Human Computer Interaction

UNIT-2

Lecture 6:

Model-based Design

Mr. Nachiket Sainis / Reena Saini

B K Birla Institute of Engineering & Technology, Pilani

Lecture 6:
Individual Models of Human Factors - II

Objective

- In the previous lectures, we got introduced to the Fitts' law
  - The law models human motor behavior for rapid, aimed, error-free target acquisition task
- The law allows us to measure the task difficulty using the index of difficulty (ID)
- We saw how TP helps in design
  - We estimate the user performance under a test condition by estimating TP
  - The TP is estimated by taking mean of the TP achieved by different persons tested with varying task difficulty levels under the same test condition.

Throughput – Design Implication

- In the previous lecture, we discussed about one design implication of throughput in HCI
  - That is, to estimate user's motor performance in a given test condition
- We can extend this idea further to compare competing designs

Throughput – Design Implication

- Suppose you have designed two input devices: a mouse and a touchpad. You want to determine which of the two is better in terms of user performance, when used to acquire targets (e.g., for point and select tasks). How can you do so?
  - You set up two experiments for two test conditions: one with the mouse and the other with the touchpad
  - Determine throughput for each test condition as we have done before (i.e., collect throughput data from a group of users for a set of tasks with varying difficulty level and take the overall mean)

Throughput – Design Implication

- Suppose we got the throughputs TP1 and TP2 for the mouse and the touchpad experiments, respectively

- Compare TP1 and TP2

  - If TP1>TP2, the mouse gives better performance

  - The touchpad is better if TP1<TP2

- Suppose we got the throughputs TP1 and TP2 for the mouse and the touchpad experiments, respectively

- Compare TP1 and TP2

  - They are the same performance-wise if TP1=TP2 (this is very unlikely as we are most likely to observe some difference)

Predictive Nature of Fitts' Law

- The throughput measure, derived from the Fitts' law, is descriptive
  - We need to determine its value empirically
- Fitts' law also allows us to predict performance
  - That means, we can "compute" performance rather than determine it empirically

Predictive Nature of Fitts' Law

- The equation is of the form

  $MT = a + b.ID$

  - a and b are constants for a test condition (empirically derived)

- As we can see, the equation allows us to predict the time to complete a target acquisition task (with known D and W)

Predictive Nature of Fitts' Law

- How we can use the predictive equation in design?
  - We determine the constant values (a and b) empirically, for a test condition
  - Use the values in the predictive equation to determine MT for a representative target acquisition task under the test condition.
  - Compare MTs for different test conditions to decide (as with throughput)

Speed-Accuracy Trade-off

- Suppose, we are trying to select an icon by clicking on it. The icon width is D
  - Suppose each click is called a “hit”. In a trial involving several hits, we are most likely to observe that not all hits lie within D (some may be just outside)
  - If we plot the *hit distributions* (i.e., the coordinates of the hits), we shall see that about 4% of the hits are outside the target boundary

- This is called the speed-accuracy trade-off
  - When we are trying to make rapid movements, we can not avoid errors
- However, in the measures (ID, TP and MT), we have used D only, without taking into account the trade-off
  - We assumed all hits will be inside the target boundary

