User Interface Design

Lecture 9: Models and Theories

Dr. Obead Alhadreti

كلية الحاسب الآلي بالقنفذة
Computing College at AlQunfudah

Learning Objectives

- Explain different types of cognitive models
- Describe Fitts' law.

Cognitive modeling

- If we can build a model of how a user works, then we can predict how s/he will interact with the interface.

➢ ***<u>Goals:</u>***

1. Predict and compare usability of different interface designs
2. Task performance, learnability, and error rates
3. No users or functional prototype required!
4. Develop guidelines for interface design

Cognitive Models

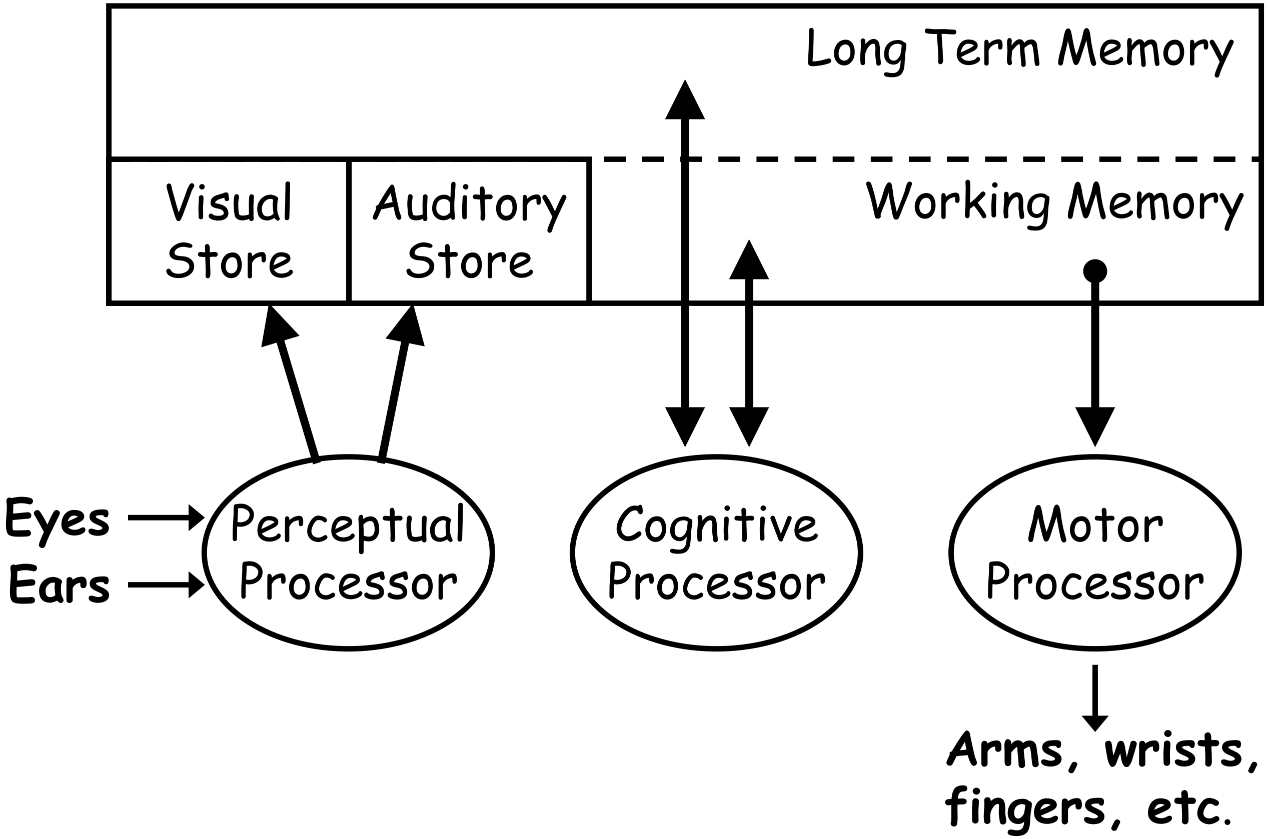
1. Model Human Processor (MHP)
2. GOMS

Model Human Processor (MHP)

- From Card, Moran, and Newell in1980.
- Models the information processes of a user interacting with a computer
- Contain three interacting systems:

  Perceptual, cognitive, motor
- Each system with its own processor, and memory

Model Human Processor (MHP)



