**Psychology of Bilingualism and Multilingualism**
**Professor Ark Verma**
**Dept. of Cognitive Sciences**
**IIT Kanpur**
**Week - 06**
**Lecture – 28**

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 and we are talking about the bilingual brain. So far, we have reviewed the areas of the brain implicated in language processing mainly in monolinguals.

However, researchers have actually asked the question that whether these same areas are implicated in the processing of a bilingualist both languages or whether there are different brain areas that take care of their two different languages. Some insights about the same can be actually gained by looking at a pattern of brain lesions causing aphasia. If both languages of a bilingual are subserved by the same regions, damage to these regions would adversely affect both the languages of a bilingual. On the other hand, if the two languages of the bilingual are subserved by different brain areas, then damage to these brain areas would selectively affect only one of the two languages of the bilingual.

Indeed, Scoresby Jackson in 1867 has documented the case of a bilingual aphasic patient who displayed a selective loss of only one of his or her language following brain injury. This finding led to the proposal that both the languages of a bilingual are actually stored in different regions of the brain. Basically, the author proposed that the native language of the bilingual is stored in the Broca's area whereas the later acquired language is stored in a region anterior to the Broca's area. However, this theory was later rejected by Pitres in 1895. More specifically, Pitres proposed that there are four areas of the brain that support language, namely two sensory centres for auditory and visual images and two motor centres for graphic and motor phonetic images.

Further, he proposed that the selective loss of one language would actually imply that the four areas corresponding to one of the two languages are selectively damaged accidentally basically, but the four areas corresponding to the other language are selectively intact. They seemed highly infeasible and therefore, this theory was sort of rejected on the ground of not being very feasible. As an alternate explanation, however, Pitres proposed that this other language was not really lost but rather had just become unavailable due to the functional impairment. More precisely, he hypothesized that the second language was actually inhibited because of the mere inertia of the language centres. It is probable that due to some kind of shock or injury to the brain, the second

language has gotten inhibited to a certain degree and is becoming much more difficult to sort of switch on or activate.

Indeed, in concurrence with this suggestion, patient studies have actually shown that bilingual physics gradually recover the lost language within a period so short that it seems unlikely that they would have relearned the language. Rather, it is more plausible that they would have rediscovered the language in their linguistic repertoire. Alternatively, the selective permanent loss of one of the bilingual languages could also be explained in terms of permanent inhibition of one of the two languages of the bilingual. Again, different factors about the two languages can actually be responsible for this. The view that bilinguals two languages are supported by different areas of the brain therefore was not really supported by later studies and researchers therefore gradually moved away from this kind of a question.

Consequently, the focus of researchers actually shifted to questions pertaining to the factors that may determine the exact recovery pattern exhibited in the patterns exhibited in the patients of bilingual aphasia. For instance, the age of acquisition of the two languages, the frequency of use of the two languages, also the relative proficiency of the bilingual in these two languages. These factors could actually determine the nature of recovery of bilinguals that are available. Also with the advent of the non-invasive brain imaging techniques that allowed researchers to look into the workings of the bilingual brain, the questions further shifted on to whether and how the two languages in the bilingual brain are lateralized. Incidentally, while there have been a large number of studies on the topic of language lateralization in bilinguals, the results from this same have been rather mixed and confusing.

So much so that Paradis actually had to conclude that almost a decade's worth of work on bilingual language lateralization was not able to advance the knowledge of the scientific community one bit. Further likened to this enterprise of discovering the causes of or patterns of bilingual lateralization to the search for the mythical Loch Ness monster, which everybody thinks it is, but nobody has an idea whether it actually exists or not. To put this research on bilingual language literalization into perspective, Vaid and colleagues conducted two seminal meta-analyses on a bunch of lateralization studies and noted that the large variability in the result could be accounted for by factors like the variability in part-time characteristics as well as the kind of paradigms and the tasks that have been used across these studies. For example, Vaid and colleagues identified the five most common hypotheses about the lateralization of the brain in bilinguals, which were examined through these meta-analyses. Let us look at these five hypotheses.

According to the L2 hypothesis, the right hemisphere is more involved when bilinguals

are processing their L2 than when they are processing their L1. But when they are processing their L1, the left hemisphere is involved to an equal extent to which it is involved in monolinguals. So the idea is that it is the second language which actually forces the brain to recruit the right hemisphere, whereas if it is only the first language, typically the left hemisphere would be enough to manage this task. The balanced bilingual hypothesis. The balanced bilingual hypothesis actually proposes that during language processing, proficient bilinguals actually exploit their right hemisphere more than monolingual participants.

And this holds for both of their languages. So in case you are a balanced bilingual, let's say I am a balanced bilingual, I speak both Hindi and English equally fluently, it would seem that I am more bilaterally organized with respect to my language function as goes to somebody who speaks only one of the two languages. The third hypothesis that was considered across a large number of studies was the stage of L2 acquisition hypothesis. Basically it says that during the initial stages when you are first learning a second language, the right hemisphere is relatively much more involved in processing their L2 and it is only with time as a person gets more and more adept in their second language, the involvement of L1 increases with increasing L2 fluency. Fourthly, the manner of L2 acquisition hypothesis is also an interesting one.

