Hello and welcome to the second lecture of the serious of this course called basic cognitive processors.
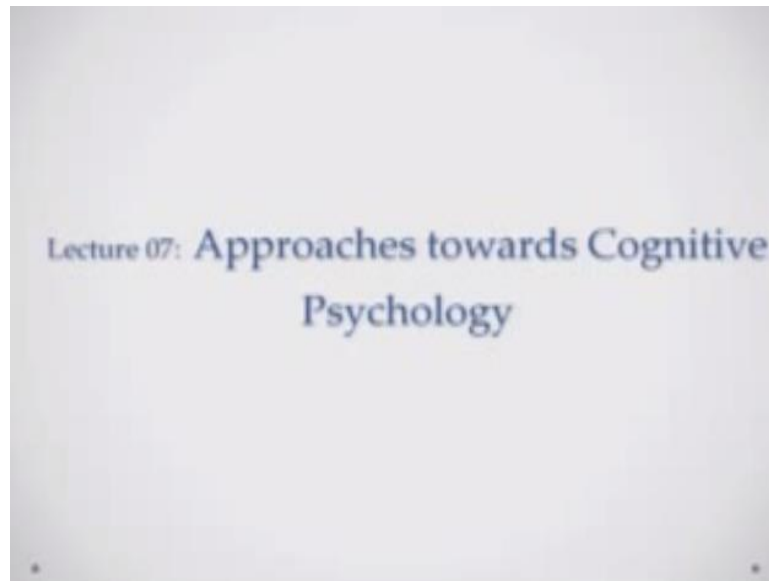
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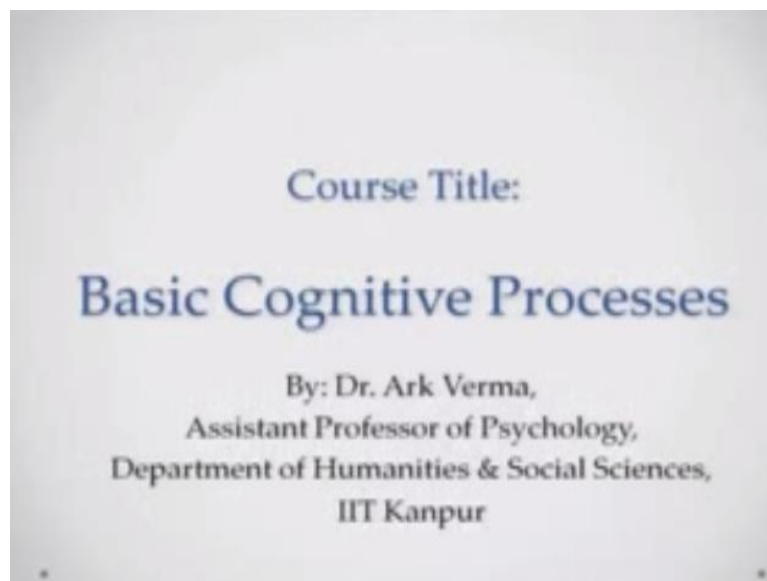
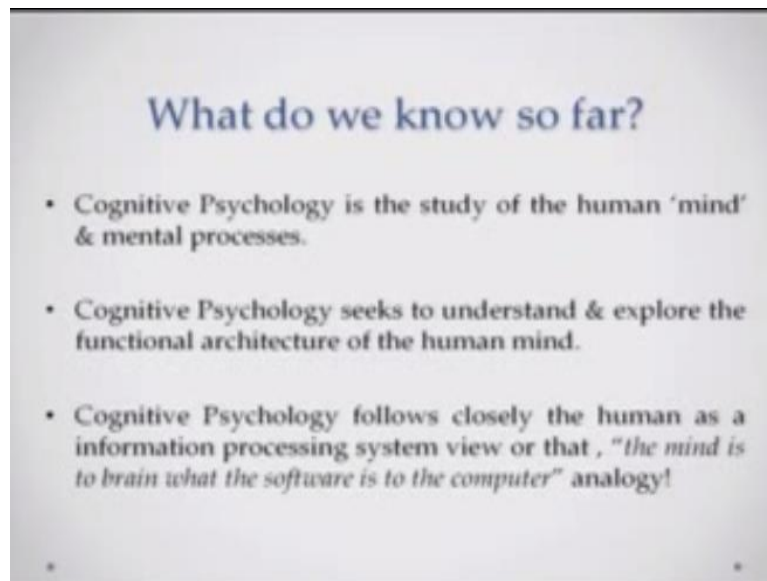I am Dr. Ark Verma, from IT, Kanpur.

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Lecture 07: **Approaches towards Cognitive Psychology**

Today the title of the lecture is approaches towards cognitive psychology.
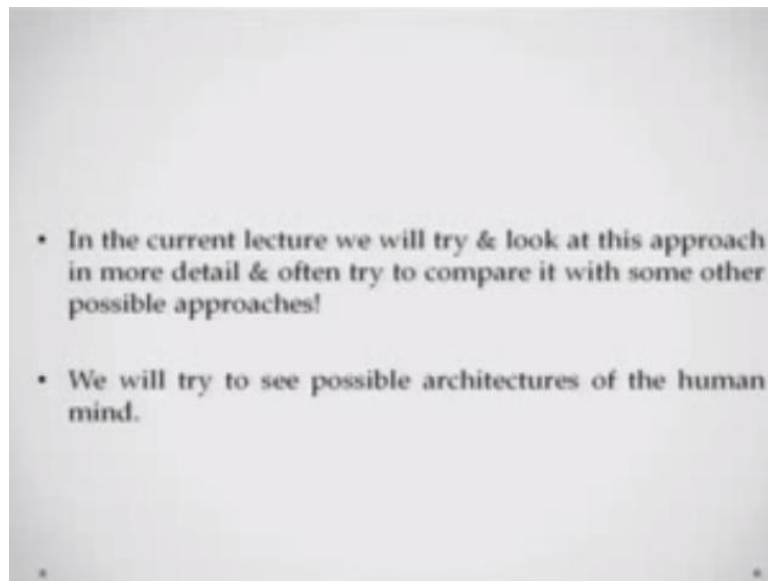
In today's lecture we will basically talk about the various approaches that have been take into understand the architecture of the mind and the mind oriented relationship. If you remember at the last few lectures if we till now talked about the definition of cognitive psychology. We have talked about that cognitive psychology is the study of the human mind and that of mental processes.

