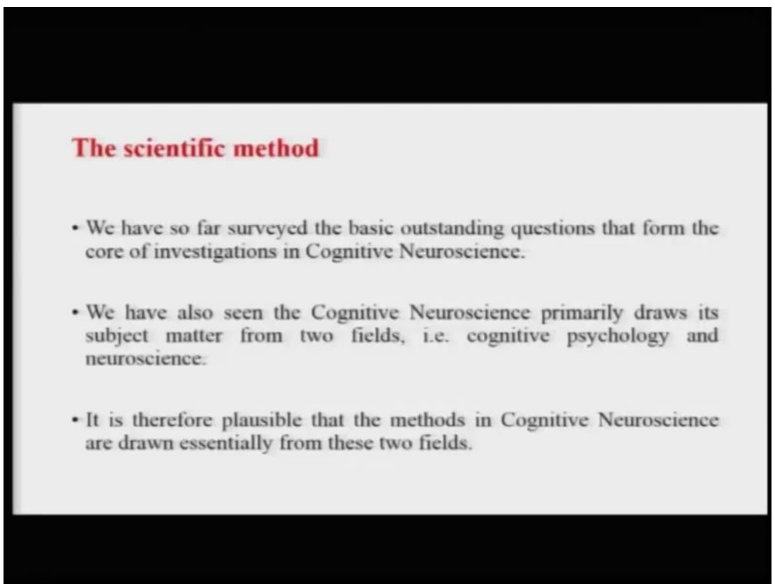
Introduction to Brain & Behavior
Professor Dr. Ark Verma
Department of Humanities and Social Sciences
Indian Institute of Technology, Kanpur
Lecture-07
Methods in Cognitive Neuroscience

Hello, and welcome to the course Introduction to Brain and Behavior. I am Dr. Ark Verma from IIT Kanpur. This is the second week of the course and we will be talking about we begin to talk about some of the basic methods that are used in cognitive neuroscience in today's day, and how these methods help us answer some of the interesting questions and hypotheses about the functioning of the human brain.

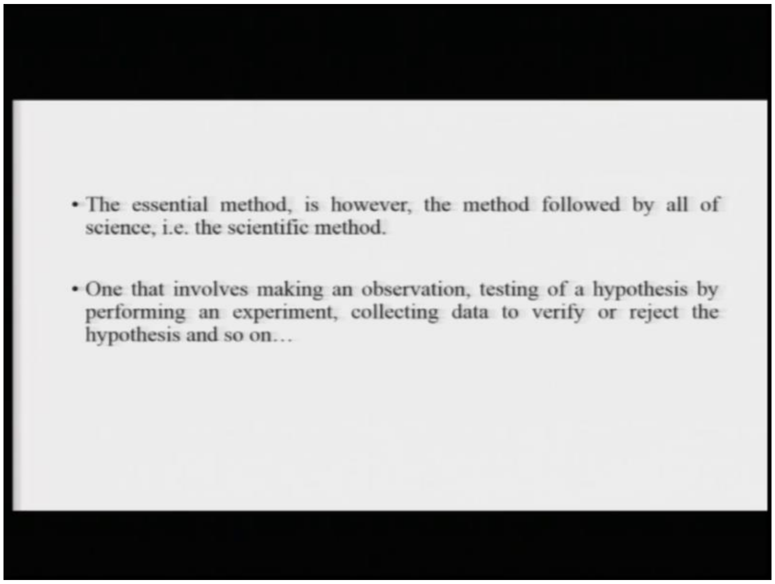
(Refer Slide Time: 0:37)



Now, the generic method in cognitive neuroscience or in any science for that matter is referred to as the scientific method. I have talked about the scientific method in a course on cognitive psychology in basic cognitive processes in a lot of detail. So I'll not go there again, if you want to really read a little bit about it, you should go and refer to those lectures.

But let me give you a very brief idea of what the scientific method would be. Now cognitive neuroscience as why we were making up the definition, we saw that it would derive from cognitive psychology as in cognition and it would derive from the methods which will be used in neuroscience. But the generic method is the same, is the basic scientific method, which has a few a few steps and a basic generic cycle that is very very essential. So, if you remember the hypothetical deductive model that we talked about.

(Refer Slide Time: 1:33)

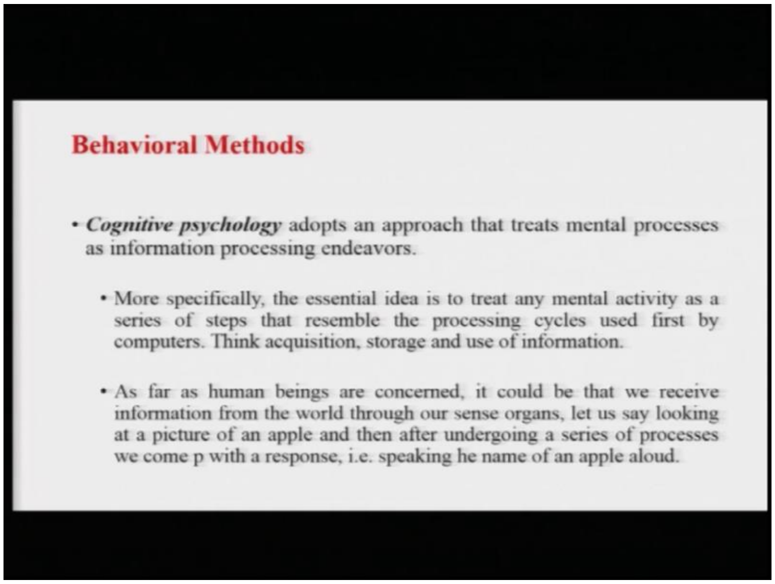


It basically begins with making observations. Once you have made some observations, you can say for example, okay, so the basic method is, essential method is basically the hypothetical deductive method. And it basically involves, it begins with making an observation. Once you have made some observations, you can create some hypotheses, specific testable statements.

