Fitts and GOMS

Scott Klemmer (sub: Anoop Sinha)

TAs: Marcello Bastea-Forte, Joel Brandt, Neil Patel, Leslie Wu, Mike Cammarano

09 October 2007

http://cs147.stanford.edu

A little bit about this lecture

- http://www.youtube.com/watch?v=p5cPVP_llfo#

A little bit about this lecture

- Why is the Wii controller so much fun to use?

- Minimizing the distance between our human capabilities and what we want to the computer to do

A little about myself – Anoop Sinha

- Ph.D. ’03 UC Berkeley / B.S. ’96 Stanford
- Group-mate with Scott
- Did research on speech, pen, multimodal, multidevice user interfaces:
  - **Sinha’s Law**: the number of electronic devices each person uses regularly increases on average by +1 every year
- Worked in industry in Consulting and previously co-founded Danoo, which puts interactive digital screens in public places
- aks@cs.stanford.edu

Material from Stu Card's Lecture and James Landay's Lecture

HUMAN INFORMATION INTERACTION
THE THEORY AND DESIGN OF COGNITIVE PROSTHESES

Stuart Card
Palo Alto Research Center
(PARC)

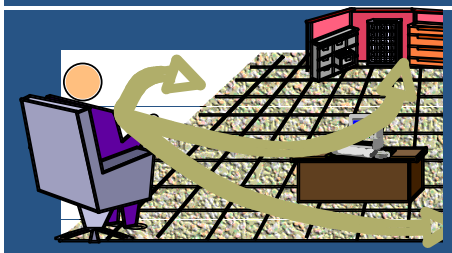
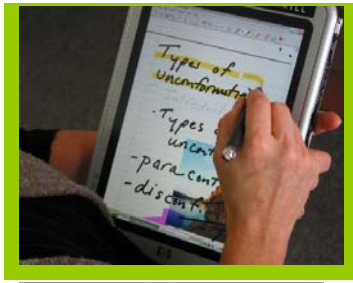
Stanford
June 4, 2007

Stu Card, Xerox PARC

http://www.designinginteractions.com/interviews/StuCard
[Stu Card video from Moggridge Book]

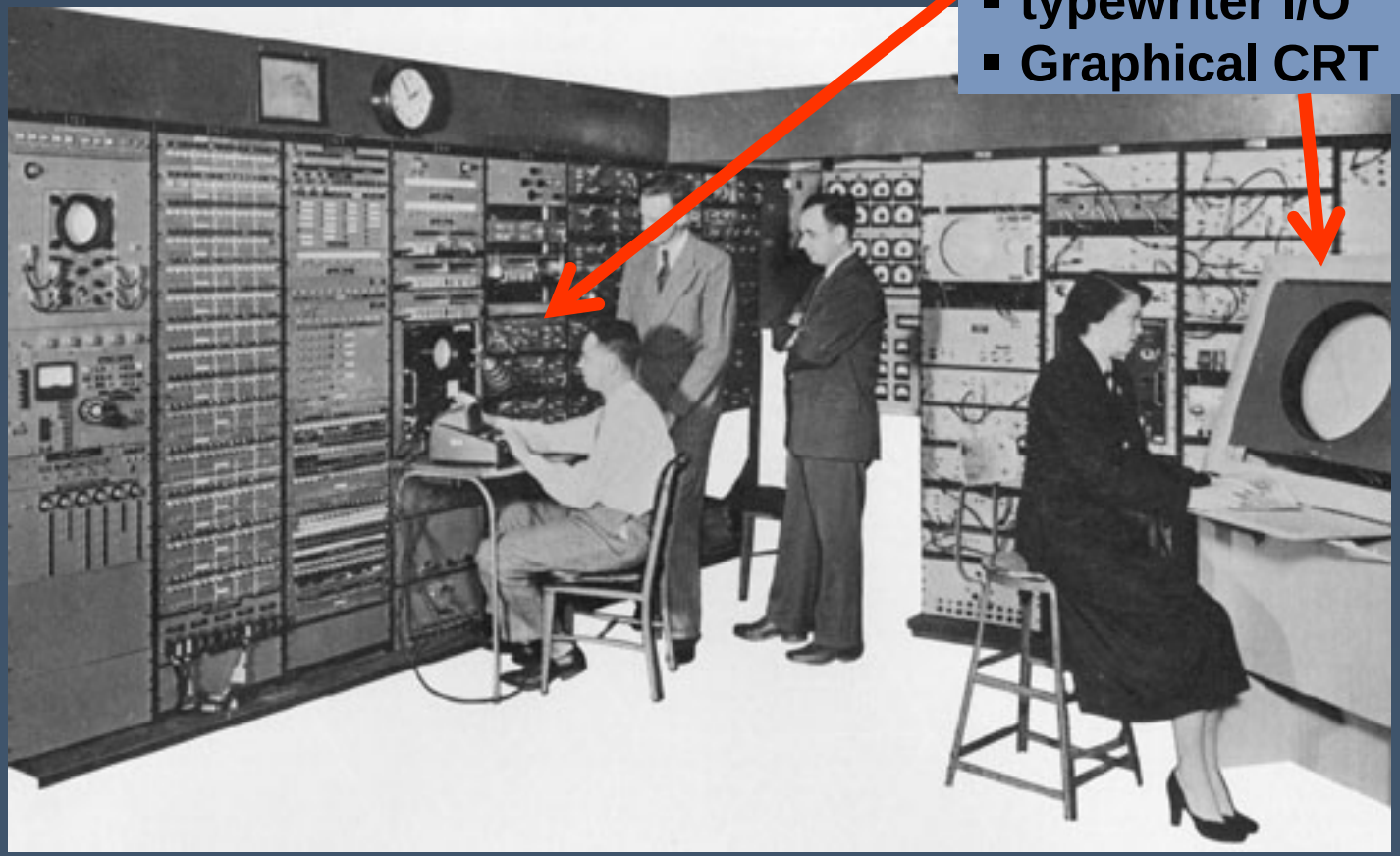
Source: Moggridge, Bill. Designing Interactions. MIT Press, 2007