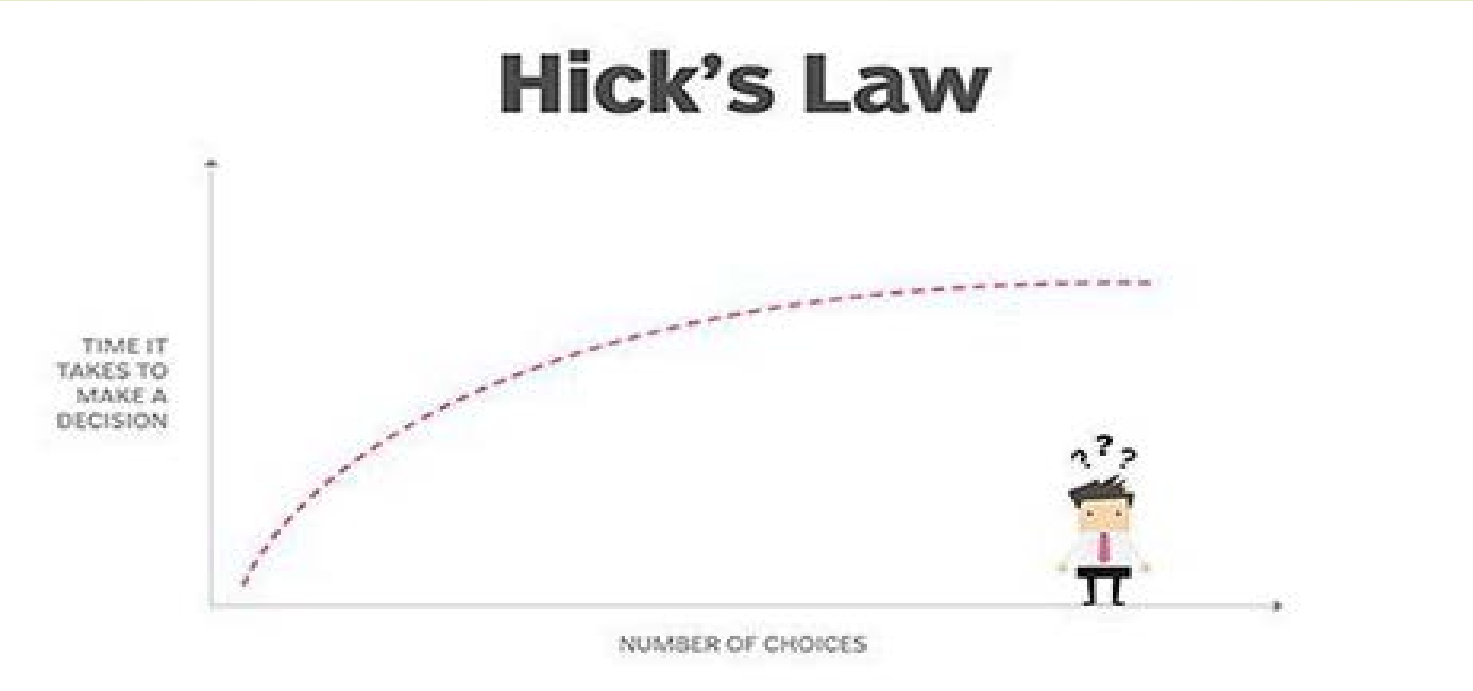
- We can resolve this in two-ways
  - Either we proceed with our current approach, with the knowledge that the measures will have 4% error rates
  - Or we take the effective width D_e (the width of the region enclosing all the hits) instead of D
- The second approach requires us to empirically determine D_e for each test condition

The Hick-Hyman Law

- While Fitts' law relates task performance to motor behavior, there is another law popularly used in HCI, which tell us the "reaction time" (i.e., the time to react to a stimulus) of a person in the presence of "choices"
- The law is called the Hick-Hyman law, named after its inventors

What is Hick's Law?

- Hick's Law (or the Hick-Hyman Law) is named after a British and an American psychologist team of William Edmund Hick and Ray Hyman.
- In 1952, this pair set out to examine the relationship between the number of stimuli present and an individual's reaction time to any given stimulus.
- As you would expect, the more stimuli to choose from, the longer it takes the user to make a decision on which one to interact with.
- Users bombarded with choices have to take time to interpret and decide, giving them work they don't want.



