Design and Implementation of Human – Computer Interfaces
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Module No # 03
Lecture No # 14
Norman's Principles

Hello and welcome to the NPTEL MOOCs course on the design and implementation of human-computer interfaces. We are going to start lecture number 13 on interface design guidelines. So, we will continue with our discussion on interface design guidelines which we started in the previous lecture before, we start let us quickly recap what we are discussing. What are these all about? So currently, we are discussing the interactive system development life cycle.

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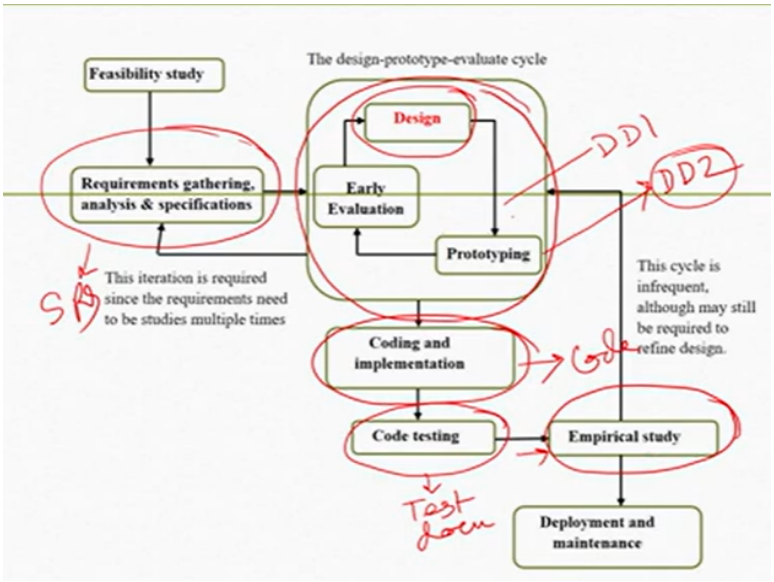

In the life cycle, several stages are there we have already covered the requirement gathering analysis and specification stage, where we have learned how to identify and specify requirements for a system? Now, these requirements include requirements from the point of view of the users or usability requirements as well as the requirements by the client or customer which are generally called functional requirements or features in the system.

Now, usability requirements can also be converted to functional requirements as we have seen in our case study. So, we have learned how to gather these requirements and how to specify them

and create SRS documents? So, that is the outcome of this stage SRS now, once that is there then we enterinto this design prototype evaluation cycle. Here, we start with design in design 2 designs are referred to one is interface design other one system design.

So, first, we talk about interface design. How to design the interface and interaction so as to ensure usability? Now that design has to be prototyped and evaluated to refine the design. Once the interface design is stabilized or finalized go for system design, which we refer to with the same stage name design. So, at the end of the interface design cycle, we geta design document say interface design document and at the endof the next design cycle that is related to system design.

We get the final design document as the output of this stage. Now, this design document is then used to implement the system which ispart of the coding and implementation stage. Here we go forward to implement the design in the form of executable programs. So, the outcome of this is a code now, this code is tested to check for its execution ability and this execution ability istested through different means, which is done in the code testing phase.

In the end, there may be a test document generated after that, we get a full executable system and then we go for usability testing of the full system throughthis method called empirical study or empirical research method. Where; we employ end users in a controlled experimental setup to determine usability issues. Determine and resolve usability issues after the system is designed as usable and executable, we go for the final stage which includes deployment and maintenance.

That is the overall life cycle for any interactive system development. So, we have already covered requirement gathering currently we are continuing with the interface design phase.

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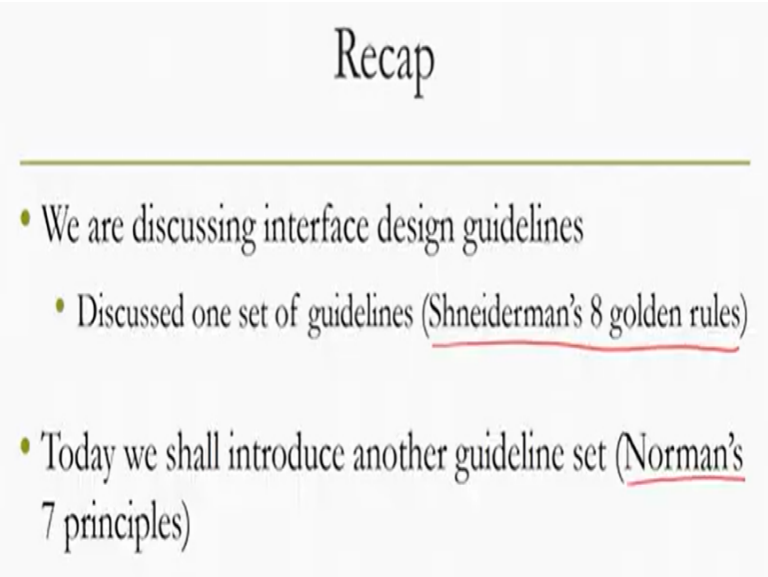

Now, in the design stage, there are 2 issues of concern one is where to start andhow to express the design. So currently, we are focusing on where to start the design of an interface. So, we saw that the starting point can be our experience intuition and it can be added or it can be done with the help of design guidelines. We have already discussed one set of design guidelines which is Schneiderman's 8 golden rules. In this lecture we will cover another set of guidelines called Norman's 7 principles. So, this set of guidelines is named after Donald Norman who proposed the set.

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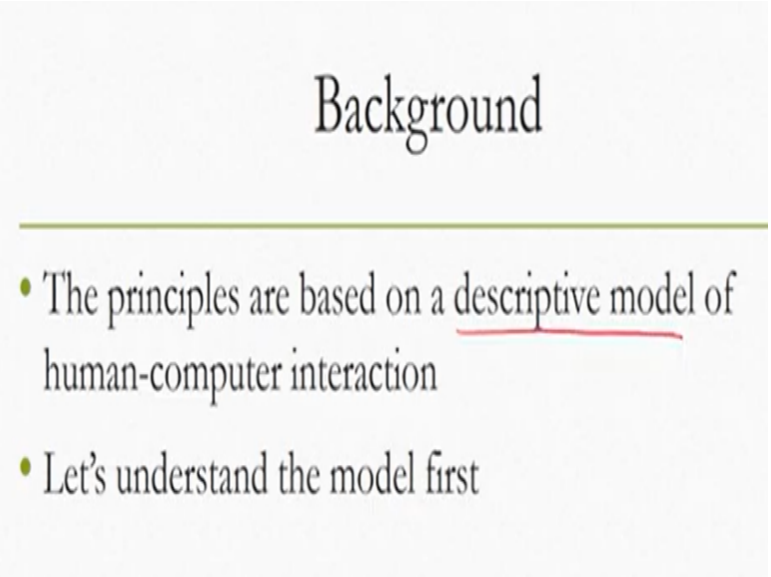

Now, before we actually turn our focus on the actual set of guidelines or principles, we should note that these guidelines or principles are based on a descriptive model of human-computer interaction. So, whenever a human user interacts with a computer system here, note that the term human user refers to layman users. Then, that interaction can be modeled. So, one such model was used to develop these principles.

Let us first try to understand that model. So, we will first try to understand the underlying model descriptive model which gave rise to these 7 principles. Now, this model is called the model of interaction by Norman or Donald Norman who proposed this model. Note that this is a descriptive model which means it can explain interaction rather than predict future effects of the interaction.

