User-centric Computing for Human-Computer Interaction
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Lecture – 17
The Hick-Hyman Law

Hello and welcome to the 17th lecture in the course User-Centric Computing for Human-Computer interaction. So, we will first recap what we have learned so far and then will start our main discussion for today. So, in the previous lecture we have got an introduction to the Fitts' law, this is a context specific behavioral model.

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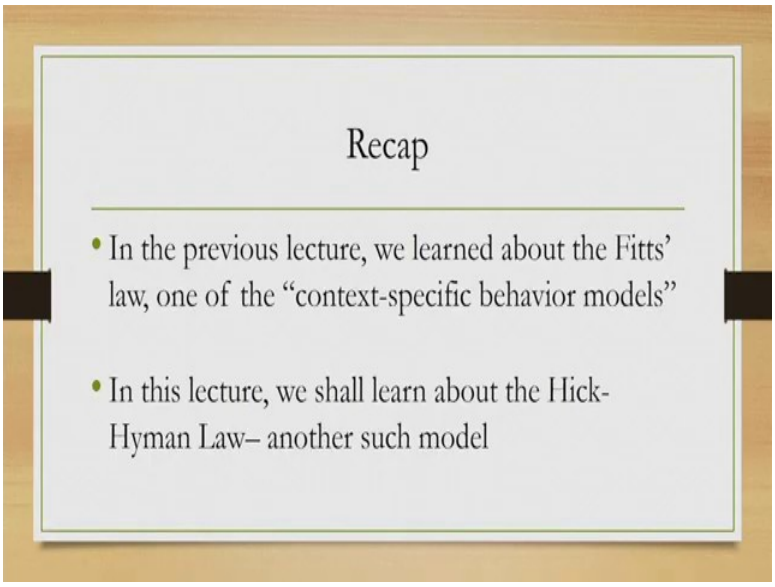

So, if you can recollect earlier we mentioned several category of computational user models, some are related to simple processing of human cognition, some are related to context specific behavioral model. Now, in the category of simple human information processing models, we have discussed the GOMS family of models the KLM and the CMN GOMS.

In the category of context specific behavioral model, we have seen the Fitts law in the earlier lecture which was inspired by information theoretic considerations. Although it was not originally meant to be used for user centric system development and design, it has found wide application in that particular area. Today we are going to discuss, another

such model which belongs to the category of context specific behavioral models and this is known as the Hick-Hyman law.

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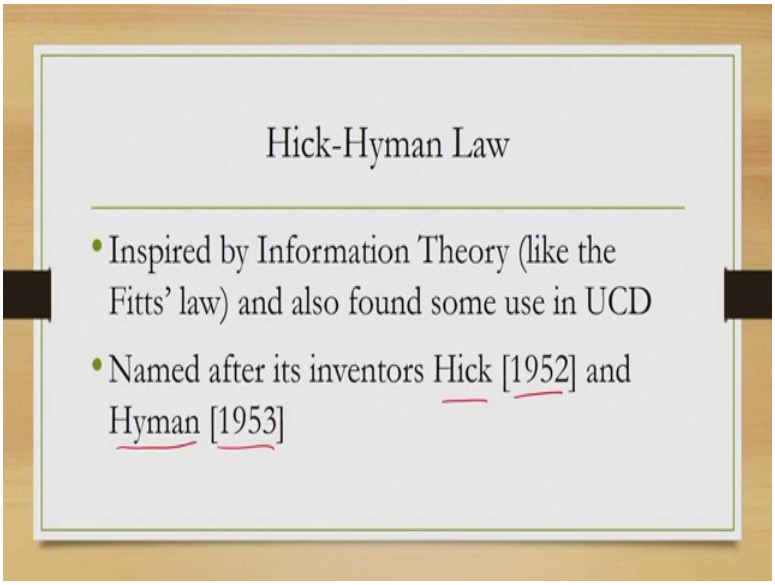

Now, this law also was inspired by information theoretic considerations just like the Fitts law and just like the Fitts law, it also found some usage in the user centric design domain. Now, although Fitts law is very popular Hick-Hyman law is not that popular, but still it has found some important applications in the domain of user centric design.

And the law got its name from its inventors Hick and Hyman, it was proposed almost 70 years ago in 1952 by Hick and in 1953 by Hyman almost at the same time, they separately came up with this idea and so the law got the name of both the inventors. So, what this law does? It models the time it takes to react to a stimulus in the presence of choice.

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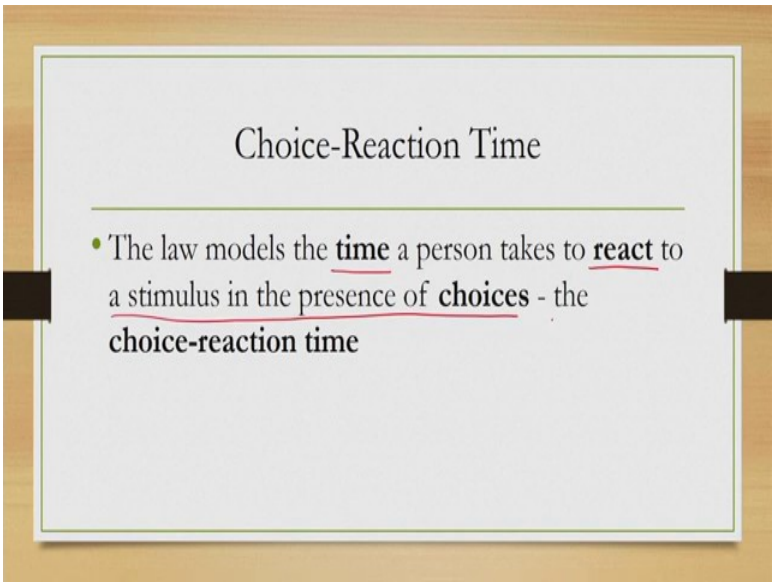

So, essentially what it tells is that given a set of choices we take some time to select one. So, that is known as the reaction to a stimulus in the presence of choices and this law models the time it takes for a person to do that. In other words, the law models the choice-reaction time let us try to understand this concept with an example.