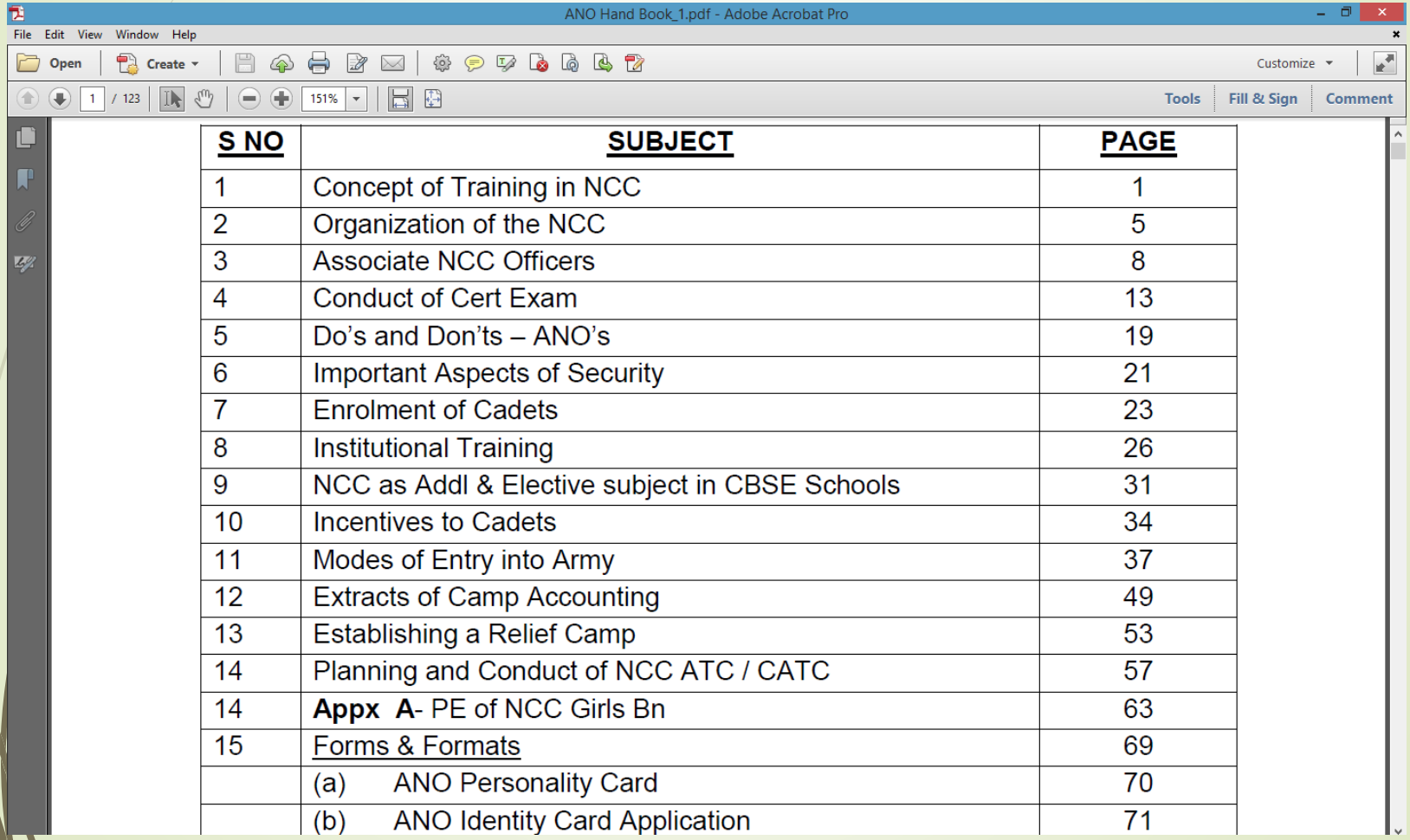
The formula for Hick's Law is defined as follows:

$$RT = a + b \log_2 (n)$$

Where "RT" is the reaction time, "(n)" is the number of stimuli present, and "a" and "b" are arbitrary measurable constants that depend on the task that is to be carried out and the conditions under which it will be carried out.