We also talked about the fact that cognitive psychology basically seeks to understand and explore the functional architecture of the human mind. If also in the last most recent class if we talked about the fact that cognitive psychology basically also in some sense follows the metaphor that the brain that the mind is to the brain what is software is to a computer hardware.

So we will try in take forward this approach towards thinking about the mind, brain relationship and we will try and see what are the various approaches that have been take into understand this relationship, this analogy between the mind being the software the brain being the hardware.

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- In the current lecture we will try & look at this approach in more detail & often try to compare it with some other possible approaches!

- We will try to see possible architectures of the human mind.

In this current lecture basically then we will look at this mind brain or the software, hardware approach and we will try and also contrasted to some of the other approaches like then neuroscience approach or the artificial intelligence approach as such.

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The Problem at Hand…

- We are faced with a black box.

- The rules of engagement are quite clear: we cannot physically attempt to open the black box &

- So, in order to make some headway, we simply accept the foundational assumption that the black box contains an information processing system & set ourselves the goal of trying to understand the nature of its putative internal states & processes.

Now just to actually begin the problem or to begin talking about the problem. Let me refresh the problem for you to really understand what are we talking about. Now in the last classes we would have seen that one of the aims of cognitive psychology is actually to understand how the brain is structured or the how the mind is structured basically. In other point is, there is a bit of problem for us as compared to somebody attempting to understand another machine.
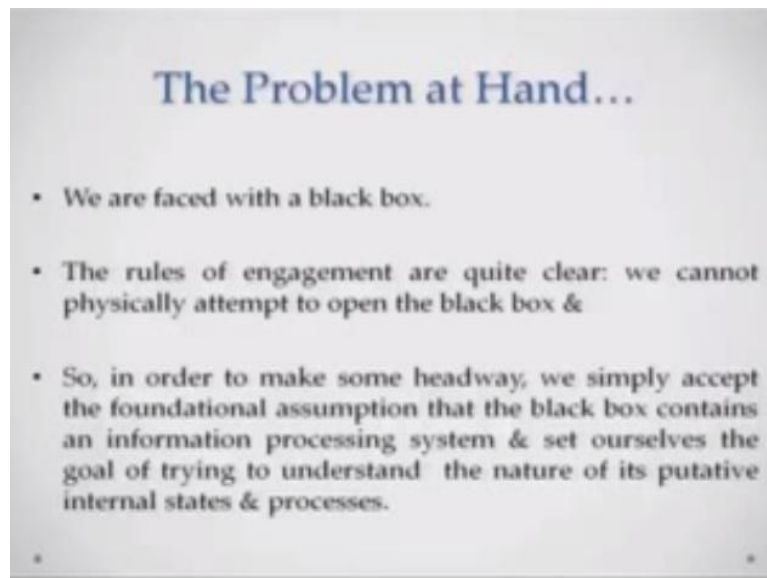
We are faced with something which is similar to a black box. We do not know or a priority what is going on in this box. We do not really also know that what are different, let us say sets of neurons in the brain are doing okay. So in that sense you can assume that we are actually dealing with the black box, we might know a set of inputs and we might note the set of out puts, but we do not have any other way to actually see what is going on inside the black box.

One of the things that is clear for researches really approaching this problem in at least in the human contacts is that we cannot really physically attempt to open this black box. Say for example, if you dealing with any other machine and you want to understand how the machine works a typical mechanical engineer might really want to open this machine down to its bolts and nuts in tools, nuts and bolts.

And actually see how each of the parts are connected and what each of the parts are doing, but we do not have that luxury when you are talking about the human brain. So we will see what could be the alternative approaches to really see what is going inside the brain. That is exactly what another focus of cognitive psychology is. So basically in order to make this head away, make or begin this enquiry what we do is, we simply accept a couple of things.
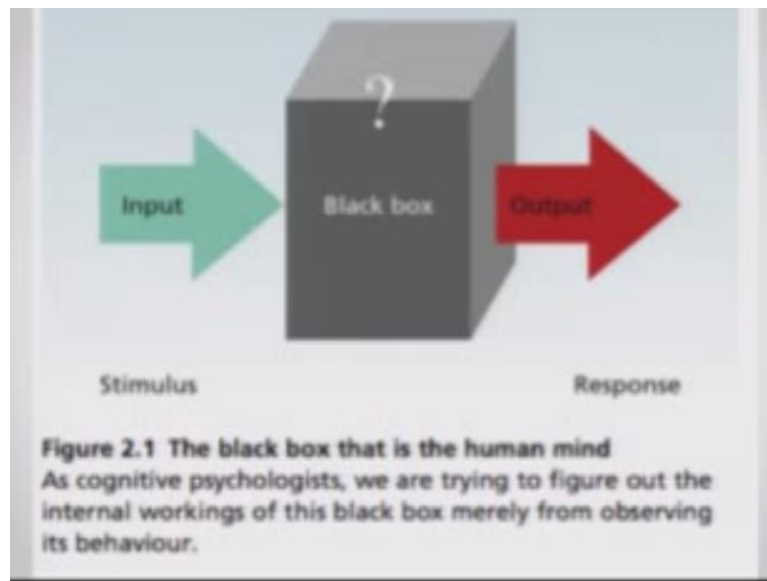
So we except this foundational assumption that the black box contains and information processing system.

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The Problem at Hand…

- We are faced with a black box.

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- So, in order to make some headway, we simply accept the foundational assumption that the black box contains an information processing system & set ourselves the goal of trying to understand the nature of its putative internal states & processes.

You give it some input, it will give you some output, whatever it is doing in the middle is information processing of some kind. And what we try and do then is to understand the nature of the internal station processes, how information is process when we are talking in a reference of the brain or in reference of this mind which is the abstract part.

Figure 2.1 The black box that is the human mind
As cognitive psychologists, we are trying to figure out the internal workings of this black box merely from observing its behaviour.