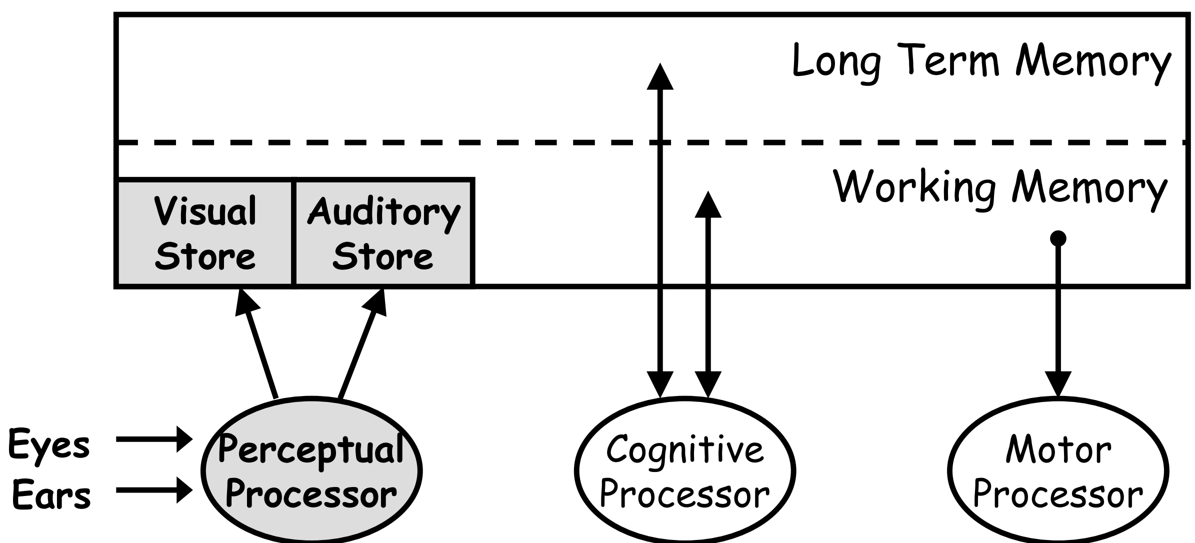
Model human processor

Components:

- Set of memories and processors together.
- Set of "principles of operation".
- Discrete, sequential model.
- Each stage has timing characteristics.

Model Human Processor (MHP)

- **Perceptual system:**
- Responsible for transforming external environment into a form that cognitive system can process.
- Composed of perceptual memory and processor.
- Processor codes information in perceptual memory for about 100ms.



Exercise 1

- **Assume perceptual cycle time = 100ms**

- If 30 clicks per second are played for 5 seconds, about how many clicks could a person hear?

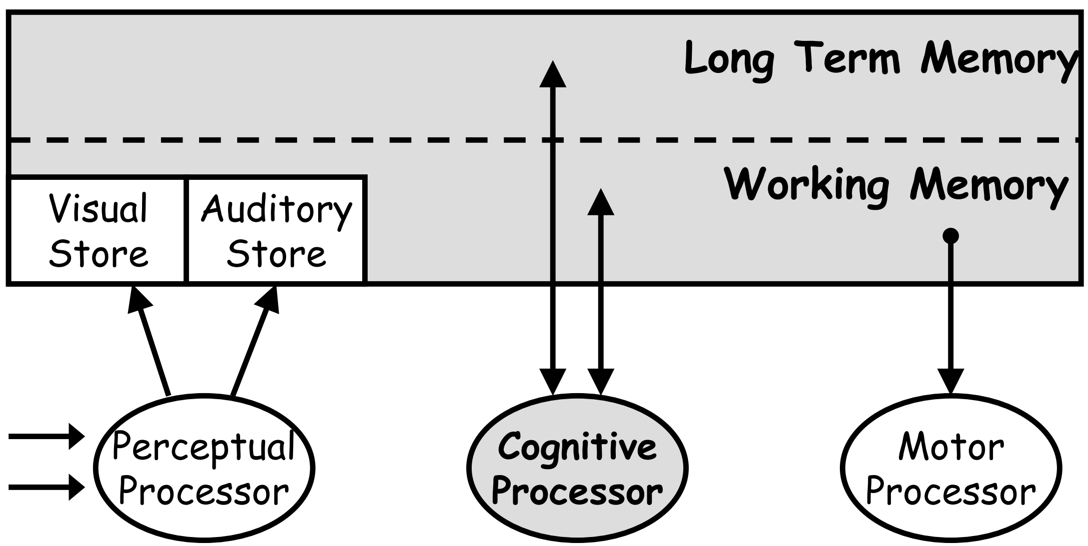
  1 seconds = 1000 milliseconds

  30 clicks/s = 3 clicks/100 ms

  (30 clicks/s * 5s) / 3 clicks = 50 clicks

Model Human Processor (MHP)

