected to the first part, is dependent on how the brain development happens – what are the changes, what are the stages of those changes that we notice from infancy to adulthood in the human brain. One interesting thing about human brain is that it continues to develop after birth for a quite for quite a some for some time.

So, as a result it is very important to understand brain development as concurrent with the other kinds of development, as one ages as one grows older through various kinds of socio-cultural and other kinds of experiences, the brain is simultaneously growing. So, language is also one of the aspects in the environment. So, from that perspective also, it is crucial. So, the question basically is in terms of brain's growth that, which areas develop early and which areas develop later in life.

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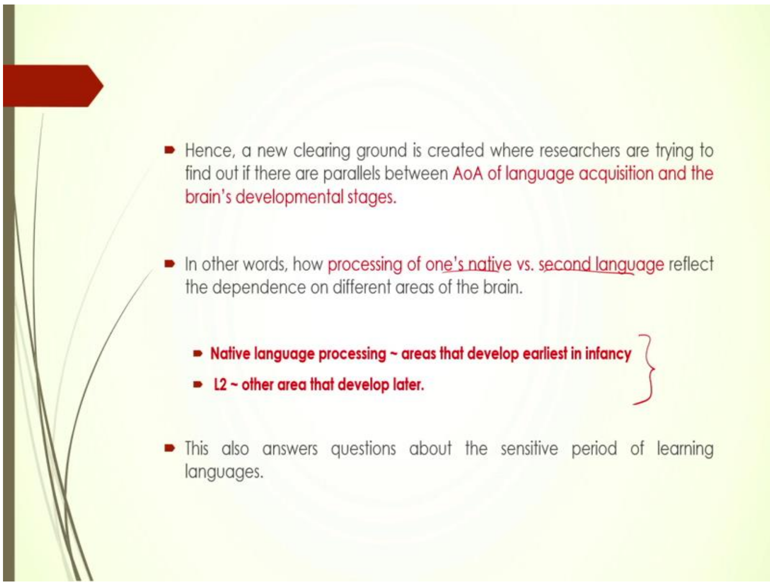

Now, this is already well known in neuroscience that there are certain domains in the brain that develop early certain domains that develop much later. Now, if we bring that understanding to language and language processing among bilinguals basically there are two things that emerge – how are different brain areas dependent on different are connected to let us say to different language processing. So, is there a difference in terms of the brain areas and language activation as a in terms of L1 and L2.

So, processing of one's native language and second language and their dependence on different areas is what the crux of the matter here is so, in terms of that so, this is how we can put it in a more simplistic way. So, native language do we see a parallel in terms of native language processing, with respect to those areas in the brain that develop earliest in our life; similarly, if is L2 dependent on those areas that are developed later in life. So, that is basically the main the question that we are trying to understand.

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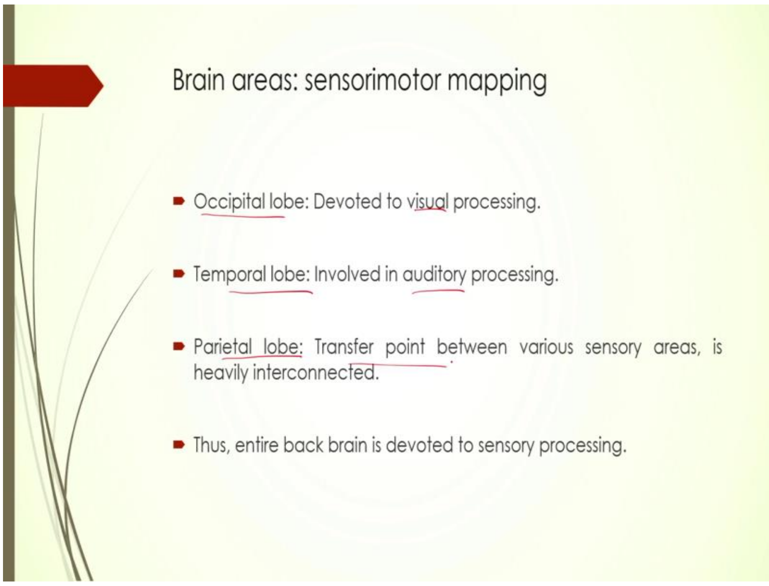

Before we get into the experimental data, we will look slightly into the different brain areas and their sensory motor mapping. There these are the main areas these are the main lobes that we that are important in terms of sensory motor a mapping of the human brain. So, occipital lobe is primarily devoted to visual processing; temporal lobe is for auditory processing and this is the this is the transfer point ok. So, this basically the entire back brain is devoted to the sensory processing.

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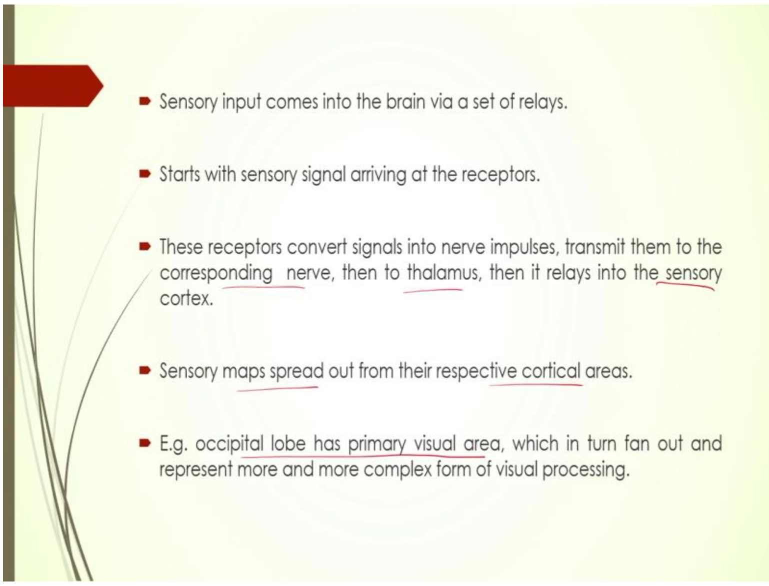

Now, sensory input is very easy to say that the particular area in the brain is devoted to sensory processing, but this is not the simplistic thing. How it happens basically is that there are signals that are received at the lowest end and then they transmit through various corresponding nerves, then to thalamus and finally, into the sensory cortex.

So, starting from the hands, let us say, when we touch something, when we touch a rough surface versus a smooth surface that understanding, that difference in tactile sensation goes to our brain via this kind of a network.

So, as a result of which there are devoted areas in the brain, there are sensory maps in the brain that come from the respective cortical area depending on the kind of sensory input that we get. So, occipital lobe has primary visual area and that pans out and then includes more and more complex forms of visual processing.

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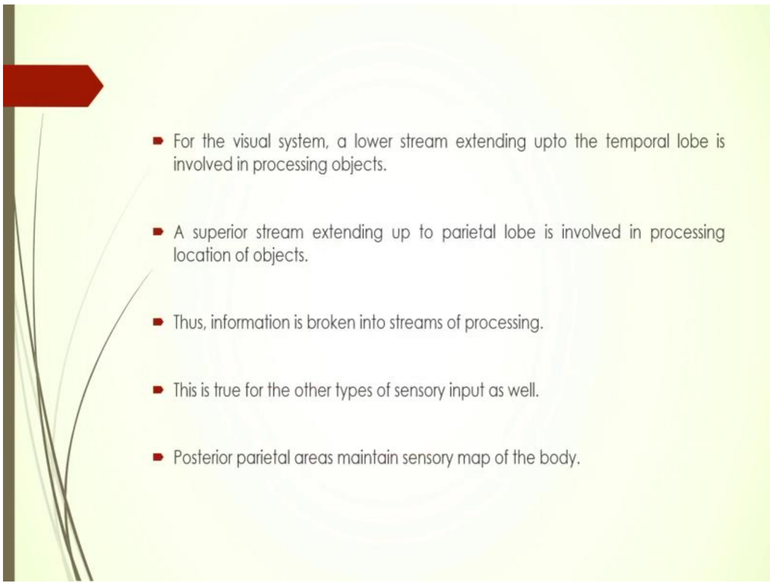

Similarly, there is the same thing also happens in the other systems, other kinds of information. So, this is basically it. So, there are the way this pans out and the way it is broken down into smaller units and so on.

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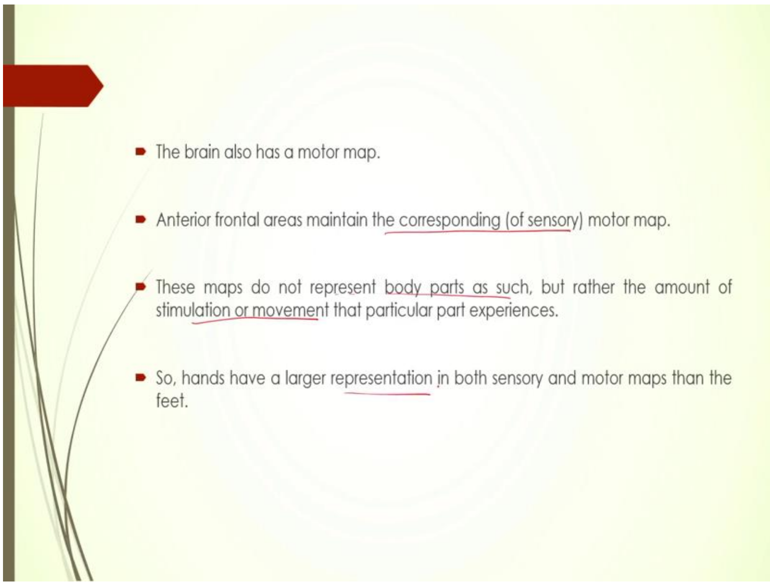

Similarly, the brain also has a motor map. The motor map is basically the way motor actions are carried out by the human body. So, hands for example, are used for writing, for eating, for lifting things and so on and so forth. So, various kinds of motor activities are carried out by the hands.

So, there is a mental map, there is a cortical map of these kinds of motor activities as well. So, this is actually in fact, we often talk about the motor map as a corresponding map of the sensory map. So, sensory and motor map in the human brain. Now, one crucial thing about this map is that it is not really representing body parts as such, right.

So, there is no hand part in the brain or a leg part in the brain, but rather it is more of a the amount of stimulation or movement. So, the amount of sensation we receive through our hands is much less as opposed to let us say the amount of sensation we receive from our feet. So, we can use our hands for a large number of activities as opposed to the feet.

So, this as a result there is a division, there is a difference between the various parts of the body in terms of the load, the amount of stimulation and the amount of motor movement that they represent. So, the similar representation is there in the brain. So, when we say a sensory motor map, this is what we mean, right. So, as a result, hands have a larger representation in terms of both sensory and motor map, ok.

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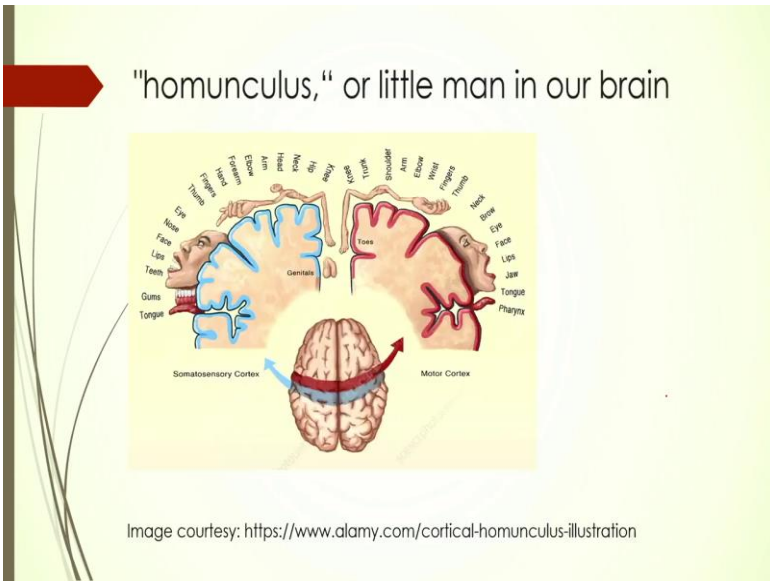

So, this is basically how it looks. This is called homunculus or the little man in our brain. So, these are the different areas and you see the in sensory cortex, sensory, somatosensory cortex, the sensory map basically has a large area for the for face. So, eyes and nose and mouth and tongue and so on, because we taste through taste we understand about the world to a large extent and so on.

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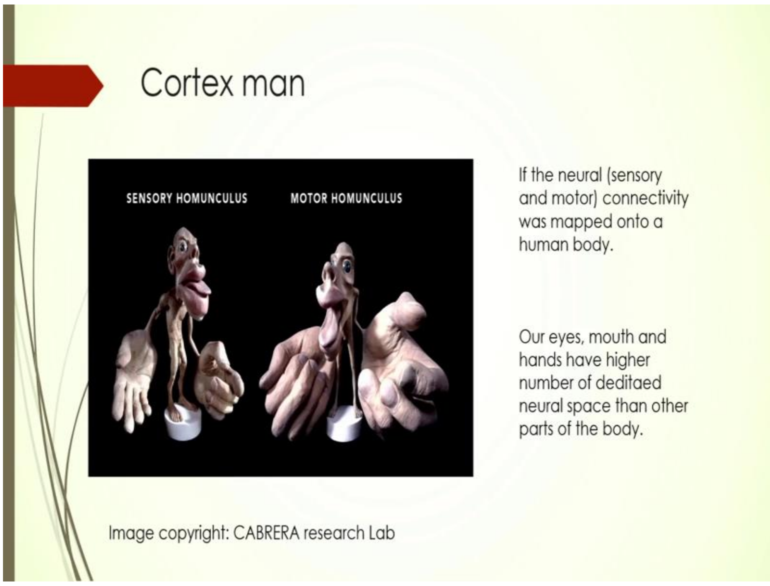

So, this is funnily it is called the cortex man. If it was a human, if the sensory map was a human, if the motor map was a human, this is how it will look.