It basically says that if you are learning an L2 in an informal setting in naturalistic context while talking with interlocutors and without formal instruction, then the right hemisphere is more involved in comparison to when you are learning the L2 in more formal settings. Lastly, the age of acquisition hypothesis. The age of acquisition hypothesis actually proposes that if L2 and L1 are acquired close in time to each other, almost in the cases of like early bilinguals, they will show a similar pattern of lateralization. However, if the two languages have been acquired apart in time from each other, they might actually show a slightly divergent pattern of lateralization as would be expected for late bilinguals. Now Vaid and colleagues actually conducted a meta-analysis of 59 studies and suggested that overall if you sort of look at these studies, language lateralization in monolinguals and bilinguals is very similar.

And the left hemisphere is the dominant language processing hemisphere in both groups of individuals. However, when they zoomed in and looked at the meta-analysis more closely, they found that the age of acquisition actually moderated the pattern of lateralization, but the level of L2 proficiency actually did not. In that sense, early bilinguals showed less left hemispheric lateralization and more bilateral involvement than the late bilinguals. However, this was not really a perfect, not really a very intuitive finding and something that could not be easily explained. And therefore, Hull and Vaid actually conducted another meta-analysis which sought to shed more light on the

phenomena and addressed a few shortcomings of the previous meta-analysis at the same time.

In their 2006 study, they included 23 studies encompassing directly a monolingual and bilingual comparison. And they also looked at some variables very specifically such as the language experience, whether the individual was monolingual versus bilingual and how long and so on, experimental paradigm used and within the bilinguals, their L2 proficiency, whether they were highly proficient or low proficient, the age of L2 acquisition, whether they were early bilinguals or late bilinguals. Typically they looked at three types of experimental paradigms that are typically used to examine lateralization. For example, the dichotic listening paradigm, the techestroscopic viewing paradigm or the visual half-real paradigm and the verbal manual interference task or the dual-modality dual-task paradigm. In this meta-analysis, some new findings actually emerged.

First, different patterns of lateralization emerged from the three experimental paradigms. Re-affirming paradigms claims that the differences in the experimental findings may actually have been due to the shortcomings of the paradigms used. Now remember, all these three paradigms are sort of touting to explain about language lateralization. And if they are actually giving disparate results about language lateralization, it basically seems that either one or all three of these paradigms are not actually very valid and they are not all measuring the same thing. This can be a source of a lot of confusion among scientists and which is something that emerges very clearly out of this review.

Another very important finding that came out of this meta-analysis was that early bilinguals who were all fluent bilinguals actually showed bilateral hemispheric involvement even in their L1 whereas late bilinguals actually were left hemispheric dominant and their performance did not differ from monolinguals. This is again slightly counterintuitive and also slightly counter slightly contradictory to the results we have seen so far. Finally, when age of acquisition of participants was matched, there was no difference on the effect of L2 proficiency on lateralization. So again, that part is there. The most interesting finding, however, from the second meta-analysis was the fact that early bilinguals seemed to be more bilaterally organized or localized than monolinguals who spoke only one language.

This finding compelled the authors to note that there must be something special about early exposure to multiple languages which is affecting the organization of languages in the brain or the lateralization of the bilingual or multilingual brain. Now given that the current meta-analysis was actually designed specifically to investigate the pattern of lateralization of the bilingual's first language, hypotheses about the lateralization of the

second language could not be tested in detail. For example, it could not be tested whether the right hemisphere is more involved in the processing of L2 or whether it is more involved during the initial stages but not in the later stages and finally it could also not be tested whether the early bilinguals had the same lateralization pattern for both their languages as opposed to late bilinguals. Now just to summarize the findings from these two meta-analyses, we can actually raise questions regarding the validity of the paradigms that are measuring the lateralization of bilinguals which certainly needs to be detailed looking into. Further, also in line of Paradis original argument, most of the studies investigating the lateralization of language function in bilinguals had actually used isolated words as stimuli.

According to Paradis, these stimuli were least suited to actually tap into the pattern of laterization in bilinguals because they do not appropriate the other more nuanced characteristics of language performance such as phonology, morphology, grammar and the vocabulary of an individual. Finally, the meta-analysis also revealed that while the three paradigms may not be suited very well to actually reveal the inter-hemispheric differences in language processing, they are actually also not very well suited to reveal inter-hemispheric processing of language in the bilinguals. So essentially we are sort of left with a confused or a mixed signal about the laterization of languages as far as bilinguals or multilinguals are concerned. For this reason, let us turn towards neuroimaging studies and see if they can provide us a little bit of more insight into these phenomena. Now one of the first questions that was pondered about by neuroimaging researchers was that whether the age at which the bilingual speaker is exposed to the second language actually affects their cerebral local organization.