So here you can see it is being very well visualized in this book by Quinlan and Dyson which the lecture is basically based on. We are actually talking about set of input, and we are talking about set of output, but at the center the basic computational tool is your black box and we do not know much about it. We are trying to as cognitive psychologist understand and figure out the internal working of this black box.
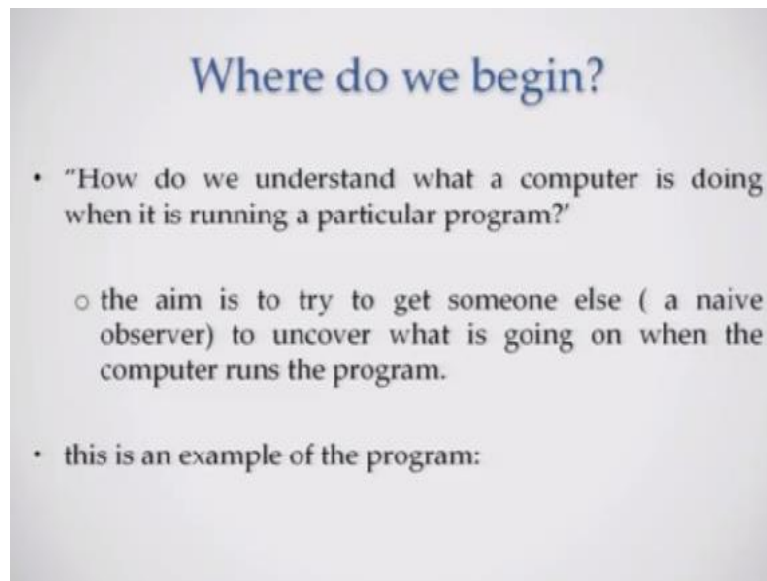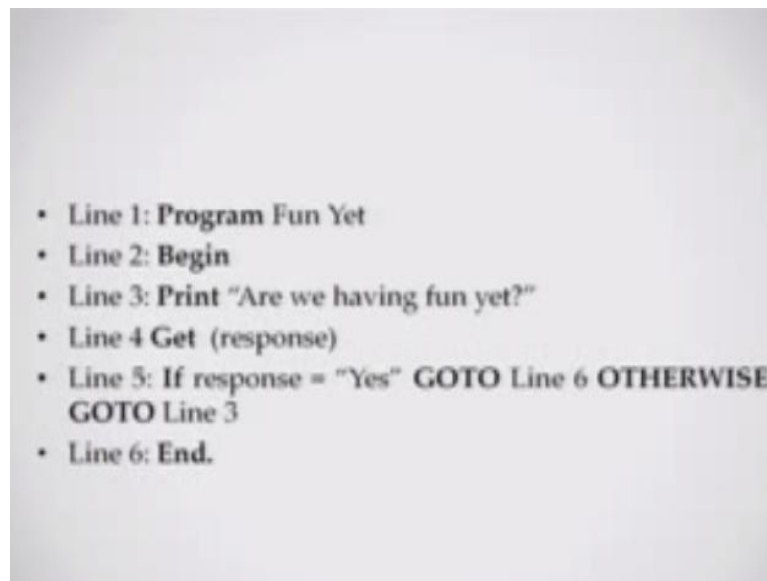
Now so where do we begin when we have to understand this black box. So how do we understand what is this computer is doing so if we may call it a computer. The aim is or one of the thing that could done is that we get somebody and naive observer let us say to uncover what is going on when the computer runs a program okay.

So I will just take because I am talking about the computer and hardware and software analogy let me give you an example in terms of a program. Now here is simple computer program of any language.

- Line 1: **Program** Fun Yet
- Line 2: **Begin**
- Line 3: **Print** "Are we having fun yet?"
- Line 4 **Get** (response)
- Line 5: **If** response = "Yes" **GOTO** Line 6 **OTHERWISE GOTO** Line 3
- Line 6: **End.**

And the idea is that the program has these different line numbers, there is a particular input and there is a particular output. So the new of the program is fun yet you begin on the second line then you kind of type something or we have in fun yet and then some responses given. The response is yes then you actually end the program and the response is no, you again ask the same question, this is very simple program.

Now if somebody really wants to understand how this answer is arrived at, he may take variety of approaches to understand this. Let us take this example to cognitive psychology update and try and see what cognitive psychology really does to approach such a problem. On the first approaches let us say could be the cognitive approach which we talking about.
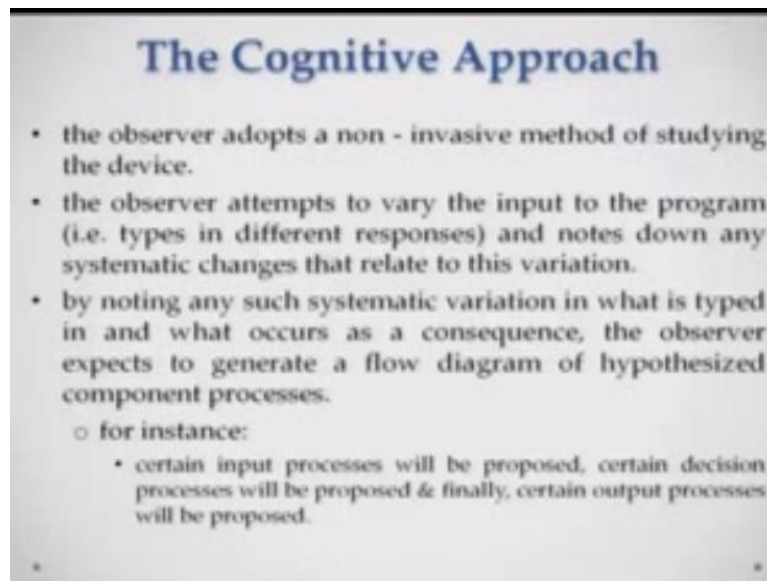
Here in what happen is that the observer has to compulsorily adopt something of a non invasive approach. So what the observer and do he can basically vary the input to the program he can type sometimes yes, he can type sometimes no, and then he actually would note down any systematic changes that had happening in the output. Say for example, if you type yes you see what is done by the program we should type no you again see what is done by the program.

And in that sense you can make out that if I say yes the program exist if I say no that the program actually stays and ask the question again. This exercise in some sense will give you some idea about what this internal processes or what the internal decision making system of the program is actually doing. Now what happens is in this sense when you actually undertake this exercise as an observer what you could do is. You can actually generate that these kind of inputs will be given and certain decision process say for example will be undertaken and a particular kind of an output will be there.

So this is the crux of what the cognitive approach. This is something very similar to what do when we are trying to study the mental states or mental process of the brain. You try and see what do you really use as a stimulus and how does the brain respond to it and then we try and guess what kind of processing the brain would have done or say for example, what kind of mental function would have operative done this input to come up with such into output.

Moving on to another approach let us talk about the artificial intelligence approach. Artificial intelligence approach the focus is slightly different. You do not merely need to understand, you do not merely want to understand what is happening in this program. You want to actually go one step ahead. And how do you do that.