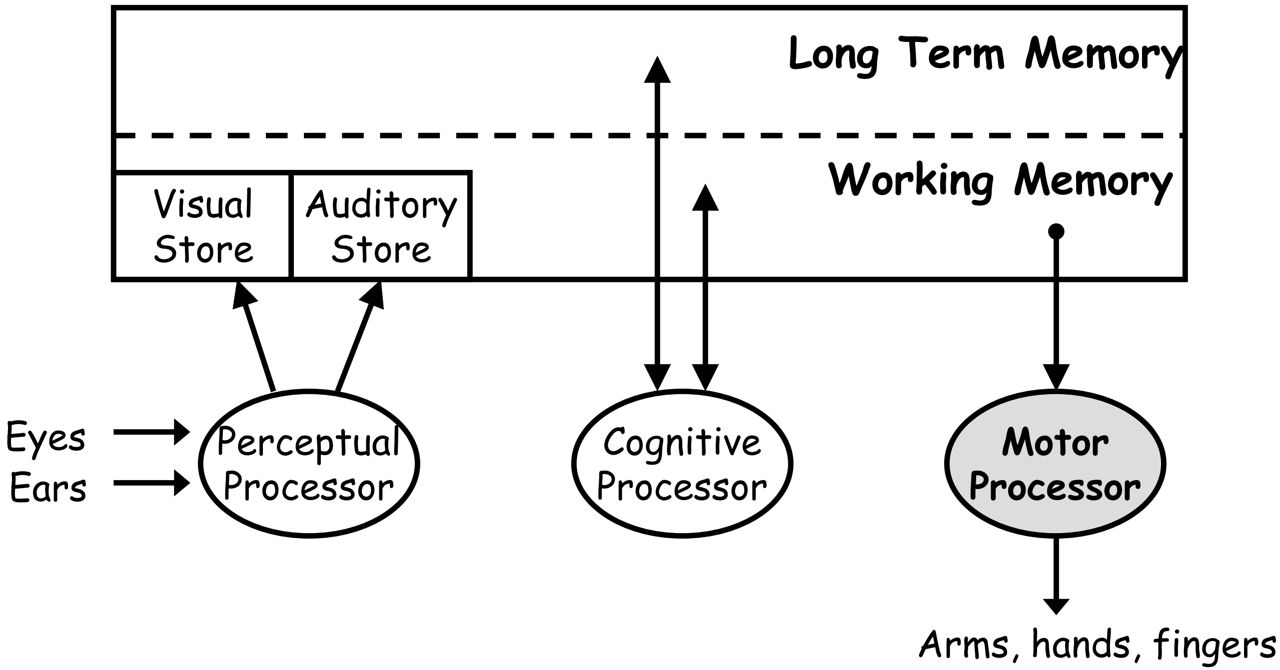
- **Cognitive system:**
  - Uses contents of WM and LTM to make decisions and schedule actions with motor system
  - Composed of a processor (with cycle time = 70ms) and two memories
    - WM and LTM