TIMESCALE OF BEHAVIOR

10^7 (months) 10^6 (weeks) 10^5 (days)	**SOCIAL**	**Social Behavior**	
10^4 (hours) 10^3 10^2 (minutes)	**RATIONAL**	**Adaptive Behavior**	
10^1 10^0 (seconds) 10^{-1}	**COGNITIVE**	**Immediate Behavior**	
10^{-2} 10^{-3} (msec) 10^{-4}	**BIOLOGICAL**		

Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

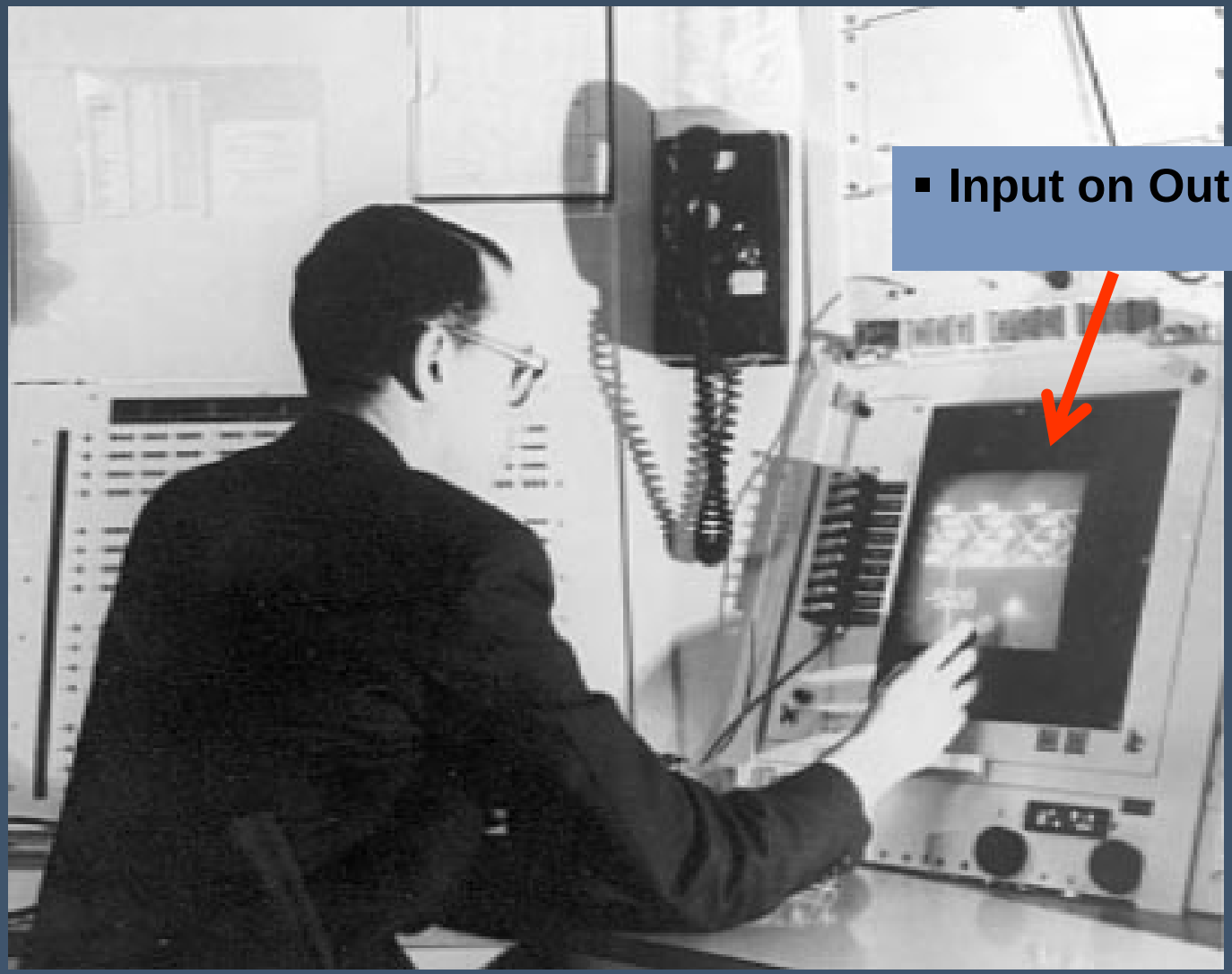
INTERACTIVE COMPUTING



Whirlwind (MIT)

Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

DIRECT MANIPULATION



Sketchpad (Sutherland, 1963)

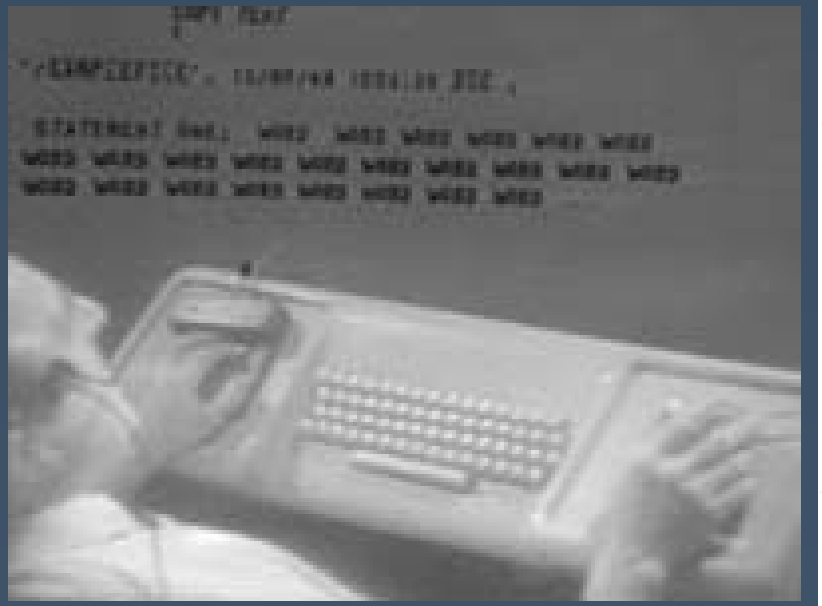
Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