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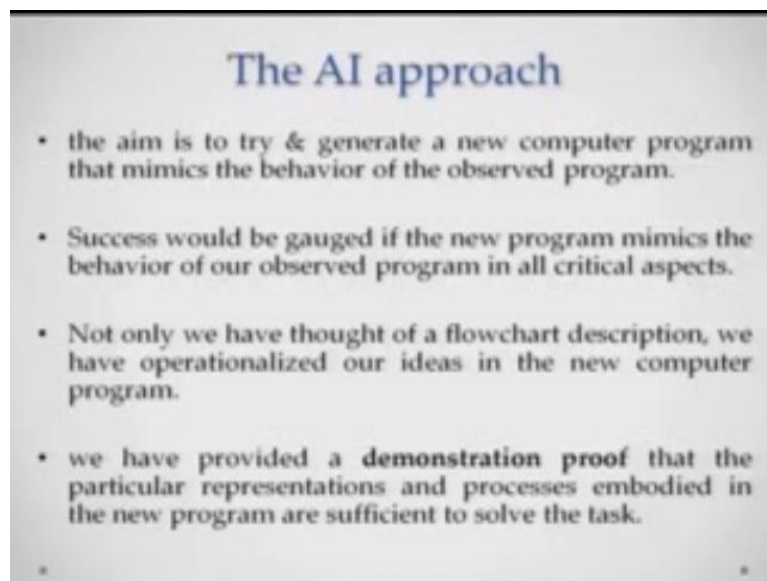
You do that by actually generating a new computer program that mimics the behaviour of the observed program. So what you doing is you not really understanding completely or you are actually understanding or you are not really satisfied with just understanding what a particular program and question is doing.

You might want to actually what do you want to actually do is, want to create a parallel program, a new program which does exactly the same as this particular program has done. And in that sense you will did use that you have completely understood the process that this program would have taken. Now the success or the failure your new program basically would be guess if the new program completely mimics the behaviour of the observe program in all critical aspects.

In the kind of outputs generated, the amount of time that is taken and taken and different of the parameters that you can think of. Now not only for this case, not only you should think of

a flowchart description, you could also operationalize the ideas in the new computer programs. So you might have some guess that okay. I think that this program and question is using a particular kind of a decision box.

And you actually have a chance of implementing the same decision box which you think is being use by this earlier program. Anyway implement that in your own program when you see is the output exactly match that of the program in question. If it matches you might assume that okay may be I have guessed correctly that this was the decision box. This was the decision process that the program in question was following.

Now this actually this kind of an approach gives you the satisfaction of having a demonstration proof. Once you actually check out all of you assumptions in this new program that you have made what you have is a demonstration proof. The demonstration proof basically tells you that whatever particular representation and processes that you would think of about this program in question are actually being followed.

Because you created the program of yourself that really mimics and that really does the same thing. It is pretty much similar if you think of what we are trying to do with the robotics. You are trying to build and create robots which would actually process the stimuli and the information in the real world as the humans are doing. Say for example, we are trying to build robots which actually talk to humans like humans would do which process the visual stimulates say for example depth and color and shape just like human would do.

You are also if you would know of that we are also thinking you are self driving cars, car driven by this artificial intelligence method which basically follow the same kind of methods that the humans would do or may be even better. This is pretty much what is the artificial intelligence approach to understanding the mind, brain relationship. What are the benefits are such an approach.

- a claimed benefit of this approach is that it forces the theorist to formulate, very precisely the assumptions that underlie theory.

- the ideas must be precise as they are to be operationalized in a computer program.

- we have a demonstration proof that the operations specified in the program are sufficient to explain the behaviour. & the theory has been shown to work.

- Such an AI approach provides the means to address detailed issues at the level of representation and the algorithm (Marr, 1982).

The claimed benefit of such an approach most importantly is that it would force a theorist to somebody who is trying to understand to formulate very very precisely the assumptions that underlie the theory of the other program that you would want to study. So unless you have actually given a very very precise statements that I think this is exactly happening, this is the next step, this is the third step and the forth step.

You will not be able to implement that in your program. So it kind of limits the scope of let us say in some sense speculative theorization. You have to come up with very very sharp and clear assumptions and those assumptions are those virtual anyways test it out in your own program. So that is a very important benefit of the AI approach. Another thing is as I said earlier that you have a demonstration proof. That tells you that operations that you specified about the earlier programs sufficient to explain the behaviour of that program.

Because you could anyway is testing it out in your own program. The same kind of output you generating. So in that sense you can actually see that a chart this is done. Now something of note here will be that you should keep in mind that it very possible for two rather different programs to actually take some input and generate identical outputs. That is something which we would need to keep in mind while you are actually following the AI approach, and I am sure that to some extend that is also being in the discipline.

So this is one of the things also if you remember in the last lecture we will talking about mars, levels of explanation the algorithmic level, the computation level and those kind of levels the AI approach forces you to generate very very here explanations on those levels as well. So that is again to the merit of the AI approach to understanding the mind, brain relationship. Now coming to the neuro science approach.

The neuroscience approach is actually something similar to what the hardware approach would be. You actually want to understand the machine you really want to understand how the different parts of the machines are connected. What is the role or the functional role for each of the parts of the machine. So neuroscience approaches pretty much the same approach apply to the human brain.

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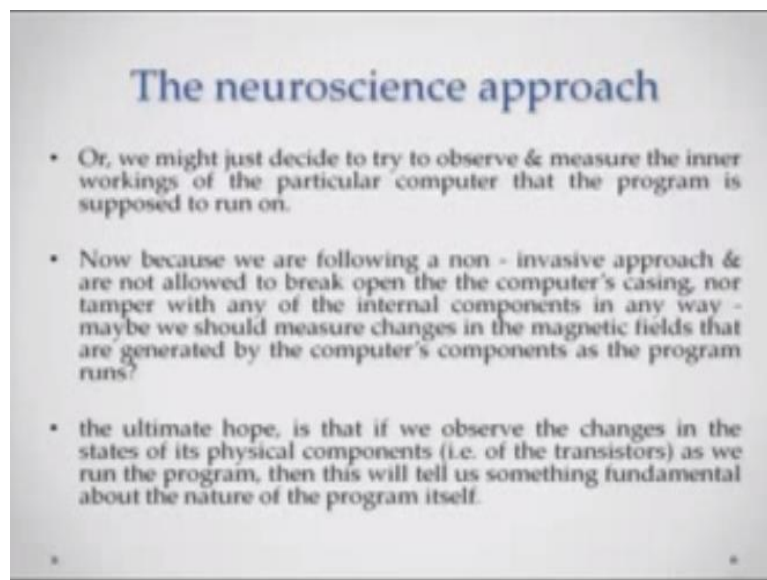
And the point is how do we proceed with the neuro science approach given the fact that we have to be non-invasive and we do not have the luxury of opening of this machine. So one of the ways could be to just trying measure the inner states or inner working of this computer or this brain we are talking about. Because you are following non invasive approach and we are not allowed to break open the computers casing and different parts what we can do is we basically trying have some indirect measures.