And then what you need to do is you need to conduct an experiment, conduct, devise a way to test these hypotheses. Once you devise this way, you will go out conduct this experiment, collect data. Once you have the data, you will analyze the data and analysis of the data will help you to accept or reject this hypothesis. Whatever the outcome be, the data that you have generated and the analysis that you have sort of done at the end, you will derive some conclusions from it.

Say for example, I believe that my data helps me accept this hypothesis or reject this hypothesis, that basically adds on to the existing body of knowledge and this is in a very short sense the idea of the whole process.

(Refer Slide Time: 2:35)



But predominantly, let us now talk about the specific methods that cognitive neuroscience is basically banking upon. So cognitive neuroscience is heavily banking upon the methods which it derives from cognitive psychology.

And we will first talk about the behavioral methods. Now cognitive psychology, if you, I mean I am sure you would have some idea of it or if you do not, let me give you an idea. Cognitive psychology predominantly looks at mental processes or at least classical or early cognitive psychology looks at mental processes mainly as an information processing endeavor.

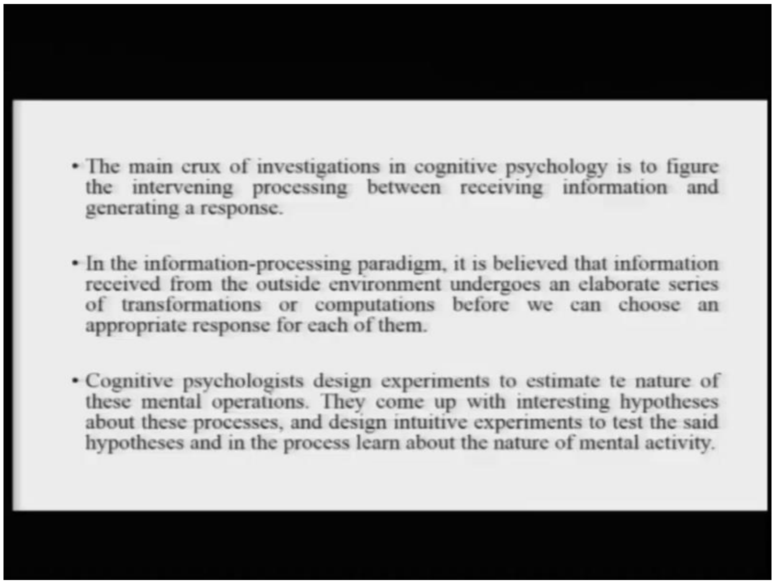
So, the idea is that the human brain must be performing these mental operations, must be performing these mental computations in the same way as the computer does, which is basically the information processing paradigm. And this paradigm will need to have certain steps and they will probably be a processing cycle, which is obviously as I said, resembling to borrow from the metaphor of computers that is typically how cognitive psychology sort of begins around 1950s. If you remember the lecture where we were talking about a brief history of neuroscience, we have talked a little bit about that.

Now, what do these steps include? So, simple things like acquisition of information, storage or manipulation of information and then using that information to arrive at say for example, what is the responses that I want to generate? What is the specific responses that I will choose and I will execute. As far as human beings are concerned, it could be that we say for example, receive information from the world through our senses, we have five senses, vision, audition, touch, taste, smell. So, we are receiving this information from this outside world.

And then what is the next step? We need to do something with this information, we need to transform this information via these neural impulses to a sort of a representation where we can manipulate this and then we can, we will decide what do we need to really do about this information, what do what are we going to do?

And then eventually, we will need to come up with a response, say for example, I show you a picture of an apple and I asked you to name it. So, you need to go through this entire series of steps before you can actually name the apple, say for example, you look at the picture, you will visually analyze it, you will sort of compare it with something in your memory, you will say okay, I had known what this fruit is, I know the name. Now you will basically then you will you know assemble towards, assemble together the sounds that make up that name. And then ask your articulators ask your vocal apparatus to create that name. That is typically how this would work.