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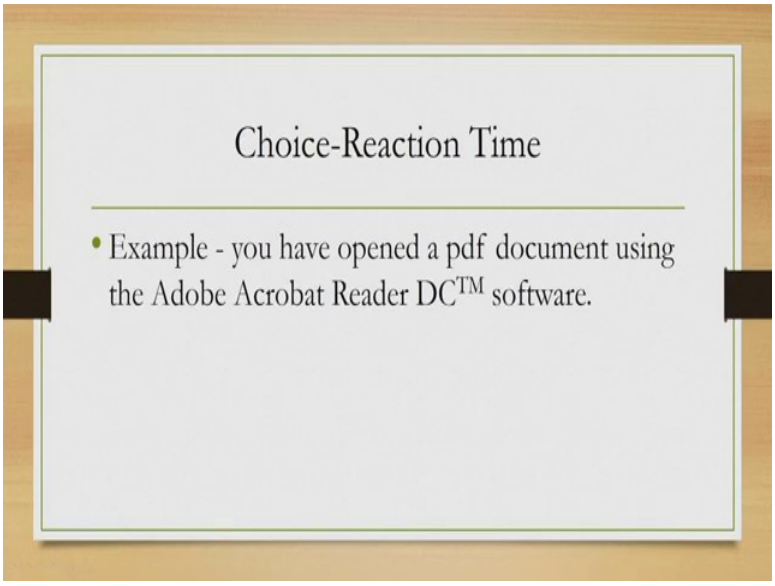

So, suppose you are asked to open a PDF document and you are asked to take a print out of it.

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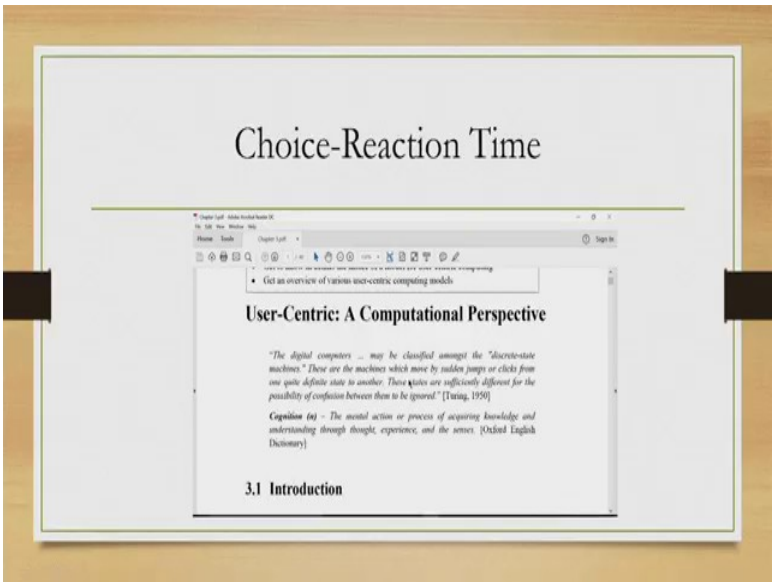

So, when you open a document you get a screen something like this. So, here the screen shows a particular version of adobe acrobat reader using which you have opened the document. Now, once the document interface is there suppose you want to print it.

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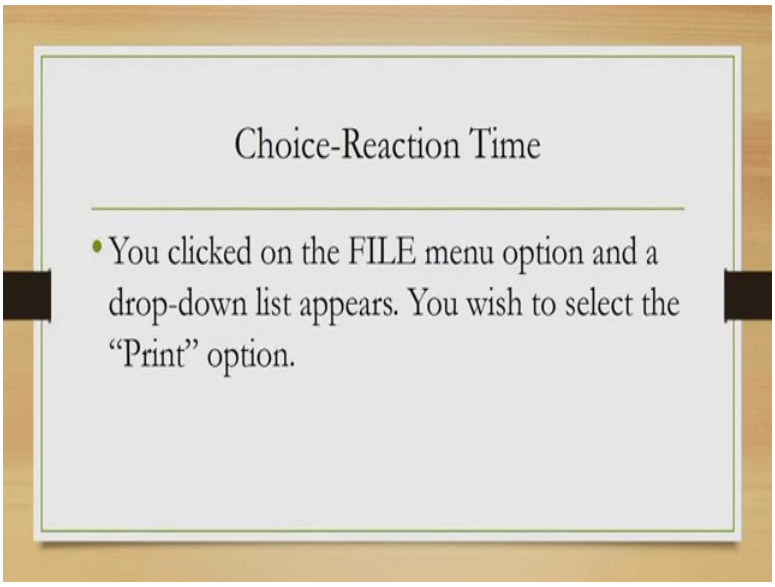

So, what you have to do? We have to select the FILE menu option and select the print option from the drop-down list that appears after you click on the file menu option, the situation is something like this.

