Psychology of Bilingualism and Multilingualism
Professor Ark Verma
Dept. of Cognitive Sciences
IIT Kanpur
Week - 06
Lecture – 27

Hello and welcome to the course Introduction to The Psychology of Bilingualism and Multilingualism. I am Dr. Ark Verma from the Department of Cognitive Sciences at IIT Kanpur. In this Lecture I will continue talking about the bilinguals and the multilingual brain.

Now, so the earliest advances in the localization of brain function were made when Paul Broca, a French physician, discovered a patient who was unable to speak at all, but his comprehension was relatively intact. This patient could at most say tan, tan and tan. A postmortem examination of the man's brain revealed that he has a lesion in the middle posterior part of the inferior frontal gyrus in the left hemisphere, which is basically referred to as the Brodmann's areas 44 and 45. This region came to be known as Broca's area and the type of aphasia observed was referred to as Broca's aphasia.

Remember from the previous lecture, difficulties in production or comprehension that are result of brain damage are referred to as aphasias and since this type of aphasia was first discovered by Paul Broca, this came to be known as Broca's aphasia. Now, an influential conceptualization of the language areas and their functions was actually offered by Leaktime in 1885 wherein the Broca's and the Wernicke's areas were supposed to be connected with a conceptual center. Now, in this model, it was assumed that the Broca's area actually stored the motor representation for words whereas the Wernicke's areas are supposed to store the auditory forms of the words. Finally, the third center was the conceptual center which was thought to store the conceptual representations of the words which are sort of in some sense you can think about them as a pre-linguistic representations. Further, the auditory and the motor areas were supposed to be connected directly as well as through indirectly through the conceptual center.

Over the years, Leaktime's model has been extremely influential in their research on aphasia serving as an important theoretical framework for providing testable hypotheses about the causes and prognosis of different kinds of aphasia. For instance, damage to Broca's area is found to lead to a pattern of symptoms collectively known as Broca's aphasia which actually include effortful non-fluent and poorly articulated speech. Also, the speech of such patients was found to be telegraphic that is composed of simple and short utterances devoid of any kinds of grammatical markers or function words. For

example, if I were a Broca's aphasic patient and I want to say I want to drink water or let's say I want to drink water in a glass, I would probably say I drink water glass and there will be no connecting grammatical rules between them and there will be no function words that are you know your articles and prepositions and conjunctions which actually provide a connection between the basic content words that we typically see. Additionally, the combination of Broca's aphasics was also found to be deficient you know with respect to grammatically complicated sentences.

The combination was relatively fine when you are talking about relatively simple utterances but when you talk to them with grammatically sophisticated utterances their comprehension was found to be wanting. On the other hand, it Wernicke's aphasia is found to result in symptoms that include nonsensical speech along with severe problems in comprehension. Moreover, Lichtheim's model has actually served as a very interesting framework to account for other types of aphasias as well. For instance, when the arcuate fasciculus was found to be damaged the resulting symptoms would be that the people would have relatively good auditory comprehension but they would be unable to repeat the speech. It was therefore attributed to you know it was therefore referred to as conduction aphasia because the area you know connecting the Broca's and the Wernicke's aphasia is damaged and therefore the conduction is not possible or incidentally if all three of these areas are damaged the Broca's aphasia the Wernicke's aphasia and the arcuate fasciculus the disorder is was referred to as global aphasia which would which would basically mean that all aspects of linguistic performance are severely adversely affected.

Now while Lichtheim's model and early work from researchers like Broca and Wernick actually threw light on some of the areas of brain involved in language functions more recent research has actually unveiled a more complicated relationship between the language and the brain. For instance, research work has produced a substantial amount of evidence against the brain against and against the you know so-called division of labor between Broca's and Wernick's area for production and comprehension respectively. In the same vein, Stowe, Haverkort and Zwartz in a seminal review actually reported that the while the involvement of the left inferior frontal gyrus which is the Broca's area and the superior temporal gyrus which is the Wernick's area were indeed essential for language functioning the hypothesis that the former supports language production and the latter supports language comprehension is not you know very strongly supported by the evidence. Moreover, later research on the topic that has delved deeper into these questions has basically arrived at the conclusion that while these areas may not be the exclusively responsible for language production and comprehension they certainly play a very significant part in these functions. In a different direction, some researchers have actually proposed alternate hypotheses for the involvement of Broca's area and

Wernick's area in language.