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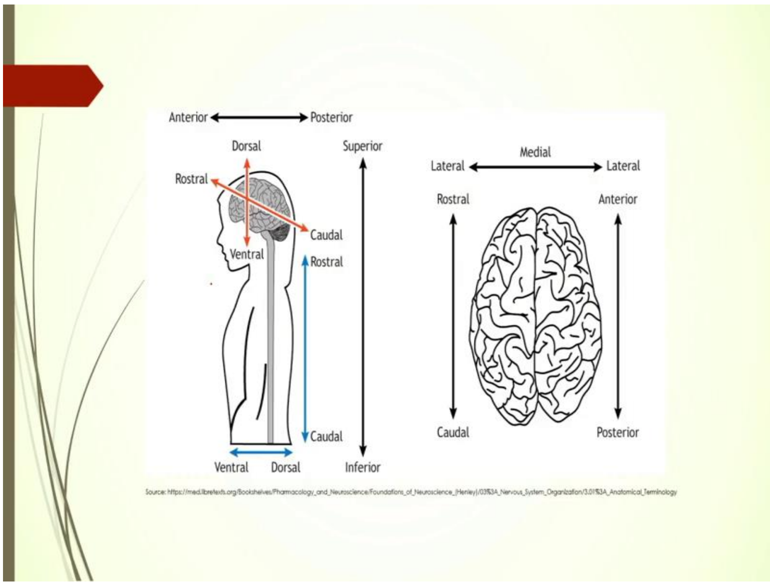

So, this is just to give you an idea about what we mean by the sensory motor map in the brain because this is what we will be used using for understanding the later things.

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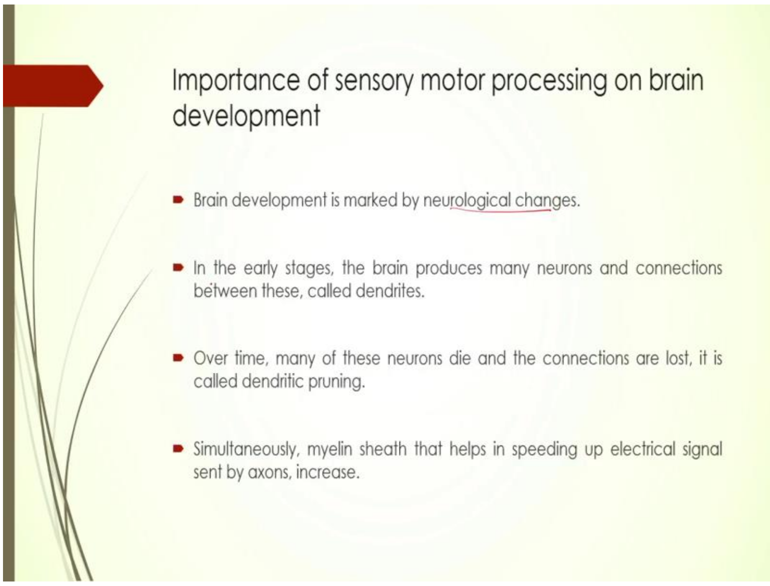

Now, as we had started talking about that the brain development is marked by neurological changes, from the starting from the very early stages, the brain basically goes through a lot of changes, lot of changes in terms of a creating new neurons, producing new neurons and some neurons will die and new connections will be made, some connections will die out and so on and so forth. But yes things happen for a long time in the child's brain in the initial stages.

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So, basically there are it is a complex process and involving very many layers of development but, to put it simply, this is the these are the stages of brain development in the children. So, they start the development happens from right to left and then primary to secondary to tertiary level and then from basal to cortical. Basal as in the middle of the brain, cortical is the top part.

So, the outer part of the brain, that is what we are mostly focusing our studies on so, cortical areas, areas in the cortex. Now, these are this is this was proposed by Best in 1988, but current techniques also confirm this kind of a this kind of a trajectory.

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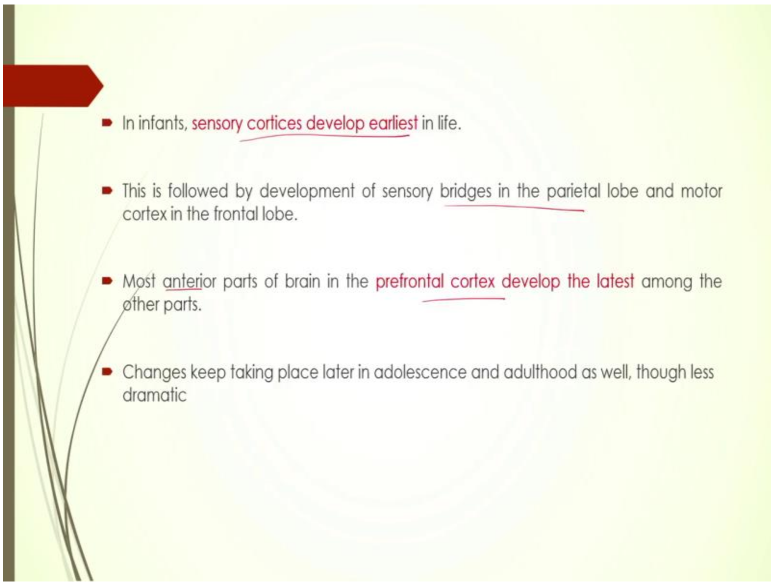

Now, for infants, sensory cortices develop the earliest as we were talking about just a little while ago. So, sensory cortex develops the first, because when the child when a small child is trying to interact with the world, negotiate with the world, you know crawling around and touching everything and to see, so, this is when this is the sensory motor stage of the child's development. And hence sensory motor a map in the brain also develops in the very beginning, the initial part of life.

And, then this is followed by the development of what is called sensory bridges in the parietal lobe, ok. And then the most anterior part of the brain, in the prefrontal cortex develops the latest. So, this is the trajectory, the starting with the back brain the sensory motor cortex to parietal to prefrontal cortex. For all these names what for example, what anterior means and so on, there is a simple map here you can refer to, alright.

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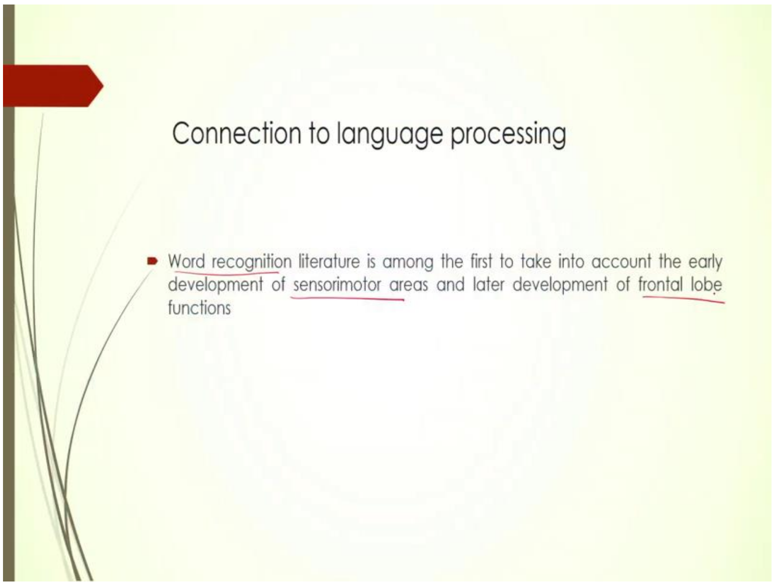

So, this is what we already know. Now, how is the connection to language a meaningful in this kind of a scenario? Now, one of the first studies to look at this, to map the sensory motor development and other developments in the brain with language function and to see if there is there are differences across, you know languages, first language versus second language if that kind of correspondence really exists.

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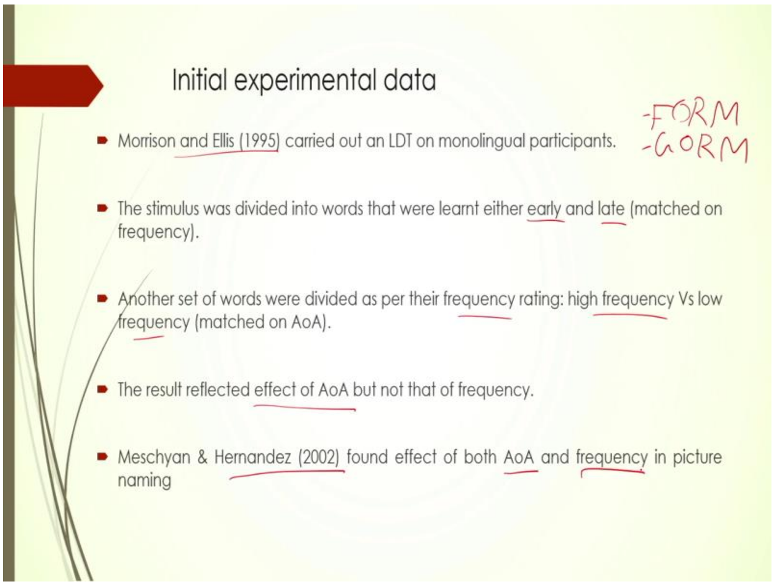

One of the first studies were what is called word recognition literature it goes back to '95, one of the very well known studies from that time. They had carried out an LDT;

LDT we have already talked about this is Lexical Decision Task. Lexical decision task is a task simplest simple task where the participants have to check between, among different letter strings to check whether they are a word or not.

So, for example, if this is a word in English and as far as I know this is not a word in English. Now, this is called a non word this is called a word the task would be to figure out which is a word; a very simple task of comprehension. So, this was done on monolingual participants, but the manipulation here was the words that were supplied, that were used as stimulus were divided on two terms.

One, they were divided in terms of when they were acquired certain words are acquired early in life; certain words are acquired much later in life, right. The and then this is so, hence this was one of the differences. Another difference was how high frequency or low frequency what they were. So, they were the different differ on their frequency rating: high frequency versus low frequency as well as whether they were learnt early or they were learnt late.

So, on these both parameters they were checked and they found that the results found that the effect of age of acquisition, age of acquisition is written like this AoA, but they did not find any effect of frequency. So, basically if the age of acquisition was the manipulation here with meaning that if it is the word that are learnt early versus word that are learnt different later, that will be a difference. However, they did not find any difference in terms of frequency.

Another study, a little later, found out that both AoA and frequency had an effect on picture in picture naming task, but earlier study in LDT did not find an effect. So, what do we mean by effect here? The idea was to check if the sensory motor areas or the prefrontal cortex are utilized, as we have seen here.

So, because we know already sensory motor areas are developed earlier compared to the frontal lobe function. So, frontal lobe functions are developed much later. So, what they wanted to see on all of these studies, was if the early learnt words are activating the are activating the sensory motor domain or and later so, what is the mapping between these, right.

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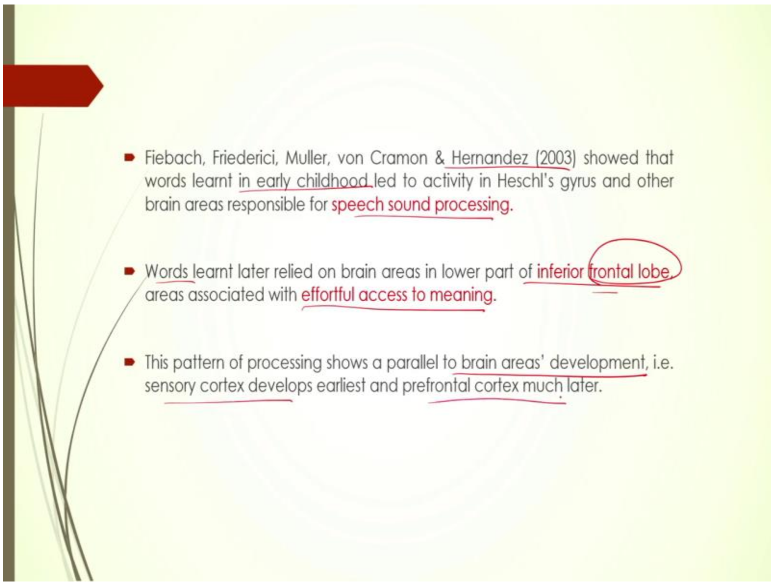

So, again another study by Hernandez and his and his group showed that words learnt early, in early childhood, led to activity in the speech sound processing area, basically the sensory motor area. Similarly, words learnt later that is the age of acquisition effect later they relied more on the brain areas where which is inferior frontal lobe.

So, this is crucial so, frontal lobe versus the occipital or the back brain; so, sensory motor area versus the frontal lobe. So, this is frontal lobe basically activation in this area means effortful access to processing. So, words learnt later were processed here, words learnt early were processed in an area which is based on which is dependent on speech sound processing.

So, again this kind of pattern of processing shows a parallel to brain areas development that is sensory cortex develops earliest and prefrontal cortex develops much later. So, there is a correspondence between words that are learnt early versus words that are learnt later and their processing areas.

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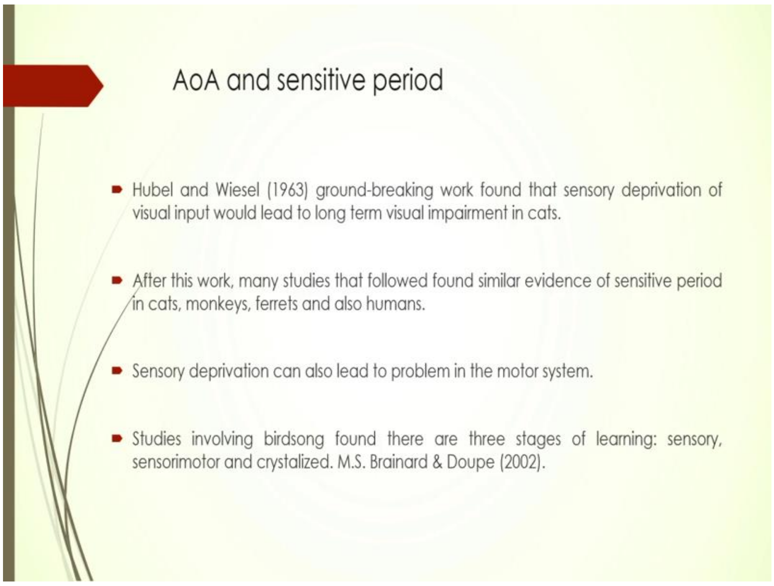

So, we have already talked about sensitive period and critical period before. So, there I have mentioned a little bit here again, one can go through, but we will not discuss it again.