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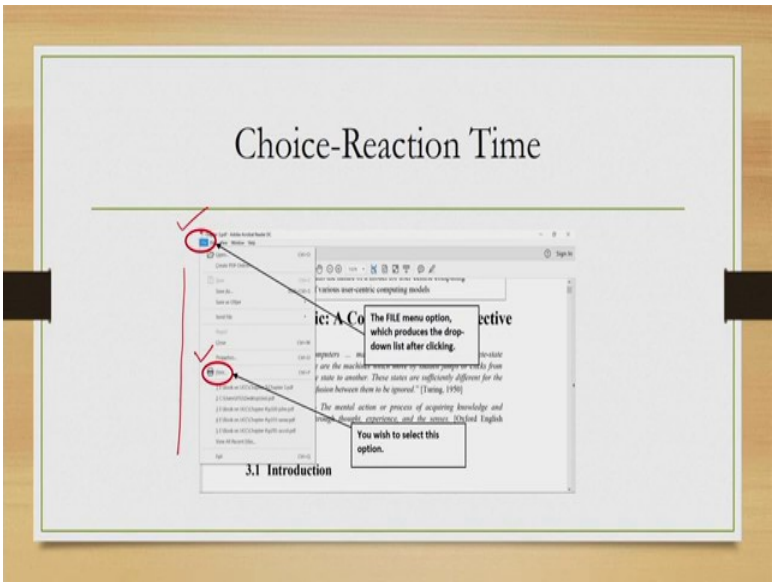

So, here within this red circle the file menu option is there you clicked on it the dropdown menu appeared and this drop down menu the print option is here within the red circle and you were supposed to select it. Now, let us consider the activity after you clicked on the file menu option. So, here once you clicked on the file menu option these list of other sub-menu options appeared in front of you and your job is to find out and decide to select the print option. So, note that it is not the same as selecting the option, selecting the option is a physical activity that you take your mouse pointer to it and select it.

However, before selection you perform some mental or cognitive activities and that is the time that is the reaction time that represents the time it take to perform those mental or cognitive activities, the decision making activities that precedes the actual physical activity of selecting the option.

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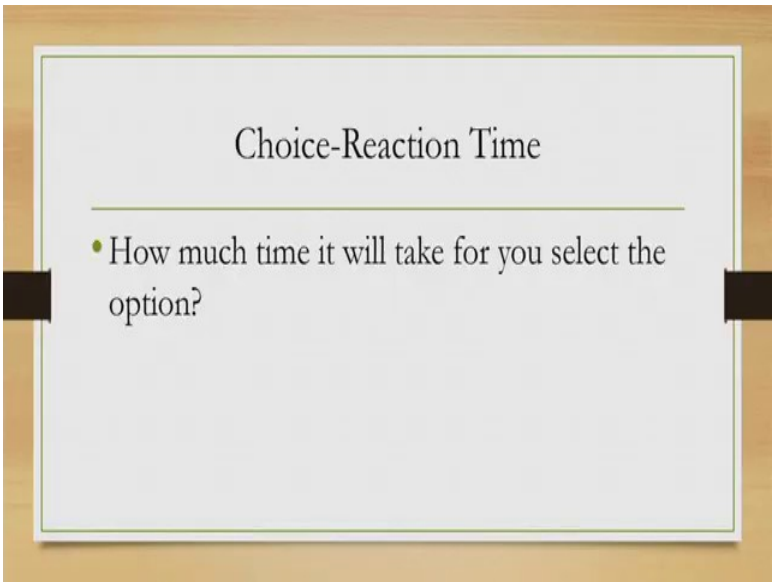

And with the Hick-Hymen law, we can actually find out how much time it will take to make that choice, how much time it will take to decide to select print after you clicked on the file menu option.

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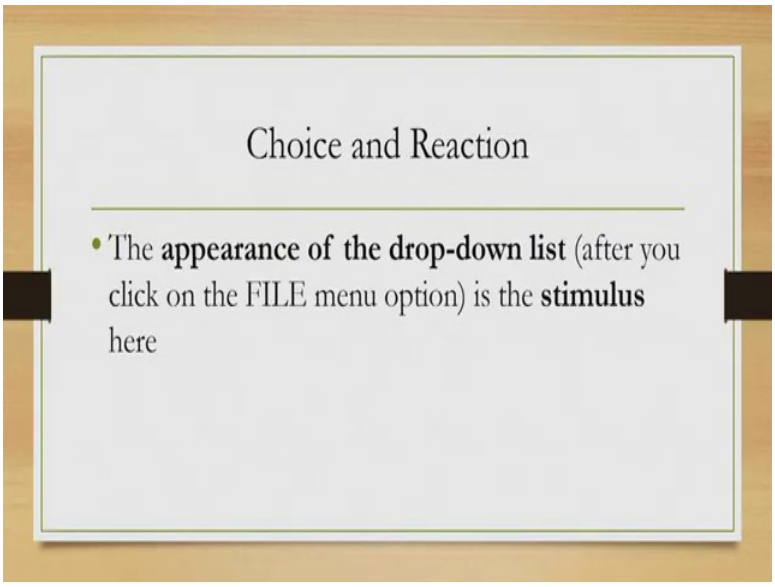

So, what then is the idea of choice and what is the reaction? As I said when you click on the file menu option the drop down list appears, so that is the stimulus the appearance of the drop down list. So, when it the least appears, then it acts as a stimulus for us to perform the decision making activity.

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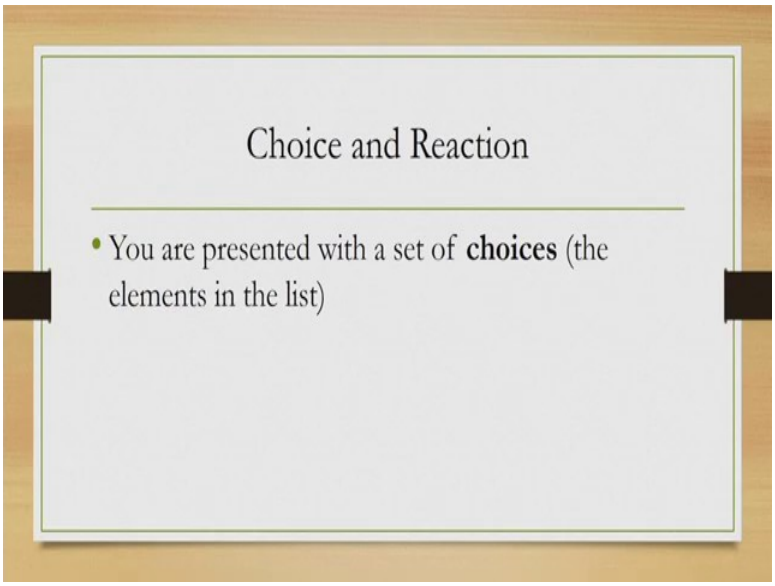

Once the list appears you are presented with a set of choices that is the elements in the list. So, these choices are the set of options out of which you have to select one.