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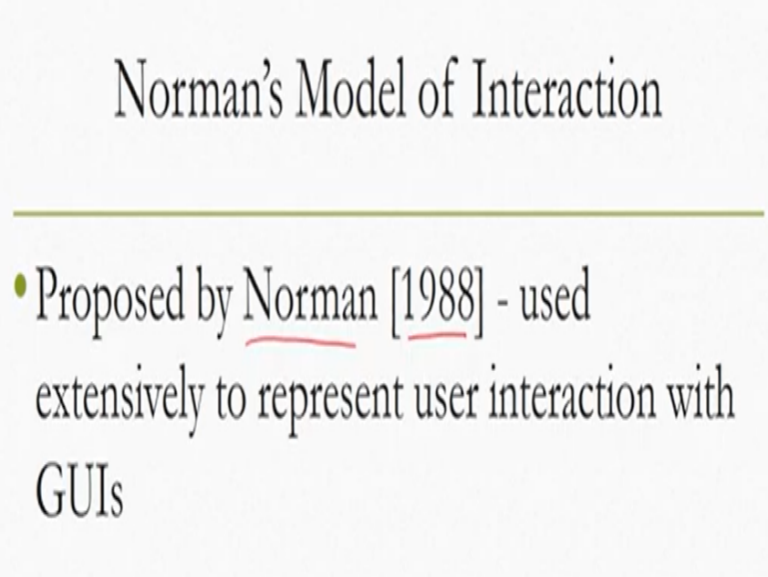

Now, the model was proposed by Norman way back in 1988. Almost, contemporaneous to the golden rules by Ben Schneiderman's, which was proposed in 1986. So, the setting was similar basically, this model was proposed to explain interaction with GUI's or graphical user interfaces. Just to recollect at that point in time the GUI was coming into focus, those were being extensively developed and used in personal computing devices that were coming up at the time, particularly personal computers.

So, because of the popularity of those interfaces, it was felt necessary to study and analyze those interactions and come up with better designs. In that context, such models and guidelines were

proposed that include the golden rules by Schneiderman's, as well as the 7 principles by Norman, which is based on the explanatory or descriptive model of interaction with GUI, which again was originally proposed by Norman.

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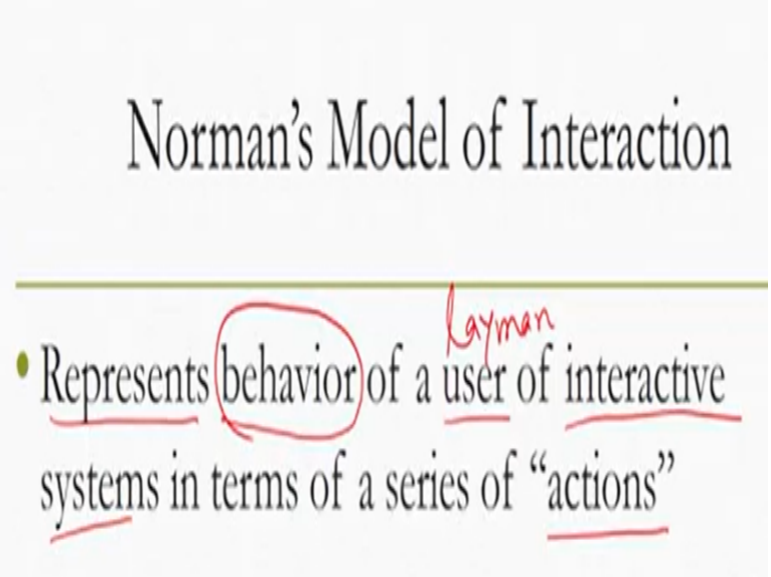

Now, the model essentially represents the behavior of a user here. The user should be understood as a layman user or someone who is not an expert in the underlying technology. So the model represents the behaviour of a layman user of interactive systems in terms of a series of actions. So, the model is nothing but a series of actions that represent the behaviour of a lay person or layman user when he or she is interacting with an interactive system.

Now, here of course although we are using the generic term interactive system, originally the model was developed keeping in mind interaction with graphical user interfaces which is one of the earliest examples of interactive systems.

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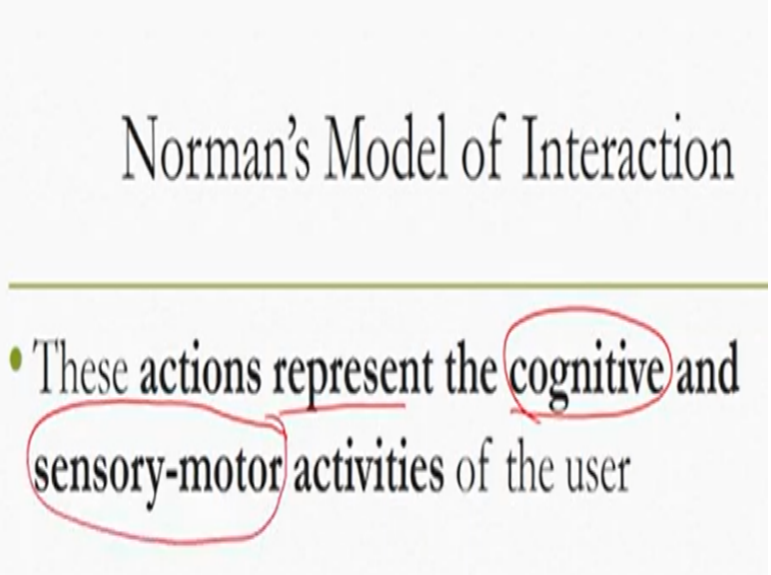

Now, these actions are the series of actions that is the model these actions represent 2 things. The cognitive activities as well as the sensory-motor activities of the users so, when we say that we are trying to model the interaction essentially what we are doing is? We are trying to model the cognitive behaviour that is the behaviour that goes on inside the mind and the sensory-motor behavior of the user. Sensory motor behavior refers to behaviour that is taking place through the use of sensory organs and motor organs.

What are our sensory organs? Namely, we have 5 sensory organs eye, ear, skin, tongue, and nose.Through this we sense the environment, and what are our motor organs. Everything can be a motor organ like the eye which can move the mouth, head, hand, and leg. So, whenever interact we make use of our sensory organs to sense the system state and take mental actions to process the sensed information and then perform some motor actions to interact with the system based on the input which is sensed through the sensory organs.

That is in a very broad sense how we can view interaction. Now in this model of interaction by Norman this broad idea is further concretized with a set of actions presented in sequence.

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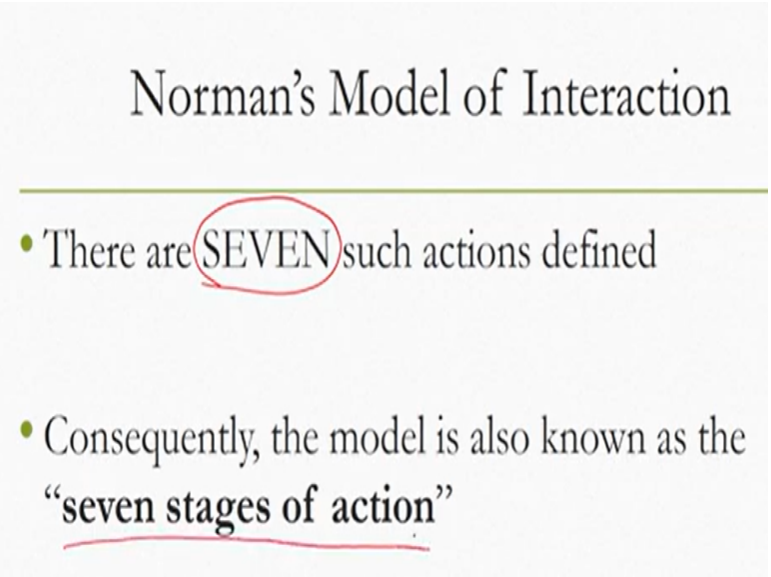

To be precise the model talks of 7 such actions covering the cognitive as well as sensory-motor activities of the user while, interacting with a graphical user interface. Now, because there are 7 actions mentioned. So, the model is also often called 7 stages of action. So, in either way, we can call it either model of interaction or 7 stages of action both refer to the same model.

