HUMAN-COMPUTER INTERACTION
CS255
LEC-3: HUMAN INFORMATION PROCESSING

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OUTLINE

- Introduction of Human Information Processing
- Human-factors knowledge.
- First section of HIP: Task Modeling and Human Problem-Solving Model.
- Second section of HIP: Human Reaction and Prediction of Cognitive Performance.

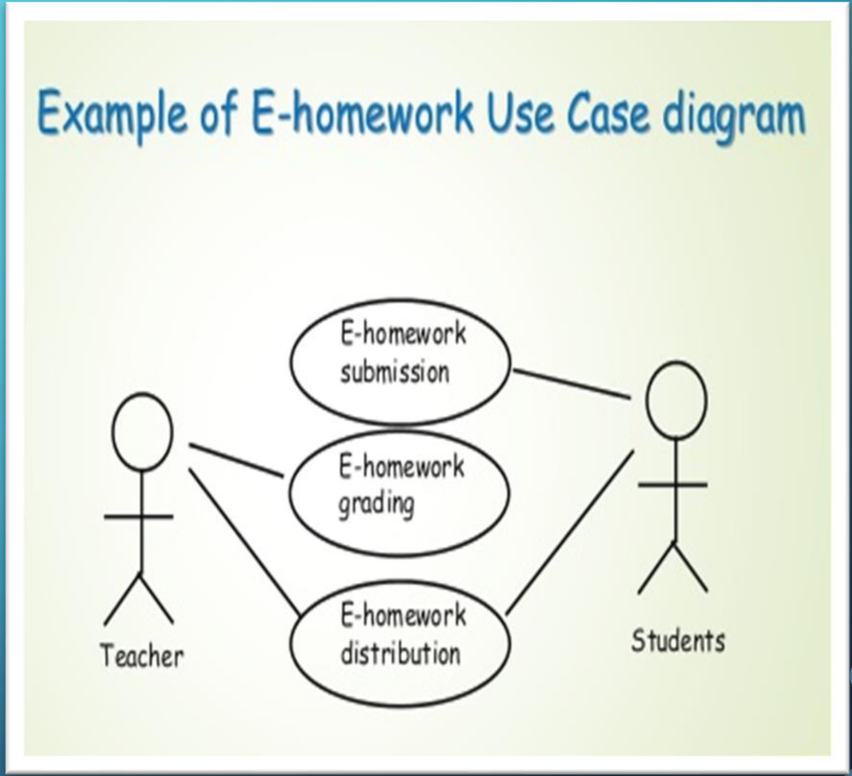
HUMAN INFORMATION PROCESSING

- Mostly, the interface requirements must often be investigated, solicited, derived, and understood directly from the target users through focus interviews and surveys.
- However, it is also possible to obtain a fairly good understanding of the target user from knowledge of human factors.
- As the main underlying theory for Human computer interaction, **human factors can largely be divided into:**
- (a) **Cognitive science**, which explains the human's capability and model of conscious processing of high-level information.
- (b) **Ergonomics (Work environment)**, which elucidates how raw external stimulation signals are accepted by our five senses, are processed up to the pre-attentive level, and are later acted upon in the outer world through the motor organs.

HUMAN-FACTORS KNOWLEDGE WILL PARTICULARLY HELP US DESIGN HCI IN THE FOLLOWING WAYS:

1- Task/interaction modeling:

- Formulate the steps for how humans might interact to solve and carry out a given (task/problem) and derive the interaction model.
- A careful Human computer interaction designer would not neglect to obtain this model by direct observation of the users themselves, but the designer's knowledge in cognitive science will help greatly in developing the model.