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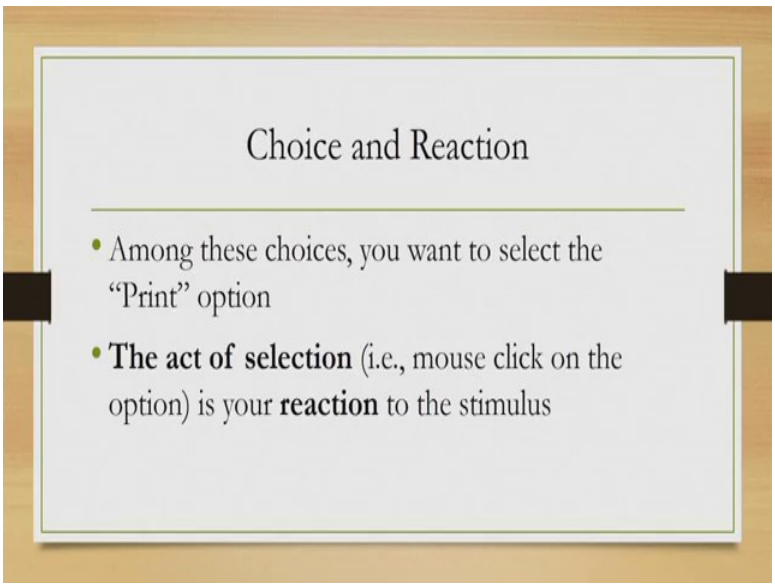

The act of selection is essentially your reaction to the stimulus. So, once you click on the file menu option, you are presented with a set of sub-menu options. Now, the act of clicking on the file menu option brings to you stimulus that is the set of options available.

Now, these set of options are the choices given to you within the set of choice you have to make a selection, you have to select the print option. The act of selecting the print option is the reaction to the stimulus.

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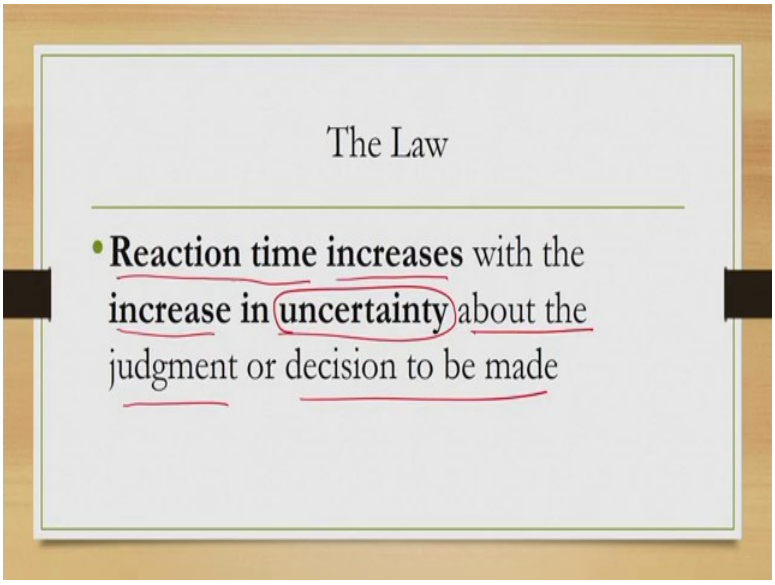

Now, what the law states? The law states that the reaction time increases with the increase in uncertainty about the judgment or decision to be made. So, the more uncertain a judgment is likely to be the reaction time will be more that is the idea of the law.

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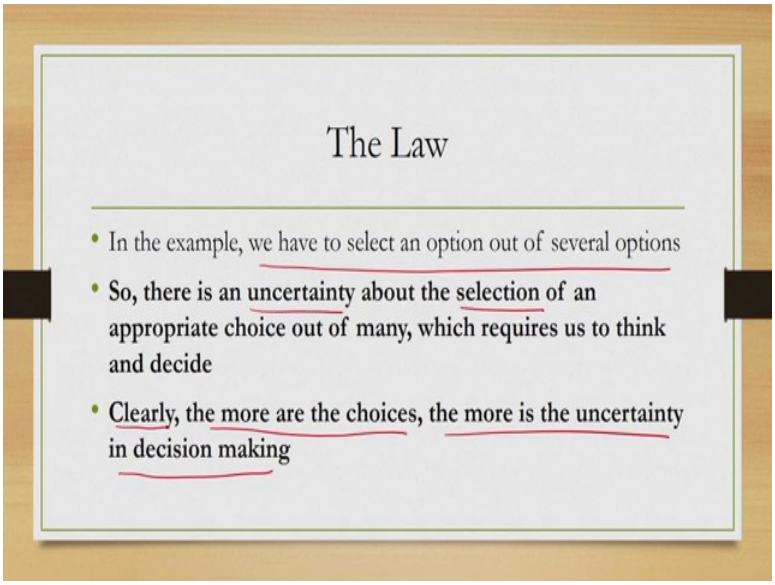

So, if I want to explain it in terms of the example, so let us go back to the example. So, we have to select an option out of several options, now that indicates that there is some uncertainty about the selection, because there are many choices available. So, which choice I want to select that I have to decide and that actually reflects the uncertainty in my decision making process.