EXAMPLE: POINTING DEVICES

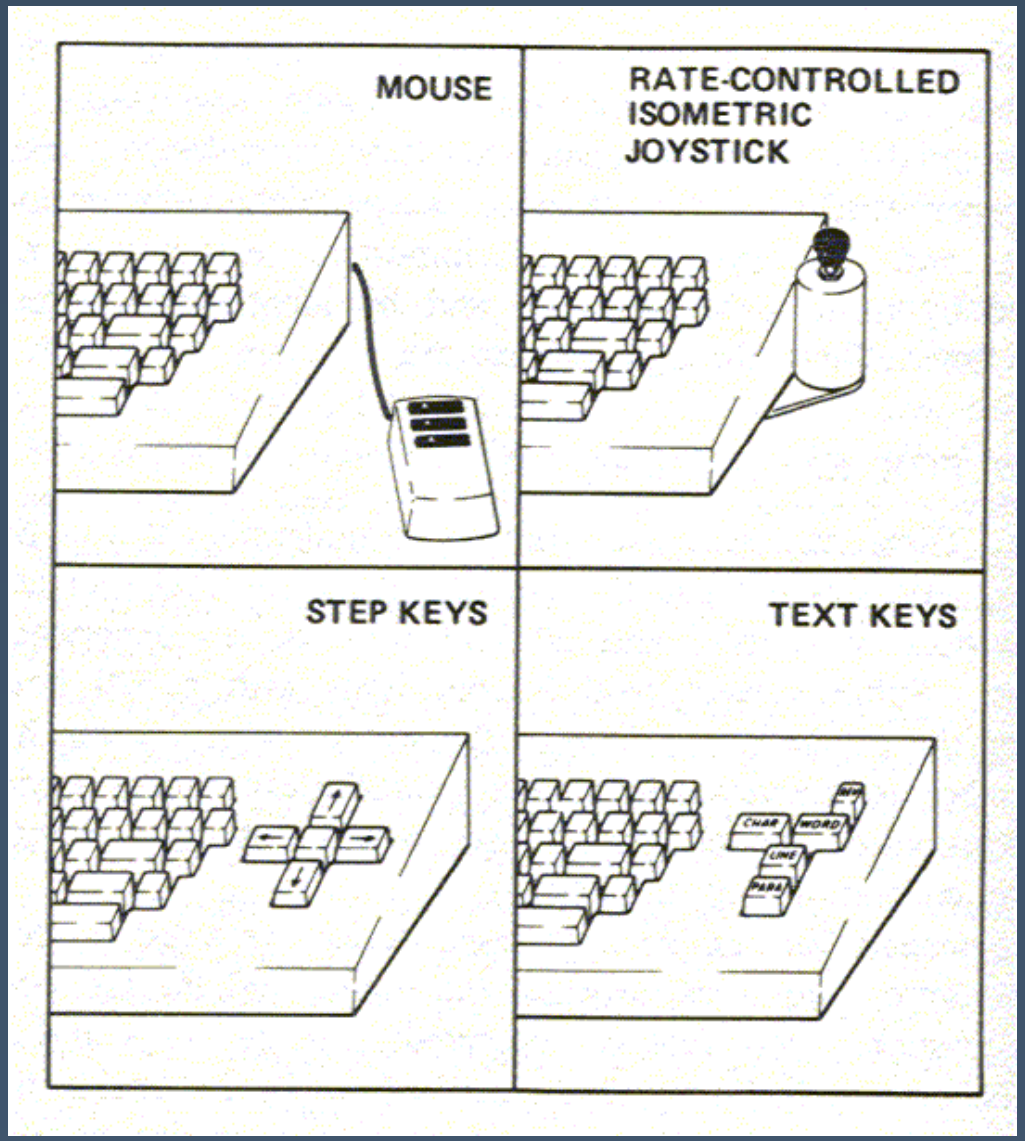
Mouse. Engelbart and English

Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

WHICH IS FASTEST?