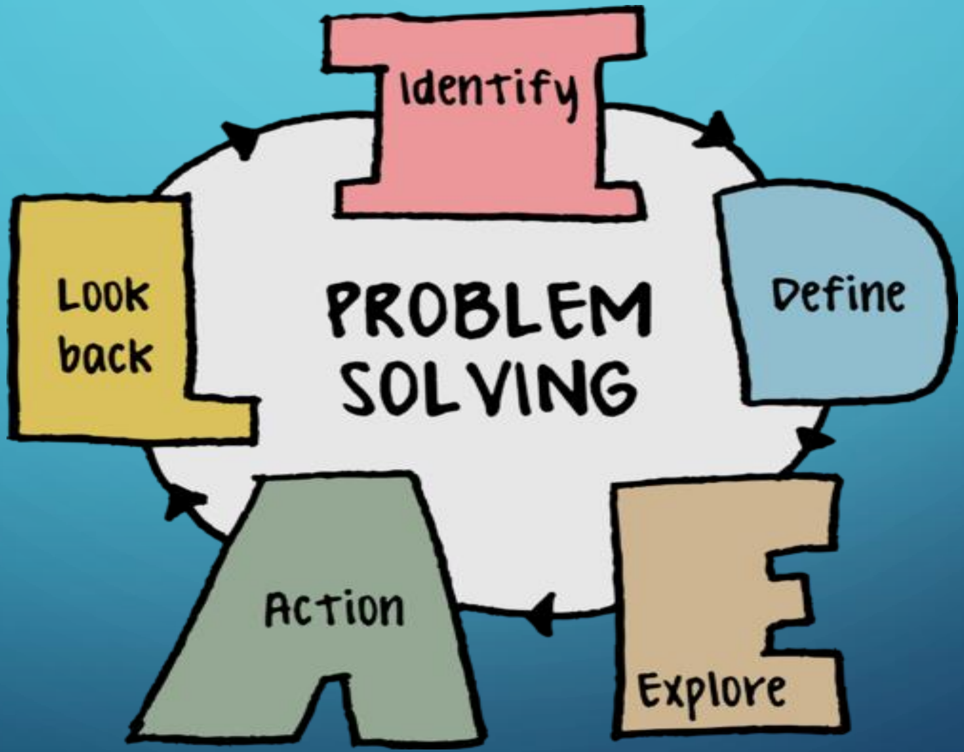
HUMAN-FACTORS KNOWLEDGE WILL PARTICULARLY HELP US DESIGN HCI IN THE FOLLOWING WAYS:

2- Prediction, Assessment, and Evaluation of interactive behavior:

- Understand and predict how humans might react mentally to various information-presentation and input-solicitation methods (طرق تماس المدخلات) as a basis for interface selection.
- Also, evaluate interaction models and interface implementations and explain or predict their performance and usability.