Clearly, the more the number of choices, the more is the uncertainty in decision making, so that up to this point it is very intuitive that I am asked to make a decision in the situation where I am given several options. The larger the number of options, the difficulty in making the decision will be proportionately more and this number of options indirectly referred to the uncertainty in the situation.

So, I am presented with more uncertainty if the number of options are more, and in that case my reaction time or the time to make the decision to select one out of many options would be more.

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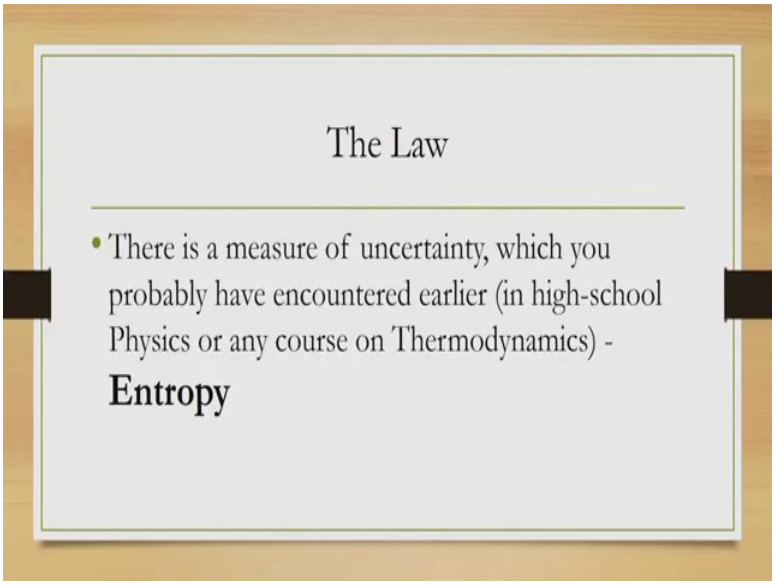

Now, we need to measure this uncertainty, we need to measure in a quantitative way this degree of uncertainty in a given situation. And this term uncertainty may not be unfamiliar to many of you, you probably have encountered this term in your high school physics or if you have done any course on thermodynamics in your previous years. Now, this measure is known as entropy and the same measure we will be using to model uncertainty in our decision making activities.

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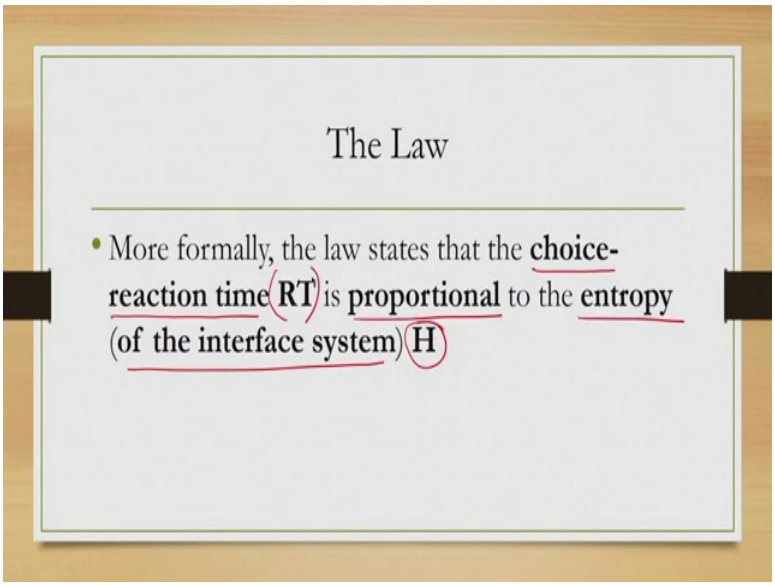

So, if we formally try to represent the law, then we can state in terms of entropy that the choice reaction time; let us denote it by the symbol RT is proportional to the entropy of the system that is represented by the interface, let us denote the entropy by H. So, RT or the choice reaction time is proportional to the entropy or H, where entropy refers to the entropy in the current setting of the interface. Or in other words mathematically we can represent it as RT proportional to H.

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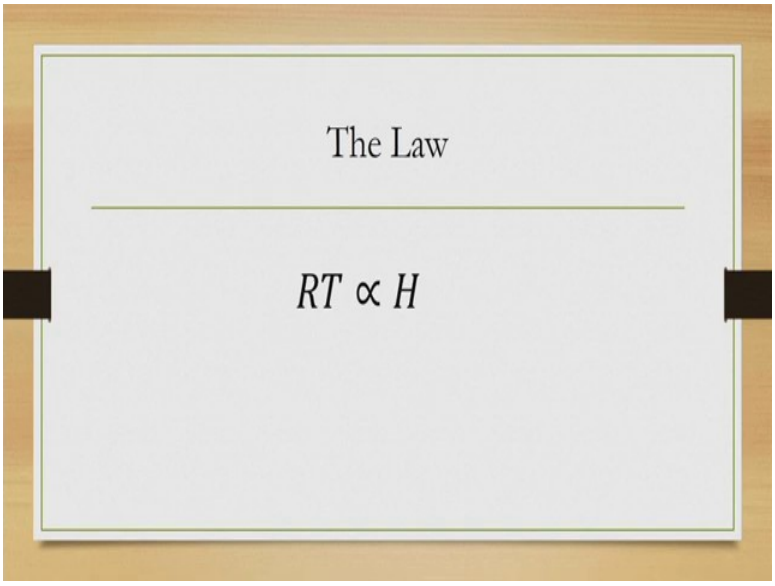

Now, from this law we can actually derive a predictive equation to compute, given the entropy compute the reaction time.