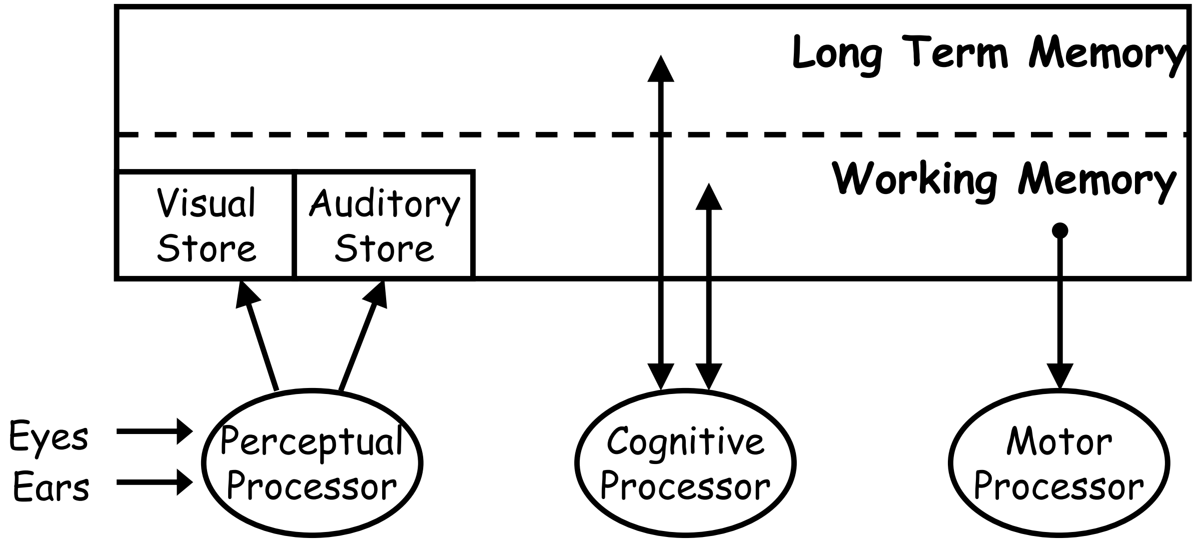
Model Human Processor (MHP)

- **Motor system:**

- Translates thoughts into actions
- Cycle time of motor processor about 70ms.

