Psychology of Bilingualism and Multilingualism
Professor Ark Verma
Dept. Of Cognitive Sciences
IIT Kanpur
Week - 07
Lecture – 34

Hello and welcome to the course introduction to the psychology of bilingualism and multilingualism. I am Dr. Ark Verna from the department of cognitive sciences at IIT Kanpur. This week I am talking to you about bilingualism and its relationship with other cognitive functions. We have talked about bilingualism and its relationship with language and thought. In this lecture, I will basically be talking to you about bilingualism and executive control.

Are bilinguals actually good at executive control? Now in the previous lectures, we have actually reviewed some of the advantages associated with being a bilingual. However, one of the most studied hypotheses that affects the, you know, that basically talks about the effects of bilingualism on other cognitive functions has been the fact that due to their practice with managing the two co-activated languages, bilinguals actually become better at tasks that require executive control. What is executive control? Now before we sort of go into the discussion in this lecture in understanding executive control, executive control is basically a set of functions that is mainly handled by the frontal regions of our brain, the DLPFC, the dorsal lateral prefrontal cortex, the anti-singulate cortex, the caudate nuclei and so on. So there are three or four regions that have been identified that take care of these, you know, the functions clubbed under executive control.

But what is this executive control? How do I explain this to you between layman terms? Now if you see in several situations, there are, you know, instances where you have to go for something or, you know, restrict yourself from something. Say for example, while you've just finished your dinner and you sort of are passing by, you know, you're taking a walk, you know, at night, an ice cream seller passes by. Now you know that you've had your dinner, you've had your whole coat of calories, but there is this, you know, very nice ice cream seller that is passing by and you're sort of tempted to, you know, go for this ice cream. Now in this case, you know, some of us would be able to suppress our urge to have an ice cream and some of us will not be able to do that. This whole capability of suppressing a particular kind of response and selecting another response is one of the examples of cognitive control.

There are other ways also of looking at it. Say for example, being alert to new information, being able to orient to new information and being staying, you know, focused at it. All of these cases where say for example, there are two possible responses and you have to give only one. See bilinguals have to do this all the time. Whenever I am presenting to you, let's say any picture of an object and say for example, you know, my favorite example, I show you a picture of an apple, you have two possible responses to give.

You have the, you know, idea of taking the word sab in Hindi or saying the word apple in English. There are always two possible responses to any concept that you are talking to with a bilingual and what the bilingual actually has to do is he has to manage one of these two, suppress the irrelevant response. Say for example, if I'm talking to a purely Hindi speaking individual, I have to suppress the name apple and I have to activate the name, you know, saeb and say it. Remember, we've been talking about the language control system in the previous week and we have seen that this language control system is very necessary. It is very important in order for a bilingual to be able to speak or manage their two languages without interference from the other and this is something that is, has been a very important area of research amongst a lot of researchers, most notable of them being Alan Bialystok and her colleagues who've actually worked in this area over a couple of decades, probably more than that and have examined various aspects of this topic.

Now, one of the most popular tasks that have been used for some of these experiments was the Simon task. Now, Simon task is actually a perceptual motor task that seeks to assess a participant's ability to inhibit or ignore irrelevant spatial information and it is basically a skill that requires a lot of executive control. The idea is participants are seated in front of a computer screen where the stimuli, for example, squares in different colors are present. Say for example, you could be present with a red square or a blue square or a green square and let's say, let's go with blue in it. So if you are presented with a red square, you have to press with your right hand and if the red square is presented on the right side of the screen, you have to present with your right hand.

If a red square is presented on the left hand of the left side of the screen, you have to present with your left hand. Now, there is this stimulus response mapping that is established. So if you see this color of a square presented on that side of the screen, you have to press with your, you know, this hand. If it is this color of a square presented on that side of the screen, you have to press with your this hand. Now, in some cases, the response, the situation will be coherent.