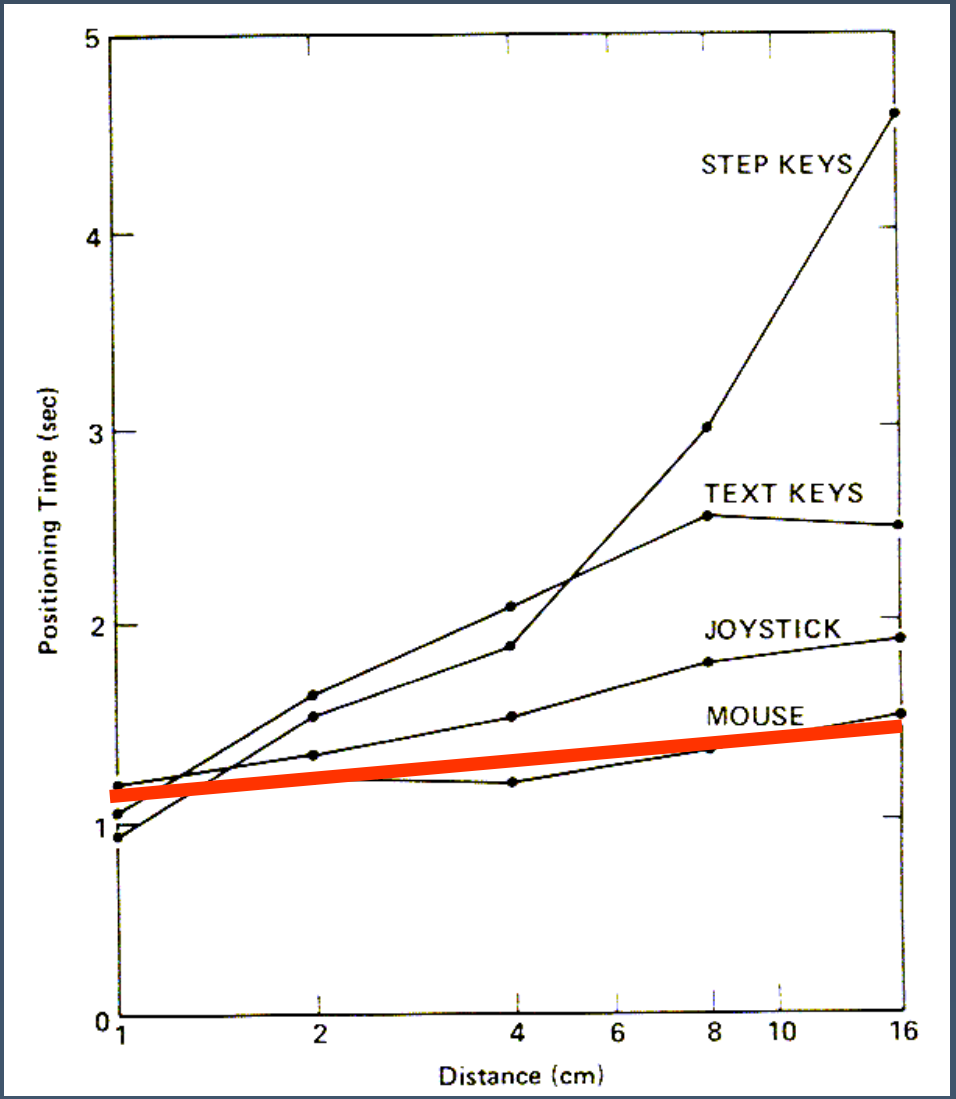


Engelbart



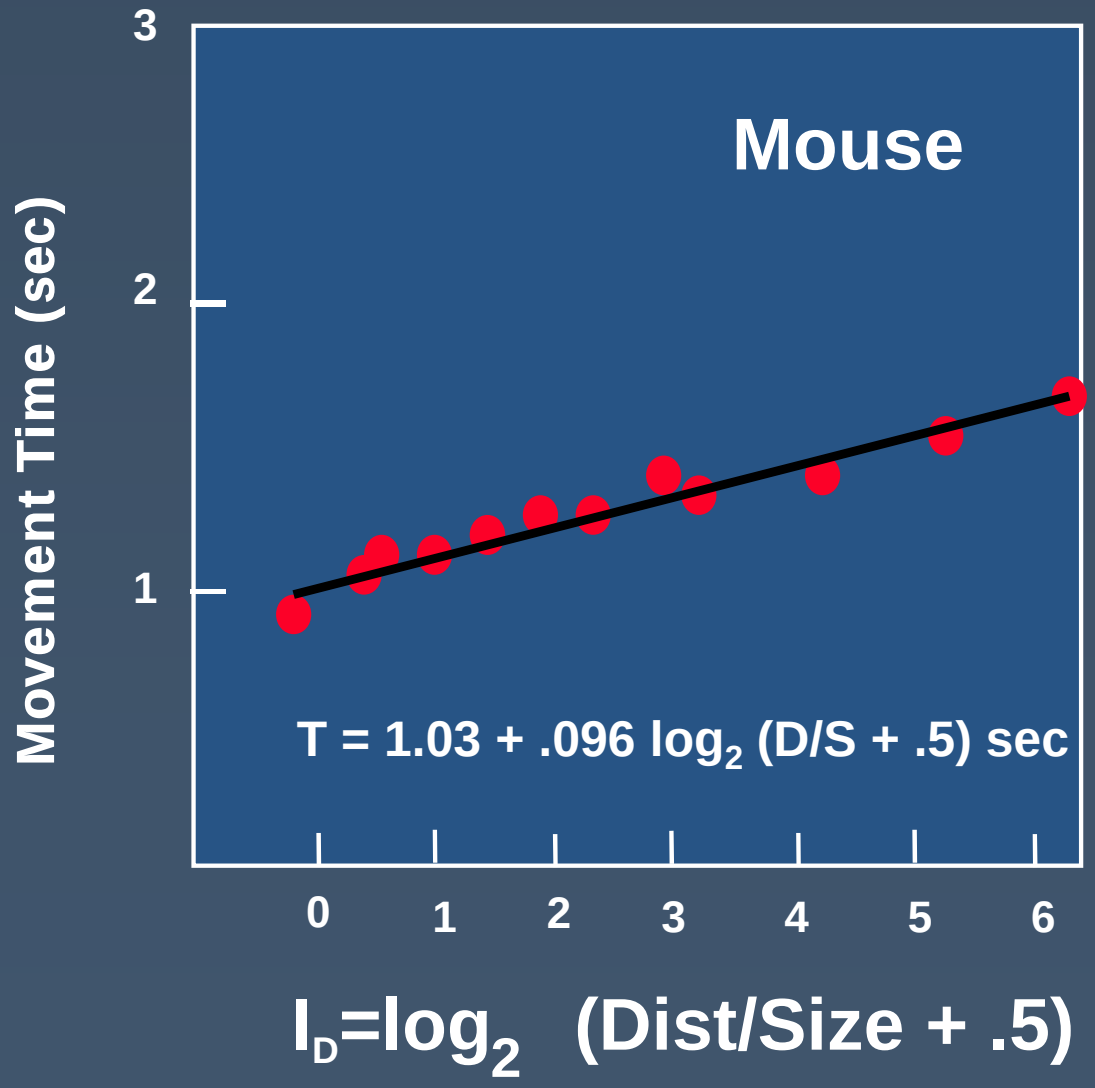
Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

EXPERIMENT: MICE ARE FASTEST



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