For this reason, Kim and colleagues tested a group of early bilinguals exposed to the two languages during infancy and a group of adult late bilinguals who were first exposed to an L2 only in their early adulthood. They used the functional magnetic resonance imaging technique and sought to analyze the data from the Broca's area in the left inferior frontal gyrus and the Wernicke's area in the left superior temporal gyrus. Participants were tasked with silent generation and to describe the events of the previous day. As far as results go, an interesting interaction between age of acquisition and the pattern of brain activation was observed. For example, in early bilinguals, the two languages gave rise to activation in the same sub-region within the Broca's area whereas in late bilinguals, the L1 and L2 activated neighboring regions within the Broca's area.

However, the two languages of both early and late bilinguals activated the same region in Wernicke's area. So as far as production is concerned, there might be some kind of anatomical separation between the two languages and as far as cooperation is concerned, there is no difference between the organization in the Wernicke's area. Now this spatial

separation between the two languages in the Broca's area is in late but not early bilinguals actually led the authors to conclude that the age of language acquisition affects the functional organization of language in the brain. So the idea is that the age at which an individual is exposed to the second language actually has some kind of consequence for the organization of languages in the brain. Remember that a similar conclusion was also drawn from a recent trilingual study in which the analysis were focused on Broca's and Wernicke's area.

In this study, it was observed that in early bilinguals, even a third language acquired late would activate the same regions as the two early languages would do. So again, when you're talking about production, there seems to be a slight separation, but when talking about comprehension, there is pretty much the same areas of the brain getting activated. Now these results are also further contested by later neuroimaging studies. For instance, Chee, Tan and Thiel actually examined brain activation in early and late Mandarin English bilinguals while they performed various silent word generation tasks in response to various cues. Chee and colleagues focused their analysis not only on the Broca's and Wernicke's areas, but also other areas both in the left and the right hemispheres.

They actually found that word generation in Mandarin and English in early and late bilinguals alike around the same pattern of brain activation involving the dorsolateral prefrontal areas and the supplementary motor area and the occipital and parietal regions in both the hemispheres. Such a common and overlapping activation pattern for the two languages is especially noteworthy given the fact that Chinese and English actually use different writing systems and we've already seen that reading Chinese characters actually includes a different region of the brain as opposed to English alphabetic symbols. In agreement with these results, Illes and colleagues actually reported very similar patterns of activation in left and right frontal regions when adult fluent late English Spanish bilinguals were actually asked to perform semantic categorization tasks on a series of visually presented words. For both English and Spanish words, the activation in these areas was found to be larger than the activation observed when in a separate control study non-semantic decisions had to be made. So when comparison is required, then also similar pattern of activation is being observed.

Also a pattern of converging activation in largely the same brain areas for different languages has been demonstrated for multilingualism in a separate study conducted by Vingerhoets and colleagues in which Dutch, English and French trilinguals all relatively fluent in these languages were made to perform a word fluency task, a picture naming task and a reading comprehension task. So you can see the neuroimaging studies are actually more coinciding about the same areas of the brain getting activated in bilinguals

and multilinguals. Now researchers have basically wondered about the cause of such a different pattern of results between the studies and especially they have sort of wondered about the reason of the variability in the effects of age of acquisition in patient studies as opposed to neuroimaging studies. Now one of the causes of these deviant results might actually be the nature of the different tasks. See, as we have seen and Paradi has pointed out that the task, different kinds of task demands in the different kinds of requirements placed by these different tasks may actually be responsible for the varied results.

Also it must be noted that different kinds of tasks tap into different specific aspects of language which may create the variability in these findings. Another aspect that could have contributed to the variable results was the level of proficiency that was attained by the participants in these studies, especially the late bilinguals. Perani and colleagues for example have hypothesized that the differential activation of several brain regions during L1 and L2 processing that they had observed in an earlier study might actually have been due to the fact that the participants in that earlier study had not only been late bilinguals but were at the same time not very proficient in their L2. Now in order to get a bit more clarity regarding this issue, Perani and colleagues next manipulated the age of acquisition variable by keeping proficiency level constant. The task to be performed by the participants was listening to stories as in the earlier study.

However, in this iteration of the study, not only the early but also the late bilinguals actually showed similar activation patterns for the two languages and that led to the conclusion that attained proficiency is actually a more important determinant than age of acquisition with respect to cortical representations or cortical organization. Further reviews of studies that employed both comprehension and production tasks at both word and sentence level have actually shown that generally attained L2 proficiency is actually a stronger determinant of the cerebral organization of languages than age of acquisition. However, the authors have actually also conceded that the grammatical processing may be an exception of this general conclusion because at least in one study, a high level of L2 proficiency did not preclude the occurrence of an age of acquisition effect when participants were performing a grammatical judgment task. So this is all about lateralization of languages in bilinguals that I wanted to talk to you about. I will meet you in the next lecture with more information about the bilingual brain. Thank you.