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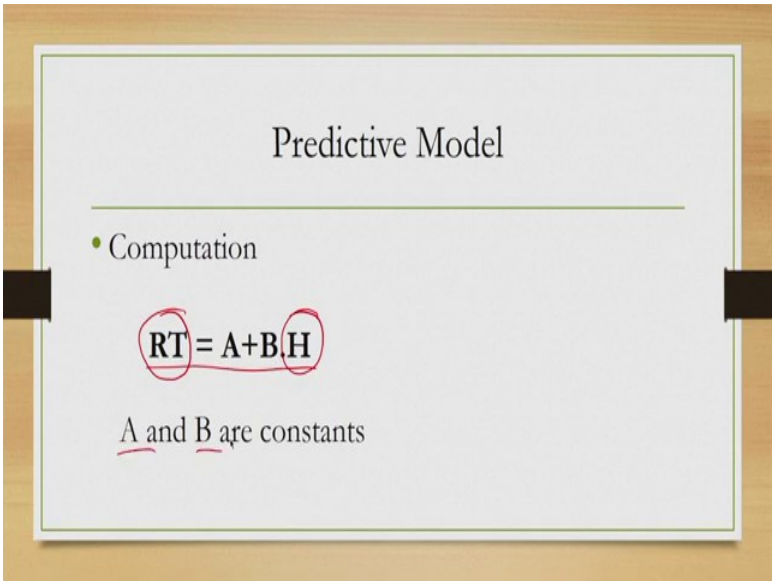

So, the model is something like this

RT = A+B.H

Now, here RT refers to the reaction time as before and H refers to the entropy as before, so RT is A plus B into H, where A and B are constants.

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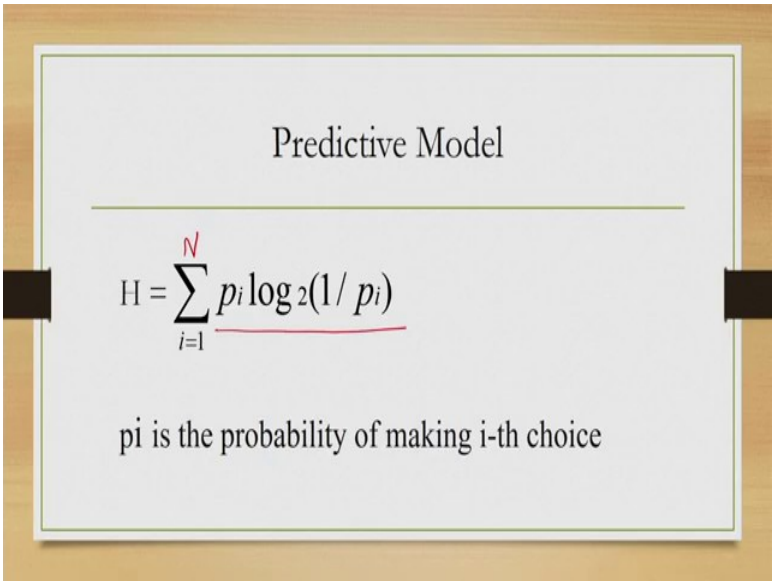

So, how to measure H? So, if you have encountered H before, you probably would know that H is essentially a summation of probabilities and logarithm of probabilities. So, suppose there are n number of choices we need to make and the probability of making the ith choice is pi.

In that case, we can represent H in terms of this pi's as H equal to summation of summation over all i's; where i equal to 1 to N where N is the total number of choices, pi multiplied by $\log_2(1/pi)$. So, this is the measure of entropy and once we know of this probabilities or we can estimate these probabilities, then using this we can estimate RT with the predictive model.

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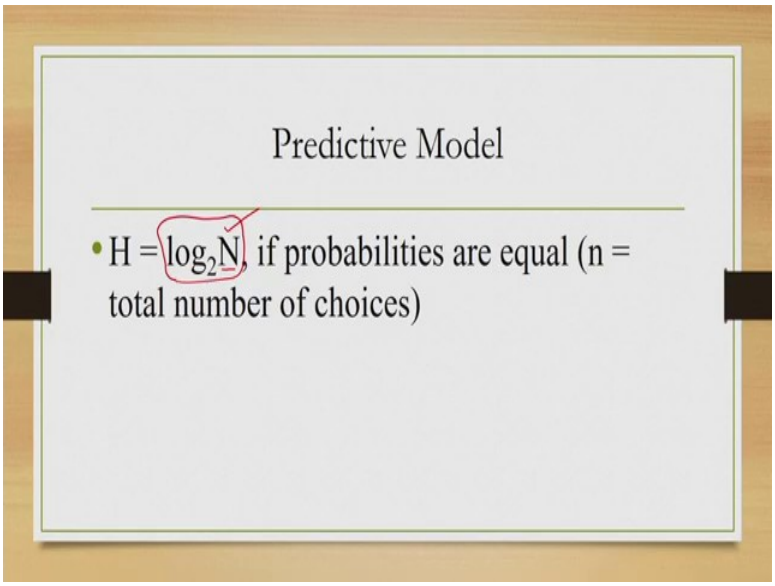

Now, in many stations we can assume that the probabilities of making individual choices are the same. So, we can choose any option with equal probability in that case all pi's will be same; so P1 will be equal to P2 will be equal to P3 will be equal to Pn.

So, in that case we can simplify the expression to calculate H. In that case H will become simply $\log_2 N$, where N is the total number of choices. So, what we can say in that case is that in the case where the probabilities of selecting any choice or the probabilities of making any choices are equal; in that case we can say that H is represented by the simple expression $\log_2 N$, where N is the total number of choices.