So a blue square will actually be presented on the right side and you can press the key on with your right hand. But in some cases, the blue square could be presented on the left side of the screen and then you have to present with your, you know, other hand and this response mapping, its congruence and its incongruence is actually the challenge in this task. It is because of this variable response mapping that can actually happen and that there could be a congruent response and there an incongruent response, a correct or an incorrect response possible because these stimuli are bivalent. They basically can be responded to with their left hand or their right hand depending upon which side of the screen they are happening. So the instruction for the participants here is to press a key on the left side of the keyboard if the blue square is presented and the right side if the red square is presented.

So depending on the color of the square. So this is something that really tests the participants, you know, executive control, their correct selection of response and their correct inhibition of a particular response. Now obviously in this task, overall the congruent and incongruent trials are presented in a random unpredictable order. Typically, what has been observed is that incongruent trials lead to longer response times and more errors and this effect has been known as the Simon effect. This effect has been referred to in literature as the Simon effect.

Now obviously initial studies have actually shown that bilinguals are somewhat better at general executive control, general intelligence and even metalinguistic tasks as we have seen so far. But the new set of studies that basically was undertaken initially by Alan Bialystok actually wanted to test whether this advantage in general intelligence extends to non-linguistic domains as well or non-linguistic aspects of executive control as well. Now more similar questions were raised about whether the advantage so far observed with young balanced bilinguals would extend to bilinguals of different age groups. People were also interested in knowing whether bilinguals could also provide a defense against the normal cognitive decline that is observed in, you know, frontotemporal dementia, Alzheimer's and so on. Finally some of the interesting questions, some of the questions that people were interested in also had to do with that what is the neural basis of this language control system of this, you know, executive control system that inhibits irrelevant information.

Some of the answers by the way if you see we have talked about in the chapter on the neuroscience of bilingualism and the brain. Now across a range of studies that actually employed this Simon task with bilinguals, a smaller Simon effect was observed in bilinguals as compared to monolinguals and the same was actually seen as the main marker of the more efficient inhibitory control amongst bilinguals. Also the researchers examined the bilingual performance over the whole task and bilinguals were expected to

be better in overall performance as well as as well compared to the monolinguals. Now to investigate these questions in more detail the initial studies by Bialystok and her colleagues you know matched monolingual children of different age groups with, you know, say for example young adults, middle-aged and older adults with groups of bilinguals in the same age groups and had both of them, I mean all of these groups perform the Simon task. So and in order to gain more detailed insight into the relationship between bilingualism and cognitive control in addition to the congruent and incongruent manipulation the researchers added three other types of manipulations as well.

For example, they wanted to when they wanted to investigate the effects of increasing memory working memory demands in the Simon task by they added a condition with four rather than two colors and instructed the participants to press the left hand key in reply of two of these colors. For example, you could have red, green, blue, orange squares and red and green have to be responded with one hand and blue and orange have to be responded with the other hand. Okay, so typically now what is happening is instead of remembering the mapping of one color with one respond and they have to remember the mapping of two colors with one response hand and this obviously increases the amount of information that they have to maintain in their working memory. Basically what they are doing is they are actually placing more working memory demands in this task of executive control that these individuals have to perform during the Simon task. So you can say at the same time both executive control abilities and working memory capabilities are being tested at the same time.

Secondly, the researchers also included a control condition in which the color stimulus to be presented always appeared in the center of the screen. So basically you don't have to basically remember which side of the screen you know the square is being presented and it basically depending on wherever the color is presenting you have to present you know accordingly. So this manipulation was actually meant to rule out the possibility that a bilingual advantage was mainly due to the you know overall speed of the bilinguals or it actually had to do something with the you know better managing of stimulus response mapping in bilinguals as compared to monolinguals. Finally, the authors also sought to observe the effects of practice. They wanted to check if increased practice was the reason for the small Simon effect observed in bilinguals as opposed to monolinguals.