FIRST SECTION OF HUMAN INFORMATION PROCESSING

TASK MODELING AND HUMAN PROBLEM-SOLVING MODEL



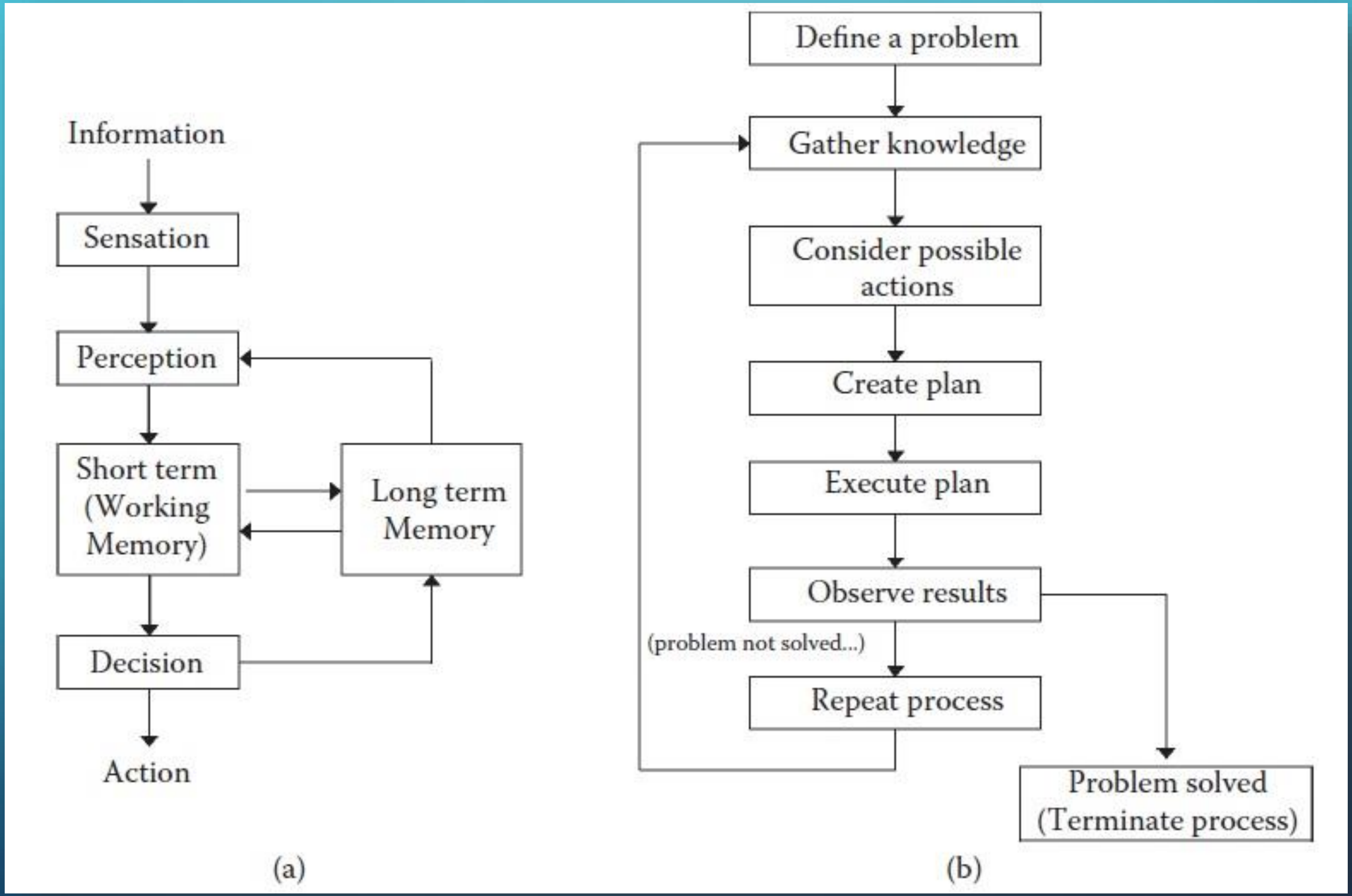
TASK MODELING AND HUMAN PROBLEM-SOLVING MODEL

- The human computer interaction principle of (task/interaction) modeling was helpful in understanding the tasks required to accomplish the ultimate goal of the interactive system.
- For instance, a goal of a word-processing system might be to produce a nice-looking document as easily as possible.
- In more abstract terms, this whole process of interaction could be viewed as a human attempting to solve a "problem" and applying certain "actions" on "objects" to arrive at a final "solution."

TASK MODELING AND HUMAN PROBLEM-SOLVING MODEL

- Cognitive science has investigated the ways in which humans solve problems, and such a model can help human computer interaction designers analyze the task and base the interaction model or interface structure around this innate problem-solving process.
- Thus for a smaller problem of "**fixing the font**," the action could be a "menu item selection" applied to a "highlighted text."
- There are several "human problem-solving" models that are put forth by a number of researchers, but most of them can be collectively summarized as depicted in next figure.
- This problem solving process epitomizes the overall information-processing model.

(a) The overall human problem-solving model and process and (b) a more detailed view of the "decision maker/executor."