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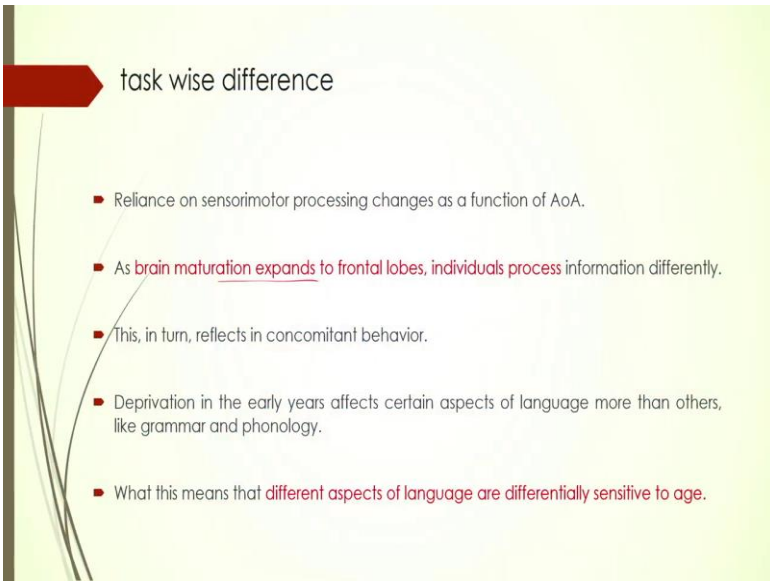

So, there are again another other kinds of tasks. So, we saw, as of now we have seen, that age of acquisition of words: early learnt words versus late learnt words are processed in two different parts of the brain, that corresponding areas that develop early versus late. Similarly, different kinds of tasks have also found difference.

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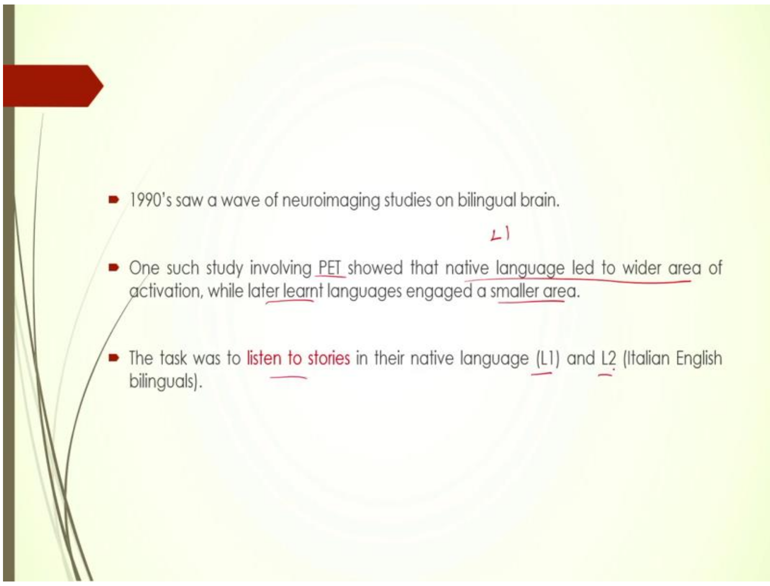

So, brain maturation expands to frontal lobe, as the brain maturation process the strategy is that we use to process also changes. So, different aspects of language, as a result, are also processed differently in terms of age. So, 1990s onward we have a lot of studies that that reported on this line, typically involving PET or fMRI on various kinds of neuroimaging techniques, that have looked at bilingual brain.

So, once a study found that native language led a led to wider area of activation whereas, the later learnt language engaged a smaller area. So, you see there are differences that in terms of language development. So, whether it is a native language, meaning L1 or whether it is L 2. So, L1 is utilized in a much wider area in terms of this and L2 was devoted to a smaller area, right. Another task the task over here was given that they have to listen to stories in the L1 as well as in the L2.

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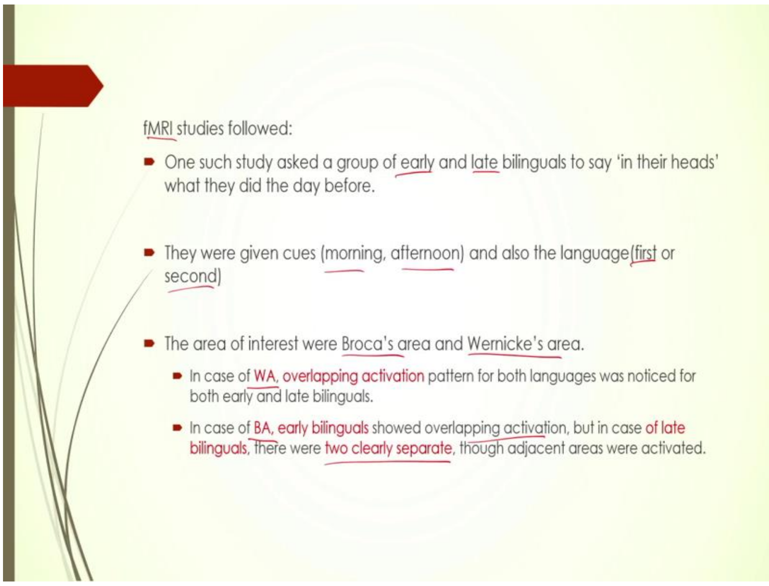

Now, how they what they found out was that different kind of activation in different kinds of areas. Another study that was which is an fMRI study, the previous one was PET. This is an fMRI study, that looked at finer differences as in the differences in within bilinguals themselves, but early bilingual versus late bilingual.

The previous study looked at L1 versus L2, here we are looking at early versus late bilinguals and the task was to say in their head what they did before basically to internally talk to yourself. And, the cues were either morning or in the afternoon as in when.

So, what did you do in the morning yesterday, what did you do in the afternoon yesterday, like this there were cues and also, they had to do this activity either in their second language or in their first language.

What they found was very interesting. In case of Wernicke’s area primary language areas are Broca's area and Wernicke’s area that you already know. So, in case of Wernicke’s area, they found overlapping pattern. So, for both L1 and L2 they had found similar kind of pattern in Wernicke’s area. However, in case of Broca's area early bilinguals were an overlapping activation, but in case of late bilinguals there were two clearly separate areas.

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So, there was a slight difference in terms of when the second language was acquired. If it was an early acquired language one kind of pattern, late acquired language, a different kind of pattern only in terms of production that is in terms of Broca's area. In terms of comprehension not much of difference was found.

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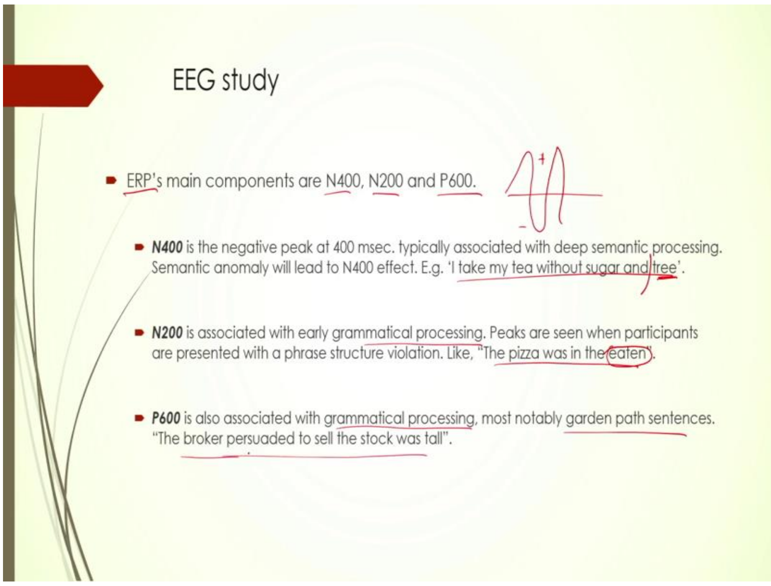

Similarly, there were also EEG studies, electro encephalography studies and in case of EEG, what we study what is the output is ERP. So, ERP is event related potential. There are many signals of ERP that are studied in terms of language, but the primary ones are N400, N200 and P600. N400 is a negative going peak at 400 milliseconds.

So, ERP signals are basically they are like sign waves. So, like this it goes ok. And so, this is a negative going peak and this is a positive going peak. So, when there is a negative going peak at 400 millisecond, it is the N400 signal. Similarly, N200 is there and there is P600, P for positive N for negative.

Now, N400 is a is an indicator of semantic anomaly. So, when you have trouble processing a sentence in terms of it is meaning we will see an N400 effect. So, 'I take my tea without sugar and tree', till here things were fine as soon as the word tree comes in there is a problem in processing that information because there is a semantic anomaly; tree typically do not have does not happen anything to do with tea, right. So, that is when we find N400.

N200 is, on the other hand, connected with grammatical processing. So, when you have this sentence has a structural anomaly. 'The pizza was in the eaten'. This is the problem word. So, when this kind of a sentence is processed, we typically find N200 effect and P600 is associated again with grammatical processing, but typically with garden path sentences.

Linguistic students will know what garden path sentences are. This is a typical example the ‘broker persuaded to sell the stock was tall’, right. So, this kind of sentence so, these are the three kinds of ERP signals that we typically study in terms of language processing.

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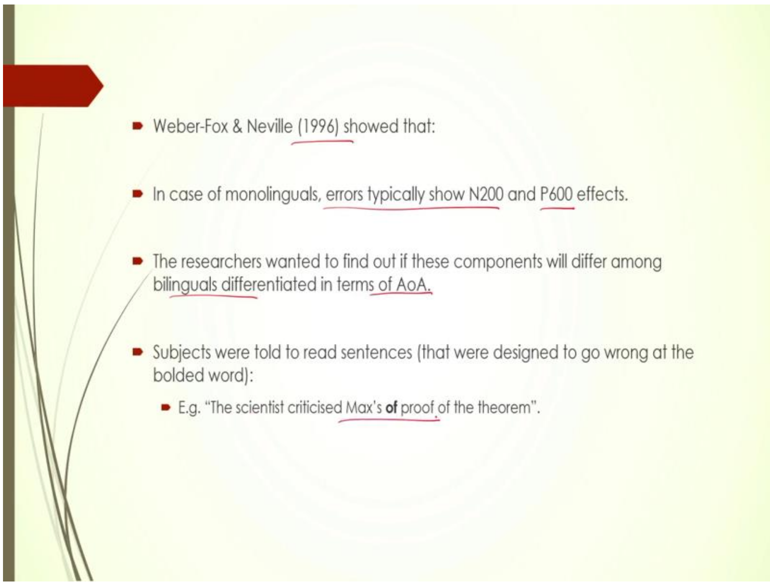

So, 1996 study by Neville and Fox found out that in case of monolinguals, errors will typically show N200 and P600 effect because both of these are connected to syntactic problems, syntactic anomalies, when grammatical structure is wrong, right.

So, now they wanted to find out if these components will differ among bilinguals differentiated in terms of age of acquisition. So, if early bilingual versus late bilingual difference is what they were looking at. The targets and the sentences were like this ‘the scientist criticised Max’s of proof of the theorem’. So, this is the a grammatically wrong sentence.

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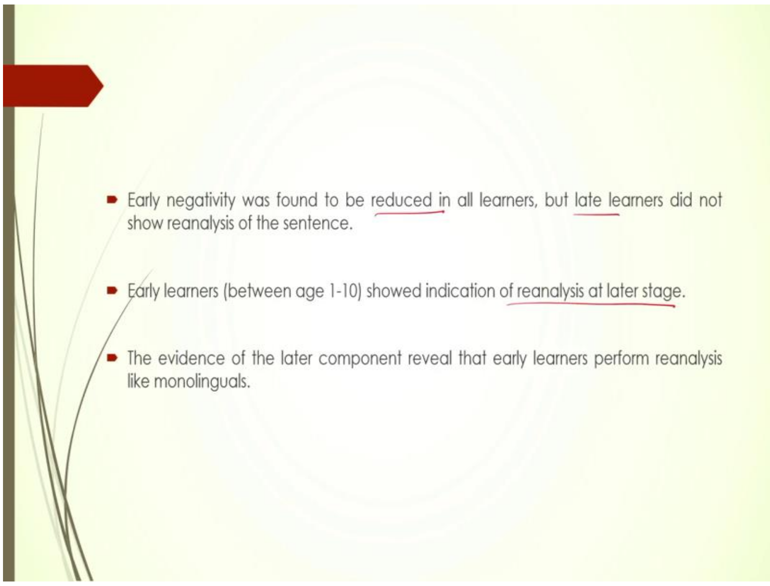

Now, the early negativity that is N200 was found to be reduced in all learners, but late learners did not show reanalysis. Reanalysis is typically P600. So, late learners did not show a P600 effect. Early learners showed indication of reanalysis at later stage, which is. So, early learners show neither of the groups showed N200 effect, but late learners did not also show P600 effect, that is the difference. So, there was a difference in terms of age of acquisition even within bilingual group itself.

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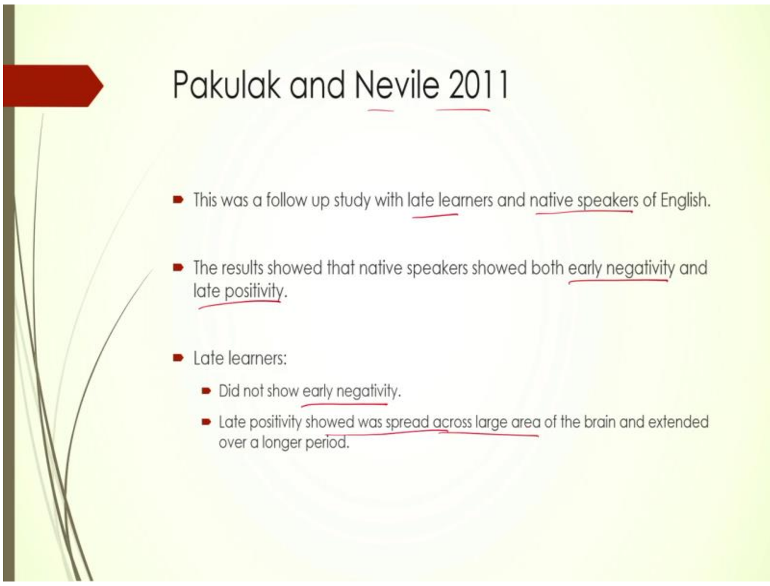

Yet another study, rather well known study, they did with late learners and native speakers of English language. So, results here showed that native speakers showed both early negativity and late positivity which is expected, that late learners will in the previous study this was not found.