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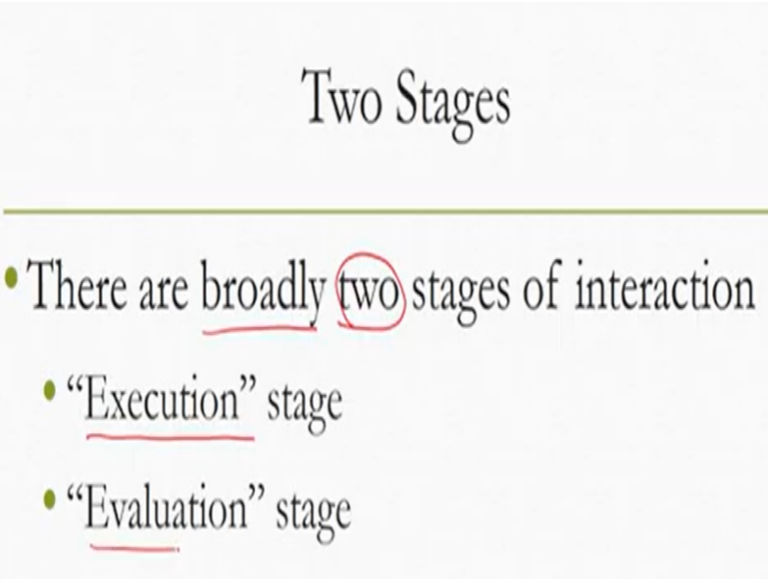

Now, these activities or actions these series of actions can be divided broadly into 2 stages. This idea stems from the fact that any interaction can be broadly divided into 2 stages. One is the execution stage another one is the evaluation stage. Let us try to understand what are these stages? And what they actually imply?

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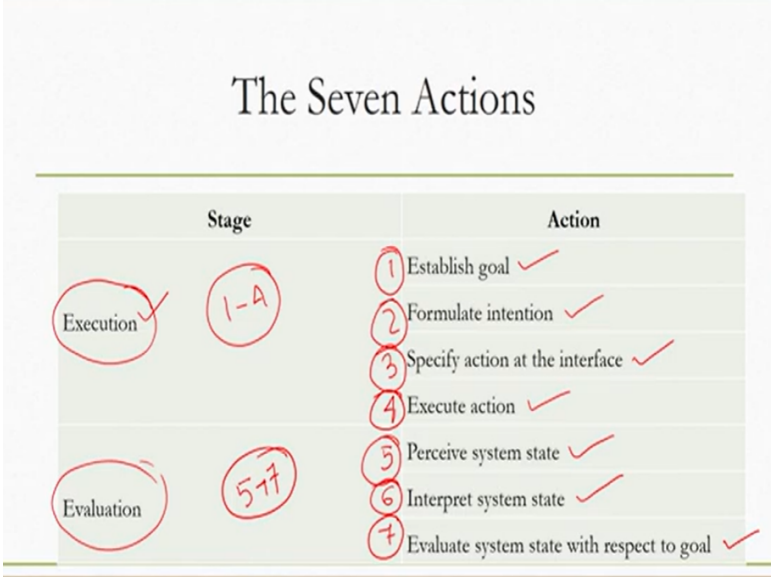

So, out of the 7 actions or activities that form the model our actions are part of the execution stage.What are these actions establish a goal that is action number 1 formulate intention action, number 2 specify action at the interface action, number 3 an execute action, number 4 the remaining 3 actions constitute the evaluation stage. Now, these 3 actions are to perceive system state, interpret system state, and evaluate system state with respect to the goal.

So, these are the 7 actions. action number 1 establishes goal, action number 2 formulate intention, action number 3 specifies action at the interface, action number 4 executes action, action number 5 perceives system state 6 interprets system state, and 7 evaluates system state with respect to the goal. Out of these 7 actions, 4, 1 to 4, these 4 actions are grouped together and called the execution stage of interaction. 5 to 7 these 3 actions are grouped together and called the evaluation stage.

So, there are 2 broad stages of interaction per the model execution stage and evaluation stage. In the execution stage, 4 actions are defined as part of the model, in the evaluation stage 3 actions are defined as part of the model. Now, let us try to understand what these actions are?

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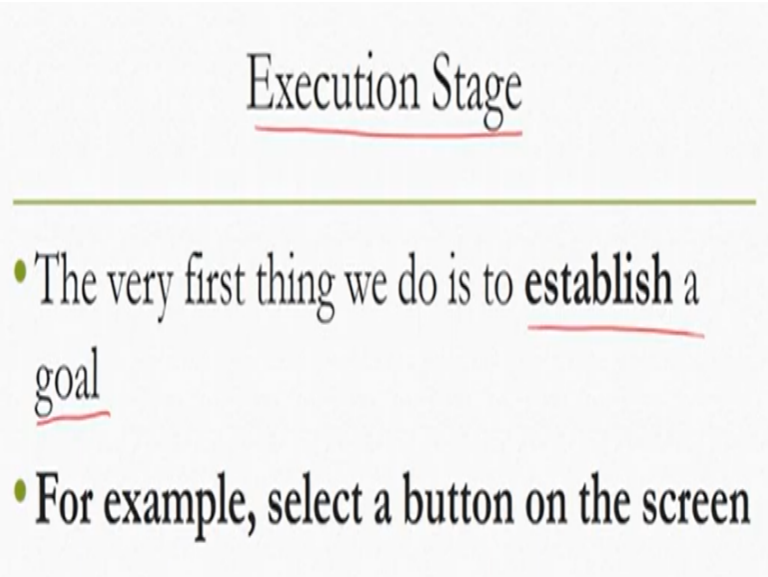

So, in the execution stage as we have just seen we carry out 4 actions what are these actions? Let us see, the very first action, that we perform it should be noted that all these actions have to be performed in sequence it is not a random sequence. So whenever, we want to explain an interaction, we have to consider these actions happening in the sequence these are shown. So, the very first thing in that sequence of 7 actions is to establish a goal, which is part of the execution stage.

So, what does it mean? It means that before we start interaction we create or establish a goal to achieve in our mind. For example we want to interact with a GUI through a selection of a button. So, our goal is to select a button on the screen that is the goal. We have not yet selected or done anything physically, but we have established the goal. There is this button I have to select it. So, that is the first action in the execution stage.

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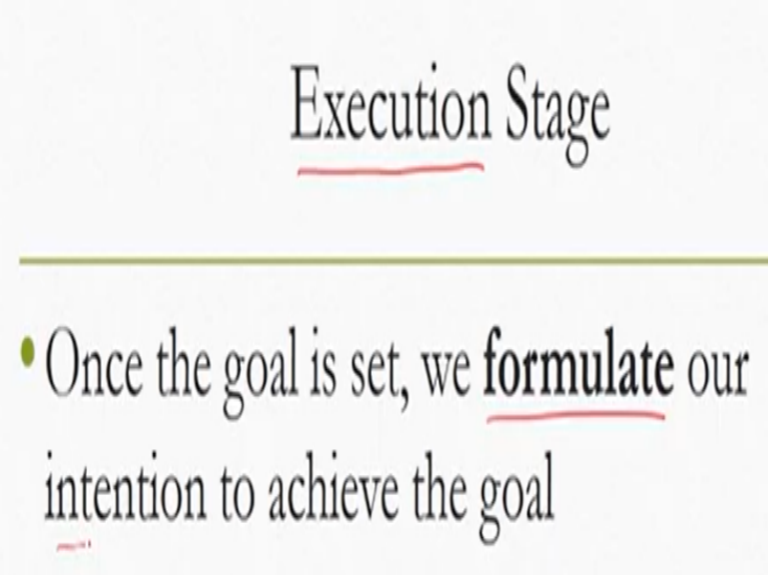

Once the goal is set, the next action in the execution stage is we formulate our intention to achieve the goal. So, that is again another mental activity that we perform before we actually start doing the physical activity. So, the first is one mental activity to establish the goal, second is another mental activity to formulate our intention to achieve the goal. That means, we think mentally that this is the goal to achieve this we need to do these things. So, that is our intention and we do that in the second act.