So the Simon task per se is a slightly complicated task and you add some of these manipulations on top of it and you make the task relatively more difficult or basically design it to test very specific hypotheses about how bilinguals actually perform in this given task. Now the combined studies which actually use the Simon task provided very clear and consistent answers to these questions. For example, to begin with accepting the population of young adults specifically university undergraduates among all participant

populations generally they actually showed reliably small Simon effects and or performed better overall on the Simon task than monolinguals. So all groups of bilinguals are actually performing better than monolinguals on this Simon task showing less disruption from misleading information and therefore better inhibitory control. Also the authors regarded the absence of an effect of bilingualism among undergraduate university students as a ceiling effect because they already have reached their peak of their performance and therefore they're not being able to show the better performance between bilinguals and monolinguals in this particular age group.

Secondly, bilinguals are actually less disrupted than monolinguals by an increase in working memory load. So not only they are being able to manage executive control relatively well, they are also being able to handle higher working memory demands at the same time. So it basically tells us that actually bilingualism is providing benefits not only in terms of inhibitory control but also in terms of handling larger working memory demands at the same time. Thirdly, as per the expectations aging was actually associated with less efficient executive control as evidenced both by relatively large detrimental effects of increases in working memory demands and by increasing the Simon effect along with age. So in older age groups you would see that performance of these individuals would be affected badly by increasing working memory demands and typically they were poorer as compared to younger adults in managing the Simon effect.

So the magnitude of the Simon effect was also found to be larger in these older adults. Fourthly, the negative effects of aging were found to be considerably smaller for bilinguals than monolinguals. Remember we were talking about the question that you know researchers were interested in knowing whether bilingualism can act as a shield for the detrimental effects of aging, for detrimental effects of normal cognitive decline that comes with age and here we see there is some evidence of the fact that bilingualism actually shields people from a normal cognitive decline as would be expected along with growing age. Fifth, in the majority of cases the possibility could be excluded that the beneficial effect of bilingualism simply concerned just a speed advantage that they are typically faster on everything. It actually focused on a very specific aspect of managing executive control, better response inhibition and better response selection that is actually leading to this disadvantage.

Finally, it was also shown that with extended practice the negative effects of increased working memory load was equally large in both groups and thus Simon effect was reduced to zero with increased practice in both groups. So it basically tells us that practice can be one of the factors you know between bilinguals and monolinguals but if you give equal practice to both then obviously bilinguals are performing slightly better. Now overall these findings if you look at them in totality actually constitute compelling

evidence that the same executive control capabilities involved in managing the two languages of a bilingual are also involved in other tasks that require general control even though those tasks will be non-verbal and the data from the working memory load experiments actually indicates that bilingualism also boosts working memory capacity for tasks that require executive control. All in all, if you look at these results collectively bilingualism actually seems to yield benefits across a larger set of studies and you know has an overall appeal to general executive processes. However, researchers have reasoned that if the beneficial effects of bilingualism are indeed the result of the use of a more general non-bilingualism specific control processes as initially the innovative control model had talked about if you remember that we were talking about you know whether this is a domain general or a domain specific effect expertise in other domains that exploit the same control processes should similarly affect performance in the Simon task and this is what you know Bialystok and colleagues wanted to test in 2005.

So what did they do? They divided a group of young adult college undergraduates into a subgroup of youngsters who spent much more time playing video games as opposed to a group who played very less time who spent very less time in playing video games. Again when they compared these groups and their performance on the Simon task the results were pretty clear. Performance on the Simon task was significantly better in the group who played video games more frequently than in the group who played video games slightly you know very less. So it basically tells us that performing you know any kind of practice with executive control abilities even if it is just playing video games actually improves executive control. In some sense you can actually connect this to the fact that any task bilingualism or you know bilingualism which is language specific or non-verbal task which actually provides some practice with executive control will have a similar beneficial effect on individuals executive control capabilities.