Late learners on the other hand did not show early negativity, that is N200, was missing. Late positivity showed was spread across large area of the brain and extended over a longer period. So, again we see difference between native speaker versus late bilinguals. Earlier we have already seen early and late bilingual difference. Now, we see this.

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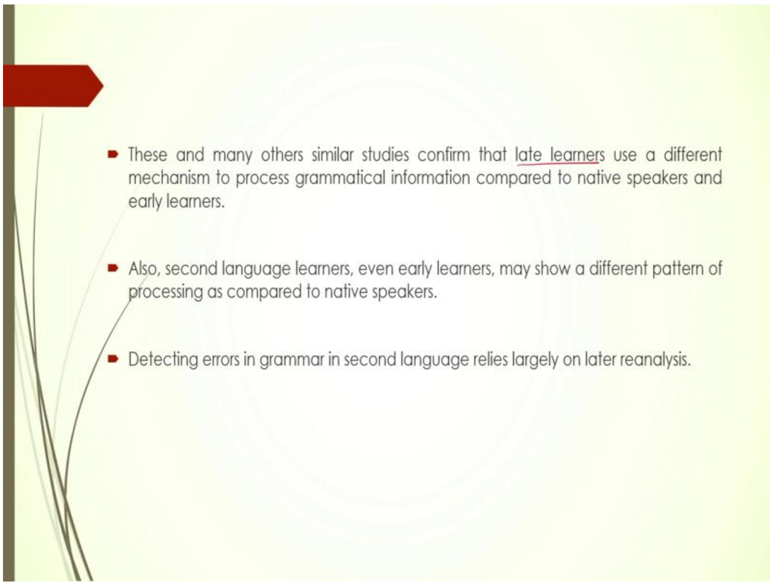

Then there are many other similar studies that basically proves that late learners use a very different mechanism to process grammatical information as opposed to native speakers and early learners. In fact, the there is a lot of similarity between early bilingual and the native speakers. Late bilinguals are always they always are found to use different kinds of techniques.

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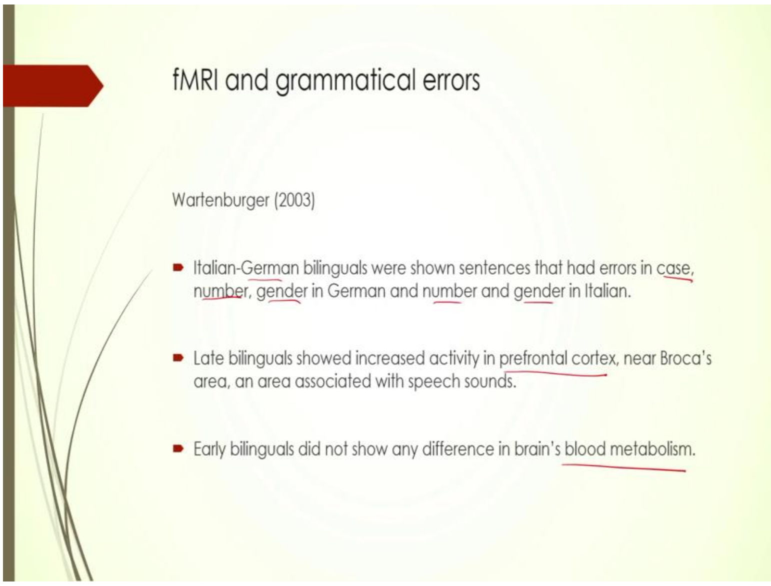

Similarly, another fMRI studies on grammatical errors also have found a very interesting results. So, in this study used German and Italian bilingual. Now, German and Italian bilinguals were shown sentences that had error in case, number and gender in German and number and gender in Italian.

So, we have case marking, number marking, gender marking in language. So, Italian-German a bilinguals were the volunteers for this study and this is what this saw was sentences that had errors in all of these counts. The finding show that late bilinguals show increased activity in the prefrontal cortex, near Broca's area which we already know.

Early bilinguals did not show any difference in the brain blood flow mechanism, blood metabolism. fMRI studies are basically based on blood flow to, the amount of blood flow to certain parts of the brain. So, early bilinguals did not show much difference, but late bilinguals showed increased activity in the prefrontal cortex.

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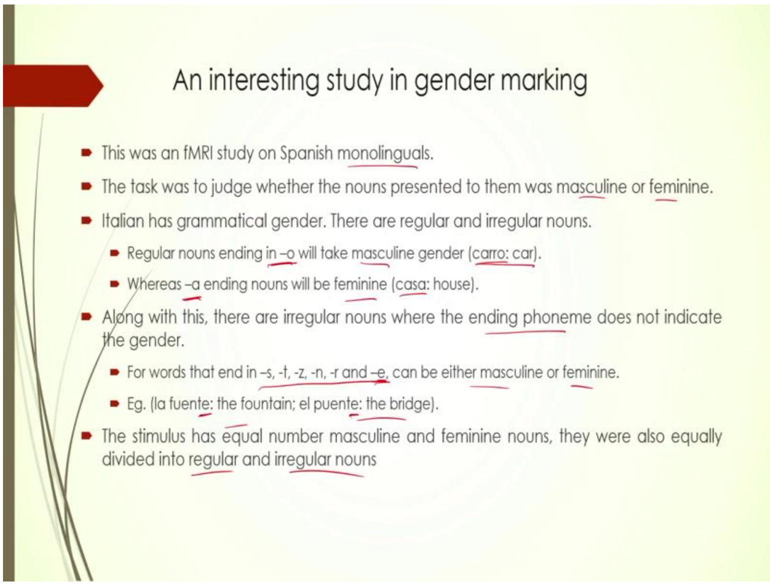

There was one interesting study on fMRI study on Spanish monolinguals. Now, they had to judge whether the nouns there are that were presented to them was masculine or feminine. Spanish has grammatical gender. So, inanimate nouns can take either masculine or feminine gender, based on certain rules. But the funny part is Italian has two kinds of nouns. One is called the regular noun; another is the irregular nouns.

So, regular nouns, which means that there is a particular pattern. So, regular nouns ending in -o will always take masculine gender and whereas, nouns ending in -a will always be as feminine gender. So, this is how it goes. So, ‘casa’ is a feminine noun and ‘carro’ is a masculine noun in this language. But they also have a large number of words that are irregular. So, ending phoneme does not really tell us what kind of gender it will take.

So, this the word that end with this the this various sounds can be either masculine or feminine, right. So, the see for example, if we have if we take –e, so, this also ends in e, this also ends in e, but one of them is this is feminine, this is masculine. ‘la fuente’ versus ‘el puente’, right.

So, this study was done by using this kind of words, both regular and irregular words and both masculine and feminine gendered words were there. And then they were divided on these two terms. They had to just judge whether it is masculine or it is feminine.

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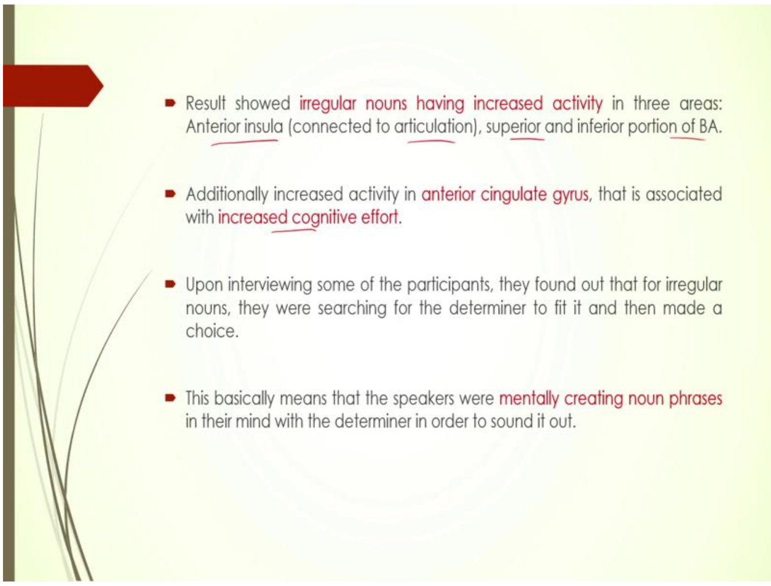

Now, as you expect, regular nouns will not pose any problem, but irregular nouns will pose a problem. So, that is what they also saw that irregular nouns had increased activity in three areas. This is connected to articulation, superior and inferior part of the Broca's area.

They also had added activity in some other parts that are connected to increased cognitive effort. Now, why do we see this in this increased cognitive effort ? Because they the subjects reported that they were mentally connecting the words with the determinant to see what fits. So, that took them an extra effort and hence we find some different kinds of pattern.

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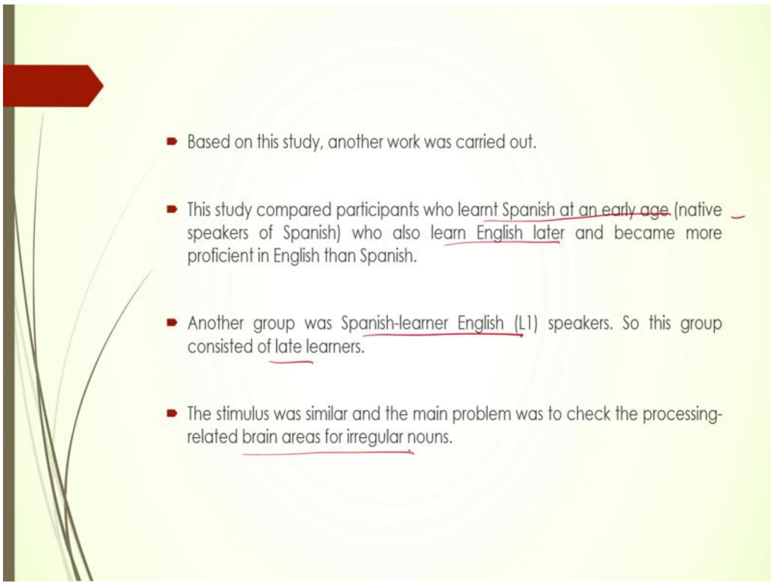

Now, based on these studies, so, if the processing is more effortful, we see a different brain area getting activated. This is what the study found out. Based on this study, another study was carried out and they compared late Spanish participants who learned Spanish at an early age, that is native speaker and who also learned English later.

And gradually, they become more proficient in English, something like many of us. So, we learned language one, first language in early life; later on learned English and over a period of time, we become more proficient in English than our mother tongue. Similar kind of participants were used.

And, another group was Spanish learner English speakers. So, they were learning Spanish, but they had first language was English. So, this was a late learning group, this was a comparatively early learner group. The stimulus was similar and the main problem was to check if the processing related brain areas are different for irregular nouns.

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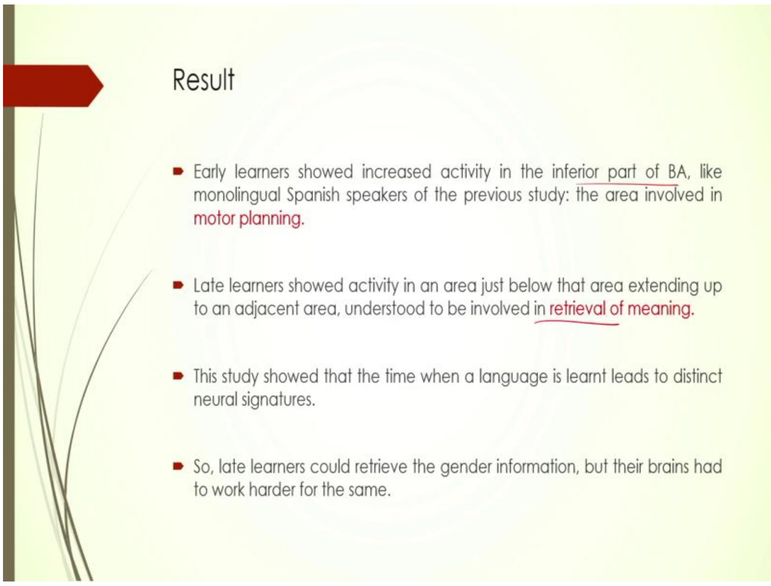

So, early learners showed increased activity, the inferior part of Broca's area like monolingual Spanish speakers would, but late learner showed activity in area just below that area. So, basically there was a difference in terms of whether the participants as early learners or late learners in given the same kind of task conditions – that is the finding.

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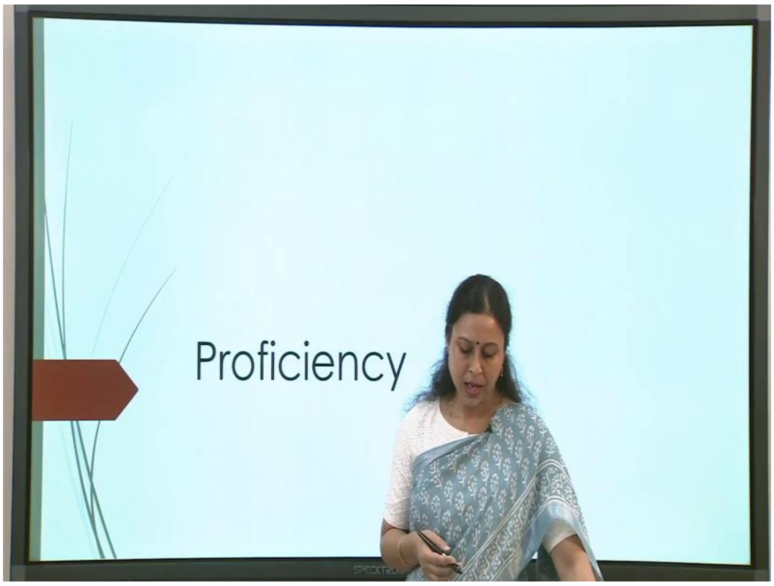

So, you see a lot of difference have emerged in terms of various kinds of task demands in terms of various language pairs, that early learning early learner versus late learner bilinguals have different they seem to utilize different parts of the brain, different areas of the brain for processing. Similarly, there are also lot of differences across monolingual and bilingual.

So, in terms of age of acquisition, we can easily say that the brain of a bilingual, the structure of the brain of a bilingual will depend on, they are different from monolingual and they also are different within the category itself in terms of age of acquisition. Monolinguals of course, learned their first language early in life and early bilinguals also learned their second language early in life so, that that is now established.