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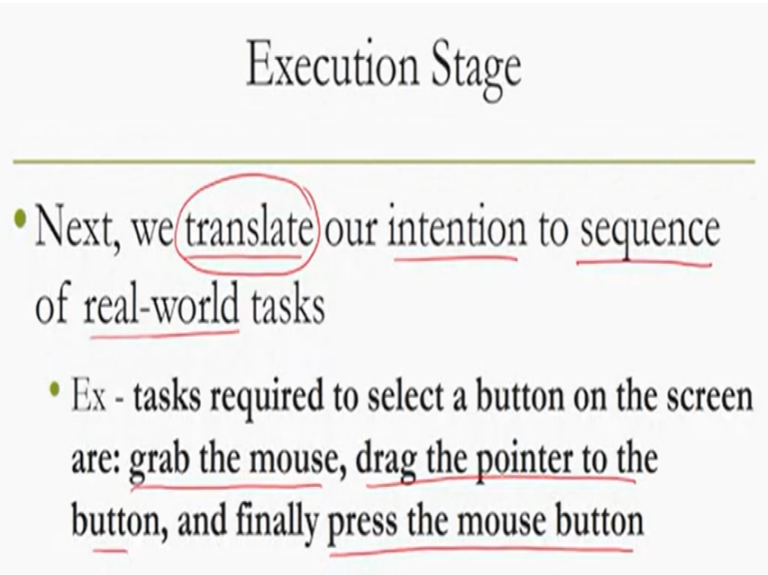

Next, we translate our intention into a sequence of the real-world task. Now, this is important so mentally we define our intention or set our intention, formulate our intention that we have to

achieve this goal, and in order to do that we need to do certain tasks. But, those tasks that we thought of mentally need not be supported by the interface. So, the third action that we should perform is mapping the mentally determining tasks to the tasks supported by the device or by the interface, which will allow us to achieve our goal.

So, we need to translate our intention intothe sequence of real-world tasks. As an example, we may have set the goal of selecting a button and formulated our intention as that to select the button we need to select, we need to point to it, and then do something to select it. Now, this series of sub-tasks that we need to perform to select it is our mental thinking. Now to point it we have not concretized anything.

Now in the third stage, we can think of mapping these intentions of pointing a button or locating a button, or selecting a button in terms of things that are supported by the system. For example, grab the mouse drag the pointer to the button, and press the button. So, these are tasks supported by the interface. So, our intention has to be mapped to these tasks which are supported by the system or interface that is the third action in the execution stage.

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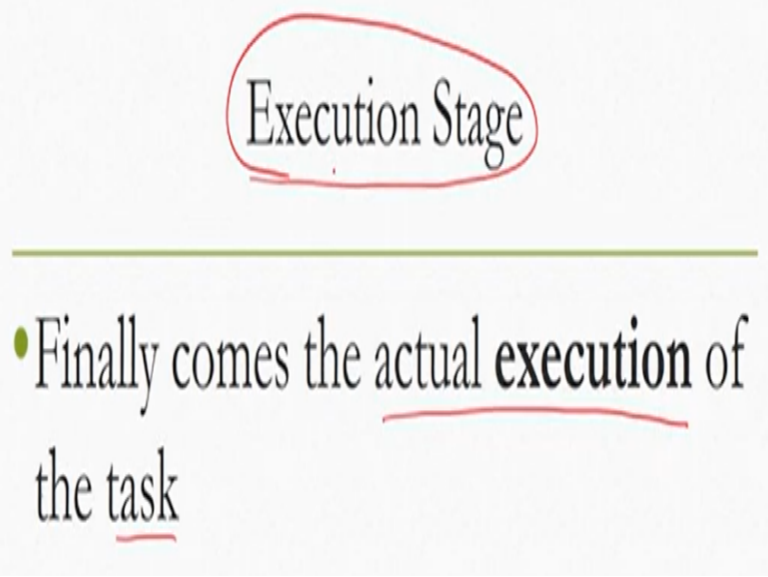

The execution stage also involves a fourth action which is the actual execution of the tasks. So, in the first action we set a goal, in the second action mentally we formulated our intention to achieve the goal. In the third action we translated this intention to real-world tasks and the fourth action is actually performing these tasks. That is actually grabbing a mouse, actually dragging a

pointer, and actually pressing a mouse button. So, that is the fourth and final action in the execution stage. So, that is the execution stage.

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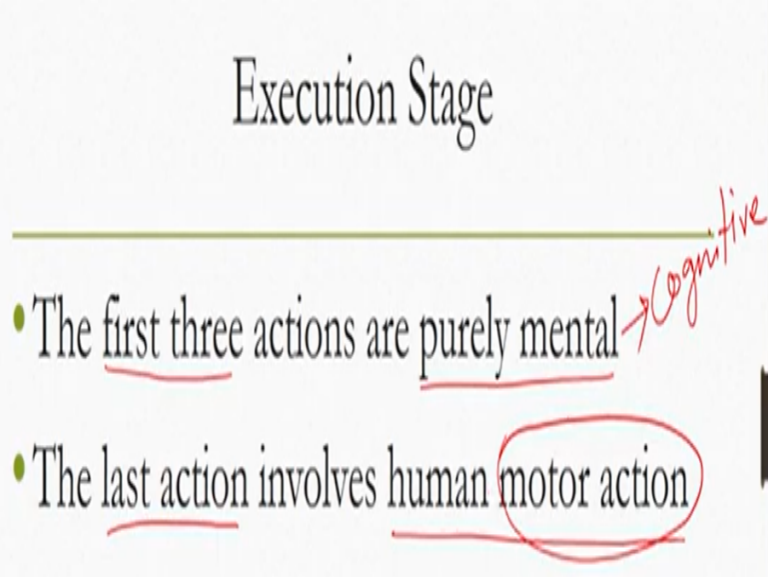

Now, if you have noticed there are 4 actions out of which the first 3 actions are purely mental. So, this mental or cognitive behaviour of the user is captured with the first 3 actions. The last action involves human motor action the last action actually captures the motor action of the user. So first, 3 capture the cognitive behaviour, and the last action captures the motor behaviour.

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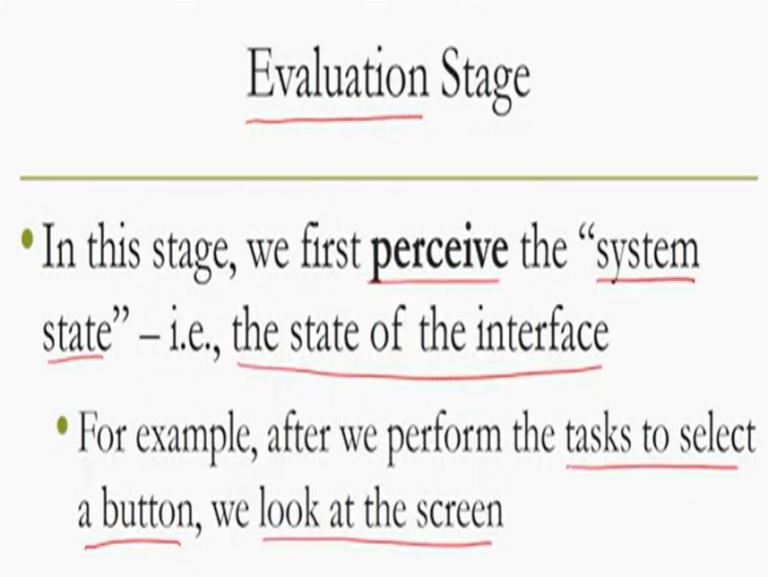

Let us now move to the evaluation stage. That is the second stage of the interaction with an interface in this context a graphical user interface. So, in this stage, we first perceive the system state or the state of the interface. So, whenever we are using the term system we are actually referring to the interface because a user interface is synonymous with a system. The user is not aware of what is going on inside the computer.

So, anything that is not visible or perceivable to the user is irrelevant and whatever is visible is relevant and that actually is the system to the user. So, in the evaluation stage, the first task is to perceive the system state or state of the interface. For example, after we perform the task to select a button, we look at the screen. So, to perceive the outcome of the selection operation so, we intended to select a button we formulated intention.

We set a goal first formulated intention, translated to actual actions, and perform the actual actions. After that, we try to perceive what happens to the interface or the screen. So, we look at the screen to perceive the interface. That is, the first action that we do in the evaluation stage.