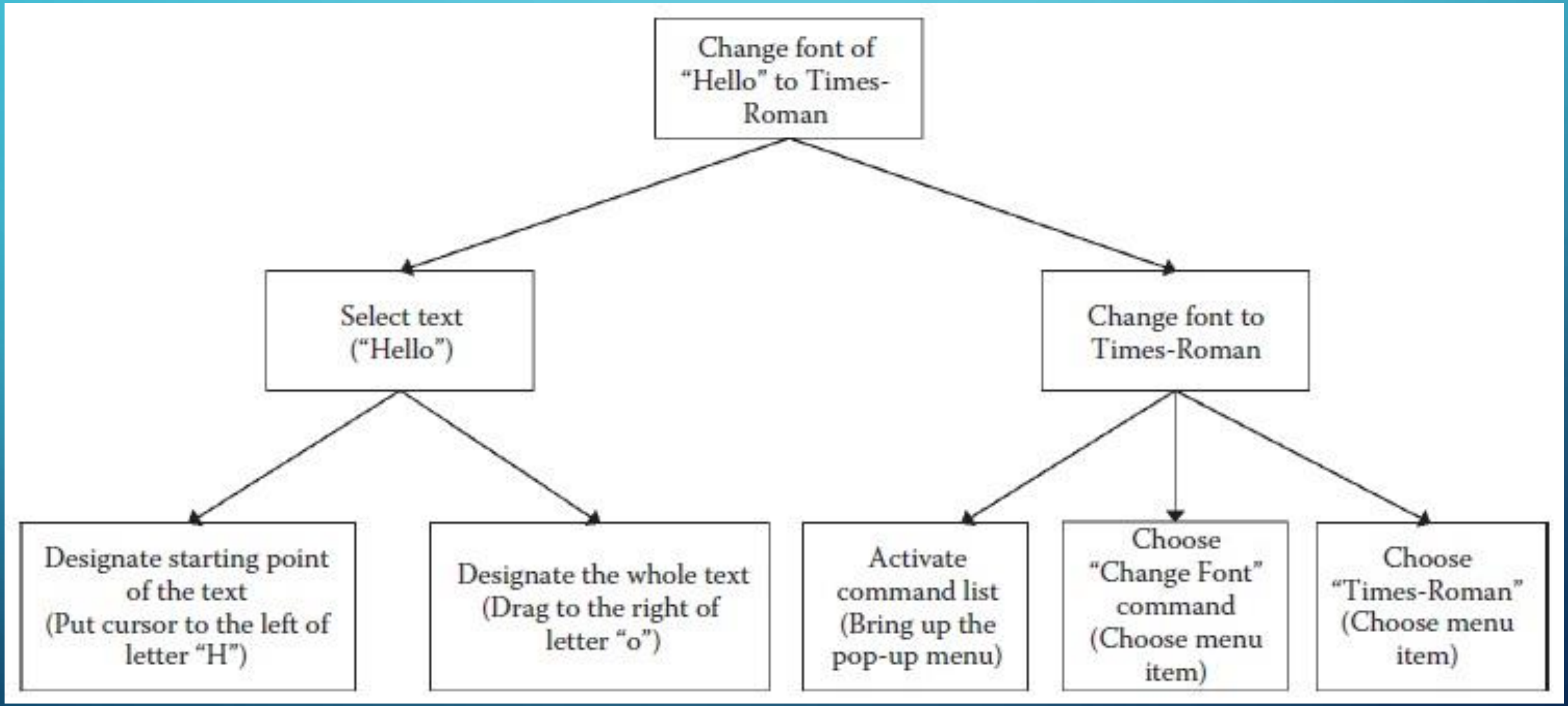
HUMAN PROBLEM-SOLVING OR INFORMATION-PROCESSING EFFORTS CONSIST OF THESE IMPORTANT PARTS:

1- **Sensation**, which senses external information (e.g., visual, aural, haptic), and Perception, which interprets and extracts basic meanings of the external information. (As a lower level part of the information-processing chain [more ergonomic].

2- **Memory**, which stores momentary and short-term information or long-term knowledge. This knowledge includes information about the external world, procedures, rules, relations, schemas, candidates of actions to apply, the current objective (e.g., accomplishing the interactive task successfully), the plan of action, etc.