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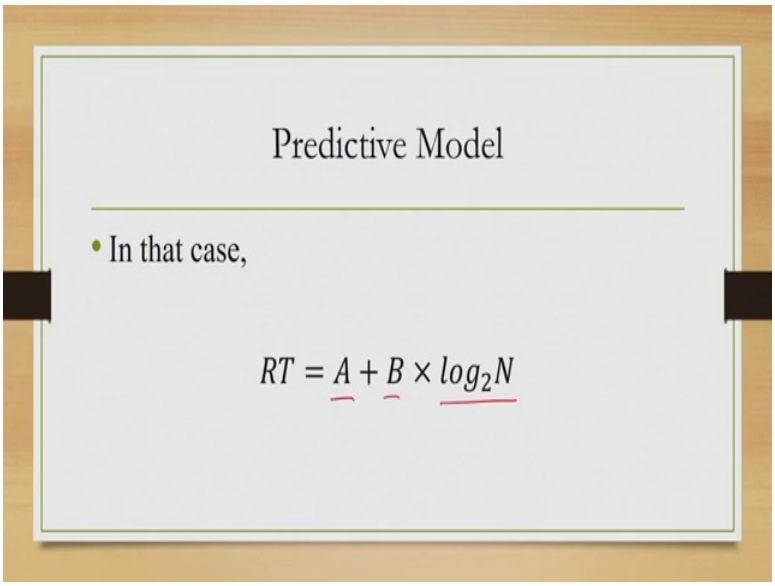

Given that situation, we can compute RT or the reaction time simply as $A+Blog_2N$, this is applicable only when we are assuming or we can make the assumption that we can choose any option out of a given set of options with equal probability. Now, in the case of the example that we have encountered before that is selecting the print option in the PDF file interface. What will be the reaction time?

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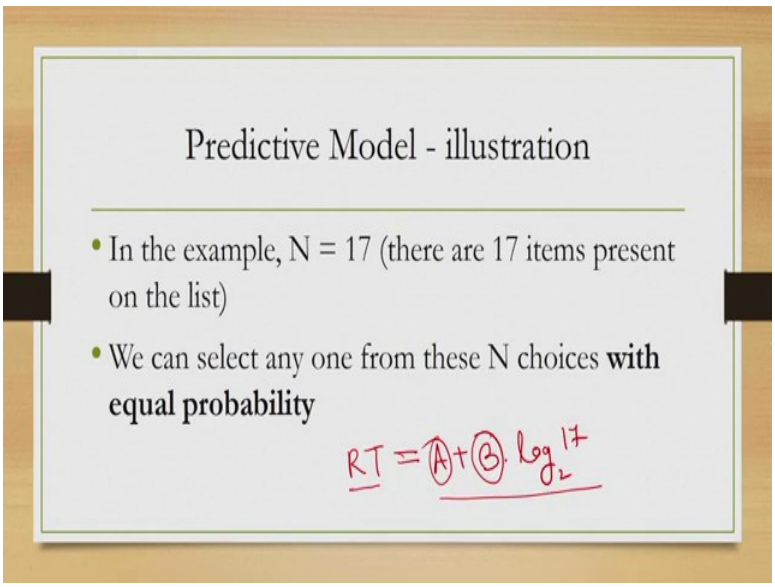

Now, after clicking we get to see the dropdown list; if you count, there are 17 items. So, in that case N will be equal to 17 along with that here we can make an assumption that

we can choose any option with equal probability. So, then we can represent H as $\log_2 N$ or $\log_2 17$.

So, then total reaction time to decide to select print option will be represented by the simple equation. And if you calculate this value, you will get the value of RT. Now, the question is that we still do not know the value of A and B the two constants. So, how to get this value? Remember in the case of Fitts law, we mentioned that there are two constants A and B and for a specific task domain, we can actually empirically determine this constants and then we can apply these constants to compute the movement time for any tasks belonging to that domain.

The same thing we can do here, for a specific task domain we can perform empirical studies to determine the values of A and B, and then apply it to predict the reaction time for any task belonging to that domain. For example, suppose our task domain selection of a sub-menu item from the dropdown list in a PDF file, after we click on the file menu option as shown in the example. So, in that case there are many tasks related to selection of many sub-menu options.

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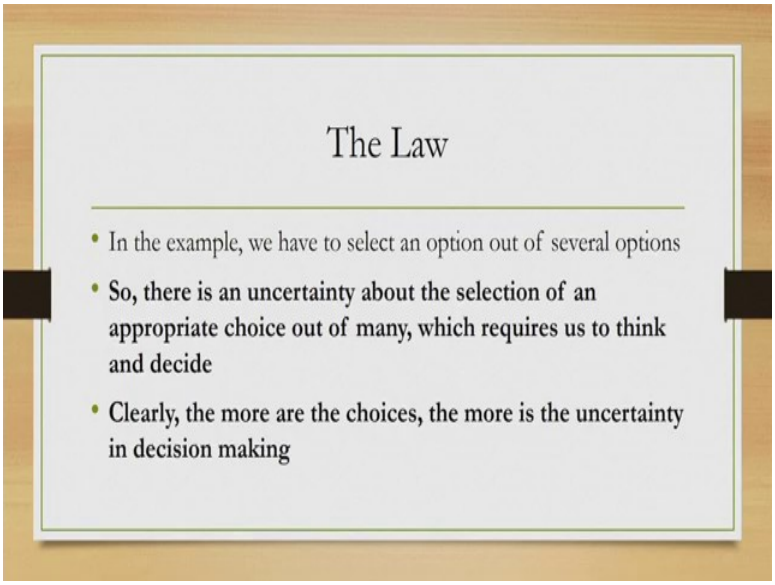

Now, for this domain where we are concerned with selecting a sub-menu option from any menu option. We can perform an empirical study to determine A and B, and then use it to find out any reaction time for any menu selection task.