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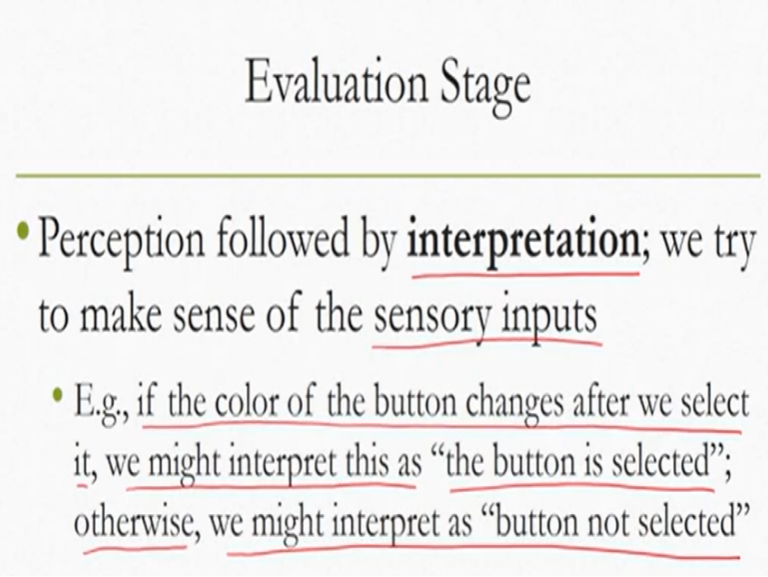

Perception is followed by interpretation we try to make sense of the sensory inputs. So, perception involves perceiving through our sensory organs. Now, that collects information from the environment then comes interpretation the second action in the evaluation stage, where we try to make or where we try to understand the meaning of the sensory input. For example, if we

continue with our button selection task for example so, if the colour of the button changes after we select it.

We might interpret this as the button selected if the colour does not change, we might interpret it as a button not selected. So, after we perceive the screen and sensed through our eyes the button with its colour and interpreted that there is a colour change. So, the button is selected that is one outcome of this action. If there is no colour change that is sensed through our visual sensing system that is the eyes.

We may interpret it as the button is not selected, so we may try to select it again. So, the second action in the evaluation stage is an interpretation of the sensory input which we gather as the first action in the evaluation stage.

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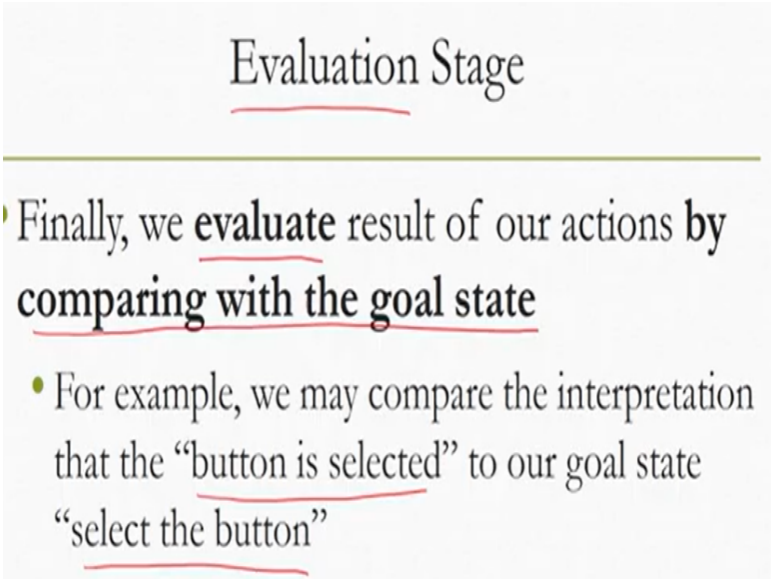

The third action is very crucial that is we evaluate the result of our action by comparing it with the goal state. So, we perceive the state interpreted the state and come to a conclusion that this is the outcome. Now, this outcome we compare with our goal to see whether we have reached the goal. For example, we may compare the interpretation that the button is selected to our goal state that selects the button.

So, this comparison is the third and final action in the evaluation stage.So, in the evaluation stage then we perform 3 actions. One is to sense the environment or sense the system state or perceive

the system state then whatever we have perceived we need to interpret as the second action and finally, the result of interpretation is compared with our goal state to understand whether we reach our goal state or not.

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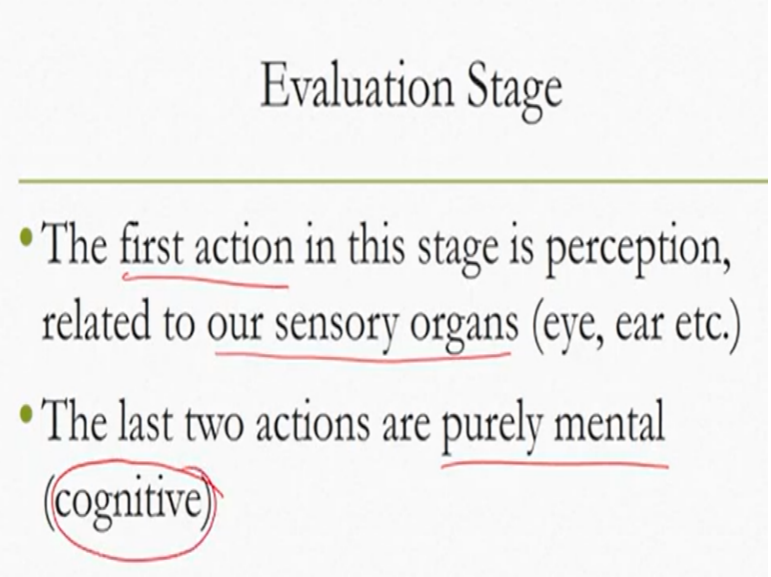

Again, if you have noticed carefully the first action that is perceived in the system state is related to our sensory organs. So, this action actually models our perception behavior. The last 2 actions are purely mental. So, models our cognitive behavior. So, in the execution stage, we have seen that there are 3 cognitive actions and 1 motor action. In the evaluation stage, we can see that there is 1 sensory action and 2 cognitive actions.

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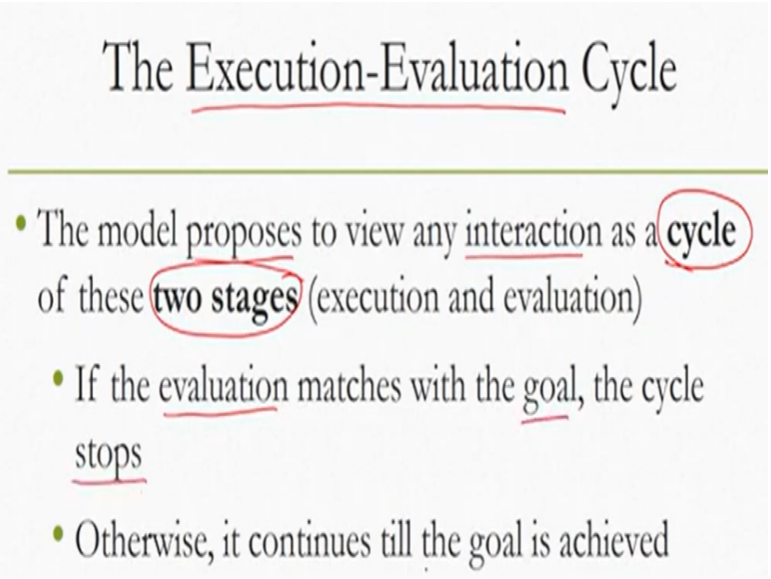

So, as you may have noticed by now that with these 7 stages, we can try to understand any interaction with graphical user interfaces in particular and generally interactive systems of any nature. Because these actions are very broad and generic and the overall model refers to any interaction rather than specific interaction. So, whenever we are interacting with any GUI, for example, one web page we can try to analyze, how we interact in terms of these 7 actions.