3- **Decision maker/executor**, which formulates and revises a “plan,” then decides what to do based on the various knowledge in the memory, and finally acts it out by commanding the motor system (e.g., to click the mouse left button).

- An example of a hierarchical task model of changing a font for a short text. Note that a specific interface may be chosen to accomplish the subtasks in the bottom.



SOME CONCLUSIONS FROM THE ABOVE

- One can readily appreciate from the simple example in previous figure how an interactive task model can be hierarchically refined and can serve as a basis for the interface structure.
- Note that, based on this model, we could "**Select**" interfaces to realize each subtask in the bottom of the hierarchy, which illustrates the **crux** (**جوهر**) of the HCI design process.
- The interaction model must represent as much as possible what the user has in mind, especially what the user expects must be done (the mental model) in order to accomplish the overall task. This way, the user will be "**in tune**" with the resulting interactive application.
- The interface selection should be done based on **ergonomics**, **user preference**, and other requirements or constraints.

SECOND SECTION OF HUMAN INFORMATION PROCESSING

HUMAN REACTION AND PREDICTION OF COGNITIVE PERFORMANCE

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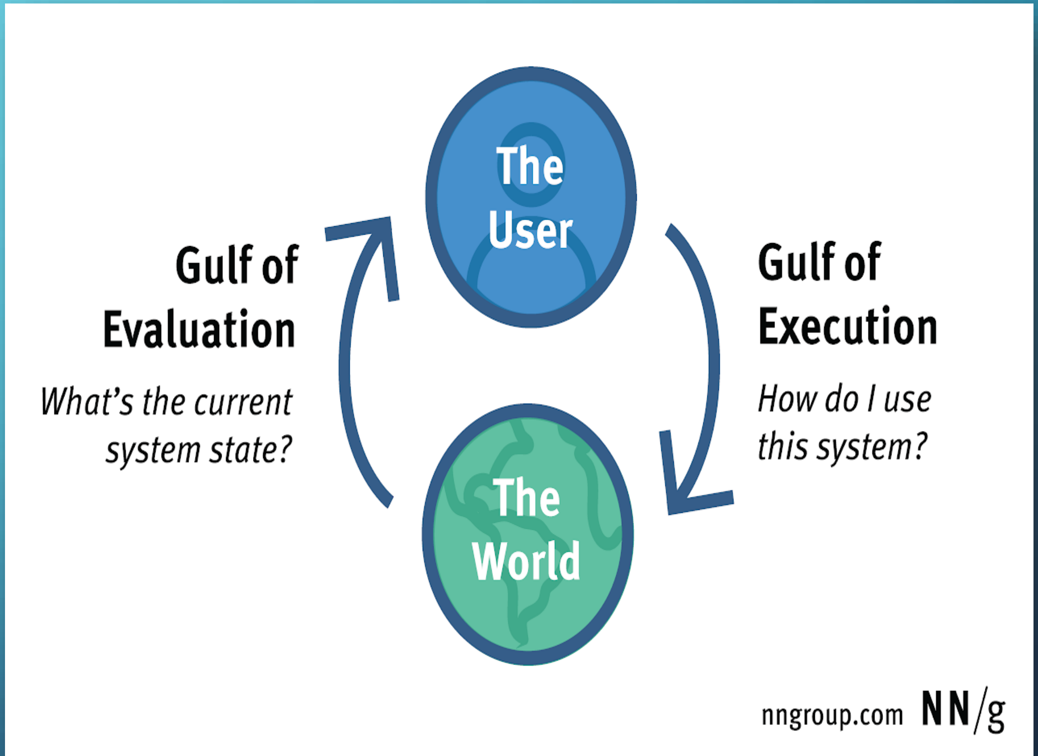
HUMAN REACTION AND PREDICTION OF COGNITIVE PERFORMANCE

- We can also, to some degree, predict how humans will react and perform in response to a particular human interface design.
- We can consider two aspects of human performance: one that is cognitive and the other ergonomic.
- A user, when solving a problem or using an interactive system to do so, will first form a mental model that is mostly equivalent to the hierarchical “action” plan for the task.