So we may try and measure the let us say the magnetic field around the parts of the components. Say for example, if a particular process as being done, what is the nature of the magnetic field of the different parts things like that. Very similar to what the current neuroscience approach is actually doing. We will elaborate on this in the coming lectures anyways.

The ultimate hope with this neuro science approach is actually that if we observe the changes in the states of its physical components the component of this machine as we run the program then they should tells us something very fundamental about the nature of the program itself. Say for example if you give a particular kind of an output, and you see how the machine is changing, how the internal states or some indices of these internal states are changing.

You would know that this is what is happening in response to this input and that is how a particular kind of an output is being generated. So I will take examples one of the typical one of the very papular methods in neuro science is this approach of FMRI wherein what we actually do is we measure the blood flow in various areas of the brain. With response to particular kinds of stimulus say for example, if I actually shown your face there is a particular area in the brain where the blood flow will maximize in a relation to other areas.

And that is how we did use, that this is area which is implicated in processing of these kind of stimulus which is the face. Again it is something similar to trying to understand what does the brain do. When you present to it a face and what kind of an output it really produces so what is the output to the face probably the fact that you recognize that it is a face, second you will recognize the person whom the face belongs to and similar other things. Now this idea is actually as I said rather similar to what is currently being done.

- The idea is very similar to the neuroscience approach that is being adopted.

- We are beginning to map out which areas of he brain become particularly exercised when a person is engaged in certain cognitive tasks.

- However, so far, little has been learnt about cognitive processes that are assumed to be associated with such changes in brain activation.

- Much is being learnt about the structural organisation of the brain (where stuff happens) but, little has been learnt about cognitive functioning (what is happening & how).
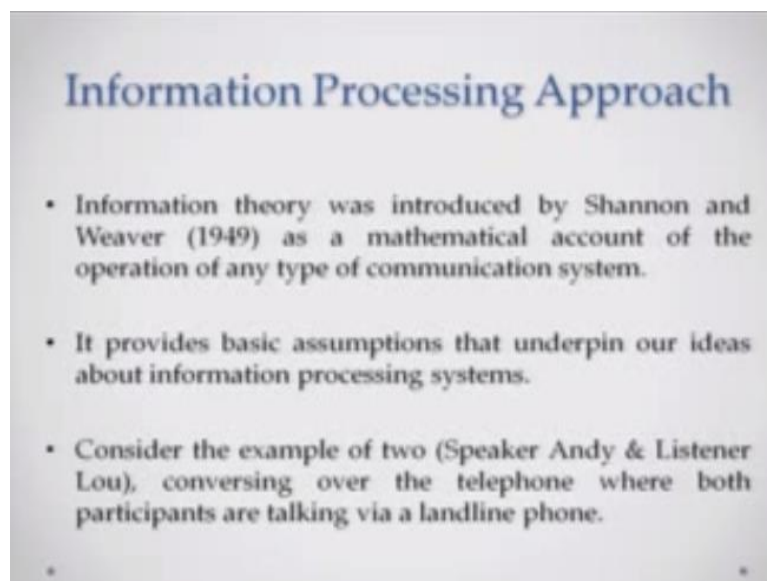
Now for current state of the hard disk like we are already now being to map out which areas of brain are particularly exercised when a person is engaged in certain cognitive task. Say for example tasks like reading, task like understanding or recognizing a face and those kinds of things. However, I might observed that so far rather little has being learnt about the cognitive processes that are resumed to be associated with such changes in brain activation.

Let us say we have a knowledge about that these, these areas are involved in these particular cognitive functions, but if you ask neuro scientist to really make a very strong claim I think we are still not there. Obviously, you can say that this area is responsible for let us say face recognition or word reading or say for example attention and stuff like that, but the point is, we are not really 100%, I mean at the place that we can explain one by one what are steps what as basically happening with respect to these different brain areas.

Already though to the credit of the field much is still being learnt about the structural organization of the brain where each of these different kind of stimulus are being process but still we have long way to go really to understand how each of these areas are implicated exactly. Now these different approaches as a part I will now take you toward rather different kind of an approach and we will slightly moving away from the example of this program and the mind, brain relationship that we were talking about.

Let us talk about cognition slightly in a more general sense. Now if you actually trying understand that cognition pretty much is basically or is very similar to somebody processing some information and coming with the particular output. So there was the very influential approach which came out in the 1940s, end of the 1940s that really try to specify how information processing happens and in that sense it also kind of created a particular kind of theoretical frame work for understanding how the human brain also process the information.
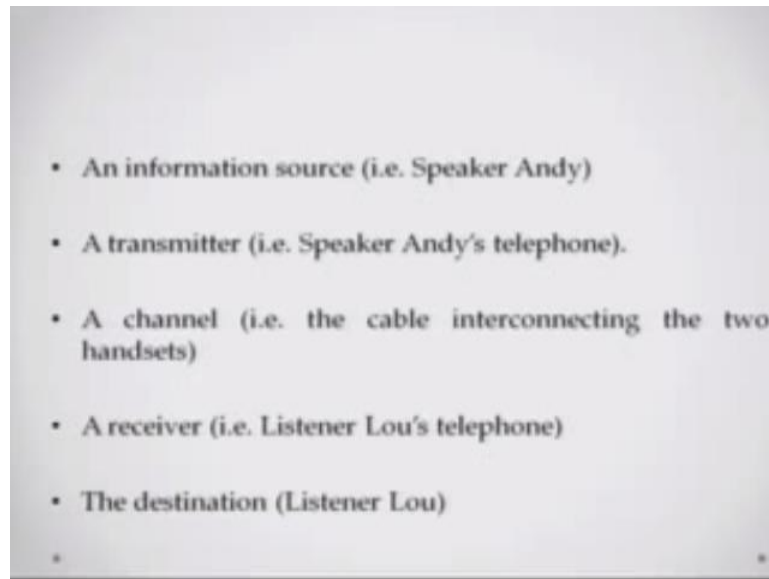
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Information Processing Approach

- Information theory was introduced by Shannon and Weaver (1949) as a mathematical account of the operation of any type of communication system.

- It provides basic assumptions that underpin our ideas about information processing systems.

- Consider the example of two (Speaker Andy & Listener Lou), conversing over the telephone where both participants are talking via a landline phone.