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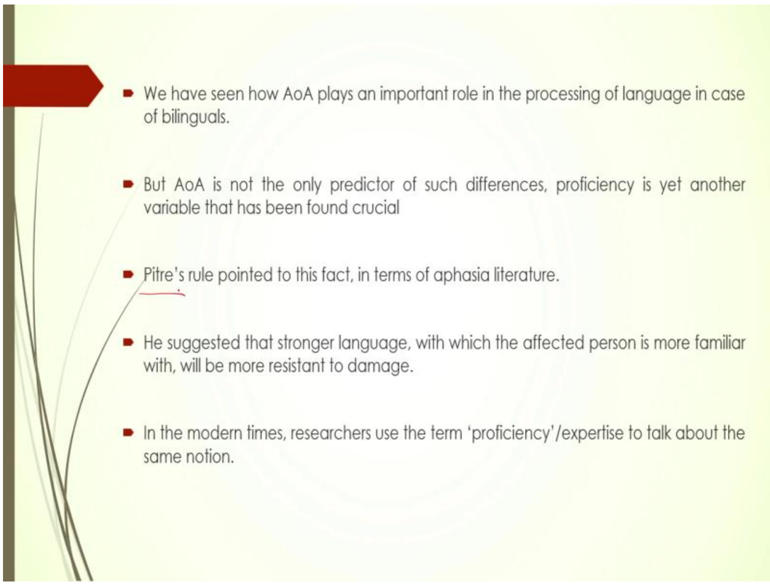

Now, we move on to the parameter of proficiency. Proficiency is something that refers to how well you use your language, whichever language, right. So, this takes us back to Pitre's rule; remember Pitre's rule in terms of aphasia, that the language that is in which the participant the subjects are better at, which they use more is more resistant to disorders. So, this is what is basically we are talking about we now call them proficiency. So, the language in which you are more proficient will be more resistant, is what the idea is.

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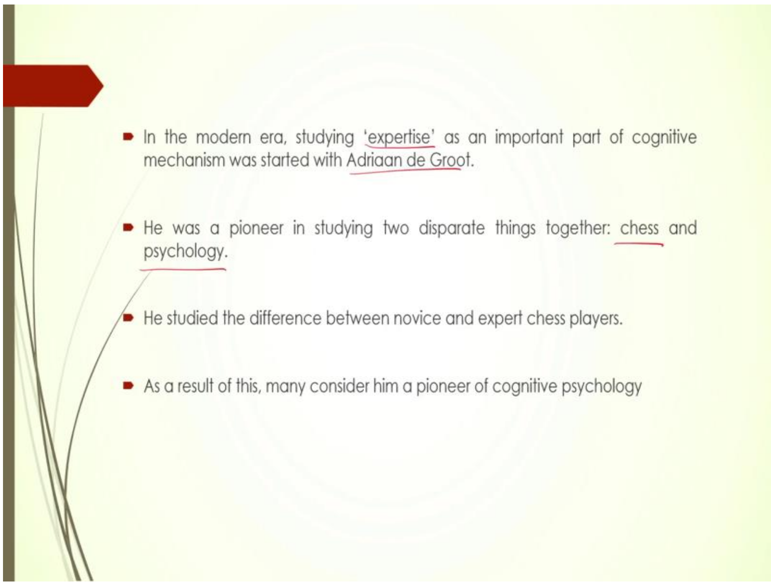

So, in the modern time studying expertise as an important part of cognitive mechanism was started by Adriaan de Groot. He was a pioneer of studying two disparate things. In fact, if he studied chess and psychology together and he looked at chess players and how they are different in terms of you know the proficiency level. So, if a good chess player versus a novice chess player, and how their mental mechanisms are different, how their cognitive strategies are different and so on.

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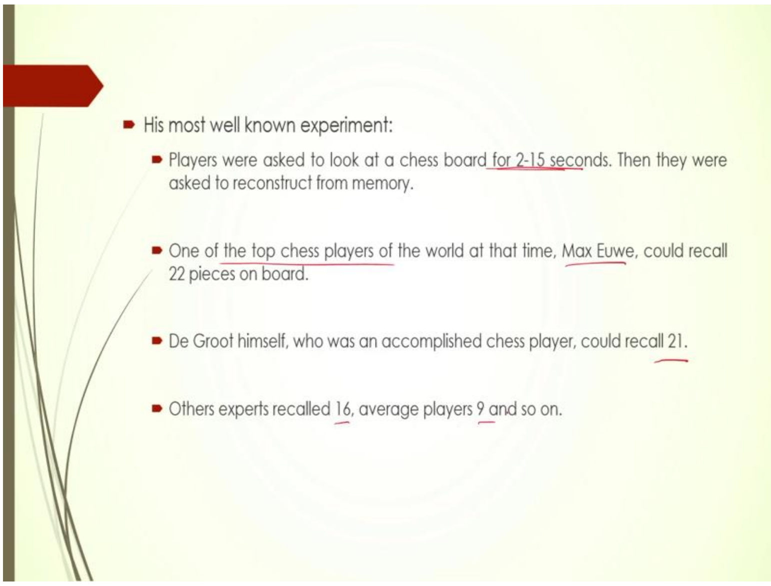

So, one of his most well known experiments: by the way this de Groot was himself a very quite an established chess player himself. So, he is in his one of his tasks they asked players were asked to look at a chess board for 2 to 15 seconds and then they were asked to reconstruct from memory. So, primarily look at the chess board, memorize how what is where and then after some time just tell the describe what was there.

The finding was that one of the top players at that time of the world at that time Max Euwe who could recall 22 pieces on board. The de Groot himself whose who did the study he could recall 21. However, other experts could recall 16, average players 9 and so on. So, as you see the higher the proficiency in the game the more the recall power, better the recall power.

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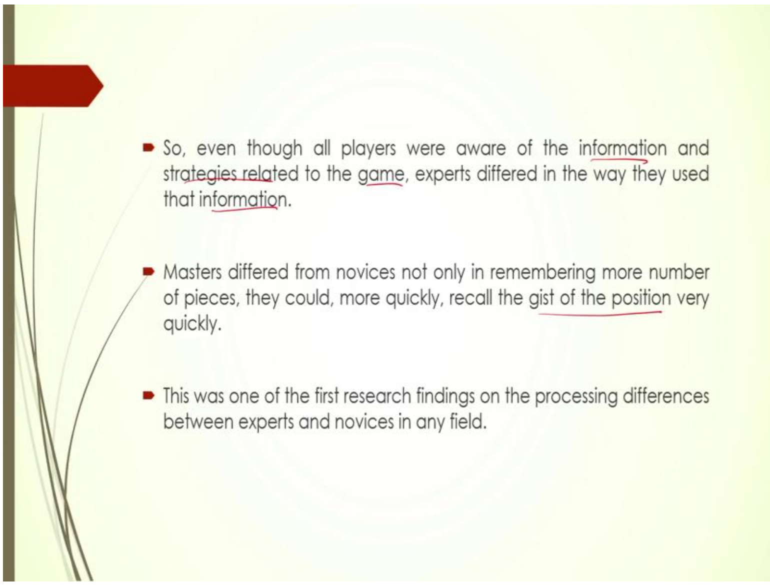

So, even though the theory now goes that even though every player, whether you were an novice or you are an expert they are all aware of the information and strategies related to the game right everybody knows the otherwise he will not be able to play. So, everybody knows the game, but where is the difference between an expert and a novice, is the way they use that information, right. So, this is the primary difference, the cognitive strategic difference how you use information to your benefit.

So, masters differ from novices not only in remembering more, but they could also quickly recall the gist of the position because in chess, it is every piece is dependent on the other piece. So, you do not really need to recall, remember each of them, right. So, if you have understood the layout, you already know where all the pieces will be. As a result, the better you are in the game the better your chances of recalling the pattern because ultimately it is a matter of pattern learning.

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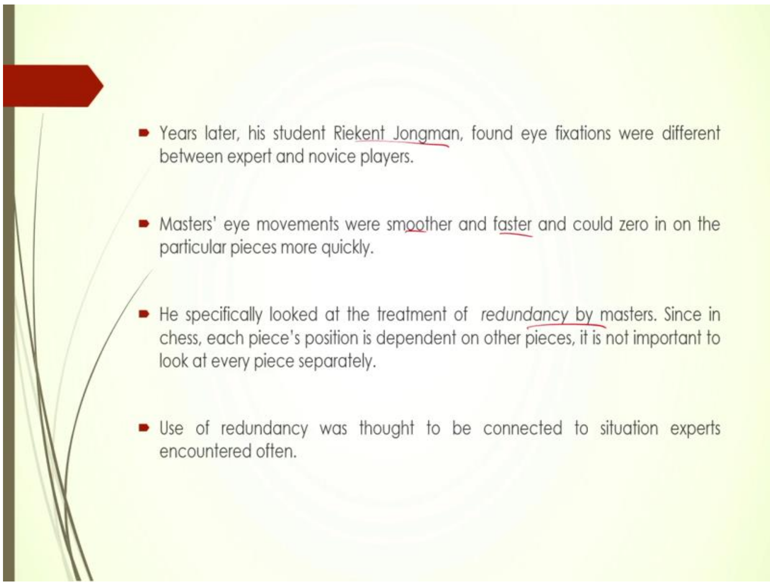

So, years later his student Riekent Jongman, found eye fixations were also different between an expert and novice players. So, the master's eye movements were smoother and faster and could zero in on the particular pieces more quickly and he specifically looked at the treatment of redundancy, what is redundant, right. So, in as I was just saying that in chess you do not really need to look at every piece that will be redundant. If you know if you have seen one piece then you know where the others will be.

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So, that bit is found in more in the experts than in the novices, because ultimately it comes down to pattern perception, in terms of chess that is what he said.

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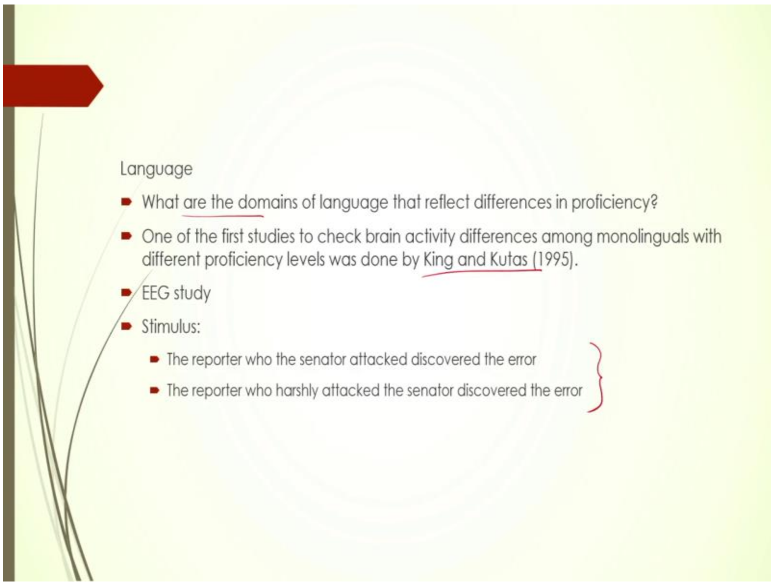

So, this is also a kind of a finding this is also this also supports Pitre's rule albeit in a different domain. Now, coming to language what are the domains of language that will reflect difference in proficiency right? That is the question that that is our primary motivation here. So, one of the first studies to check brain different activity differences among monolinguals with different proficiency level was (Refer Time: 35:38) Kutas and King 1995. This was an EEG study.

So, these are the sentences that they gave. ‘The reporter who the senator attacked discovered the error’ and ‘reporter who harshly attacked the senator discovered the error’, right. So, the idea was to check differences in brain activity levels. The participants were based on proficiency level. So, they were high proficient versus low proficient people.

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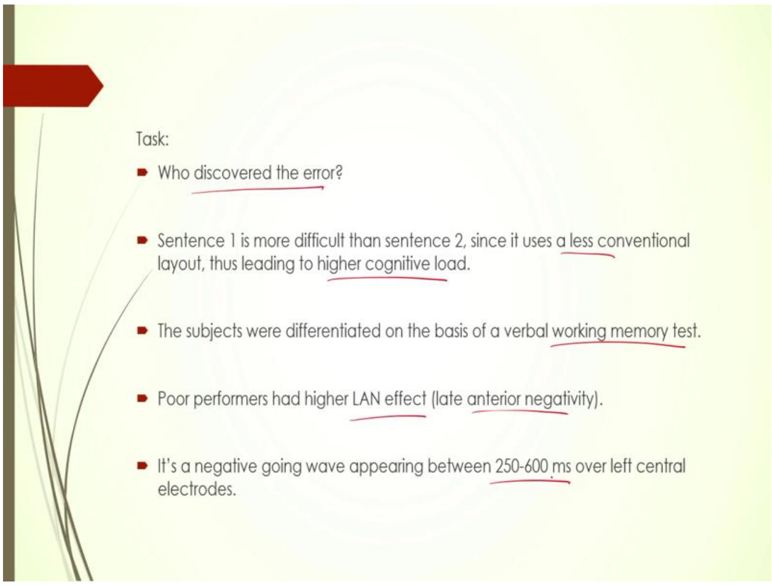

Now, the question was who discovered the error, right. Now, sentence 1 is more difficult than sentence 2 because of the structure, because of the way it was, because this uses a less conventional layout and this leads to higher cognitive load. Now, this is this as a result is more difficult to process.

Now, these subjects were differentiated on the basis of verbal working memory test that is how we know who that some people are low proficient, some people are high proficient. So, the poor performer that is the low proficient performers had higher LAN effect which is late anterior negativity. It is a negative going wave between 250 to 600.

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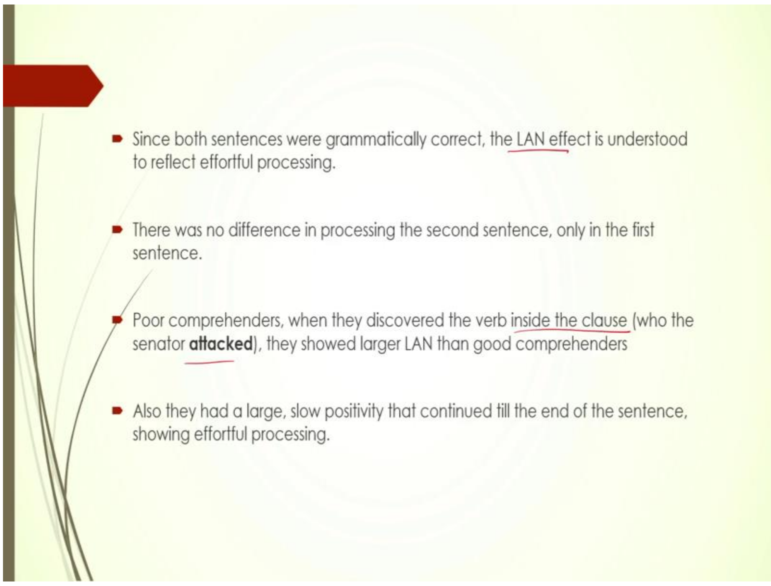

Now, both sentences were grammatically correct. However, the LAN effect is understood to reflect more effortful processing and that is why, because the first sentence was grammatically correct and it was it also had higher cognitive load because of the structure basically the using the clause inside the sentence where 'who the senator attacked'. So, that created slight more cognitive load for the participant to process.