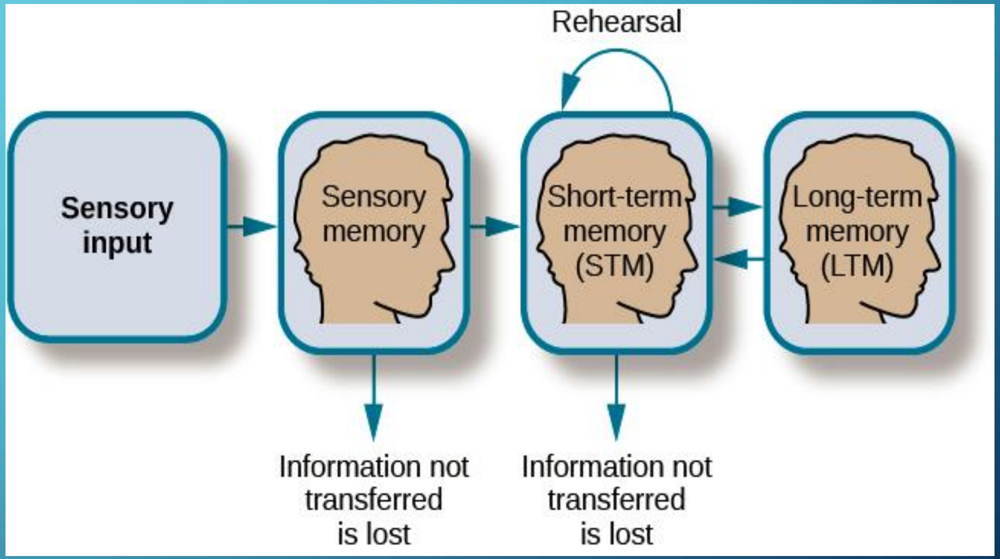
HUMAN REACTION AND PREDICTION OF COGNITIVE PERFORMANCE

- The mismatch between the user's mental model and the task model employed by the interactive system creates the "gulf."
- On the other hand, when the task model and interface structure of the interactive system maps well to the expected mental model of the user, the task performance will be very fluid.