So while the results from the Simon task have actually supported the notion that bilinguals do have a certain advantage with respect to their abilities of executive control in order to get a even better and even deeper understanding of the underlying issues researchers have also started comparing the performance of monolinguals and bilinguals on other tasks that may allow the measurement of different aspects of cognitive control. For example, Martin Rhee and Bialystok in 2008 administered the Simon task along with the Stroop-Lite task which is a day-night task wherein the participant monolinguals and bilingual children of around four or five years were asked to say day to a picture of a you know moonlit sky night sky and night to a picture of a bright sunny day. So basically you have to see pictures of day and say night you have to see pictures of night and say day and again see this is a case where a certain degree of response inhibition is required and the performance can be compared on two tasks which are measuring similar kinds of things so it would provide a sort of a cross correlation of whether the same abilities are

being tested or not. What did they find? The day-night task obviously efforts the researchers to examine their participants ability for response inhibition as opposed to the Simon task which is better suited to study interference suppression and bivalent stimuli. So here you can see that the demands in the two tasks with they are typically broadly in the same domain they are both exudative control tasks but the most specific aspects of exudative control are actually different in these two tasks which are being tested in the study.

Interestingly in the current experiment the bilingual advantage was observed only on the Simon task but not in the day-night task. So which led the authors to actually assume that bilingual children are better than monolinguals on tasks that require attention to be selectively directed to specific cues and in conflict resolution where but not on tasks that actually elicited a habitual response you know something that is very very over learned looking at pictures of day and same day is something that they have habitually learned and in this case there is no bilingual advantage that they are observing. Moreover, these results also pointed out that the selective advantage of bilinguals results actually from a practice and attentional control that they gain from managing the interference from their two co-activated languages which gradually transfers to increased levels of exudative controls in similar non-verbal tasks like the Simon task. Now obviously similar conclusions could be reached from a study that measured the general scope of bilingual advantage by administering a much larger battery of tasks in nine tasks in all and which were all hypothesized to index some different aspect of executive control although all of these nine tasks involved some type of inhibition. Now Carlson and Meltzoff actually conducted this study on three groups of kindergarten children among which they were the three groups were a group of Spanish-English bilingual children who had been exposed to both languages since birth another group of L1 English children who attended an immersion elementary school where they received instruction in English for half the time and either in Spanish or Japanese for half the time so these are mixed groups and a control group of L1 English children who attended traditional schools you know receiving only English education.

Now despite the fact that the children in the bilingual group had relatively lower scores on a test of verbal ability and had parents coming from relatively lower educational levels their scores on the all of these tests were actually equivalent to the scores of the other groups however interestingly when the verbal ability and parental education level were statistically controlled for the composite executive functioning score for the based on all the nine tests actually showed superior performance for the bilingual group as compared to other groups so you can say that while initially you know the the differences could have been because of lower parental educational level socioeconomic status and so on but you actually when you control for them and basically just are looking for differences in