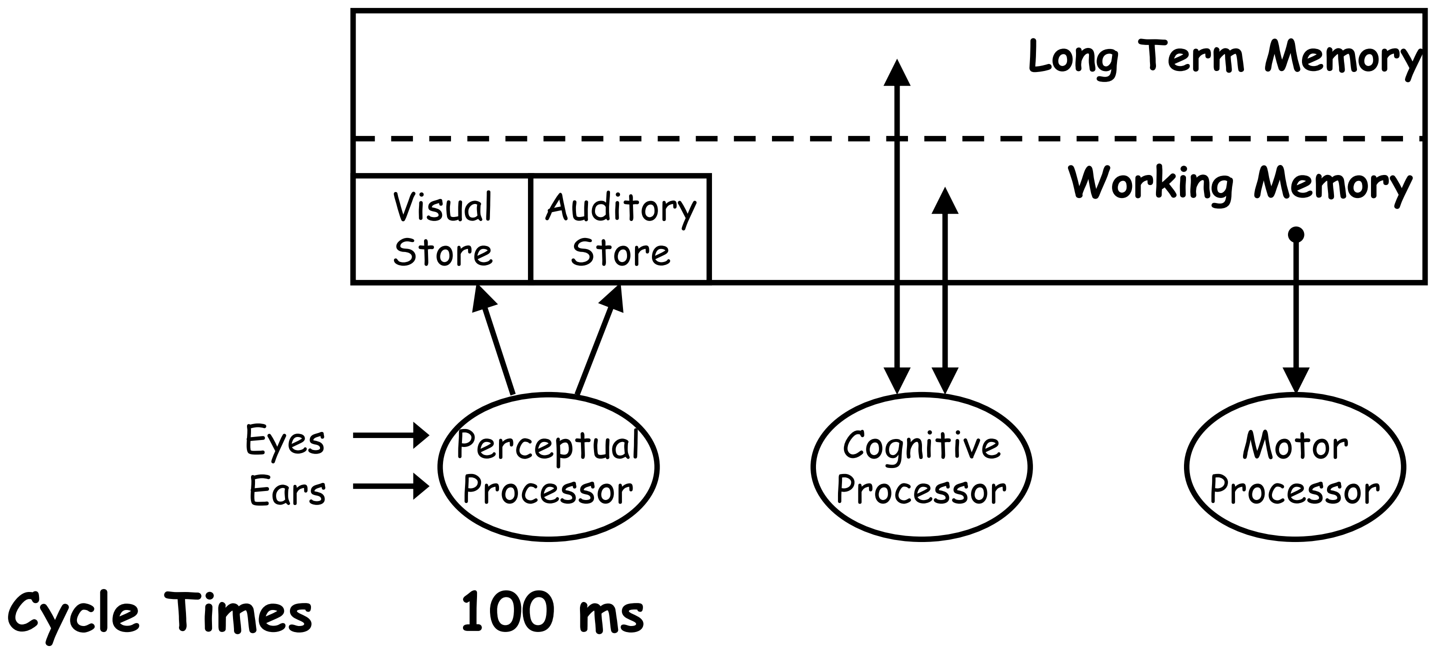


What We Know So Far

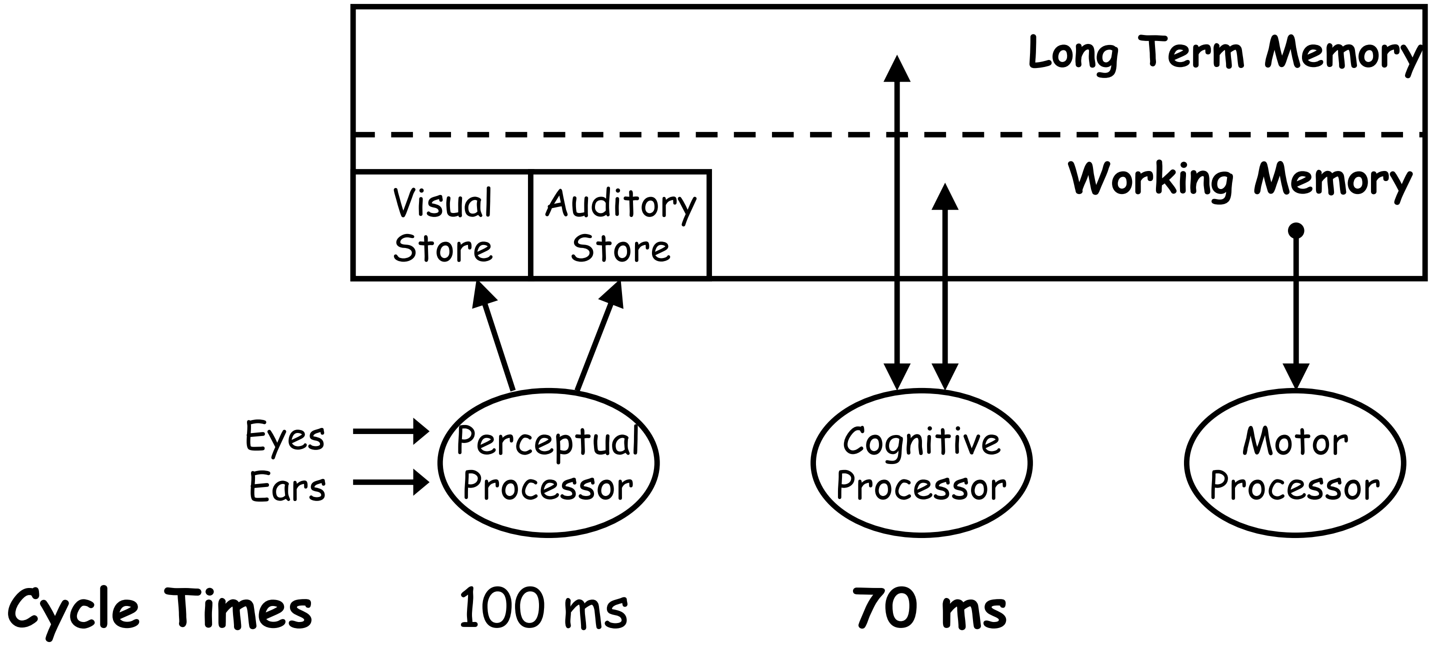


Cycle Times

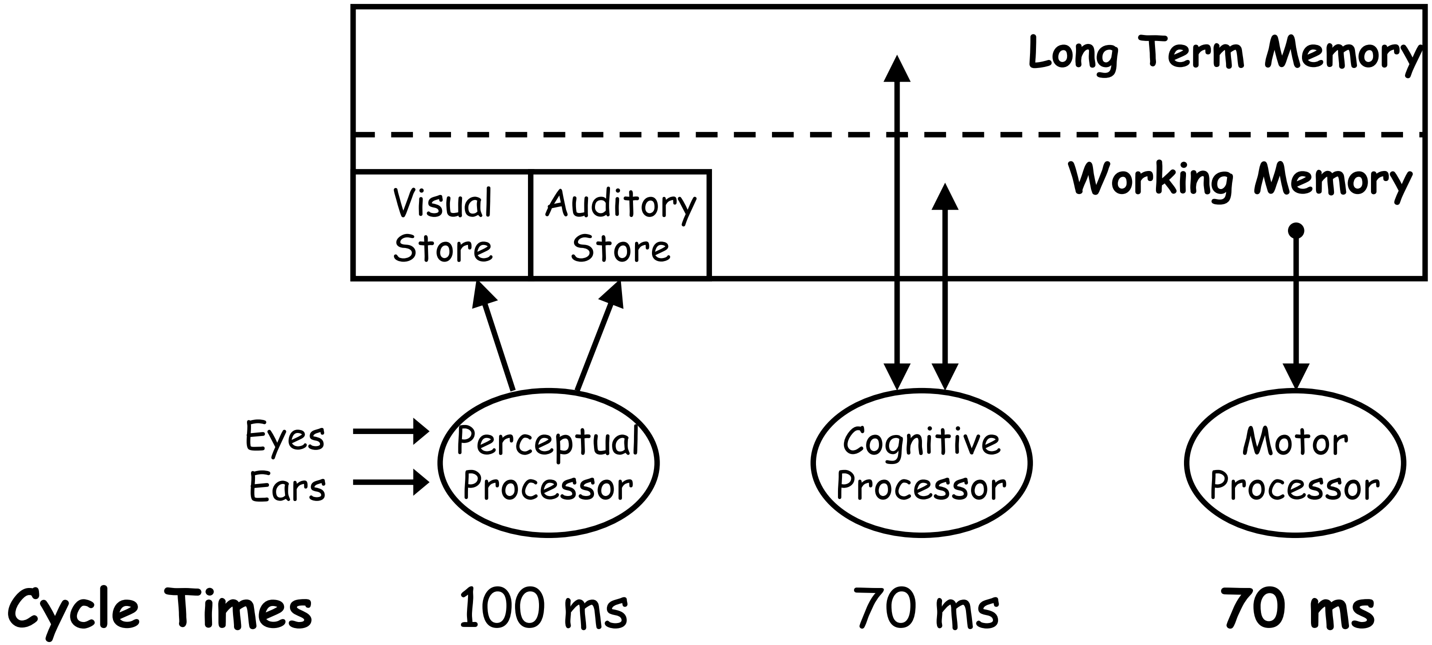
What We Know So Far



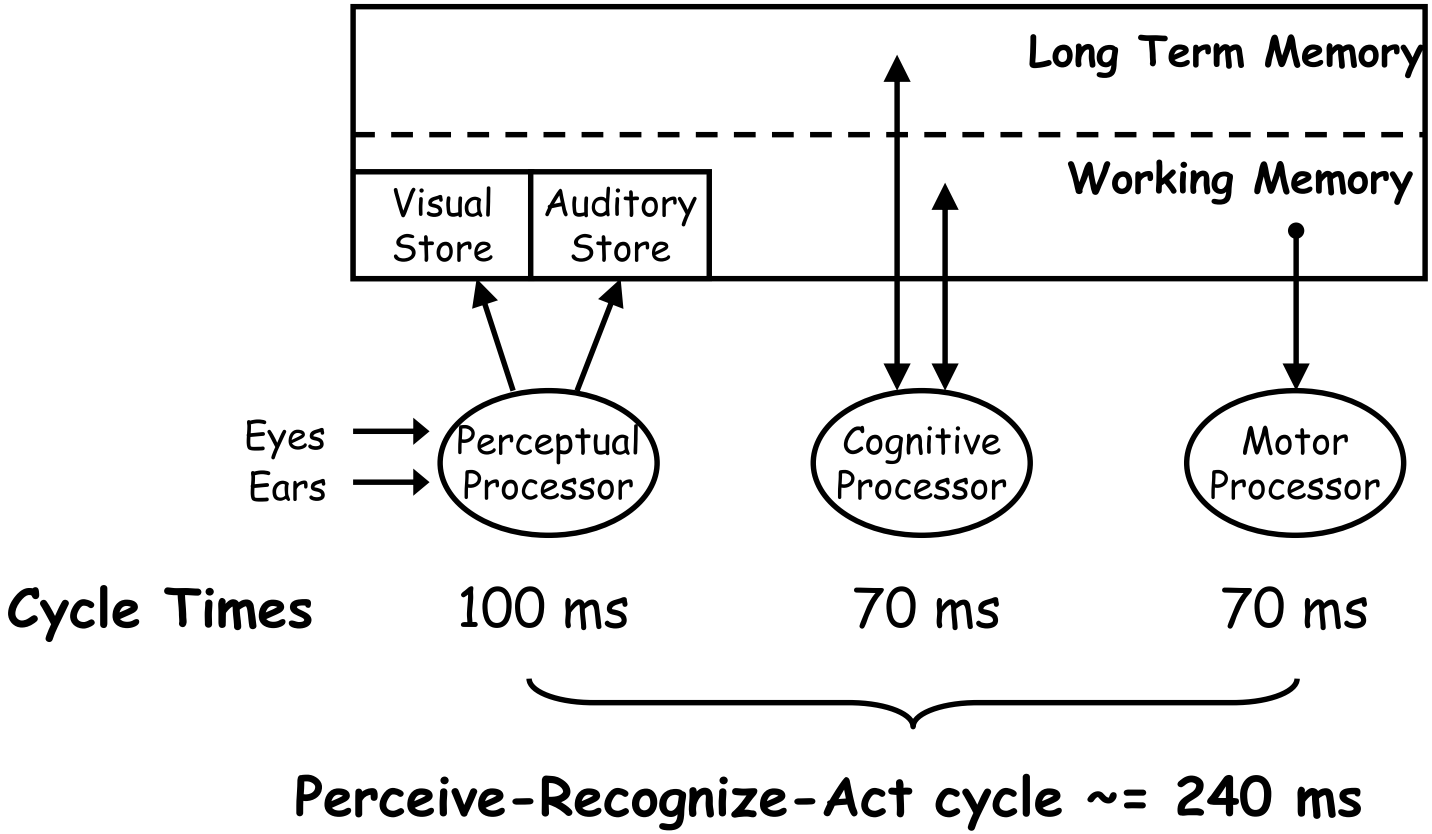
What We Know So Far



What We Know So Far



Model Human Processor (MHP)



Exercise 2

- **Use Model to Compute Reaction Time for Simple Matching Task**

- A user sits before a computer terminal. Whenever a symbol appears, s/he must press the space bar. What is the time between stimulus and response?

Tp + Tc + Tm =

100 + 70 + 70 = 240 ms

Exercise 3

- **Use Model to Compute Reaction Time for Symbol Matching Task**

- Two symbols appear on the computer terminal. If the second symbol matches the first, the user presses "Y" and presses "N" otherwise. What is the time between the second signal and response?

Tp + 2Tc (compare + decide) + Tm =

100 + 2Tc (70 + 70) + 70 = 310 ms

In General Case

- Need a bridge from task structure to MHP
  - Enables top down as opposed to bottom up analysis

- Analyze goal structure of the task, then for each step:
  - Analyze user actions required (motor system)
  - Analyze user perception of the output (perceptual system)