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So, this was the finding. So, after this study, there were many such similar kind of studies that were carried out. Neville, again 2010 found out short, smaller waves for both

LAN and P600 among high proficient monolinguals compared to low proficient speakers.

So, there is a difference in terms of brain activity as picked up by EEG in terms of proficiency. So, higher proficient people will have a different brain activity as opposed to low proficient people even in monolingual scenario.

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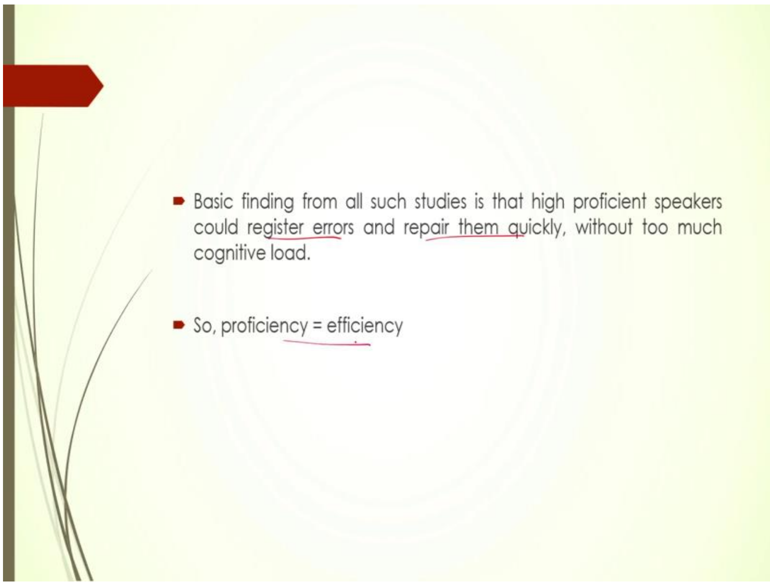

The basic finding from all studies all such studies is that high proficient speakers, what they primarily do is they could register errors and repair them quickly as we have seen in the EEG studies because of the kind of EEG signals that we already have found.

So, basically proficiency means more efficiency. high proficient a monolingual or difficult grammatically complex sentence could be processed with much more ease of as opposed to. And how do we know that? Because of the brain activation levels which you already know are connected to differential stages of complexity.

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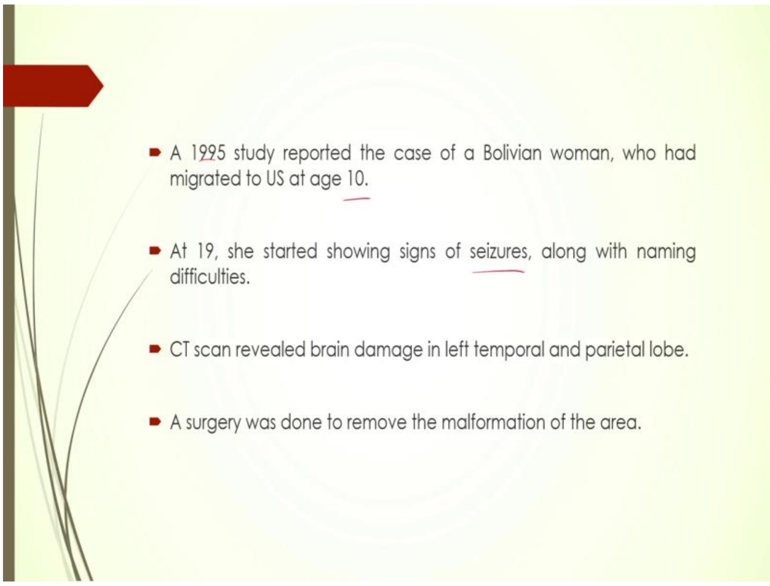

One 1995 study reported the case of a Bolivian woman, who had migrated to US at the age 7. Now, this is an interesting study that talks about that proficiency is actually not a very concrete thing, proficiency can change, proficiency can really have probabilities. So, this lady she started showing signs of seizures at the age 19, and later on it was found that she had a brain damage in the left temporal area.

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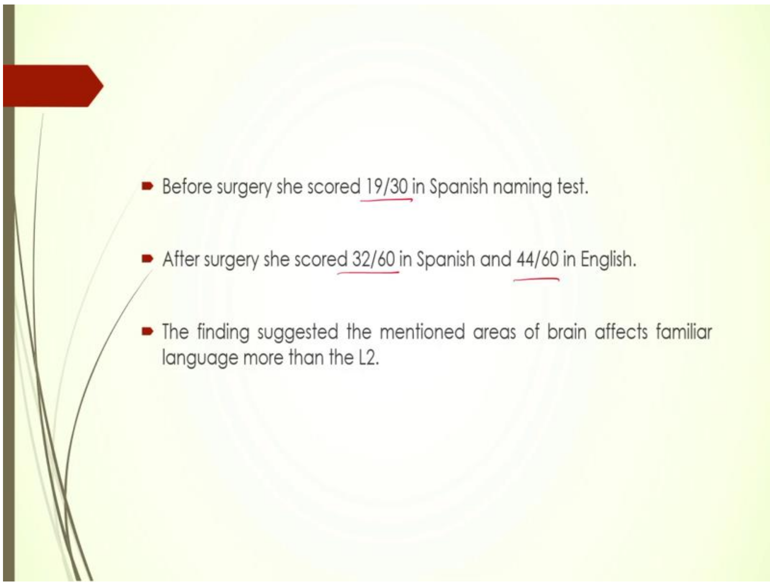

So, after a she needed a surgery and after the surgery her language scores changed so, before surgery she had she scored 19 out of 30 in Spanish naming test. However, after surgery she scored only 32 out of 60 in Spanish. However, her score in English was good that certain areas in the brain affects your L1 and L2 differently. Certain areas of the brain represent L1 and L2 differently was found out in this study.

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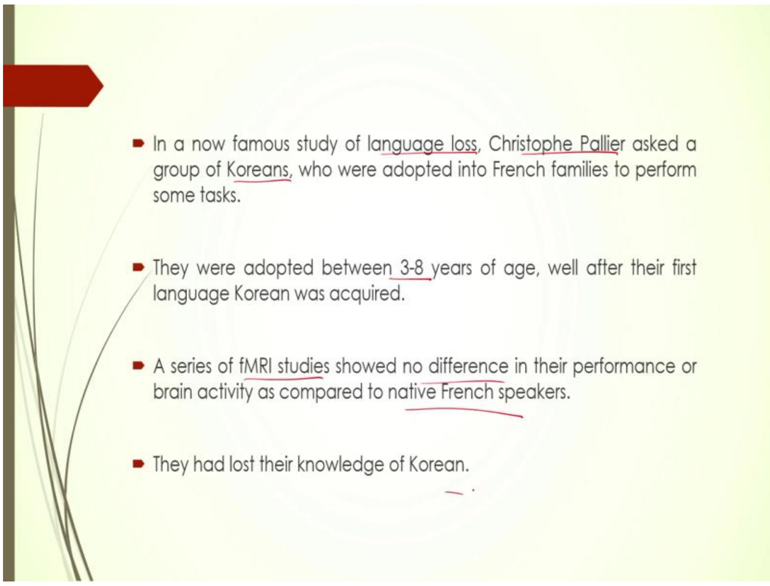

Yet another study in the domain of language loss, it is perfectly possible to typical understanding is that L1 which is learned first is the language in which we are more proficient in, it is the most it is the stronger language by as far as Ribot's rule goes. Now, there is a study that takes us to the end of the spectrum, where the researchers asked a group of Koreans who were adopted in French families.

So, Korean children adopted into French families in their childhood. However, the age is very crucial here they were adopted between 3 to 8 years of age. So, what that means? That means is that their first language was well in place right they were already speaking in their first language when they were adopted.

So, when series of fMRI studies were carried out and they showed no difference in their performance in the brain activity, as compared to native French speaker. So, they were trying to see if they are different in any way different compared to the native French speakers because they are L2 learners of French. So, as a result it was taken as a proof that they had lost their knowledge of Korean.

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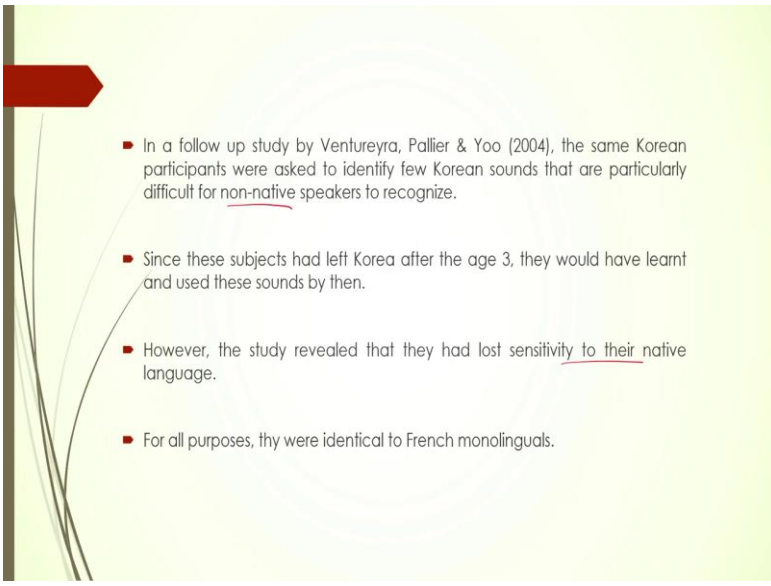

In a follow up study on the same Korean group participants, they were asked to identify Korean sounds, some sounds that is that are typical to Korean language which are easy for the Koreans, but then very difficult to determine for non-native speakers. So, non-native speakers will not be able to recognize them, but native speakers of Korean can. These subjects were asked to recognize those sounds.

Now, the fundamental premise here is that since they had left Korea after age 3, they were already speaking the language and meaning the sound system of the language must also be quite well ingrained in them. However, the study revealed that they had lost sensitivity to their native language entirely.

They could not recognize those sounds which are typical to their language, which is typical to Korean. So, in all for all purposes these Koreans were behaving like French monolingual. So, it is perfectly possible to even lose your first language entirely.

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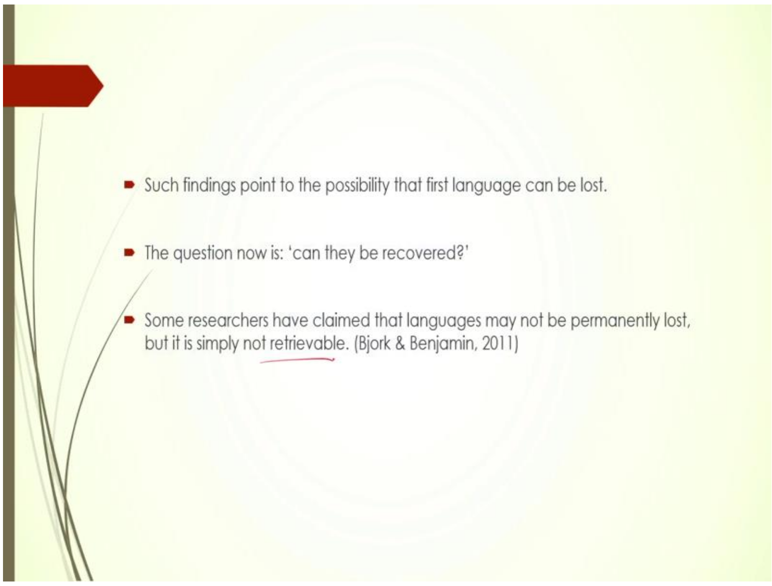

Now, the question is can they be recovered? There are some claims that even though we can say that if there is a possibility that the first language can be lost, but not everybody agrees. They say that, it is not retrievable, but may not be completely irretrievably lost.

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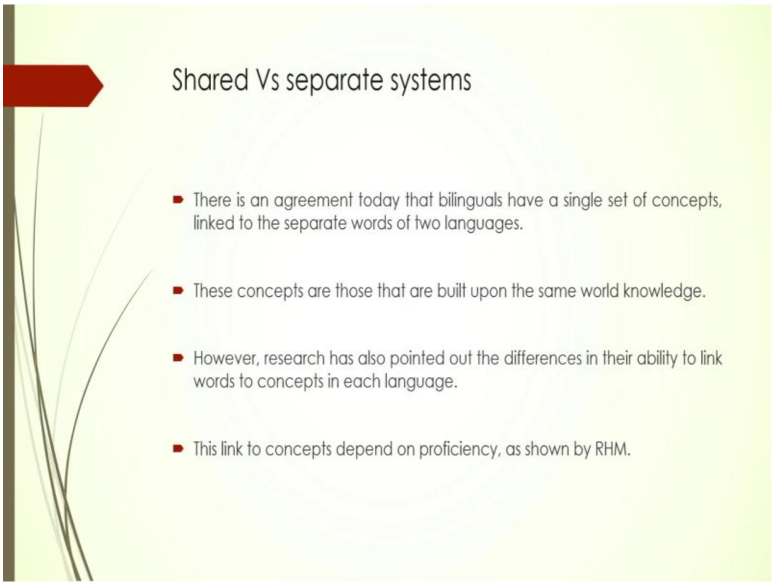

So, this is the case of language first language, language loss in the in L1. There is now an agreement we have already looked at separate versus shared system in the brain, that there are in the initial stages there is L2 is interpreted through L1 and L1 has an has a direct connection to your concepts.