Now this information this approaches basically the information theory approach which is actually introduced by Shannon and Weaver in 1949, and it was supposed to be a mathematical account of the operation of any type of communication system. Any communication system can actually we approach theoretically through this particular approach. So what is this approach do?

This approach basically it provides the basic assumption that underpin our ideas about what information processing systems are. How information processing is actually done. What are the various parameters. So let us say it takes the example of two speakers may be connected by a wireless phone or wired phone or something like that. We are talking about this telephone and some kind of messages being interchange.

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It is components of such a typical setting. So you have an information source that is a speaker 1 he could be a Andy or anyone. And then you have a transmitter, so the information source actually transferred some kind of message through this transmitter which is the transmitter in this case let us stay Andy's telephone over which Andy is speaking who is the information source.

Then you have to have channel through which this information will be pass through so let us the cabal connecting the two handsets or let us say a satellite connecting the wireless connecting these two phones wirelessly. And then you have receiver which is Lou's phone who is the person Andy is talking to, that will be the receiver. Another aspect is the destination which is Lou himself who is actually receiving this message which is basically sent via the speaker who is Andy.

So typically an information arising system or other simple idea is that you have an information source you have transmitter, you have a channel, you have a receiver and you have the destination. These are the five components of any rather simplistic information system.

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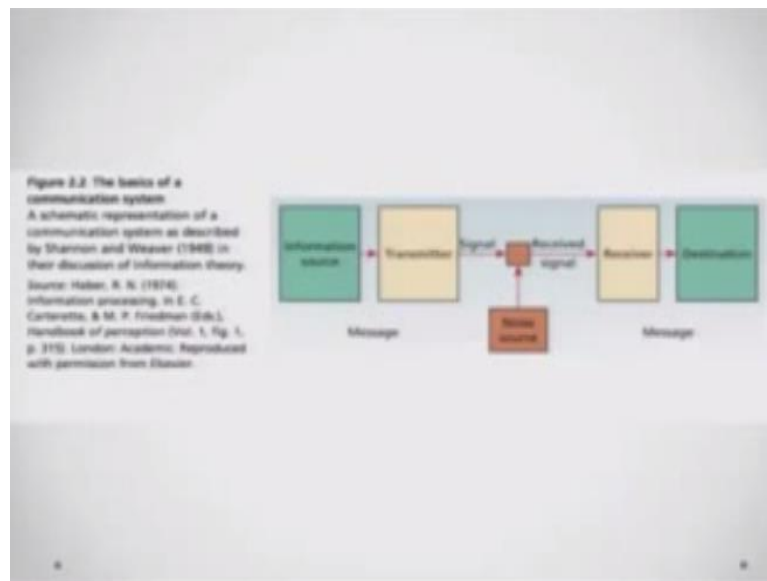
Here you can actually see the visualization of this information processing system. So you have an information source, you have a transmitter, you have place where there is a source has being transferred and in a receiver and a destination. So this is typically the set up.
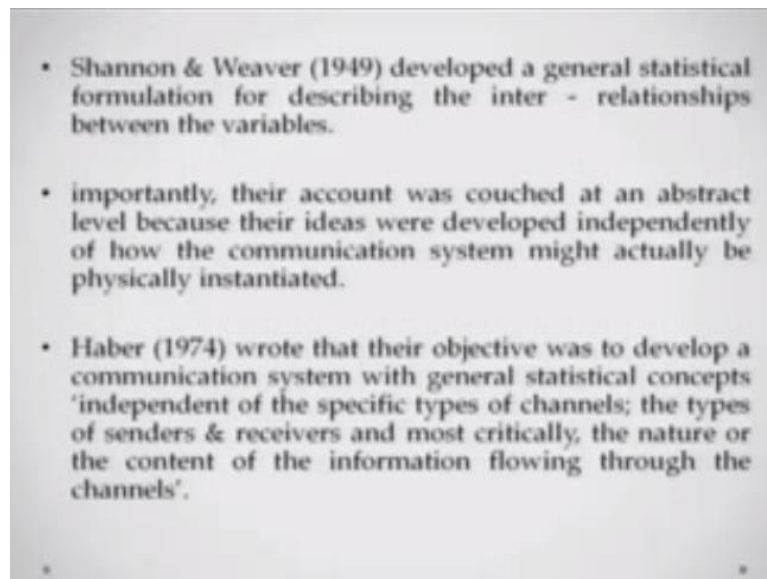
Now what happens is in this communication system the auditory input is actually in first needs to be converted by the transmitter into an electrical signal which will actually travel through the channel okay this is one of the steps. Another is that the same signal which has been converted the same in an electric signal which was basically earlier information sources has to reconverted into the information source that kind of information that was being sent already at the point where the receiver is at the point whether receiver basically gets this information from the channel.

So what Shannon and Weaver did is they actually considered these important issues and they said they could be few variables which might be necessary to take into account when we are talking about such a system of the variables as channel capacity. How much information can this channel actually carry okay. The second is the rate of transmission how fast, nowadays we are talking about high speed internet.

So what is the rate of transmission? The third is the redundancy of encoding. How much meaningful information can actually be transmitted? I will talk about these things in more detail as we go ahead. And the fourth is the noise, how much meaningful information versus how much noise or how much non-meaningful information you actually transferred through the channel.

So these are the four factors. And these four factors or a radio those these four factors should decide how efficient your communication system is. If you be with me and if you try and think this over you will kind of get the idea of what we are trying to do here what trying to actually create an analogy of the way the brain might be processing this wide variety of information that it is getting from the environment. But I will come to that in a way.

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- Shannon & Weaver (1949) developed a general statistical formulation for describing the inter - relationships between the variables.

- importantly, their account was couched at an abstract level because their ideas were developed independently of how the communication system might actually be physically instantiated.

- Haber (1974) wrote that their objective was to develop a communication system with general statistical concepts 'independent of the specific types of channels; the types of senders & receivers and most critically, the nature or the content of the information flowing through the channels'.

Now Shannon and Weaver were basically they trying to develop a general statistical formulation for describing the interrelationship between these four variables we talked about importantly what they did was that their account was actually couch or at another abstract formulation, this was this entire variables and how information processing system is designed having all these four, five factors we talked about earlier is other attend abstract level.

It is independent of what kind of transmitter or what kind of receiver you are actually considering or what kind of information being transported through this particular channel. We are not really talking about those specific details as if now just talking about a typical communication system and what are the components of this communication system. Now Haber 1974 basically writes that their idea of that Shannon and Weaver had, was basically that they wanted to develop communication system with the general statistical concepts.