More specifically, it has been proposed that Broca's area subserves supporting of syntactic knowledge and processing whereas Wernick's area supports storage of word meaning knowledge and semantic processing. Now indeed research has shown that individuals that have Broca's aphasia have grammatically deficient speech output. Moreover, many of these patients actually find it difficult to understand sentences which require not only understanding of word meanings but also sophisticated grammatical analysis of the input. Just as I was saying earlier, this seems to be you know in line with these newer hypotheses. Interestingly, neuroimaging studies have also yielded mixed results in this regard.

For instance, few studies have shown that the syntactic analysis of the stimulus does not always recruit the Broca's area or the semantic manipulations of stimulus materials do not always activate the Broca's and the Wernick's area together. Even in lesion studies, similar findings have emerged. For instance, patients deficient in the performance of morphosyntactic tasks have shown damage to both Wernick's and Broca's areas instead of just the Broca's area and on the other hand some patients with the damage to Broca's area actually did not show severe deficiencies with morphosyntactic processing. So the assumption that we sort of started with in the 1800s that you know as per Paul Broca, Broca's area is responsible for production of language and syntactic processing and Wernick's area is responsible for comprehension of language and semantic processing is probably much more complicated as it appears on the outset. Also, it has been observed that patients with damage to Broca's area sometimes and who have shown deficiencies in morphosyntactic processing in particular tasks do not show the same deficiency in morphosyntactic processing across all types of tasks and different circumstances.

Rather, these deficiencies show up only under very difficult circumstances. So these results altogether suggest that why the Broca's area might not actually be you know the storage of syntactic knowledge as was originally assumed. Another important view about the function of the Broca's area was put forward by Stowe and colleagues and following from research findings that have you know that have basically been coming up about the Broca's area it supports that I mean is it proposes that Broca's area actually supports some type of computation or knowledge units that is retrieved that are retrieved from other parts of the brain and that it maintains these units for the duration these computations are performed. The view is akin to you know the view of a working memory kind of system where we are basically saying is that the system takes information from the long-term memory and the short-term memory, performs you know allows for some temporary manipulation to be happening on the stimuli and typically functions as a work desk. Similarly, you can see that maybe Broca's area does not really

store syntactic knowledge or anything but it basically you know derives meaning units from the long-term memory and you know derives task demands from the current scenario and basically manipulates that meaning inputs in using grammar it sort of soothes them into a particular multi-word utterances so that it can meet the demands communicated demands of a given scenario.

An instance of such a position can actually be found in the research of Hagoort in 2005 who actually adopted a design based approach to administering linguistic experiments and started laying out the various components of language use and mapping the brain regions that were responsible for these component processes. Hagoort actually proposed that there might be three major components in language processing which are memory, unification and control. Commonly referred together as the MUC network. Now what do these terms actually mean? Hagoort basically says that memory refers to the information stored in the long-term memory, for instance the knowledge about word forms and meaning stored in the mental lexicon. More interestingly he proposes that the mental lexicon does not only store the words meaning or its phonological and phonetic form it also stores the so-called structural frames that allow for the grammatical analysis of sentences using these items.

The idea is that once you are understanding a word or let's say the way the information about a word is stored in the mental lexicon it carries all types of information associated to that word and once you have access to that information you can very easily understand not only the words meaning but also its syntactic function in a given sentence. Such a view has actually been referred to as the lexicalist view of language that does not really assume a major distinction between lexical items on one hand and syntactic rules on the other. According to this view all the grammatical information including that for parsing of sentences is actually stored in the mental lexicon itself and that the component responsible for this is the memory component that is responsible for both retrieving this information and using it at the same time. Further the term unification has actually been taken to refer to the process of integrating information received from the mental lexicon including syntactic semantic or phonological information in the form of multi-word expression. So the component of unification basically what it does as I was saying is that it brings together you know these informations about these words and actually integrates them into multi-word expression so the integration or the unification part is done.