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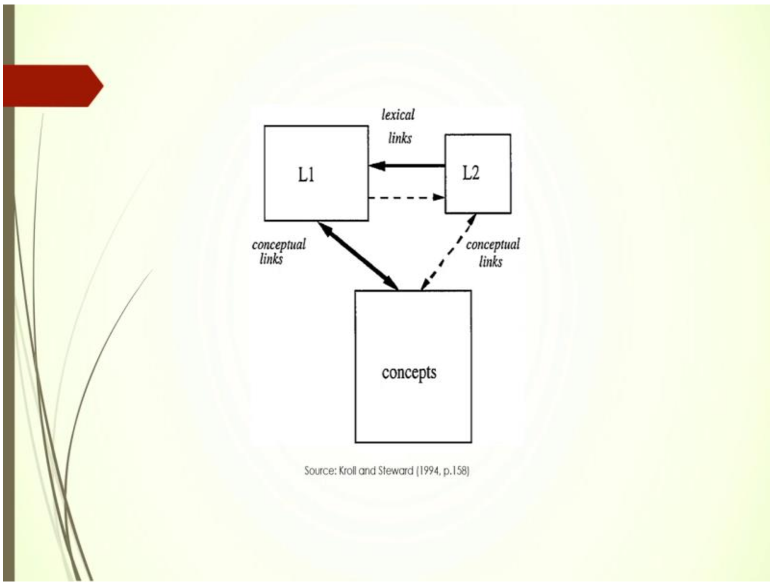

As your proficiency grows, you develop a better connection L2 also develops connection with the concepts and that gets better with proficiency, as proficiency goes higher.

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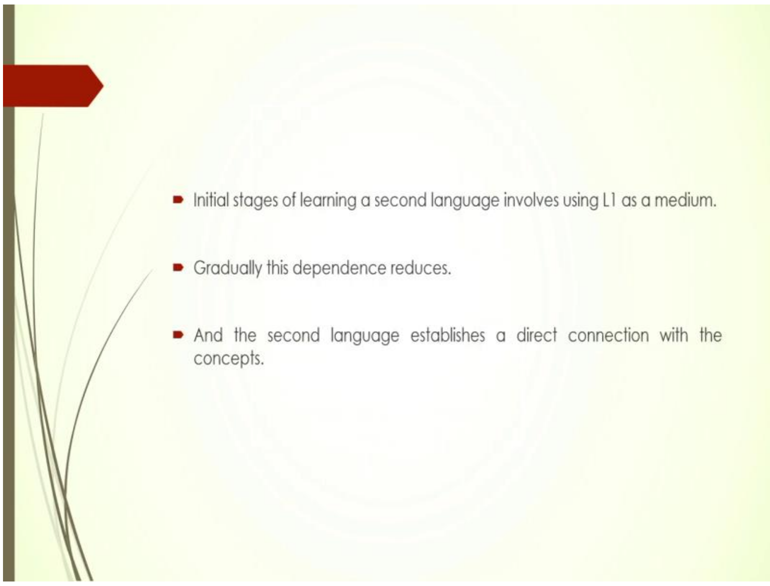

So, this is what we already have seen. So, we will not get into here.

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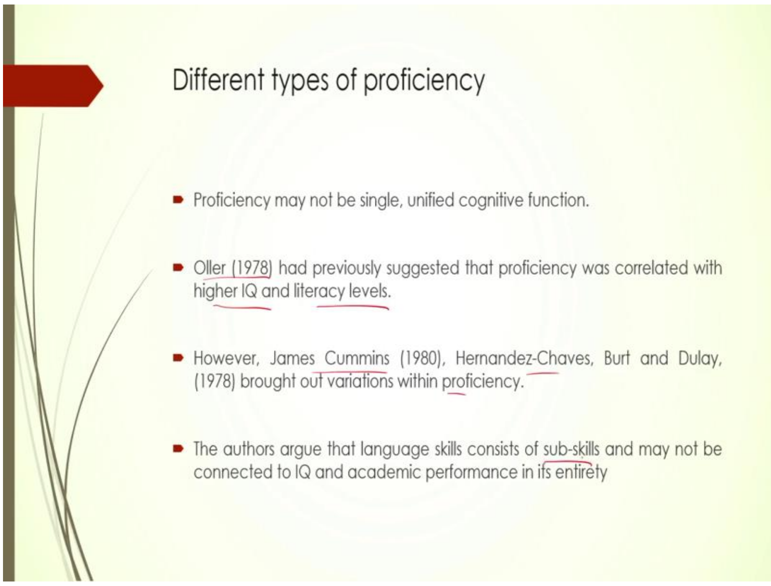

Now, depending on what we have seen till now, there have been proposals that proficiency should not be taken as a homogenous entity. Proficiency also may have different types within itself, inbuilt in build differences, because typically the tests of proficiency that are done are correlated with higher IQ and literacy levels.

However, in the later on later James Cummins and Hernandez and others, they have brought out variations within proficiency. What are these variations? Variations are basically in terms of, the argument that they have given is that, that language consists of sub-skills. Language is not just one homogenous skill.

So, there could be various layers of proficiency and hence it cannot be connected to IQ and academic performance entirely. So, it is quite possible that somebody is not you know academically very well, but that does not really mean that they lack proficiency in their language entirely.

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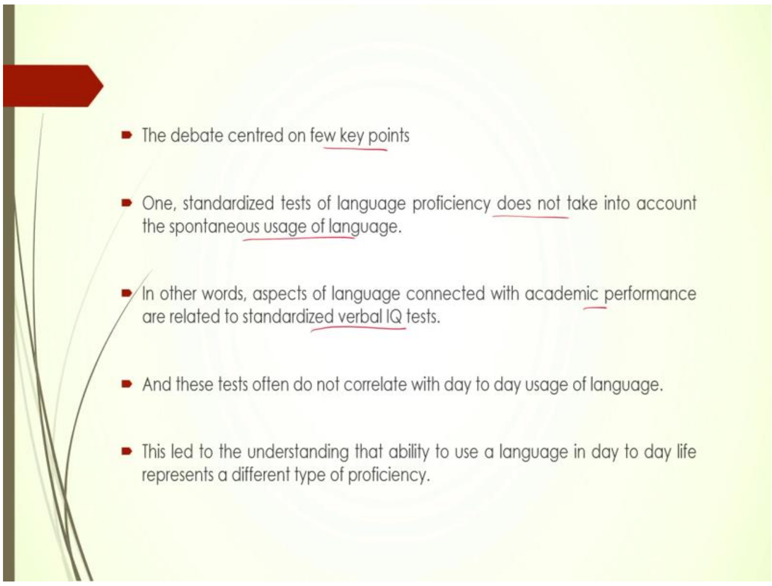

So, the entire debate is based on a few points, few key points, that one is the standardized tests are the typically they do not take into account the spontaneous use of language. In other words, aspects of language connected to academic performance are typically related to standardized verbal IQ test. These tests do not have that they do not really reflect the you day to day spontaneous, everyday use of language, right.

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So, this based on this, there are two possibilities that they have come up with. One is called the cognitive and language proficiency; another is called basic interpersonal communicative skill. So, the first kind of proficiency is what we have been traditionally been testing through various kinds of tasks, which are in turn connected to IQ level and academic performance, literacy level and so on. However, the basic interpersonal communicative skill is also a kind of a proficiency level which does not necessarily depend on the IQ level.

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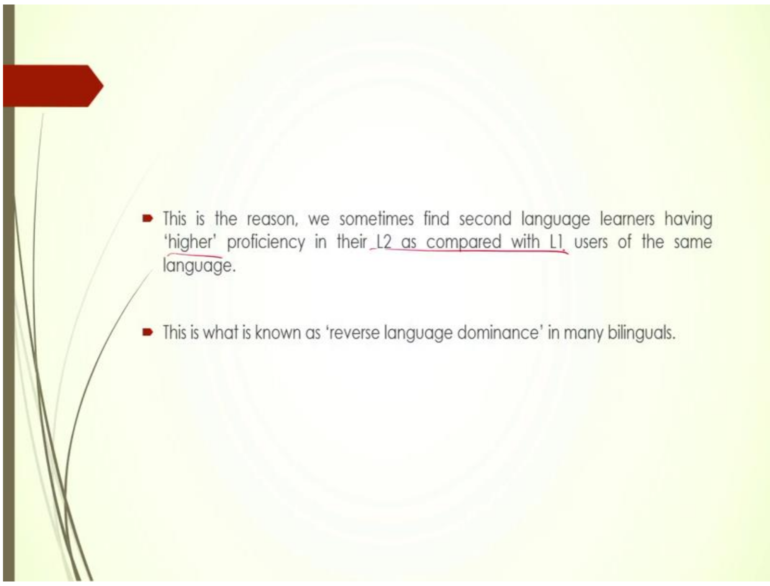

Now, this is the reason that we sometimes find second language learners having higher proficiency in L2 as compared with L1 users. Because when we learn a second language typically through formal training, the language used is the standard language and there and also because it is typical of the setting.

As a result of which they we are taught in that academic language or the formal language and thereby which so, may often many quite often many people show higher proficiency in L2 even compared to the L1. So, this is called the case of reverse language dominance.

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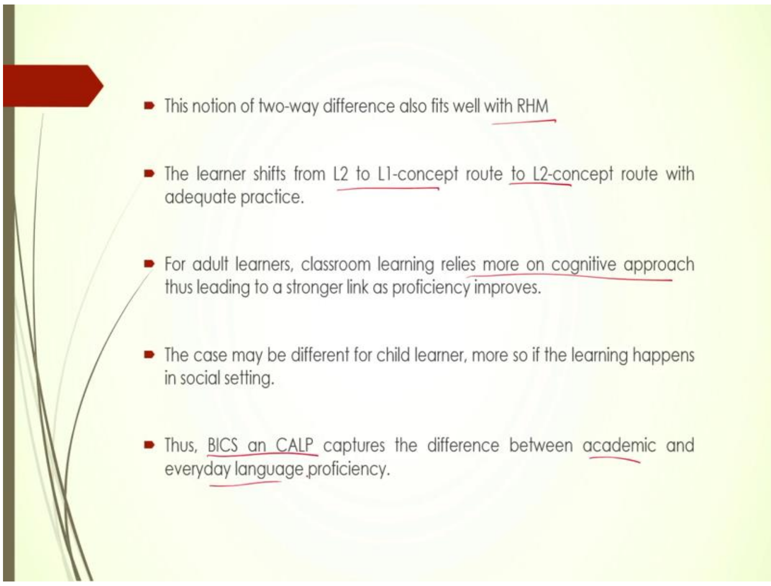

Now, this notion of two-way difference with proficiency also kind of gel gels well with a revised hierarchical model that we have just seen. So, learner initially they are they shift from L2 to L1 to concept load to L directly L2 to concept route with adequate practice over a period of time as and proficiency goes up and so on. So, for adult learners, classroom learning relies more on cognitive approach thus leading to a stronger link as proficiency improves.

So, because of the method of teaching L2 to adults, the connections that are set are different as oppose to when the L1 is learnt. L1 is typically learnt in a non-formal societal kind of a setting, as a result of which this does not really have a strong connection to cognitive approach. As a result of which the that is a completely different trajectory there. So, thus, BICS and CALP capture the difference between academic and everyday language proficiency.

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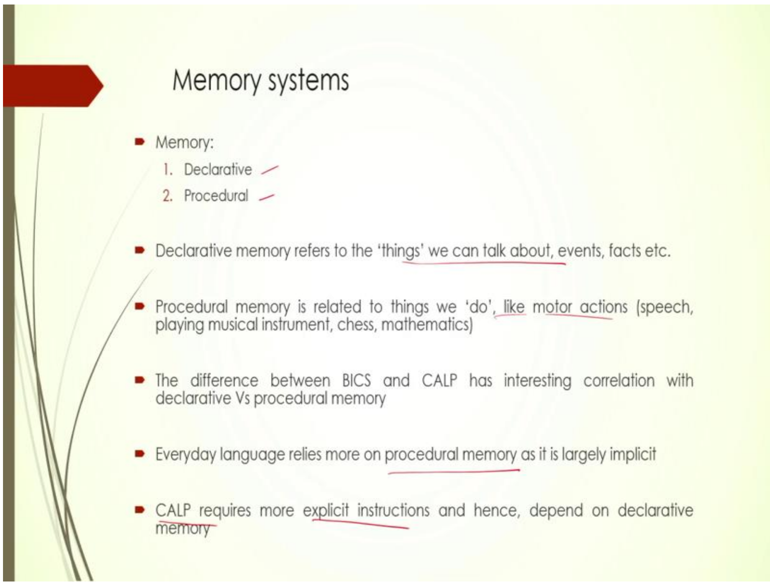

Now, depending on this they have also the dependence on different kinds of memory. We have already seen in terms of bilingual memory storage system that we have declarative and procedural memory. Now, declarative memory refers to the things, right the 'what' of it and procedural memory refers to 'how' we do things like the motor actions and so on.

Now, the difference between BICS and CALP has can also be found out with you know correlating them with the two kinds of memory system in humans. So, everyday language depends more on procedural memory, that is the sensory motor memory and on the other hand CALP requires more explicit instructions. So, you see how we are able to connect all of these things.

So, declarative memory is connected to CALP. CALP is connected to the cognitive and you know higher IQ and when we connect language learning to cognitive aspects and formal training. However, BICS is the everyday use of language which is connected to procedural memory, which is basically about sensory motor memory.

So, naturally there are when you talk about proficiency in this term when you proficiency is divided into two categories, then it is easier to understand as to why early learners and late learners show different kinds of activation level, because they also have dependence on different memory systems, right. So, that is about proficiency.

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Now, we go on to control mechanisms.

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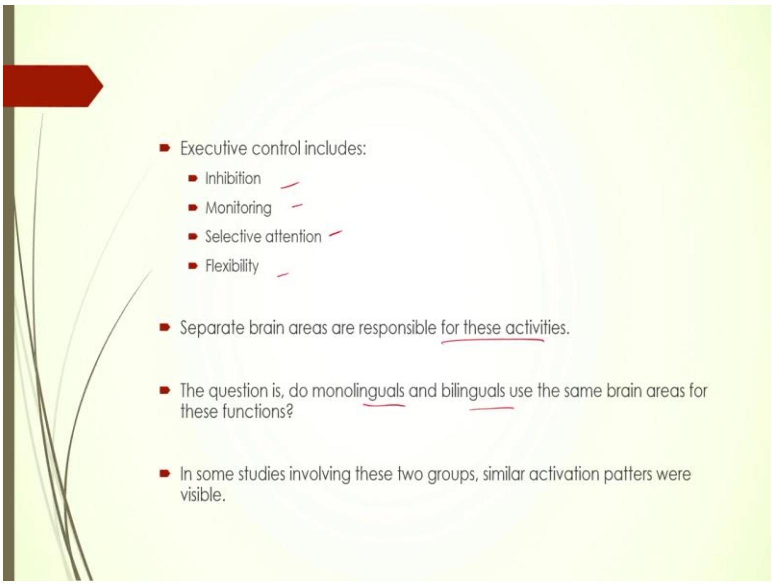

Now, executive control mechanisms basically include executive control. Executive control is primarily control mechanism that takes care of our top down processes. So, this includes things like attention, selective attention, monitoring, inhibition, primarily talking about conflict monitoring and conflict resolution. This is what it is, right. Executive control is it finally boils down to this.