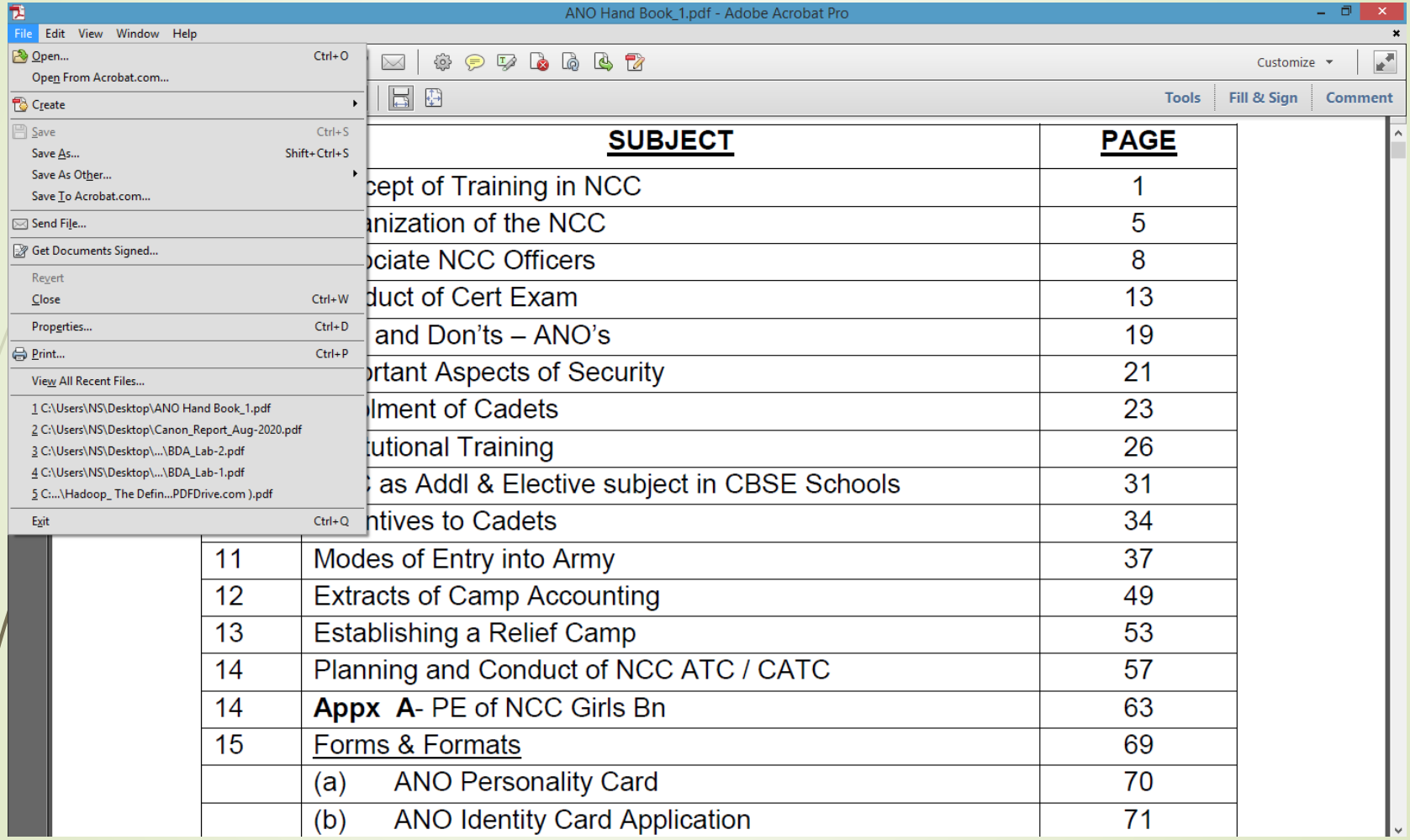
Example

- You have opened a pdf document using adobe acrobat reader.



S NO	SUBJECT	PAGE
1	Concept of Training in NCC	1
2	Organization of the NCC	5
3	Associate NCC Officers	8
4	Conduct of Cert Exam	13
5	Do's and Don'ts – ANO's	19
6	Important Aspects of Security	21
7	Enrolment of Cadets	23
8	Institutional Training	26
9	NCC as Addl & Elective subject in CBSE Schools	31
10	Incentives to Cadets	34
11	Modes of Entry into Army	37
12	Extracts of Camp Accounting	49
13	Establishing a Relief Camp	53
14	Planning and Conduct of NCC ATC / CATC	57
14	**Appx A**- PE of NCC Girls Bn	63
15	Forms & Formats	69
	(a) ANO Personality Card	70
	(b) ANO Identity Card Application	71

- You clicked on the FILE menu option and drop- down list appears. You wish to select print option.



	SUBJECT	PAGE
	cept of Training in NCC	1
	anization of the NCC	5
	ociate NCC Officers	8
	duct of Cert Exam	13
	and Don'ts – ANO's	19
	rtant Aspects of Security	21
	lment of Cadets	23
	tutional Training	26
	as Addl & Elective subject in CBSE Schools	31
	ntives to Cadets	34
11	Modes of Entry into Army	37
12	Extracts of Camp Accounting	49
13	Establishing a Relief Camp	53
14	Planning and Conduct of NCC ATC / CATC	57
14	**Appx A**- PE of NCC Girls Bn	63
15	Forms & Formats	69
	(a) ANO Personality Card	70
	(b) ANO Identity Card Application	71

Example

A telephone call operator has 10 buttons. When the light behind one of the buttons comes on, the operator must push the button and answer the call. When a light comes on, how long does the operator takes to decide which button to press?

In the example,

- The “light on” is the stimulus
- We are interested to know the operator’s “reaction time” in the presence of the stimulus
- The operator has to decide among the 10 buttons (these buttons represent the set of choices)
- The Hick-Hyman law can be used to predict the reaction times in such situations

The Law

- As we discussed before, the law models human reaction time (also called *choice-reaction time*) under *uncertainty* (the presence of choices)

  - The law states that the reaction (decision) time T increases with uncertainty about the judgment or decision to be made.

- We know that a measure of uncertainty is entropy (H)

  Thus, $T \alpha H$

  or equivalently, $T = kH$, where k is the proportionality constant (empirically determined)

The Law

- We can calculate H in terms of the choices in the following way

let, pi be the probability of making the i- th choice

Then, $H = \sum_i p_i \log_2(1/p_i)$

Therefore

$$T = k\sum_{i=1} p_i \log_2(1/p_i)$$

When all the probabilities of making choices becomes equal, we have $H = \log_2 N$ (N = no of choices)

– In such cases, $T = k \log_2 N$

Example Revisited

- Then, what will be the operator's reaction time in our example?
  - Here N = 10
  - A button can be selected with a probability 1/10 and all probabilities are equal
  - Here k=a+b
  - Thus, $T = k \log_2 10$

    $= 0.66$ ms (assuming a = 0, b = 0.2)