(Refer Slide Time: 5:27)

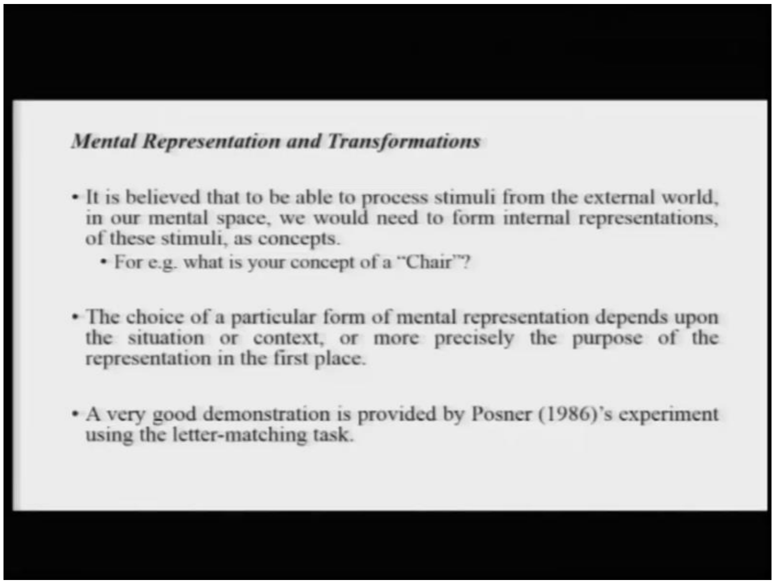


Now, the main crux of investigations in cognitive psychology is basically to figure out the intervening processes between receiving of information and generating of response. This is typically what cognitive psychology has been most concerned with. In the information processing paradigm, typically it is believed that information received from the outer environment undergoes an elaborate series of steps, elaborate series of transformations or computations before we can generate or choose an appropriate response for whatever stimulation is received.

Cognitive psychologists typically design experiments to estimate the nature of these mental operations. They keep coming up with the interesting hypotheses about this is how this process would be, this is how that process would be, and these mental processes, about the nature of these mental processes, and then the design intuitive experiments to test these hypotheses to accept or reject these hypotheses.

In this process what they do is they learn a little bit about the nature of mental activity, they learn a lot about how the mental activity, I mean different mental activities are linked with each other, how are they organized in the brain, and so on. Now, let us talk a little bit about these mental representations or transformations.

(Refer Slide Time: 6:37)



It is believed in, under the tradition of cognitive psychology, it is believed that to be able to process stimuli from the external world, which are physical stimuli, and the mental space is a metaphysical world, we need to perform this, we need to perform this conversion of the physical stimulus to a form that the mental space can talk about it, can manipulate it, store it work with it.

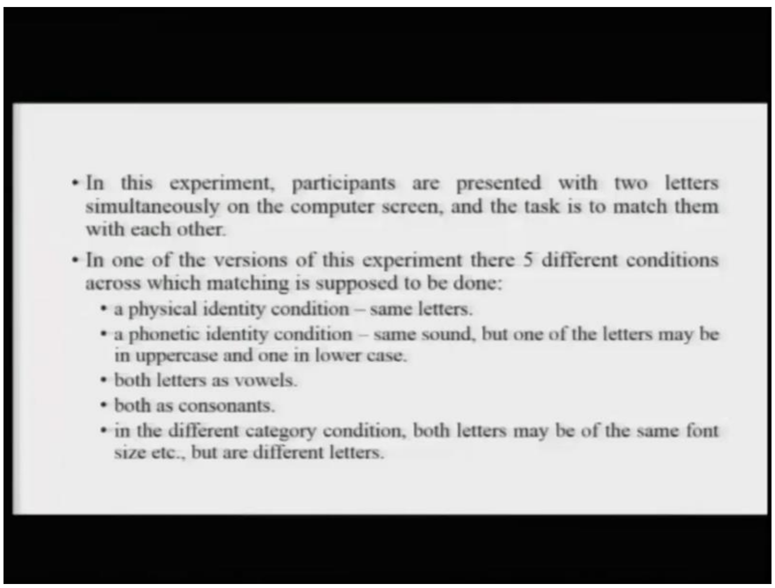
Again I have talked a lot about this in the course on basic cognitive processes, but let us say, let us discuss for the sake of an example. And if I show you a chair, if you say for example, think about the chair if you were asked to. You would have a representation of a chair, you will have a concept of a chair that a chair is something that affords you to sit, it should have some height, it should have some kind of a flat surface on which you can sit.

And then once you have this concept, you can apply that concept to many many different kinds of chairs, many, many different designs of chairs that are available sometimes even to objects that afford seating, but are not typically regarded as chairs in your daily life. So, there has to be some kind of way in which using which we can represent the stimuli in the outer world to our mental space. So, that is the first part.

And the choice of the kind of mental representation that you would have, say for example, whether you will have a visual representation, which will have the shape and the color etc, whether you have a audible sound-based representation, you could just have the sound chair in your head and on the basis of that you will generate all the information that there is to be generated.

Or say for example, you could have a different kind of a thing maybe, say for example, people who are congenitally blind usually will have a tactile sort of a representation of how things are. A very good demonstration of the fact that there can be different kinds of representation for similar stimuli is basically given, is discussed by Posner's experiment using the letter matching task. And in this task, basically the task of the participants is that they have to look at the screen.