Independent of the specific types of channels, the type of senders and types of receivers and most critically then nature of the contained of information that is pretty much what they wanted to really do. Now let me come to rather important aspect of the information theory which is a redundancy.
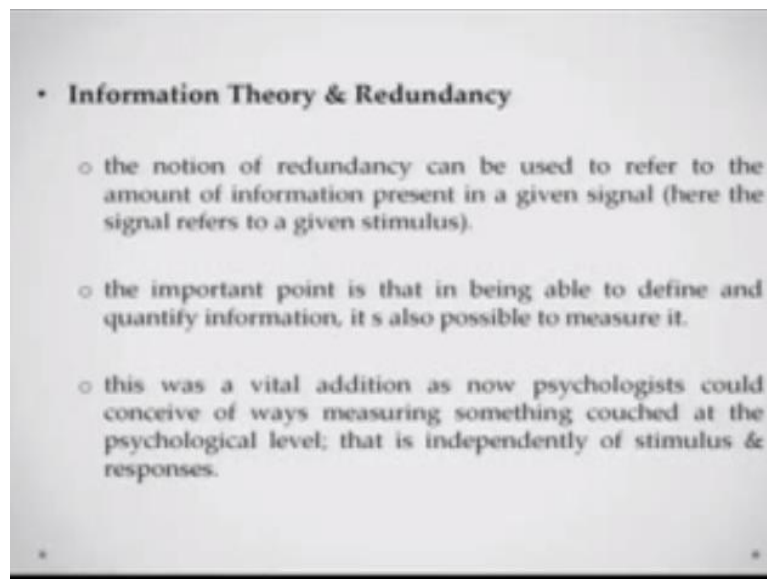
The redundancy basically is it can be used to refer to the amount of information present in a given segment, if we take an example here, say for example I would say X is my brother and X is also the son of my father. So what I am trying to say here is that if I write these two sentences in a message I am actually one of these two sentences will actually be redundant, because say for example if I am already saying that x is my brother it should imply that is son of my father or if I actually just say that x is the son of my father it automatically implies that x is my brother.

So the whole point is that the entire message actually contains less information as compare to the length of this entire message. So one of the ways of computing redundancy is basically from mathematical formula that it done the amount of redundancy is sees redundancy in a particular messages log2 of the amount of information as compare to the total length of the message.

That is one mathematical formulation we do not really want to talk about that in detail for our purpose, but just to explain, you have just given the idea of what redundancy should mean. The important point in redundancy invite as valuable to us, that it kind of helps you to define and countrified amount of information present in a particular message. It also in some sense, gives you a way of measuring it. Now this was rather vital addition to the field of cognitive psychology in a sense that it allowed cognitive psychologist to conceive waves of measuring something couch psychological or abstract level.

If you remember the classes that have happened till now we have talked about the fact that things we are actually cognitive psychology the entire conception of what the mind is, or what the mental states are. They are couched in an abstract world. In an abstract reality. So this is something which you would need to keep in mind. Another way of thinking about redundancy is in terms of how much the signal can be correctly predicted by other parts of the signal.

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- another way of thinking about redundancy is in terms of how much of the signal can be correctly predicted from the other parts of the signal.

  o a highly redundant signal is highly predictive. But how is this to be measured?

  o in addressing this, the aim was now to try & quantify how predictive signals are. for e.g. if a message is highly predictive, we could get away with deleting the irrelevant bits and just leaving the relevant.

So if you give the particular information whether that information can be already predicted from what is already known. Say for example if let us say message let us is highly predictive what is basically one could actually get away in that sense by deleting the irrelevant bits and just leaving the relevant part. Say for example, if there is a various eggs and it is always followed by variable we do not need to specify separately for the variable, you would know

that okay if excess there why we will anyways be there. That is how basically people could actually quantify information and find ways of measuring it.

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- Shannon & Weaver took it upon themselves to try to quantify information purely in terms of statistical means by using things like the frequency of co-occurrence of parts of the message. for instance, they realized that the amount of information increases with the number of things that might have occurred at a given point in the signal.
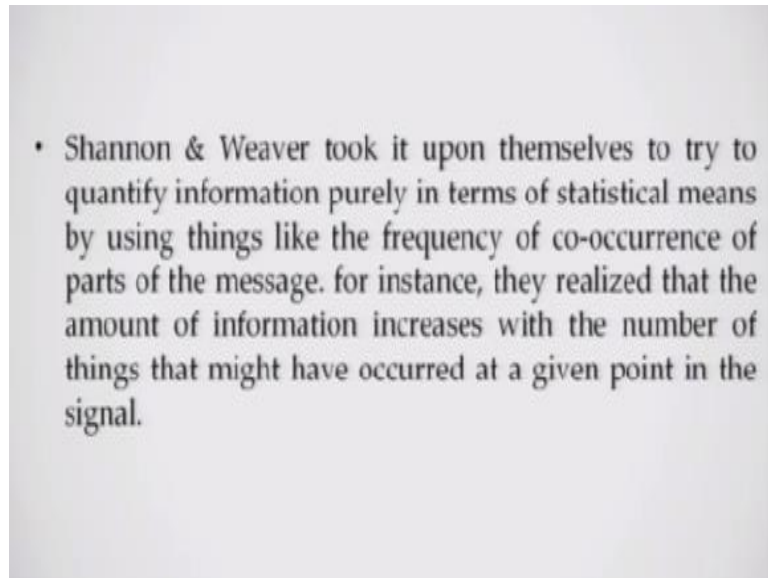
Now Shannon and Weaver basically took it upon themselves to try to quantify information purely in terms of statistical means by using things like frequency of co-occurrence of parts of the message. For instance, they realized with amount of information increases with the number of things that might have occurred at a given point in the signal. So if we are just idea of the temporal unfolding of the signal, those kind of things.