WHY? (ENGINEERING ANALYSIS)



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

Why these results?

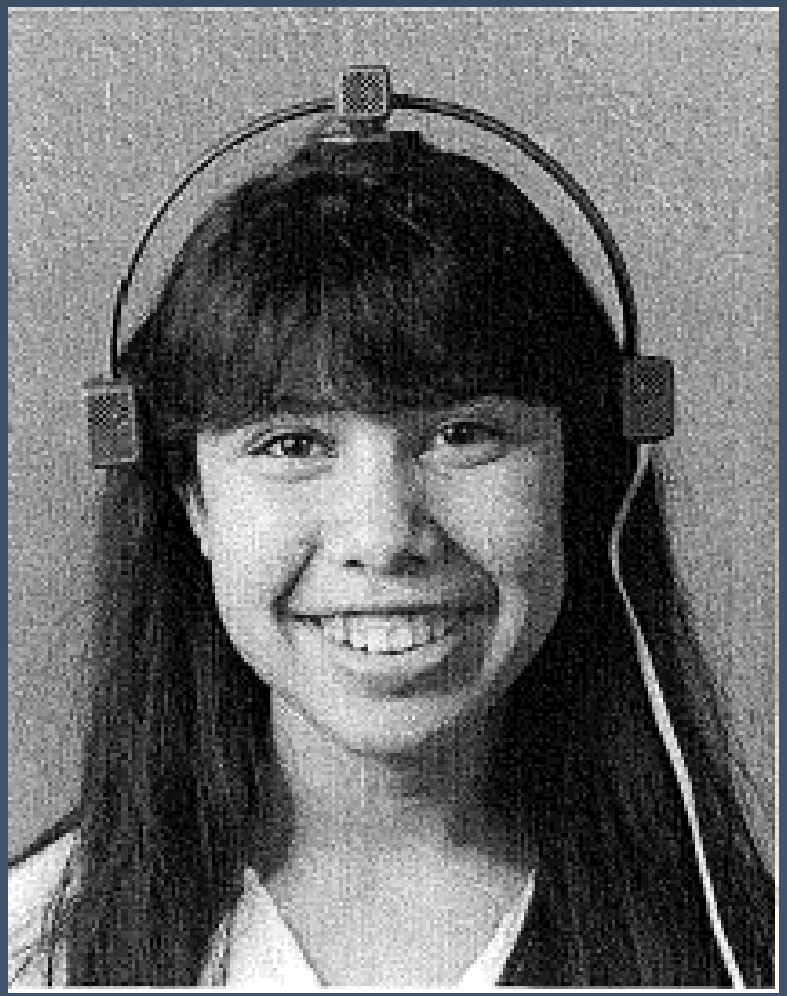
Time to position mouse proportional to Fitts' Index of Difficulty I_D.