  - Analyze mental steps to move from perception to action (cognitive system)

- Sum the processing times from each step to get a reasonably accurate prediction of task performance

GOMS

- **G**oals, **O**perators, **M**ethods, **S**election Rules.

  (Developed by Card, Moran and Newell in 1983)

- Models task structure (goals) and user actions (operators, methods, selection rules)

GOMS

- **Goals:** End state trying to achieve. Then decompose into sub-goals.
- **Operators:** Basic actions available for performing a task (lowest level actions)
- **Methods:** sets of goal-operator sequences to accomplish a sub-goal
- **Selection rules:** Rules to select a method

Example – Online Dictionary Lookup

- Goal: Retrieve definition of a word
  - Goal: Access online dictionary
    - Operator: Type URL sequence
    - Operator: Press Enter
  - Goal: Lookup definition
    - Operator: Type word in entry field
    - Goal: Submit the word
      - Operator: Move cursor from field to Lookup button
      - Operator: Select Lookup
    - Operator: Read output

GOMS Variants

- GOMS is often combined with a keystroke level analysis
  - KLM - Keystroke level model
  - Analyze observable behaviors such as keypresses, mouse movements
- It allows predictions to be made about how long it takes an expert user to perform a task.

KLM Operators

- **Operators*:***
  - – K: keystroke, mouse button push
  - – P: point with pointing device
  - – D: move mouse to draw line
  - – H: move hands to keyboard or mouse
  - – M: mental preparation for an operation
  - – R: system response time

KLM Operators

Keystroke-Level Model (assumes no errors)

Operator	Description	Time (s)
K, press a Key or button (incl shift, control), time varies with user skill	Best typist (135 wpm)	0.08
	Good typist (90 wpm)	0.12
	Avg skilled typist (55 wpm)	0.20
	Avg no-secretary typist (40 wpm)	0.28 or…
	Typing random letters	0.50
	Typing complex codes	0.75
	Worst typist (unfamiliar with keyboard)	1.20
P, Point with a mouse	Point with a mouse (range is 0.8 to 1.6 sec, not incl. button press)	1.10
H, Home to/from keyboard or other device		0.40
D (nd,ld), Draw nd straight lines of total length ld		9nd+.16 ld
M, Mentally prepare		1.35 Olson and Nilsen say 1.62
S, Scan	e.g., find coordinates of spreadsheet, not in original KLM	2.29
R(t). Response by system	varies with command, including wait if required	t