(Refer Slide Time: 8:55)

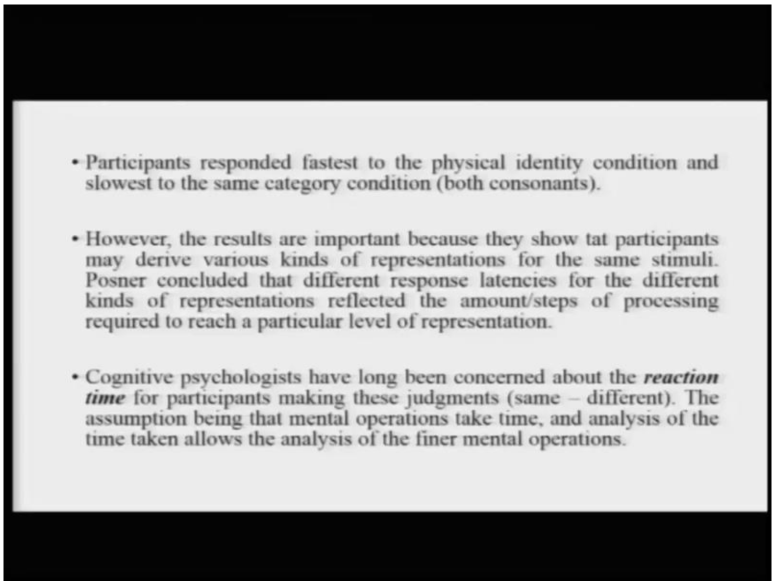


On the screen, they are presented with two letters adjacent to each other simultaneously and they have to see whether they, these two match with each other or not. If they match, you press a one key, if they do not match you press another key.

The interesting part is the design of this experiment which has around five conditions. It has physical identity condition which is the same letters in the same format. It has a phonetic identity condition, say for example, one of the letters is in uppercase, the other letter is in lowercase, so it could be a C and a small c, you have to sort of say that this matches.

Similarly, both letters are from the same category as vowels or consonants or it could be different category condition in which both letters may be of the same type size, font size, color of ink, etc, but are different letters, okay? So the participants sort of have to judge on what criteria things are similar and make these judgments.

(Refer Slide Time: 9:47)



What happens was it was found that participants respond fastest to the physical identity condition, because that is the shallowest and that is something most easy to compute and they are slowest to really answer in terms of the same category condition where you have to evaluate whether both are vowels or both are consonants.

So, typically, why is there a difference in the response times to these different kinds of conditions? The idea is that these results show that participants may be able to derive different kinds of different levels of representations for the same kind of stimuli, the letters that are, that are being used here.

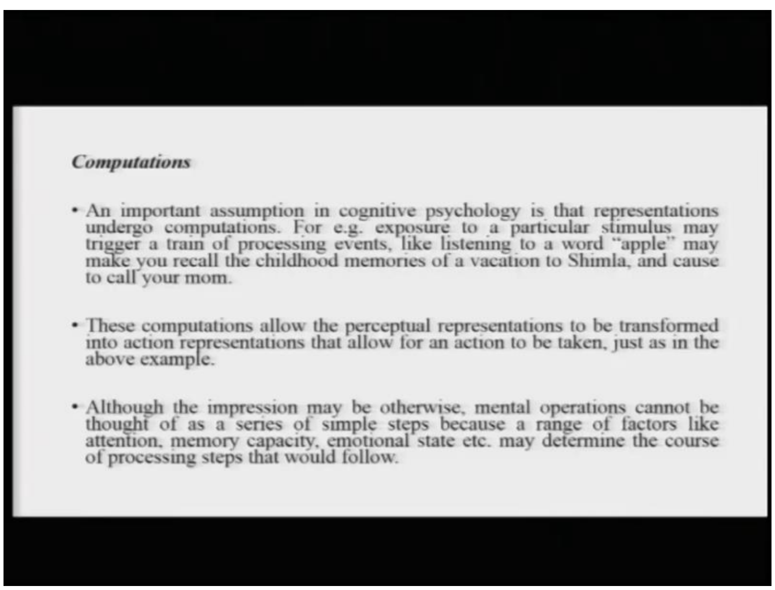
Cognitive psychologists have been concerned a lot with the kinds of representations we derive out of different kinds of stimuli, and how we sort of convert one kind of representation to into another kind of representation, depending upon what is the task at hand, what is, say for example, if I have to draw a visual impression, a visual representation would work best. If I have to speak, auditory representation would work best. So, this is something that cognitive psychologists have been sort of talking about and have been concerned about since a long time.

Another thing that cognitive psychologists have been doing and it is very very interesting is that they have been concerned about the reaction times, they have been concerned about the time it takes to perform each mental operations. I have briefly mentioned this in one of the earlier lectures in this course as well, that the time that the brain takes or the time that the individual takes in processing, a particular or menial stimulus or in performing a particular mental operation is of extreme importance.

It tells us to some extent the degree of complexity involved in performing a particular task. It also in some sense sort of tells us because these times are additive, it tells us that whether a task has just one process or a series of steps or series of processes. So cognitive psychologists have believed for the longest time that the analysis of the time taken in these mental operations is very very important, because it reveals a lot about the nature and the complexity of the mental operations that are involved.

So, this is also something that sort of gets borrowed in, in cognitive neuroscience and we will see a lot of that in the coming chapters.