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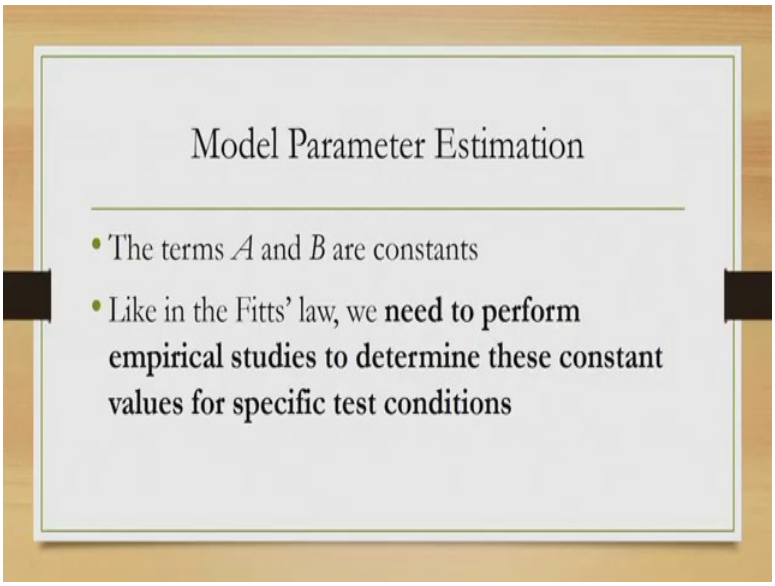

So, essentially we have to perform an empirical study as we have done in the case of Fitts law to determine the model constants. So, in this case also similar steps we need to follow.

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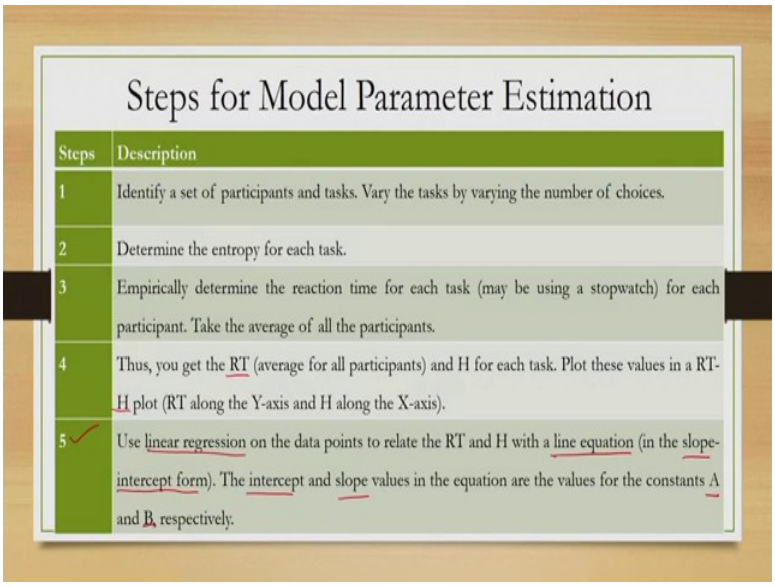

So, what are those step to determine the values of A and B. First thing is to identify step 1, to identify a set of participants and tasks and vary the tasks by varying the number of choices. Then in step 2, you determine the entropy for each task. Step 3, empirically determine the reaction time for each task you may use stopwatch or any other device to

determine this time. Then step 4, so up to step 3 what you got is RT which is the average for all participants and H for each task.

Now, you need to plot these values in a RTH plot in the graph, where RT will be along the Y-axis and H will be along the X-axis. So, after the graph plotting in step 5, what you do is use linear regression on the data points that you have plotted on the graph and find out a line equation in the slope intercept form like we did in the Fitts law. The intercept and slope values in the equation at the values for constants A and B, respectively.

So, essentially the steps that you identify participants and tasks and the tasks should be varied in terms of number of choices. For each task you determine the entropy and in step 3, you empirically determine the reaction time for each task that is you carry out the actual experiment and during the experiment you determine empirically the reaction time by using a stopwatch or something similar.

And in step 4, you plot the data values that you have got up to step 3 in a RTH plot where RT will be along the Y-axis and H will be along the X-axis; here RT means the Reaction Time that you are empirical determined and H means the entropy that you have calculated using the entropy equation.

And finally in step 5, you perform linear regression and find out a line equation in the slope intercept form. The intercept value that you will get is the value of A and the slope value that will get is the value of B. So, once you managed to get these values, then you can apply the equation to predict the reaction time for any task belonging to the task domain.

So, in this case if you calculate A and B empirically and then use it in the equation, then you will be able to use the equation to predict the reaction time for any task that involves making a selection from a drop-down menu which is the task domain here.

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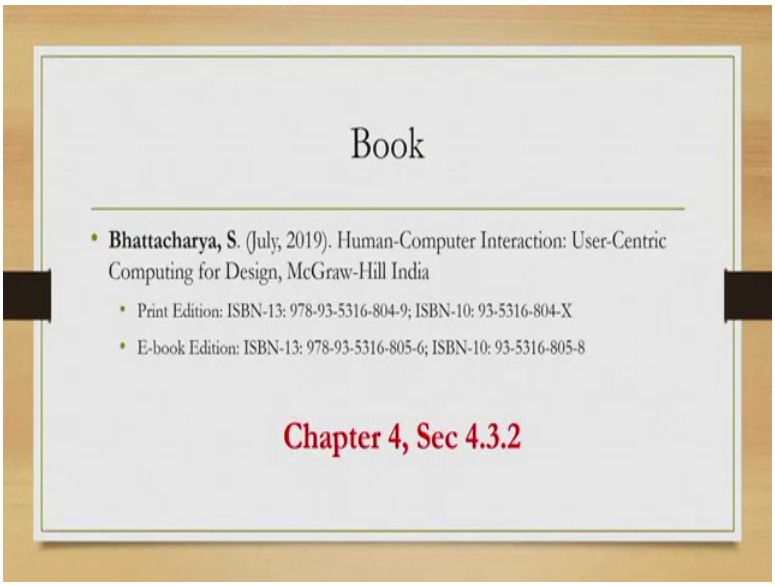

So, what I have discussed here are taken from this book, so all the materials.

Thank you and goodbye.