executive control the bilingual group is actually performing much better than the monolingual group the performance in the immersion and control groups however did not really differ from each other so that is also something to consider now each of the individual tests when you start zooming in when you're looking at each of the individual tests actually suggested an advantage for the bilingual group but it was statistically significant only a small number of you know tests wherein the shared feature of these subsets or subtests was that they shared the property of inhibition of attention to misleading contextual information so here we are seeing that while you know you can talk about a degree of general executive control advantage the actual advantage is in a very specific ability of inhibiting misleading information wherein the bilinguals actually shine and outperform you know correspondingly matched monolingual groups now this pattern of results was further confirmed through the results of a factor analysis that was conducted on this data of all the nine tests which revealed two distinct factors that the researchers interpreted as measuring the children's ability to manage conflicting attentional demands and the ability to control impulses the bilingual advantage so there are these there are these two factors first is managing conflicting attentional demands the second is ability to control impulses you know now the bilingual advantage was however found to be limited to the first of these two factors which is managing conflicting attentional demands but not in the ability to control impulses so if you look at this in totality in conclusion it appears that the bilingual advantage does not apply generally to all situations that require inhibitory control but to only circumstances wherein distracting information must be inhibited or ignored which is analogously similar to you know for similar to the bilinguals task of inhibiting or suppressing their non-target language also another caveat from these findings was that the extent of the bilingual advantage actually depended upon the degree of bilingualism how proficient in both the languages these bilinguals were how early they had started learning both the languages and so on now while it was established that a certain degree of bilingual advantage actually exists in younger children we can also look at you know studies investigating whether the advantage exists in younger adults and older adults and so on so one of the first studies that we could talk about was conducted by Costa and colleagues who tested young adults all highly proficient spanish-english bilinguals they compared their performance with spanish monolinguals matched with these bilinguals on age and educational levels the participants actually perform the ANT task or the attentional networking task which was developed by a fan and colleagues and which is designed to reflect three types of attentional processes executive control which is basically performance or of performance monitoring and conflict resolution alerting to basically becoming and staying alert and orienting basically orienting and selecting a subset of information from the input now before i go on to describe this task you can imagine the ANT task as a task having five arrows on the screen the central arrow could face towards the left or towards the right whereas the flanking two arrows on this side and two arrows on that side could be facing

on the opposite side to the central arrow or on the same side to the central arrow basically the task of the individuals is to base to respond to the direction of the central arrow while ignoring the distracting information that are being provided by the flanking arrows in this sense basically the ANT task provides a very interesting and a very highly high high resolution test of their executive control abilities if you want to read more about it you are welcome to read the fan your fans paper wherein it talks about the different nuances of this task for the scope of this lecture and sort of limiting myself to just this very small description of this task now in line with the results of bialystok and colleagues which were gained through the simon task the bilinguals actually suffered less interference from incongruent flangers than the monolingual participants suggesting that they actually had better abilities of conflict resolution in the face of misleading information the bilinguals were also found to be overall faster than monolinguals also it was seen that bilinguals could make better use of alerting q than the monolinguals suggesting that the alerting mechanism works much better in bilinguals as opposed to monolinguals so while the fans ANT task actually provides a highly resolved way of looking at the different aspects of executive control in terms of executive control alerting and orienting here you can see that there is a very significant difference in bilinguals and monolinguals on very specific aspects of this task which again sort of conquers with the evidence that we have been seeing so far another study with adults was conducted by colzato and colleagues who investigated the nature of bilingual advantage by comparing two manners of cognitive control remember we talked about proactive and reactive control proactive and reactive inhibition when we are talking about language control let's just recap it a little bit so the active inhibition is supposed when the central control system is directly inhibiting or deactivating memory nodes associated with the non-target language whereas reactive inhibition is supposed to operate if the current goal let's say for example the intention is to speak in english actually boosts the activation in the memory nodes representing the target node so basically you are indirectly boosting the activation of the target language and through lateral inhibition suppressing the you know nodes from the non-target language so Colzato and colleagues actually wanted to basically compare active and reactive inhibition in this task now according to this view inhibitory effects actually do not result from actual inhibition exerted by an inhibitory control system but from a control mechanism that works through facilitation Colzato and his collaborators actually examined the nature of bilingual advantage by comparing the performance of adult balanced dutch english bilinguals and spanish and spanish monolinguals on the three non-verbal cognitive control tasks that according to the authors differed from one another in the type of inhibition mechanism that they appealed to based on the results the authors concluded that the bilinguals performed better than monolinguals in maintaining action goals which basically involved activation in the goal relevant memory representations so again what we can see is that bilinguals are obviously you know showing some kind of a beneficial advantage as opposed to monolinguals when it comes

to you know the very specific aspect of inhibiting irrelevant information so all in all it can be concluded that if you look at both the child studies and adult studies it clearly suggests that bilingualism brings superior cognitive control that is manifest from early childhood and last up till adulthood this is what i wanted to talk to you about in this lecture i will see you in another lecture with more about bilingualism and other cognitive functions thank you.