MEMORY CAPACITY

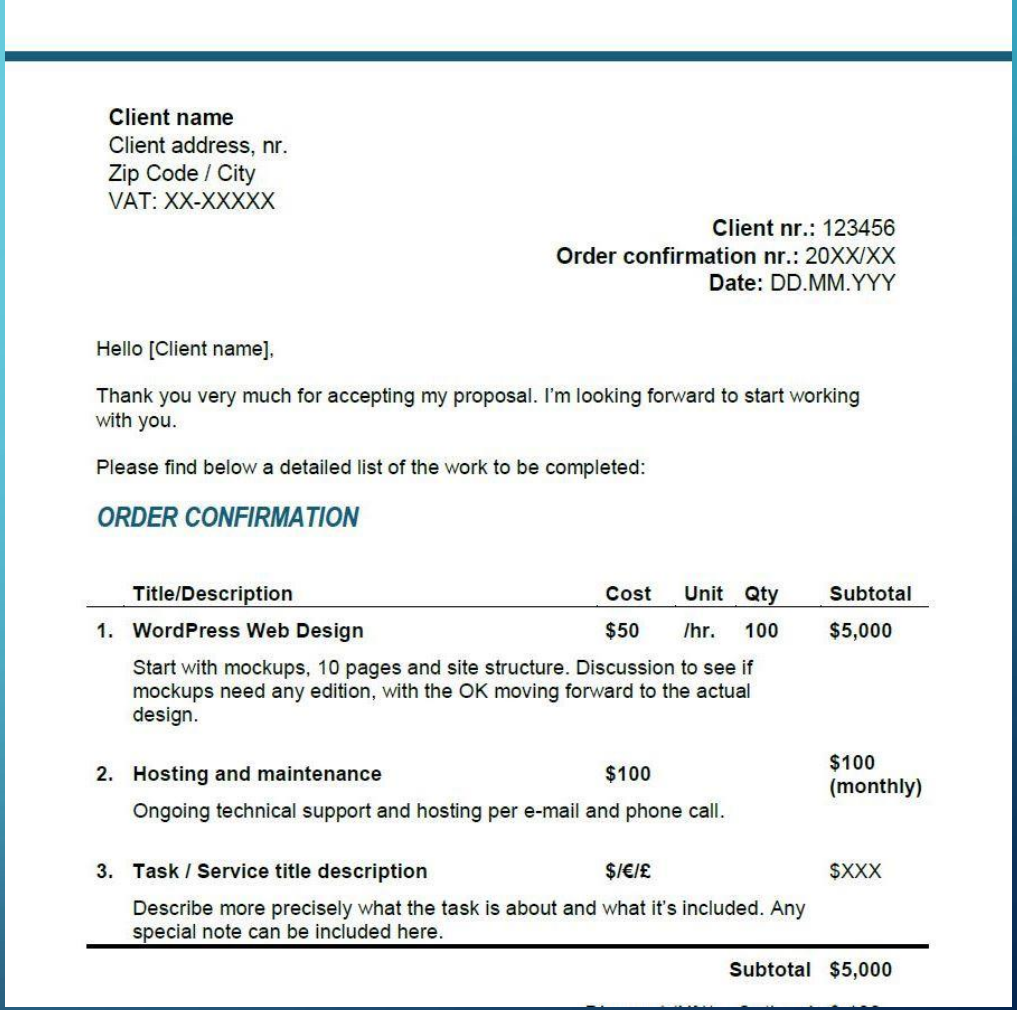
- Memory capacity also influences the interactive performance greatly.
- There are largely two types of memory in the human cognitive system: **the short term** and **the long term**.
- The short term memory is also sometimes known as **the working memory,** in the sense that it contains (changing) memory elements meaningful for the task at hand (or chunks).



MEMORY CAPACITY

- Humans are known to remember about eight chunks of memory lasting only a very short amount of time [2].
- This means that an interface cannot rely on the human's short-term memory beyond this capacity for fast operation.
- Imagine an interface with a large number of options or menu items. The user would have to rescan the available options a number of times to make the final selection.

- In an online purchasing system, the user might not be able to remember all of the relevant information such as items purchased, delivery options, credit card chosen, billing address, usage of discount cards, etc.
- Thus such information will have to be presented to the user from time to time to refresh one’s memory and ensure that no errors are made.



Client name
Client address, nr.
Zip Code / City
VAT: XX-XXXXX

Client nr.: 123456
Order confirmation nr.: 20XX/XX
Date: DD.MM.YYY

Hello [Client name],

Thank you very much for accepting my proposal. I'm looking forward to start working with you.

Please find below a detailed list of the work to be completed:

ORDER CONFIRMATION

	Title/Description	Cost	Unit	Qty	Subtotal
1.	**WordPress Web Design** Start with mockups, 10 pages and site structure. Discussion to see if mockups need any edition, with the OK moving forward to the actual design.	$50	/hr.	100	$5,000
2.	**Hosting and maintenance** Ongoing technical support and hosting per e-mail and phone call.	$100			$100 (monthly)
3.	**Task / Service title description** Describe more precisely what the task is about and what it's included. Any special note can be included here.	$/€/£			$XXX
				Subtotal	$5,000

- **Retrieving information** from the long-term memory is a difficult and relatively time-consuming task. Therefore, if an interactive system (e.g., targeted even for experts) requires expert-level knowledge, it needs to be displayed so as to at least elicit "recognition" (among a number of options) of it rather than completely relying on recall from scratch.
- Memory-related performance issues are also important in multitasking.
- So, many modern computing settings offer multitasking environments.
- It is known that when the user switches from one task to another, a "context switch" occurs in the brain, which means that the working memory content is replaced (and stored back into the long-term memory) with chunks relevant for the switched task (such as the state of the task up to that moment).
- This process can bring about overall degradation in task performance in many respects.