(Refer Slide Time: 12:07)



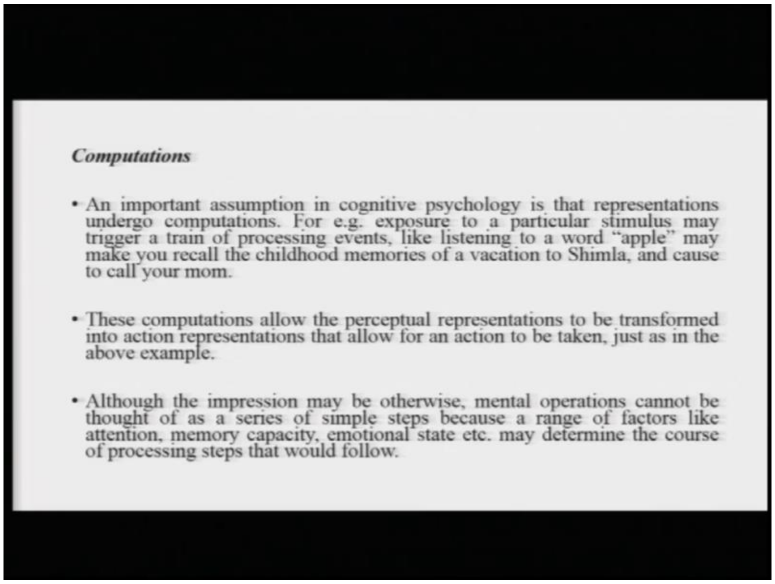
So we have talked the mental representations, let us talk about the computations or transformations that might be needed. Now an important assumption in cognitive psychology is that the representations that we derive out of the stimuli from the world will need to undergo several transformations or computations.

Say for example, if you are exposed to a particular stimulus, that, the that will lead you down a train of processing events, which basically say for example, let us take an example listening to what apple may make you recall your childhood, if you have been to an apple orchard during a vacation in Shimla and that because it could make you nostalgic and you could decide that, okay, need to talk to my mother, I need to make this call.

So just exposure to a stimulus can lead to several of these pressing events that may eventually cause changes in your behavior or lead to particular consequences. Now, these computations typically allow the perceptual representations to be transformed into action representation. So, here the picture of an apple could be a perceptual representation or the sound of the word apple could be perceptual representation.

But once that perceptual representation is taken in, it is processed, it is linked with memory, and it makes you recall some of the other things, it leads to a sort of an action-based representation or action representation, which helps you sort of decide or make the call to your mother.

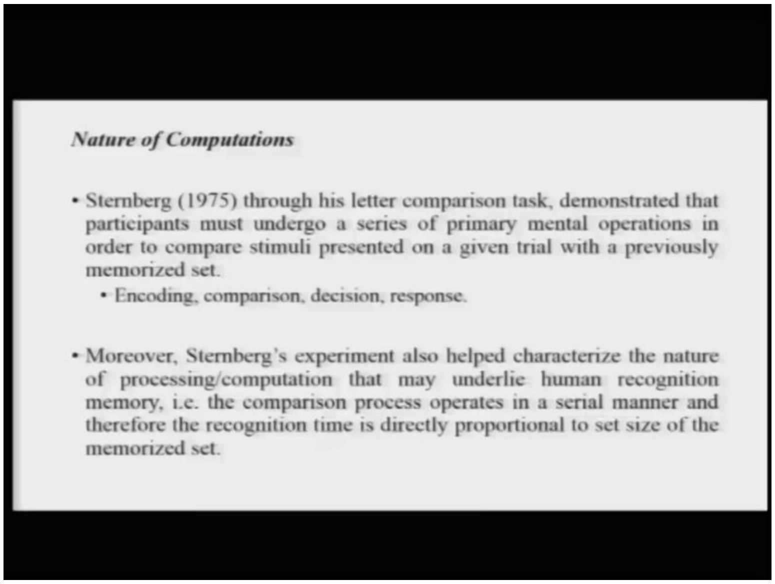
(Refer Slide Time: 13:35)



So, that is something that happens all the time and that is something which we will talk about in great detail going further. Now, although the impressions may be otherwise mental operations cannot be really thought of as just a series of simple steps, entirely a series of one comes after, one and then two and then three, it can also be thought of as, say for example, several operations in a cascaded fashion, sometimes in a parallel fashion as well.

So keep an eye out for that, we will, and keep an ear out of out for that, and we will sort of see how these processes are organized and linked to each other. And let us talk a little bit about the nature of these computations.

(Refer Slide Time: 14:12)



Now, Sternberg in 1975, through his very famous letter comparison task, demonstrated that participants must be undergoing a series of primary mental operations in order to sort of perform very simple tasks that we anyways do in our daily lives.

So his task was the letter comparison task and the idea was that he would firstly make participants memories a set of letters, and then later he would present the participants on the computer screen with separate letters. And the idea was the parliament had to sort of match that whether this letter presented on the screen was part of that memorized set or not.