Finally the more important part or a very important part is the control component which is assumed to be responsible to oversee whether the language system is operating in a manner that meets the communicative demands of the individual say for example whether the sentences are being constructed appropriately for a given communicative scenario. More precisely in case of bilinguals the control component would actually

enable the bilingual to meet the demands of the communicative scenarios when let's say only one of the two languages are needed or when both the languages are needed in a more flexible manner. Further, Hagoort actually you know tried to investigate the brain regions that would subserve these three hypothetical components the memory, unification and control. He pointed out to the left inferior frontal gyrus as the site for unification and localized the memory function in the large region in the left temporal lobe also including Wernicke's area and Brodman's area 38 which and 21. Interestingly the different sub regions in within the left inferior frontal gyrus actually appear to be specialized for unification of different types of information both phonological, syntactic and semantic information.

Finally, Agut proposed that the control function is localized in the network for areas in the frontal cortex containing the ACC that is the anterior cingulate cortex and the dorsolateral prefrontal cortex. So here you can see that the three areas can be roughly mapped onto regions in the brain. Here you can see is the unification part which is in the Broca's area, control part which is in the frontal cortex, DLPFC in ACC and the memory part which is mainly in your temporal lobe. Now the areas of the brain dedicated for the control function have also later been implicated in executive control functions that allow a bilingual to manage their dynamic communicative demands. The three regions involved in language functions have also been supported in recent reviews of neural imaging work on language processing.

So it seems that you know to some extent the MUC model put forward by Hagoortt actually finds neurocentric or neural imaging support as well. These results therefore confirm the importance of these regions for language use. However, depending upon the exact characteristics of task and stimulus materials utilized in you know these specific experiments, additional areas of the brain may also be executed. So it is not like just the three you know hypothetical regions and regions of the brain associated with them will only be you know activated in language functions. It is depends on the you know task demand depends upon the communicative scenario as to which regions of the brain will be dynamically allocated for language functioning.

Now the other region of the brain that is supposed to be very very important in language processing is a large region in the left temporal lobe that covers the areas assigned a memory function by Hagoort and also the area such as the Wernicke’s area which was traditionally sort of you know assigned for comprehension. Now these researchers actually proposed that the left temporal lobe is committed to word retrieval and also the different parts of this temporal lobe are actually specialized for different retrieving different types of words. You know it probably has some bearing on the organization of concepts in the memory as well. To investigate this hypothesis the authors actually

presented a group of patients having lesions throughout the brain with a set of photographs showing faces of well-known people, animals or tools and asked them to name the entities on these photographs. The performance of these patients was compared with that of a group of neurologically healthy people and the patient showing name naming performance relative to this group.

What did we find in the results? The results actually indicated that the naming deficit of these patients was not really caused by damage to conceptual knowledge because the patient's responses clearly showed that they knew about these concepts. For example when they were presented with a picture of a skunk they could actually describe the animal by saying oh that animal makes a terrible smell when you go close to it it's black and white it gets washed on the road by carts a lot of times and so on. Brain scans were subsequently made to locate the damaged you know region of the brain and out of the 30 patients 29 patients actually had damage to the left temporal lobe thus indicating that word retrieval is indeed served by this particular area. Further the scans actually revealed the exact site of the brain lesion was correlated with the specific types of word retrieval deficit. Now see this is something similar to in some sense localizing different kinds of conceptual knowledge to different regions in the brain and therefore I would request you to take this with a bit of with a pinch of salt because there are obviously theories about localized you know regions in the brain for particular concepts and there is a contrary theory that says no concepts are distributed across the brain.

In our context we are just you know going through these studies but we will sort of try and take them with a pinch of salt and address them as we go further. Now patients just to sort of recount the results that they found in the study patients with lesion in the anterior part of the left temporal lobe the temporal pole that is exhibited impaired naming of persons those with the lesion in the middle of the left inferior temporal gyrus showed impaired naming of animals finally those with lesions in the posterior part of the left inferior and middle and upper temporal gyri were actually impaired in naming tools. A subsequent PET study with neurologically intact individuals also corroborated the results of the present study. So yes the evidence is there for a certain degree of you know localization of particular concepts in the region of the temporal lobe. However there are other studies also which I have discussed earlier in the you know course on the introduction psychology of language the more dominant or the more popular sense is that this is more distributed rather than localized to different areas of the brain.