But once we do that, then what? So, what we gain by analyzing in terms of 7 actions. In fact, these actions are the model if deployed properly, to understand an interaction can lead to many interesting outcomes. One interesting application of the model is in terms of the execution evaluation cycle. So, the model proposes to view any interaction as a cycle of these 2 stages, the execution stage, and the evaluation stage.

So, with this model, we can think of any interaction as comprising of cycles of these 2 stages execution stage and the evaluation stage. If the evaluation matches the goal then the cycle stops. Otherwise, it continues till the goal is achieved. So, the last action in the evaluation stage is to compare with the goal state. If the goal is achieved, we stop it otherwise, we start the execution stage again with the 4 actions and then go to the evaluation stage again to compare whether we reach the goal stage and this cycle goes on till we arrive at the goal state. So, that is a very interesting way of looking at any interaction.

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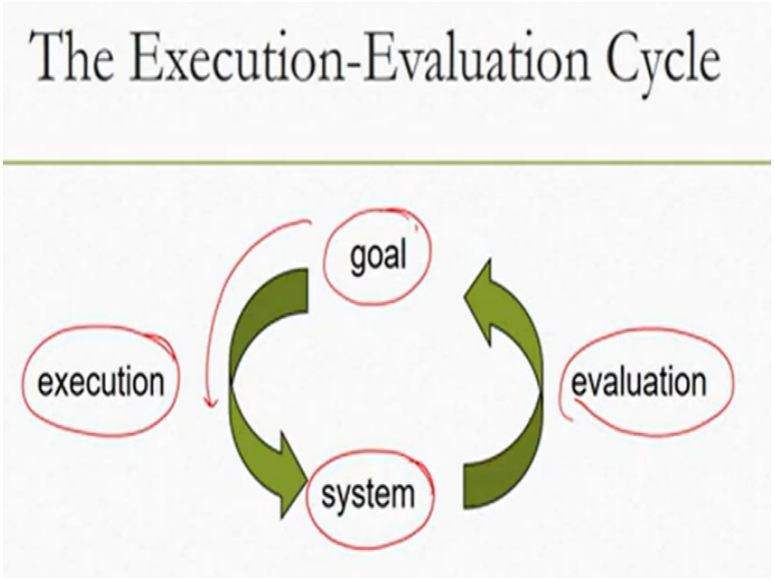

So, graphically we can represent an interaction in this cyclic form we have an execution cycle, and evaluation cycle, so the execution cycle starts with the establishment of coal and come to the actual action on the interface. The evaluation circle start after the actions are performed and the perception of the state begins and it reaches the final act where the goal state is compared with the outcome of the evaluation stage.

If it matches, then the execution stops the execution of the cycle. Otherwise again we go to the execution stage and this continues. So, that is a nice way of looking at any interaction.But again, so what so we get to know this cycle. Then what we can do with this knowledge?

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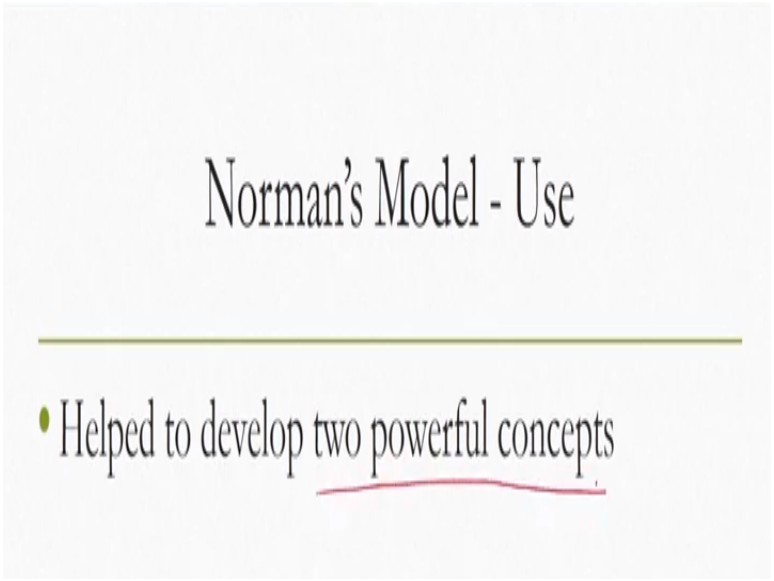

(refer time: 29:07) This simple descriptive model of interaction can be put to much significant use. Now, this model helps to develop 2 powerful concepts. What are these concepts?

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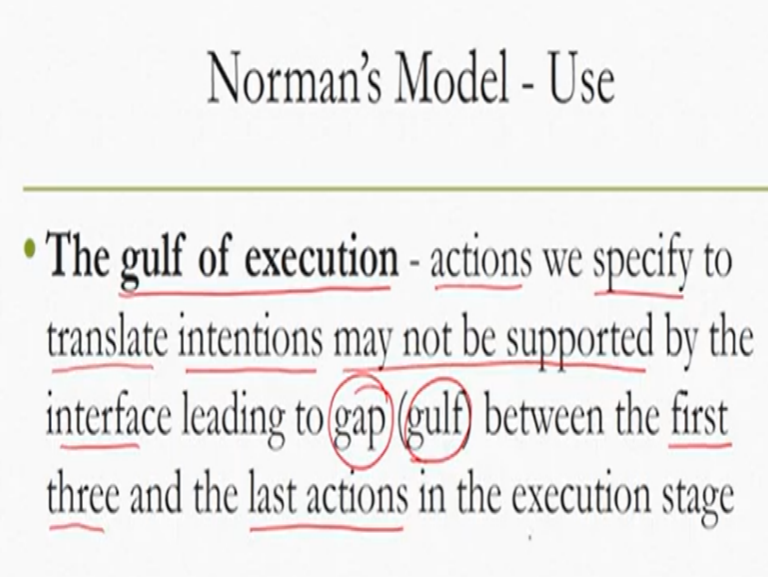

One is called the gulf of execution. Now, this concept states that actions that we; specify to translate intentions to action supported by the system, may not be supported by the interface. Leading to a gap or gulf between the; first 3 actions in the execution stage and the last action in the execution stage. So, the first reaction just to recollect tells that we first establish a goal then formulate intention and translate intentions to some set of actions that are doable on the interface.

It may so happen that the interface does not support those actions that we identified after the translation stage. Then in spite of having come up with a set of actions to be done on the interface is not supporting those actions. So, we will not be able to perform those, actions. If there is such situation then we call that there is a gap or gulf between the first 3 actions and the last action of the execution stage so, this is called the gulf of execution.

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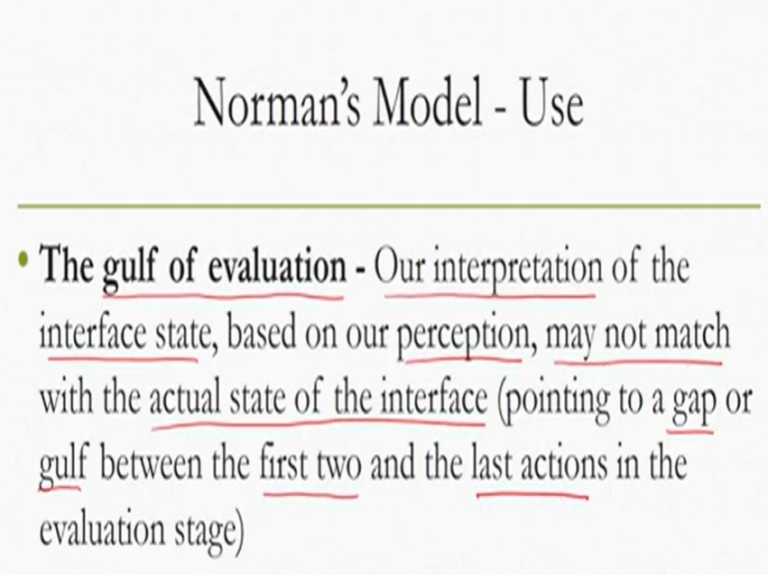

Similarly, we can have a gulf of evaluation our interpretation of the interface state based on our perception may not match the actual state of the interface. So, what we are perceiving and interpreting as the system state may not match with the actual state of the system. In that case, we call it a gap or gulf between the first 2 actions in the evaluation stage and the last action in the same stage so, in case of a gulf of execution, we have a gulf or gap between the first 3 actions and the last action in that stage.