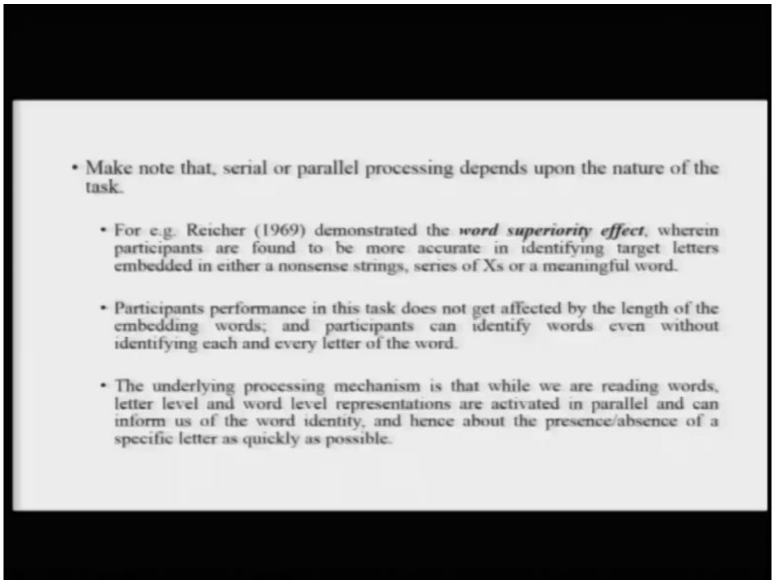
So this is basically what the participant has to do. Now this process basically would involve at least four different things that the participant will need to do in order to make the correct response. First, when the participant sees the letter on the computer screen, they will have to encode it, they will have to visually analyze it and encode it.

Suppose the letter is M, so I will have to visually analyze and understand, recognize that, okay, this is the letter M. Then I have to do a comparison with the letters that I have already memorized. So whether I suppose the letters were A, B, C, D and E or A, B, C, D, F, so I will compare M with these six letters and will try and come out with a decision whether this, this is part of that set or not. And then once I have made the decision that, yes, this is part of their set, or no, this is not part of their set, I will be able to make the decision, I will be able to press the key that the experimenter has asked me to.

This is a very interesting experiment, is a very simple but a very intuitively designed experiment. What it shows us is also a very interesting thing. Sternberg reasons when he actually finds out that basically the response times that participants actually take is directly proportional to the set size of the memorized set. If I have just memorized one letter, and there is one letter on the screen, the time is the least. If I have memorized two, the time increases, and it increases in fixed the number of, in fixed amount of time for each item that I keep adding to this memorized set.

So, in some sense, what it sort of tells us is that this process of comparison of this stimulus with the stimuli that I have in my memorized set is a serial sort of a process. I am comparing M with each of A, B, C, D, E and F. And that is basically what is taking up all sort of, all of this processing time that I am showing. So this is a little bit interesting, but here is a demonstration of the fact that you have to sort of undergo a series of computations, a series of steps in order to process a certain kind of information and perform these very simple tasks that you anyways do in your daily life.

(Refer Slide Time: 17:14)



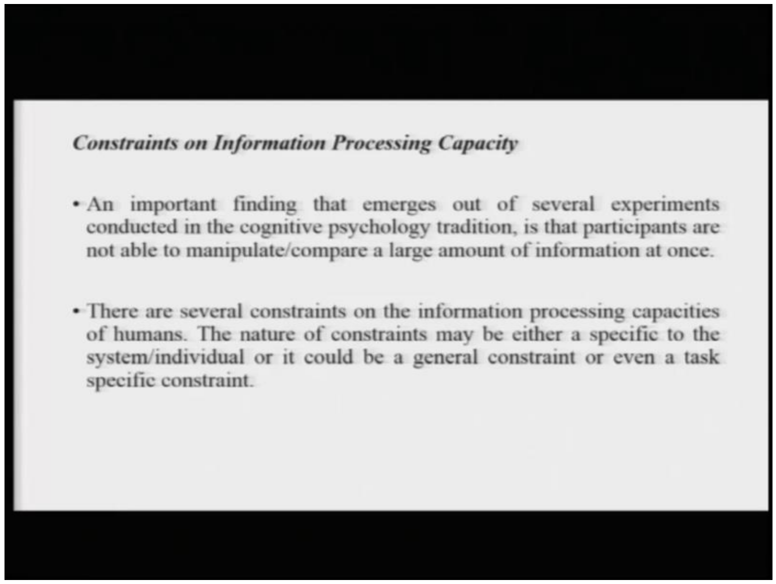
Now, it's not that everything that the brain does is happens in a serial manner, because in other task say for example, Reicher’s word superiority effect. It has demonstrated that this task sort of happens in a sort of a parallel manner. The task is very simple, and the task is that the participants have to identify a set of target letters from three kinds of embeddings. They could either be embedded in a series of Xs, they could, either they could be embedded in a series of non-sense words or they could be embedded in a actual word.

Say for example, if you have to look at, if you have to identify the words, the letter R, it could be embedded in X, X, X, R, X, X, X, then I have to sort of see whether it is there or not. It could be in a non-sense thing like say for example, blar, an R is there I have to recognize it or it could be in a word like fork or frock, where I have to recognize it.

It was found that participants do this task rather quickly, but they do it fastest when the letter is embedded in a meaningful point. Why are they doing this? They are probably doing this because when you are reading a word, there are two levels of representations that are simultaneously activated, there is a later level representation that gives you the identity of, identify of each of the letters, and there is a word level representation which is also much faster and easier to remember. If you remember that word in your mental lexicon, you will be able to do it much, much faster.

So, the point here is that the processing of these mental steps is basically in that sense, is not always serial or not always parallel.