What do we mean by control, conflict monitoring? Let me give you a simple example. So, there are two tasks that are given to me. There are two important salient cues in the environment, but I have been asked to do only one. How well I can suppress the other cue is a reflection of my executive control.

So, in order to suppress the other cue, I have to selectively attend to the important goal at that time. So, that is that the cue that is important for my goal at that time. So, that is in a crux what an executive control includes. Now, separate brain areas are responsible for these various activities within executive control.

Now, the question is again the same question, whether monolinguals and bilinguals use the same brain areas or they use different brain areas for these functions, for executive functions. In some studies involving these two groups, similar activation patterns were visible.

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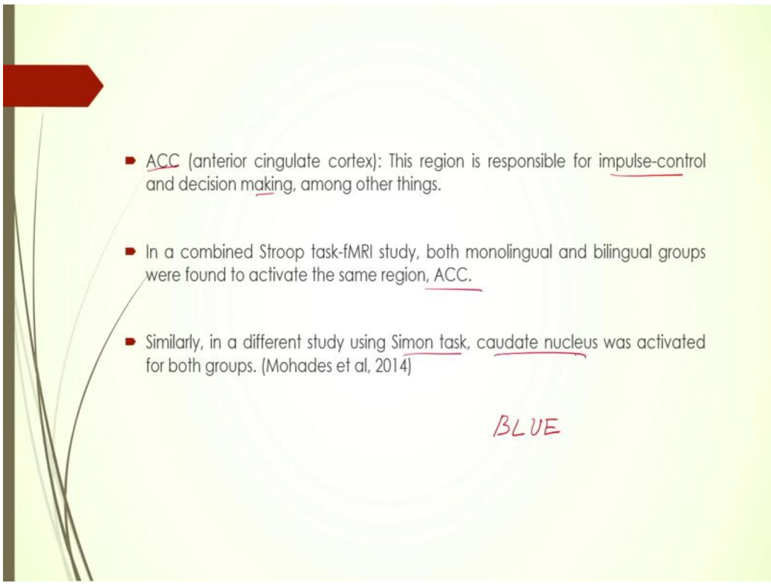

For example, ACC, these are the brain areas typically understood to be controlling our executive control mechanism. So, anterior cingulate cortex, which is ACC, this is responsible for impulse-control, impulse control decision making, various things like this. Now, in a combined Stroop task, fMRI task, Stroop task is a task that that is used to check our conflict monitoring and conflict resolution capacity.

For example, if I ask somebody to now, I have written ‘blue’ with red ink. Now, the task will be name the color of the ink. Now, typically if you see this, we will be more, we it will tend to more name the name the word. So, we will read it ‘blue’, but actually the answer should have been ‘red’.

So, this is a Stroop task, right and so, in a Stroop task combined with fMRI study, both monolingual and bilingual groups were found to activate the same region that is ACC. Similarly, in a different study using Simon task, I will include all of these studies in the in the appendix. So, the caudate nucleus was activated for both groups. So, basically, they are seem to be some similarity across groups in these task.

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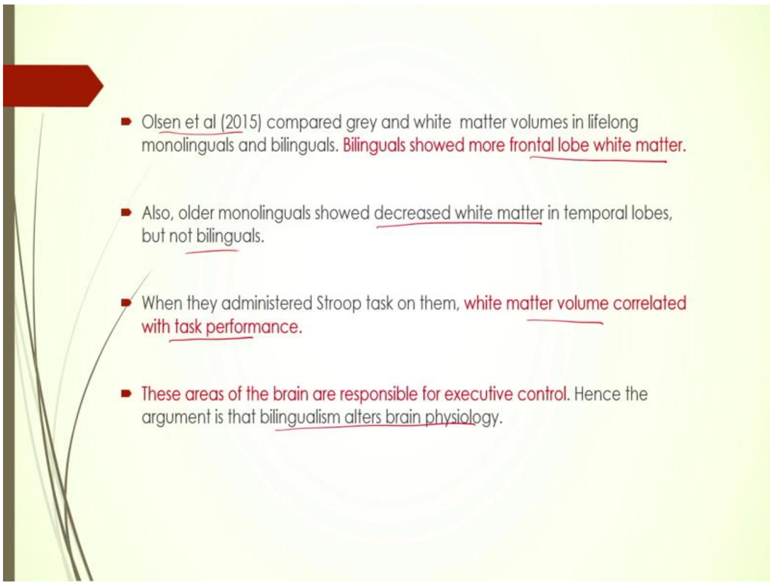

However, another, yet another study they compare grey and white matter volumes in lifelong monolinguals versus lifelong bilinguals. They found some difference. What is the difference? They found that bilinguals showed more frontal lobe white matter. Remember, in every other parameter also, we have seen more dependence of bilinguals on the prefrontal cortex as opposed to the sensory motor areas, right.

So, this also, they are takes us there, that bilingual showed more frontal lobe white matter. Also, older monolinguals showed decreased white matter in temporal lobes, but not bilinguals. So, when they administered Stroop task on them, white matter volume correlated with task performance. So, the higher the white matter volume, the better the performance and the other and the other way round.

So, these are the areas of the brain that are responsible for executive control. Hence, because we have already seen that bilinguals have greater volume of a white matter, monolinguals have comparatively less and a bilinguals also perform better. So, there is a correlation.

Now, the finding also takes us to a rather controversial domain, which is the domain of bilingual advantage. Now, what it says is that bilinguals are better equipped to handle challenging tasks, to handle tasks that require inhibition of the another cue. So, as of here in this particular study, the finding also suggest that bilingualism itself alters brain physiology; brain physiology in terms of white matter density, white matter volume and so on.

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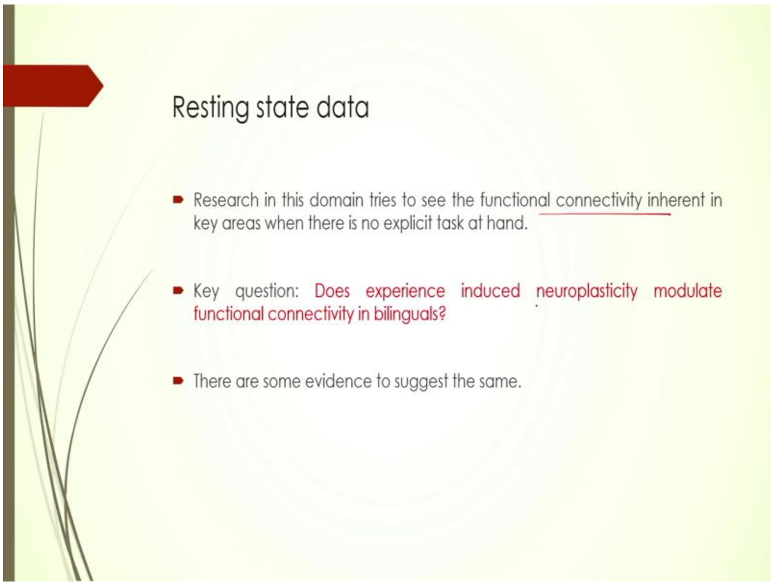

So, bilinguals outperforming monolinguals on this kind of task also has a correlation with the brain, the very structure of the brain the very brain physiology. Similarly, the data from resting state research also has tried to see if the functional connectivity inherent in key areas are different when there is no explicit task. That is why it is called resting state. So, there is no task given to the participants, but they are just checking the functional connectivity.

Now, the question they were asking is, does experience induced neuroplasticity modulate functional connectivity in bilinguals? What this means is that, because bilinguals are handling two different languages at the at all the time, we just saw that it is it there is a probability that it also alters brain physiology. Does it also show in neural connectivity in the resting stage phase, which seems to be the case, then the evidence points towards the same.

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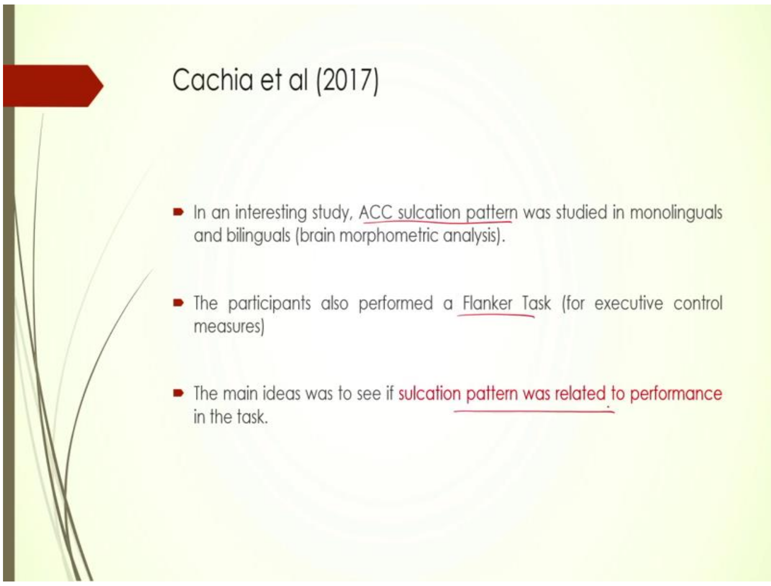

Another one study in 2017, they looked at ACC sulcation pattern in monolinguals and bilinguals. And, participants also performed a Flanker task. I will, as I said, Simon and Flanker and Stroop task, I will give one example of this. All of this I will add in the appendix, you can check.

So, the main ideas was to see if sulcation pattern was related to performance. We just saw white matter density having a correlation with performance in monolingual versus bilingual. This study looks as at sulcation pattern.

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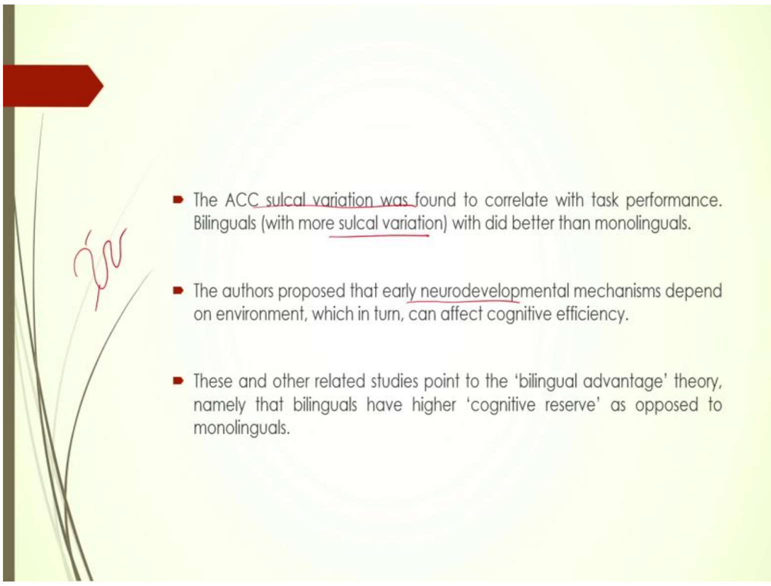

Now, ACC sulcation variation was found to correlate with task performance. Bilinguals had more sulcal variation. We talked about sulcus and gyrus. So, this is the how the convoluted the brain's, the cortical areas are. So, this is gyrus, this is a sulcus. So, bilinguals had more sulcal variation and they also did better than monolinguals on all of these tasks.

So, the authors proposed that early neurodevelopmental mechanisms depend on environment, which again it can take us to cognitive efficiency and of course, we go this ultimately, this entire debate goes to bilingual advantage. Bilingual advantage we will discuss in another module in more detail as to how bilinguals, by virtue of being bilinguals, probably train their brain differently.

But till now, so far, we have seen that the bilingual brain does have some differences as opposed to monolinguals. Not only that, in terms of physiology, in terms of activation pattern, in terms of how they perform on in different kinds of task, there are differences and also, within bilinguals themselves, there are differences in terms of the activation pattern as well as structural pattern. So, which area of the brain gets activated, whether it is sensory motor area or it is prefrontal cortex? There are differences in that.

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So, yes, bilinguals, the bilinguals do have some differences from the monolingual brain in terms of all of these factors discussed. So, this is where we come to the end of this segment.

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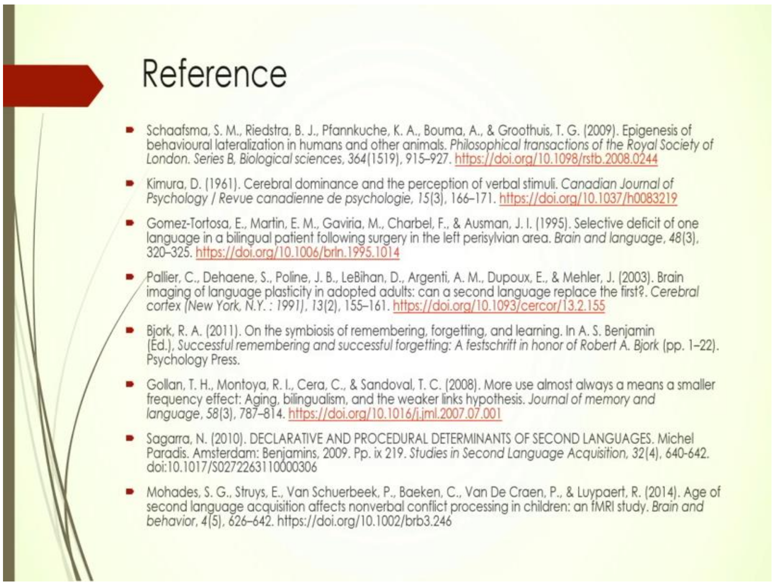

These are references.

Thank you.