GOMS – Advantages and Disadvantages

Advantages:

- Enables quantitative comparison of task performance before implementation

Disadvantages

- Assumes error free and rational behavior
- Predicting movement time based on the level of micro-movements not plausible

Fitts' law

- Models human motor performance
  - Aimed at arm-hand movement
  - Established in 1954 by Paul Fitts

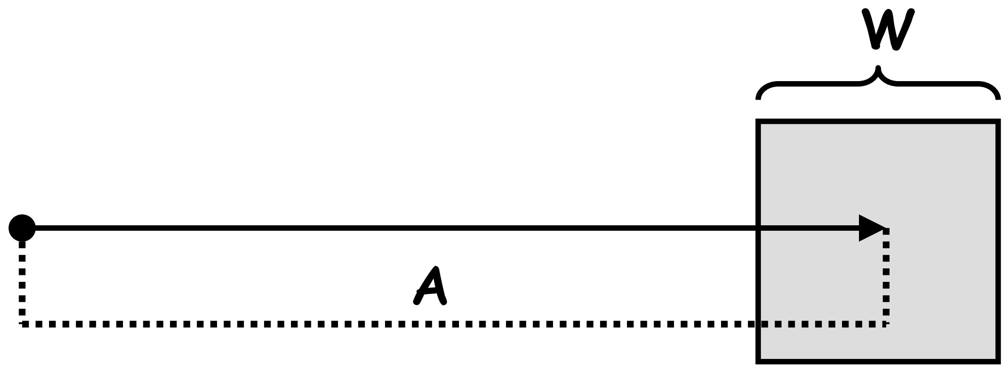
- Enables prediction of movement time (MT)
  - Movement assumed to be rapid, error-free, and targeted

- Fitts's Law states "...the time to acquire a target is a function of the distance to and size of the target"

- As the distance increases, movement takes longer and as the size decreases selection again takes longer.

Task Environment

- Models movement of arm-hand to a target
  - Hand is A cm from the target (Amplitude)
  - Target is W cm wide (tolerance)
  - Assume movement follows straight horizontal path



Model – Movement Time (MT)

- $MT = a + b * I_d$

where

a: y-intercept
b: slope (msec/bit)
a, b = constants (empirically derived)

I_d (Index of Difficulty) $= \log_2(A/W+1)$
A = distance
W = size

$MT = 590 + 230 * I_d$
Time (in msec)

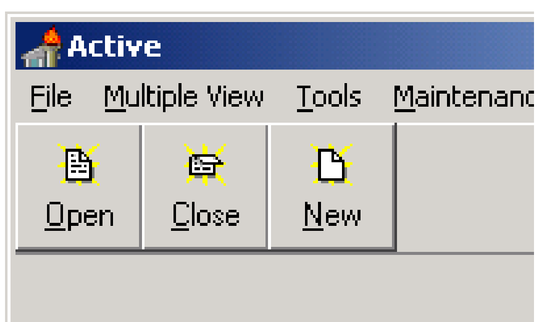
Exercise 4

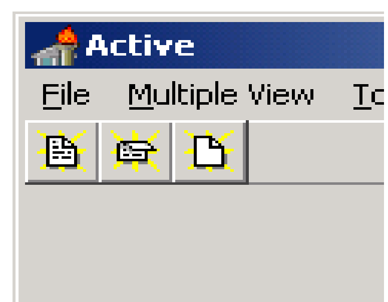
- **Predict time for user to move the cursor from current location to a button**
  - Button is 400 pixels to the right of the cursor
  - Button is 50 pixels wide

  - **MT = 590 + 230 * Log2(A / W + 1)**
  - **MT= 590+230 * Log2 (400/50+1)**
  - **MT= 820* Log2 (9)**

Fitts' law

- Microsoft Toolbars allow you to either keep or remove the labels under Toolbar buttons
- According to Fitts' Law, which is more efficient?





Fitts' law

1. The label becomes part of the target. The target is therefore bigger. Bigger targets, all else being equal, can always be accessed faster, by Fitt's Law.
2. When labels are not used, the tool icons crowd together.