And in case of a gulf of evaluation, we can have a gap or gulf between the first 2 actions and the last action of the evaluation stage.

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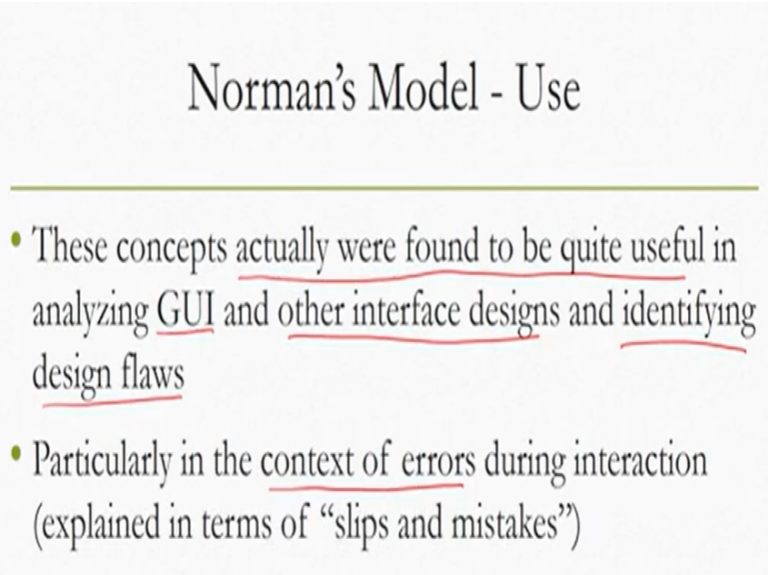

Now, these 2 concepts gulf of execution and the gulf of evaluation can lead to further application of the model. These concepts were actually found to be quite useful in analyzing GUI's graphical user interfaces and many other interface designs and they were useful in identifying design flaws. So, these concepts of the gulf of execution and gulf of evaluation were used heavily in analyzing designs of GUI as well as other interactions.

That this is particularly true in the context of errors analyzing errors that may happen due to design flaws in interfaces. The explanation of errors can be done in terms of 2 concept slips and mistakes. So, we can make use of the outcome of the model namely the gulf of execution and the gulf of evaluation concepts, to explain the occurrence of errors in user interaction with interfaces particularly GUI's in order to do that we can take the help of 2 concepts slips and mistakes.

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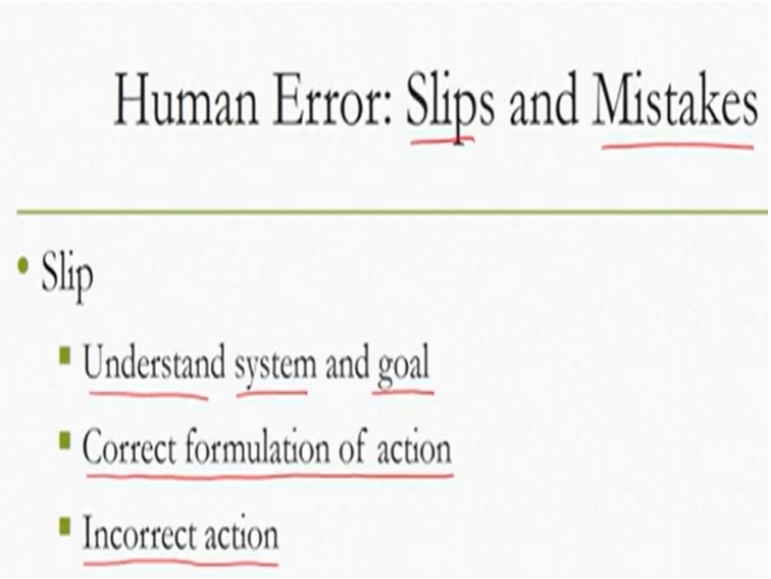

So, there are 2 types of human error slips and mistakes. Norman's model of interaction tells us when slips can occur and when mistakes can occur. Based on that information we can take corrective measures in our interface design. So, let us first understand what are these concepts? When we say that a slip has occurred during an interaction, we can explain it as due to these 3 things taking place that the user has understood the system and the goal.

The user has correctly formulated mentally the actions required to achieve the goal. But the user has made some mistakes made some errors in performing the actions sleep happens when the users have understood the system and goal formulated intention correctly and specified the

sequence of actions required to achieve the goal. But, made incorrect actions on the interface to achieve the goal ten if some error happens, we call it a slip.

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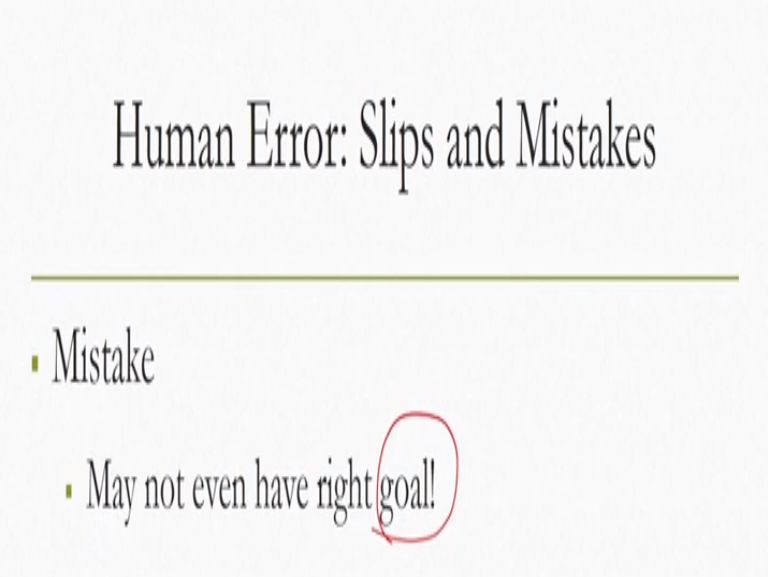

In contrast when you say that mistake happened? This may happen because there is some problem in formulating a goal properly. So, if the user is able to formulate a goal and specify actions. But could not perform the actions correctly then that is one type of error we call slip. If the user is unable to specify or establish the goal itself the very first action in the execution stage then if that leads to an error then we call it a mistake.

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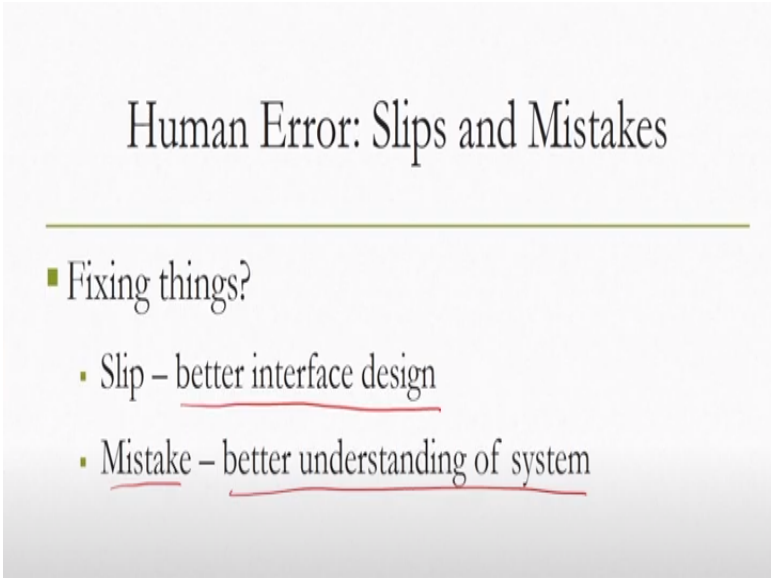

So, once we are able to understand the nature of the error whether it is a slip or a mistake we can think of corrective actions. So, in case of slips, if we notice that slips are happening, that can be fixed with a better interface design. So, those incorrect actions are difficult to perform. But if a mistake happens then, interface design change may not be helpful and users need to be trained on the interface properly.