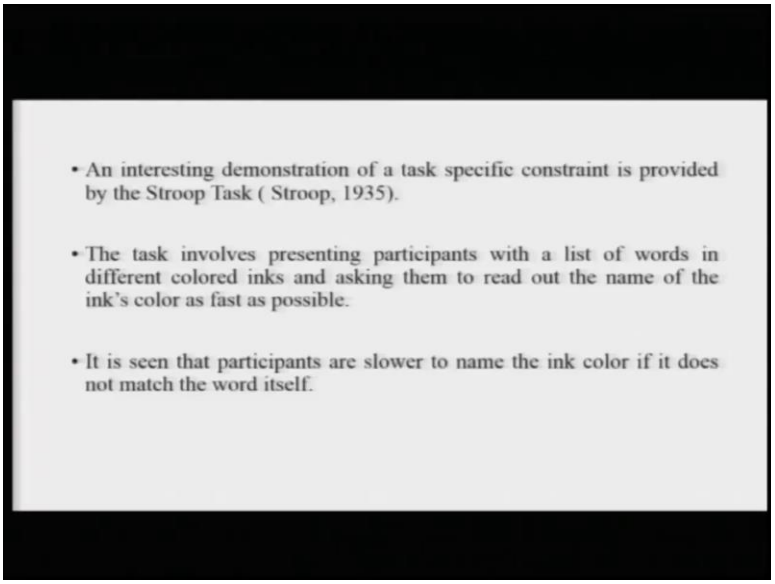
(Refer Slide Time: 18:55)



Now, there are some of the constraints on the information processing capacity of the brain and this is something which keeps emerging out of a range of cognitive psychology experiments that have been performed and we will come through, come across a lot of these different kind of experiments as well.

Now, the constraints on this information processing capacity of the human brain or of humans typically be, can typically be of various kinds, they could be specific to a system or the individuals say for example, there could be individuals which have lower working memory capacity, there could be individuals who have higher working memory capacity or generally just work memory capacity, there could be, it could be a general constraint that the task is very very difficult or that it is, it will be difficult to do this in any case, or it could be very task as we consider that this that this processing in this task is difficult if it were in a different task, it would be very fast or very quick. Let us take an example.

(Refer Slide Time: 19:58)



J. R. Stroop demonstrated this different kind of constraint, the task specific constraint in a task that he devised, which was called the Stroop Task, and the Stroop Task is a very very interesting task.

(Refer Slide Time: 20:12)

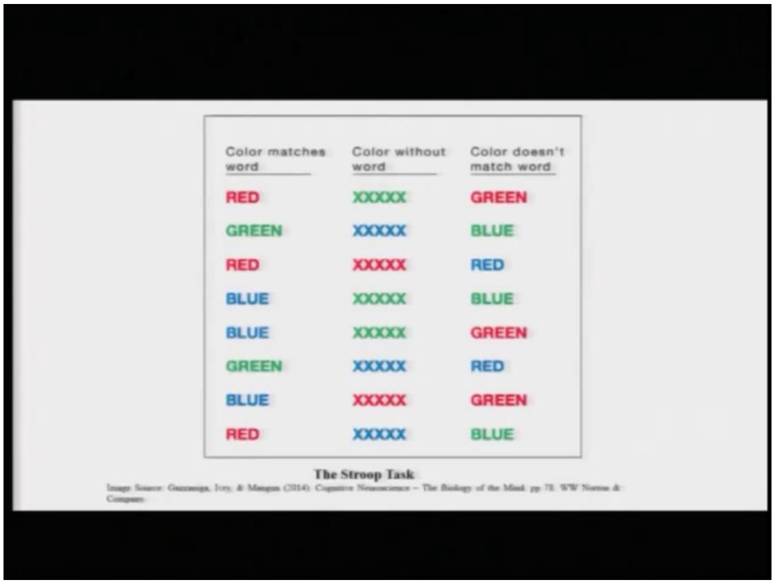
I'll just quickly show you the task. In this, you have basically letters, basically color words and the color words are basically written with inks of different colors. Say for example, you can probably see red, written in red ink color, green written in green ink color, blue written in blue ink color, or you can have a different version where you have red written in blue ink color, green written in red ink color, blue written in green ink color, and so on.

So, in this case, you, and you can sort of mix these stimuli up, and you can ask their participant to name it and what you will typically find is that when the name of the word and the color of the ink they match, participants are fastest. When the name of the ink and the name of the word do not match, the participants are slowest.

This is a fairly simple demonstration, has a very robust effect, because it stays on even after thousands of practice trials, if they are afforded to the participants. What is happening here? Again, I am sure you would be able to answer that, that there are two levels of representations that are simultaneously getting activated in parallel. Name of the word is something that as soon as you see it, it automatically activates. It is a very fast, very quick, all or none kind of a process.