All in all the three left temporal areas that Damasio and colleagues actually showed to be involved in word retrieval actually largely coincide with the area that subserved the memory component in Hagoort's model albeit these areas serve a slightly different function in the model. According to Damasio the three regions that they have delineated

were actually intermediary regions rather than and you know that in the sense that they do not contain the names of persons animals and tools rather they contain knowledge about how to reconstruct these names from a distributed network. All right so this is again something that you can see that there is a bit of a conflict between studies but the more predominant view is that you know the knowledge about concepts is more distributed in the brain and these regions that you know Hagoort is finding or Damasio is finding is actually regions that are coordinating the collection of these information rather than storing this information at themselves. Another interesting illustration of the diversity of use on the functions of the classical language areas you know Broca's, Wernick''s and the Ullman for Sigilas in the left hemisphere concerns the divide between declarative or procedural memory which was developed by Ullman and colleagues. Now as per this model there is certainly a difference in the types of memory function that is involved in the learning, representation and use of facts and events on one hand that is declarative memory and the memory involved in learning and control of motor and cognitive skills and habits that is your procedural memory.

According to Ullman, lexical knowledge that is knowledge of the sounds and meanings of words can actually be considered as a part of a of declarative memory and hence will primarily be taken care of by the temporal lobe whereas including the vernix area whereas you know aspects of procedural memory you know basically are rooted in left frontal structures and the basal ganglia. So basically what we are seeing is that the distribution is not in terms of you know specific types of concepts but the specific way in which these concepts are actually acquired whether they are acquired as facts and stored in a place whether these are acquired as skills and stored in a different place. Now an interesting suggestion made by Ullman concerning bilinguals was that a dysfunction of the procedural memory can actually be compensated by increased dependence on declarative memory in the sense that the linguistic structures that are normally computed using the procedural system are actually memorized by the declarative memory. Basically what we are trying to say is that if you are a bilingual and you are trying to pick up a second language it will obviously be difficult for you to grasp you know the grammar of the language and hence learn it in a procedural manner so what happens is at least in the initial stages the you know the individual or yourself will rely more heavily on the declarative memory basically the mapping between the words of language one and language two and basically you know a lot of this task will be done by declarative memory whereas for L1 a lot of this task would actually be taken care of by the procedural memory. Ullman actually went ahead and proposed that languages that are acquired later in life in the two memory systems actually play a different role than in L1 because later exposure to languages may actually impair the ability of the procedural memory to grasp these rules typically what would happen is that you know linguistic forms that are computed grammatically in the present memory for L1 depend largely on

declarative or lexical memory in L2.

This is precisely what I was trying to tell you a moment ago. The later the age of L2 exposure the larger the role of declarative memory and the lesser the role of grammatical processing or procedural memory. Now this was a bit about how you know languages are organized in the left hemisphere let us read a little bit about right hemisphere involvement in languages well. Now we have seen so far that the areas of the brain implicated in language processing are mainly in the left hemisphere this basically underlines the view that has been known as the language lateralization view which believes that language is entirely and exclusively lateralized to the left hemisphere. Now while there are a range of studies that have shown that different areas in the left hemisphere are implicated in language processing the right hemisphere has also been implicated in specific types of language processing for instance Tan and colleagues actually show that several areas of the right hemisphere are strongly activated during the processing of logographic Chinese characters.

Now just a bit about logographic Chinese characters because they require they have a much more visual spatial component than alphabets in English or Hindi for that matter even. It is expected that given that right hemisphere is adept at visual spatial processing decoding or deciphering Chinese logographic characters would take help from the right hemisphere in solving this task. Further, Stough and colleagues also report that the right hemisphere is implicated in the processing of flexibly ambiguous words and in-depth forms of languages such as metaphors, irony etc. These findings suggest that the right hemisphere can actually provide an alternative interpretation when initially constructed grammatical meanings turn out to be incompatible with the contextual information. Now this has led to some kind of an alternative hypothesis about the role of right hemisphere in language processing by basically saying that the right hemisphere is typically recruited when there is some reason or the higher processing demand is surfaced.

Support for this computational load account of the right hemisphere involvement language processing also comes from an account of special populations say for example the elderly people for whom most of the language tasks would be more effortful, schizophrenics or even bilinguals where the typical task of managing a language is much more than it is in normal developing monolinguals. So that is why you will see and you can expect that lateralization of bilinguals would be slightly more bilateral as opposed to exclusively unilateral or left hemispheric in most monolinguals. So this is what I wanted to sort of talk to you about in this lecture. I'll meet you in the next lecture with more about language lateralization in bilinguals. Thank you. .