[i.e. how well can the muscles direct the input device]

Therefore speed limit is in the eye-hand system, not the mouse.

Therefore, mouse is a near optimal device.

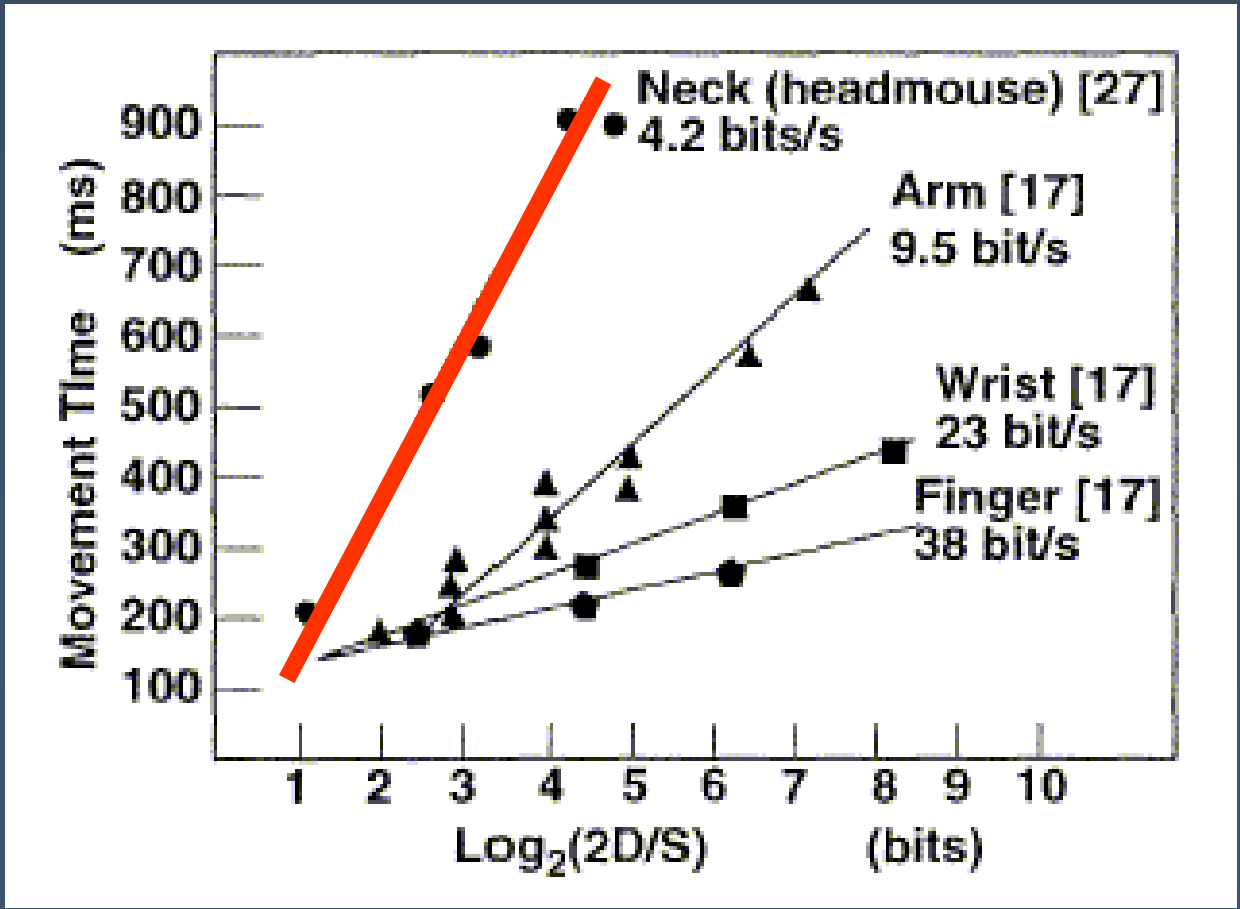
EXAMPLE: ALTERNATIVE DEVICES



Headmouse: No chance to win

Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

PERFORMANCE OF HEADMOUSE



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

Principles of Operation

- Fitts' Law
  - Time T_{pos} to move the hand to target size S which is distance D away is given by:
    - $T_{pos} = a + b \log_2 (D/S + 1)$