- For an individual application to help itself in its use during multitasking, it can assist the user's context-switch process by capturing the context information during its suspension, and by later displaying, reminding, and highlighting the information upon resumption.
- Reminding the user of the context for multitasking for fast application switching

PREDICTIVE PERFORMANCE ASSESSMENT: GOMS

- GOMS (Goals, Operators, Methods, and Selection).
- **GOMS is a task analysis technique Very similar to Hierarchical Task Analysis (Indeed, GOMS is a hierarchical task analysis technique)**
- The **Goal** is what the user wants to accomplish. The **Operator** is what the user does to accomplish the goal. The **Method** is a series of operators that are used to accomplish the goal. **Selection** rules are used if there are multiple methods, to determine how one was selected over the others.
- GOMS is quite simple in that it can only evaluate in terms of the task performance, while there are many other criteria by which an HCI design should be evaluated.

TYPE OF OPERATION	TIME ESTIMATE
K: Keyboard input	Expert: 0.12 s Average: 0.20 s Novice: 1.2 s
T(*n*): Type *n* characters	$280 \times n$ ms
P: Point with mouse to something on the display	1100 ms
B: Press or release mouse button	100 ms
BB: Click a mouse button (press and release)	200 ms
H: Home hands, either to the keyboard or mouse	400 ms
M: Thinking what to do (mental operator)	1200 ms (can change)
W(*t*): Waiting for the system (to respond)	*t* ms

Source: Card, S. K., Moran, T. P., and Newell, A., The Model Human Processor: An Engineering Model of Human Performance, in *Handbook of Human Perception*, vol. 2, *Cognitive Processes and Performance*, ed. K. R. Boff, L. Kauffman, and J. P. Thomas, 1–35, John Wiley and Sons, New York, 1986 [7].

Table 1 : Estimates of Time Taken for Typical Desktop Computer Operations from GOMS

PREDICTIVE PERFORMANCE ASSESSMENT: GOMS

- The GOMS evaluation methodology starts by the same hierarchical task modeling we have described in (Slide 10).
- Once a sequence of subtasks is derived, one might map a specific operator in the previous table(or, in other words, interface) to each of the subtasks.
- With the preestablished performance measures (table 1), the total time of task performance can be easily calculated by summing the task times of the whole set of subtasks.
- Different operator mappings can be tried comparatively in terms of their performance.

PREDICTIVE PERFORMANCE ASSESSMENT: GOMS

- The original GOMS model was developed mainly for the desktop computing environment, with performance figures for mouse clicks, keyboard input, hand movement, and mental operators (Table 1).
- Even though this model was created nearly 30 years ago, the figures are still amazingly valid. (While computer technologies have advanced much since then, humans' capabilities have remained mostly the same.)
- GOMS models for other computing environments have been proposed as well [8].

- Table 2 shows two designs of the main task of “file deletion.” Each design is decomposed in a slightly different manner and with operators mapped to the individual subtasks, resulting in different total times of operation (the first in 4.8 s and the second in 2.7 s).

DELETING A FILE

DESIGN 1		DESIGN 2[a]	
1. Point to file icon	P	1. Point to file icon	P
2. Click mouse button	BB	2. Click mouse button	BB
3. Point to file menu	P	3. Move hand to keyboard	M
4. Press and hold mouse button	B	4. Hit command key: command-T	KK
5. Point to DELETE item	P	5. Move hand back to mouse	H
6. Release mouse button	B		
7. Point to original window	P		
Total time = 4.8 s		Total time = 2.66 s	

Note: The total time is computed by adding the corresponding figures in Table 3.1.

[a] Design 2 is the “expert” version that uses a hot key [7].

Table 2 : Estimates of Time Taken for Two Task Models of “Deleting a File”.

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- Marois, Rene, and Jason Ivanoff. 2005. Capacity limits of information processing in the brain. Trends in cognitive sciences 9 (6): 296–305.
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Thank You