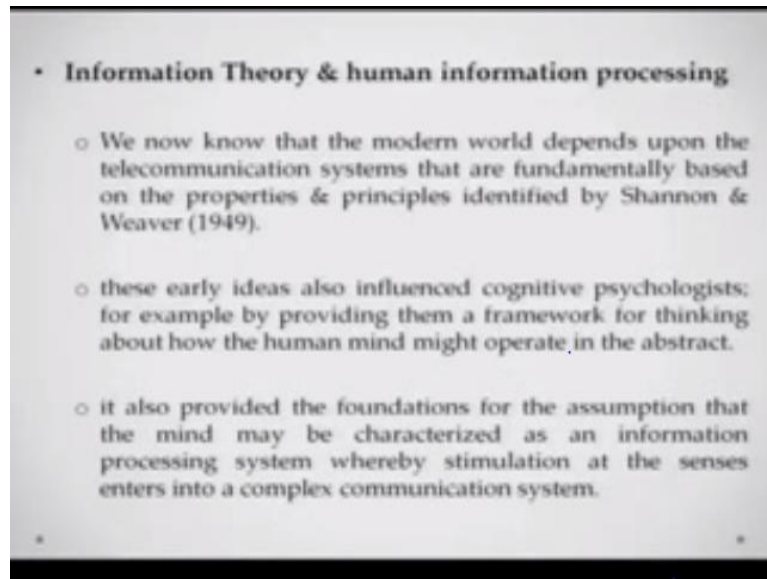- e.g. in the message, "We should meet tonight because that's a good time to elope'. it has very low redundancy as Lou would be unable to reconstruct the intended meaning if all that he heard was "We should meet ****** because that's a good ***** to ****."

- here Andy could have asked Lou to meet "at the corner" or "at 9 pm" etc.

- In contrast if you take another example: if y invariably follows x and hearing x implies hearing y, then y is fully redundant with respect to x.

Say for example there is a message that we should meet tonight because that is the good time to elope, has a very low redundancy as Lou would be unable to reconstruct the intended message. Say for example what he heard was we should meet because that is good dash to dash. Here and he could fill in different kinds of things, so the whole point is it is not easy to predict what the message was, so the message in that sense as low redundancy. Now what is information processing theory give us about human information processing.

- **Information Theory & human information processing**

  o We now know that the modern world depends upon the telecommunication systems that are fundamentally based on the properties & principles identified by Shannon & Weaver (1949).

  o these early ideas also influenced cognitive psychologists; for example by providing them a framework for thinking about how the human mind might operate in the abstract.

  o it also provided the foundations for the assumption that the mind may be characterized as an information processing system whereby stimulation at the senses enters into a complex communication system.

We know now that just modern world really depends on the variety of telecommunication systems that are fundamentally based on the properties and principles which were identified by Shannon and Weaver. So these early ideas also influence cognitive psychologies for example by providing them a frame work of thinking about how the human mind might be operating, how the human mind might be taking, and let us information about colour and shape and different things and processing it.

So in that sense it actually provided rather new theoretical frame work. It also provided the foundation for the assumption that the mind may be characterized as an information processing system whereby stimulation at the senses enters the complex communication system and then if kind of gets to a particular point.

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- Models of cognitive processing based on the central tenets of this information processing framework soon began to appear.

- Psychologists were quick to realize that for humans, the notion for information was more difficult to define than by the simple sorts of statistical measures used in the information processing theory.

- It is not so much about the words which are spoken but the what meanings are trying to conveyed (Mac Kay, 1961): 'dog bites man' is much less informative than 'man bites dog'.

- But the approach forced psychologists to consider a whole new way of thinking about human cognition.

Now these different models of cognitive processing then which would be founded at that point in time were based on the central tenets of this information processing frame work Shannon and Weaver had given. Say for example one of the earliest models of memory that can sent different model and those kinds of models. Now psychologist at that point then are very quick to realise that for humans, the notion of information would be slightly more difficult as compared to the notion of information for machines.

Say for example, dog bites man or man bites dog basically is the same set of information, but dog bites man actually makes much less of a sense than man bites dog or the other way actually. But this entire thing actually forced the psychologists to really consider a whole new way of thinking about human cognition. It helps the people come up with theories about how memory would work or how sensory processing would work and those kinds of things.

- The classical information processing view is that the human organism consists of certain sensory systems (eyes, ears etc.) which operates as receivers of external inputs; these receivers operate to encode these inputs via sensory transduction.

- the encoded information is then passed on, via abstract information processing channels, to more central systems.

- the central system operate on the information in such a way that an appropriate response can be made.

- While it might resemble the behavioral stance, cognitive psychologists are more concerned with the internal (abstract) events that intervene between the stimuli & responses.

So this classical information processing view is basically that human organism really contains these many sensory is that so much eyes, ears, nose, the skin which operates as receivers of external input, these receivers operate to encode these inputs via sensory transduction. So encoded information is then passed on, via abstract information processing systems to more central system like in the cerebral cortex or in the brain.

These central system which are there in the core of the brain, or they basically try to operate the on information in such a way that an appropriate sense of that information could be made. Say for example, if you are seeing a bunch of shapes or bunch of colours what the processing system will try to do is operate upon that mean search a way that you actually see shapes in there or you actually see that these are the objects in this amount of colours in lines and shapes.

Now this might resemble slightly the behavioural stance the cognitive psychologists towards basically more concern with the fact that how this internal abstract events are happening what is happening between the stimuli and the responses.

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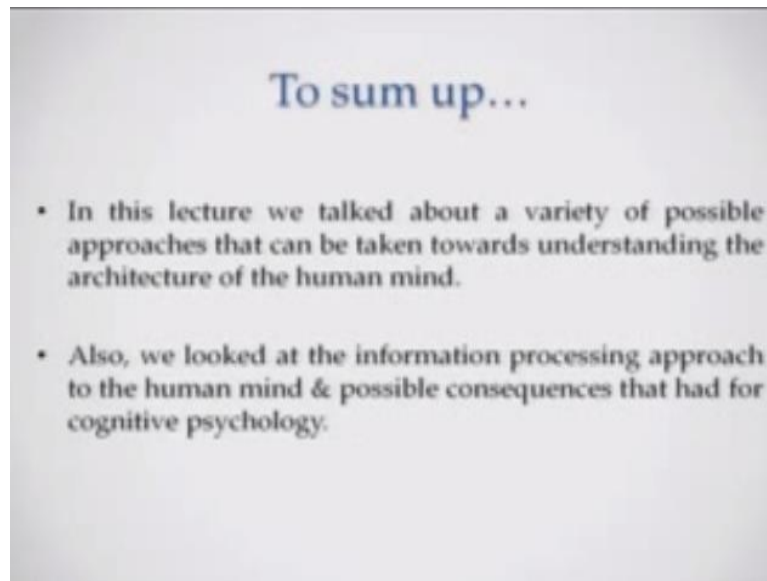
So to sum up today's lecture what we talked about today was these various approaches towards understanding the mind, brain relationship or what goes on in the mind and we also talked about a very important approach which is the information processing approach. Thank you.

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Ashutosh Gairola

Dilip Katiyar

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