So, it requires a better understanding of the system rather than, changing the system of course changing the design can help in understanding. But only changing the design will not be sufficient in case of slip so here along with the refinement of the design if required the user has to be thoroughly trained to make him or her understand the system in a better way. So, for errors that slip we can take one corrective measure.

For errors that are due to mistakes, we can think of other corrective measures. So, it is very important to know what; kind of errors are happening more frequently, and accordingly, we can take corrective measures to elevate the problem.

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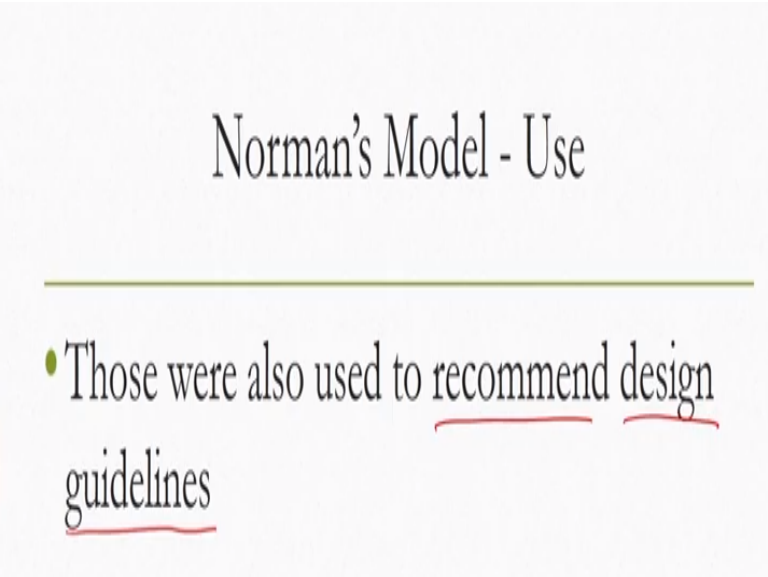

So, that is one very interesting application of Norman's model of interaction. So, it gave us these powerful concepts of the gulf of execution and the gulf of evaluation. Using these concepts, we can understand why an error happens and what kind of error happens for a given interface. And we will be able to judge better the nature of the error, and based on that judgment, we can take corrective measures. That is one interesting and important application of Norman's model of interaction.

Now the same model can also be used to recommend design guidelines which can serve as the starting point of any interface design activity like the way we can use the 8 golden rules by Schneiderman. Now, these recommendations in the form of guidelines there are 7 such recommendations called 7 principles. Let us see what are those 7 principles which is an outcome of the model of interaction.

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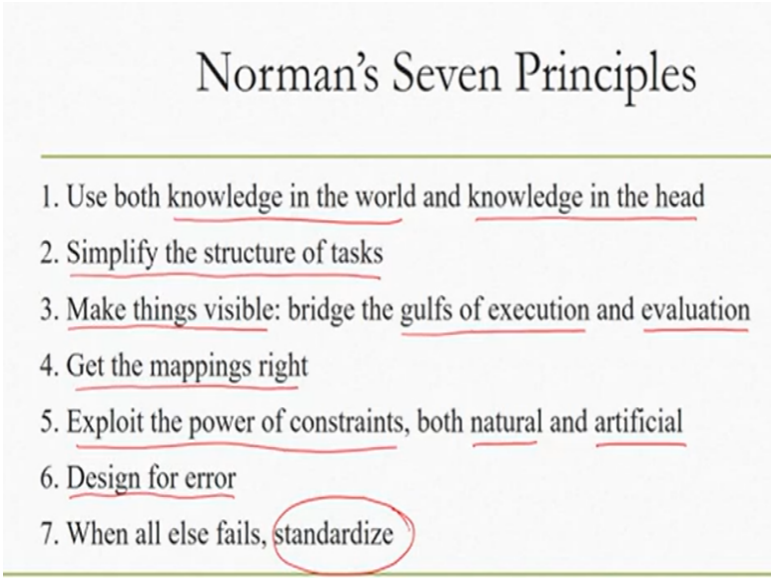

The first principle is while designing any interface, the user should be able to make use of both knowledge in the world and knowledge in the head, use the interface and the design should support in that behavior. The second principle states that any task that is performed by the user who is using the interface should have a simple structure. So, the structure of tasks should be simplified and presented in a simplified manner for the user to perform.

The third one is very important; whatever the interface does should be visible to the user so make things visible.This helps in bridging the gulps of execution as well as the gulfs of evaluation. The Gulf of execution and gulf of evaluation both can be bridged if things are made visible. Now, the model talks about the mapping from intention to actual physical action.The design should be made in a way such that this mapping is done appropriately and rightly.

So, the user is able to map rightly so the design should support actions that are easy to understand and easy to map to intention. That is one of the important principles. While designing the principles; also advises the designer to exploit the power of constraints both natural constraints and artificial constraints. So, this is another recommendation that whenever you are designing something you should be aware of the limit of interaction and you can impose constraints in the interaction and interface elements to make it easier for the user to understand comprehend and use the system.

The sixth principle talks about taking care of errors if during interaction error happens the design should support error handling. So, we should design for handling errors knowing that it will happen and the last one is somewhat interesting that if in spite of best efforts the designs are not behaving the way they should be expected to behave. We can standardize all the interactions and interface elements. So that it is enforced on everybody to use the way it is recommended.

So, flexibility is reduced and minimized with the process of standardization. Flexibility in the use of the interface, as well as flexibility in interaction with the interface, is reduced with the standardization of the design. So, that expected outcome is achieved. So, these are the 7 principles that resulted in one of the outcomes of the descriptive model of interaction proposed by Norman.

Now, these 7 principles can be used as a starting point for interface design. So if we have any design in mind we can see whether these principles are followed in the design of that interface. Then, we can go ahead and prototype test and do the other things in the design prototype evaluate cycle. So these 7 principles can act as a starting point in the same way. We can use the 8 golden rules as a starting point for interface design.

So, with that, we come to the close of this lecture. So, here in this lecture what we learned, we learned about a model of interaction which is a descriptive model that means it cannot predict. What is going to happen rather it can explain what is happening and why it is happening? Now, based on that model or idea of the interaction we can do several things so the model talks of 7 actions as representative of any interaction these actions are grouped into the execution stage and evaluation stage.

In the execution stage, there are 4 actions performed in sequence. In the evaluation stage, 3 actions are there performed in sequence and the evaluation stage actions follow the execution stage actions the model says that these actions represent the cognitive sensory and motor behavior of the users and these actions are performed in a cycle the execution evaluation loop, till we achieve the goal of interaction.

So, this model gave rise to powerful concepts such as gulf of execution and gulf of evaluation which help us to understand interactions better and interpret things that are happening with the

interaction.It also leads us to analyze the erroneous situation, understand the nature of errors that are happening with an interface, and can help us take corrective measures to reduce or minimize the occurrence of errors.

So, this gulf between execution and evaluation helps us to understand that errors can be of 2 types slips and mistakes.If sleep happens, we can go for a better design.If a mistake happens, then along with design we have to train the user on the interface.If trending is turning out to be too hard then that means the design is faulty. We need to change the design, but train on the refined design nonetheless to avoid mistakes.

That is one of the outcomes another outcome is to come up with a set of design guidelines. So, in this case, we have the 7 principles, that were formulated based on this model and these principles can be used as a starting point for interface design. I hope you enjoyed the learning so far and understood the concepts, explained in the lecture.So, that is all for this lecture.In the next lecture, we will take up the other stages namely prototyping, evaluation, and the subsequent stages.

That is all for now whatever I have discussed can be found in this book, particularly in chapter 3 section 3.3.2. If you go through this book this chapter and section you will get to know more about this descriptive model and how it leads to the principles so thank you and see you all in the next lecture goodbye.