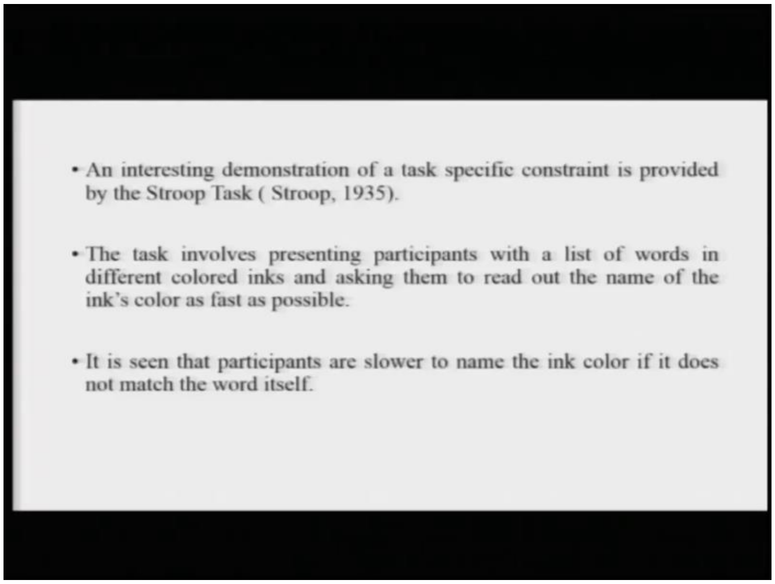
You cannot unread a word or you cannot stop in the middle of reading a word. As soon as you see a word and you know the language and you are aware of that word, you will read it immediately. So, that is something that is activating very very quickly and that is something that is interacting with your main task which is naming the ink color.

(Refer Slide Time: 21:46)



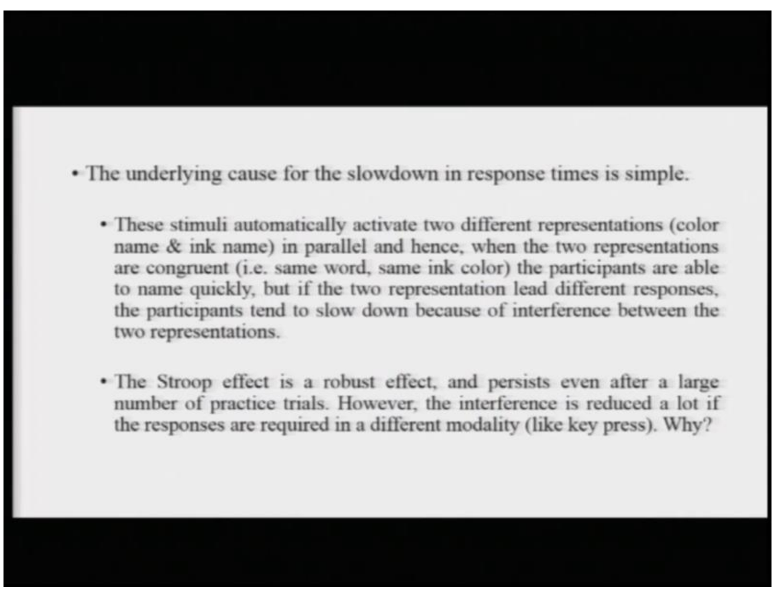
So if both of these things are generating the same response, say for example, in stimuli, for stimuli on the left, if red if the word red is written in red color ink, I will be fast, because both of my activated representations are leading to the same response. But if I look at stimuli on the right where the word green is written in red ink color, I have to say red, but the I am also activating the name of this word which is green, this will sort of cause, interference with each other and we slow the participant.

(Refer Slide Time: 22:33)



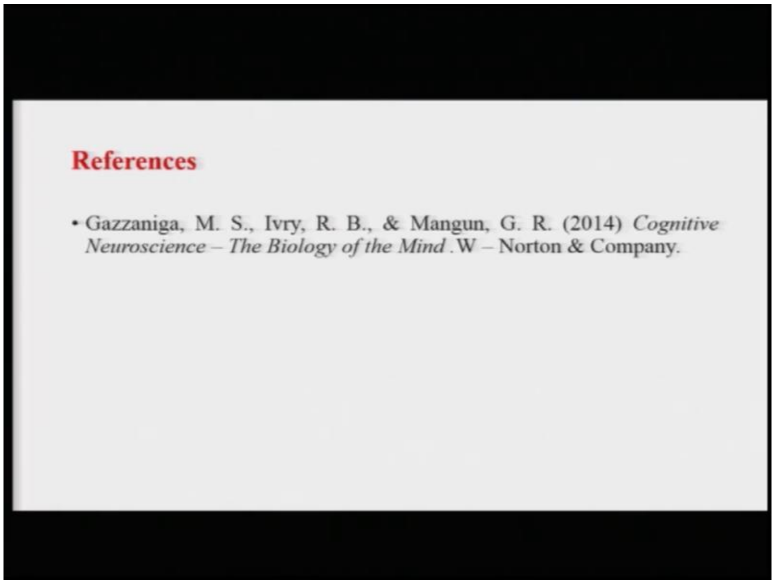
So, this is a very good example of what is referred to as a task specific constraint and this is something which has been demonstrated over and over again and participants have sort of shown this effect again and again and obviously, this effect has been used in different other paradigms as well.

(Refer Slide Time: 22:41)



So, this is just an example of what is called a task specific constraint and it does a very important thing, it tells us that while the human brain might be processing, let us say, for now, be processing information in this information processing paradigm, but it does not have unlimited capacity. Also, it cannot handle an unlimited amount of information at the same time.

(Refer Slide Time: 23:16)



So this is something which is very very important and one of the things that we will keep in mind going further. So I have sort of given you a brief very very sort of a sketchy outline of the kind of methods that are used in cognitive psychology. And the idea is that cognitive neuroscience as a field derives a lot of its methods from cognitive psychology and we will be talking about these methods more and more and again and again in the course of this semester. Thank you.