  - summary
    - time to move the hand depends only on the ***relative precision*** required

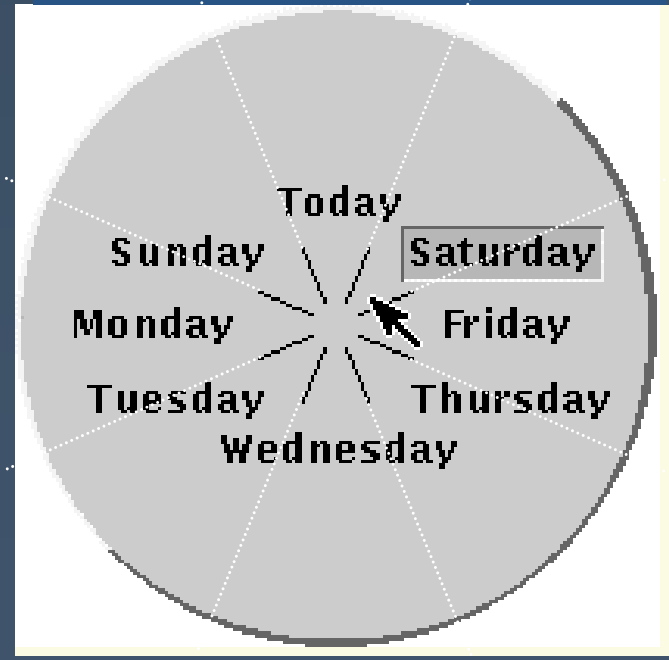
Source: Landay, James. "Human Abilities". CS160 UC Berkeley.

Fitts' Law Example

Pop-up Linear Menu

Today
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

Pop-up Pie Menu

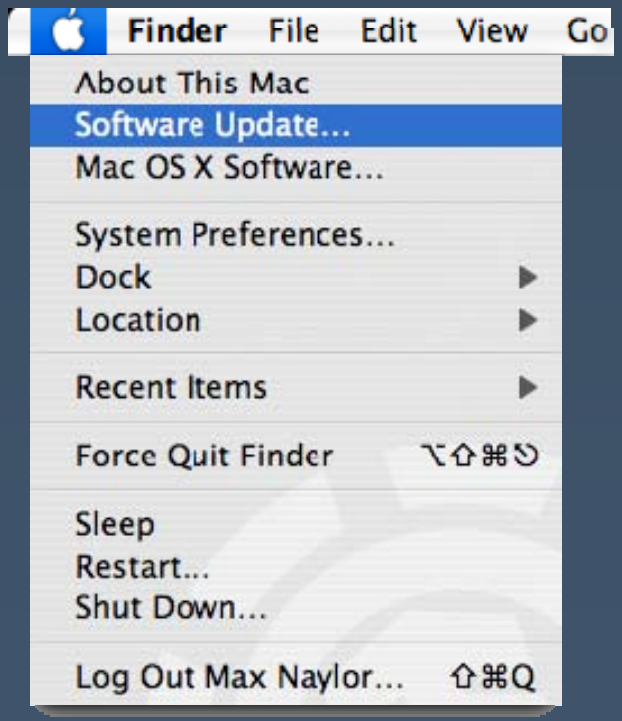


- Which will be faster on average?
  - pie menu (bigger targets & less distance)

Source: Landay, James. "Human Abilities". CS160 UC Berkeley.

Fitt's Law in Windows vs Mac OS

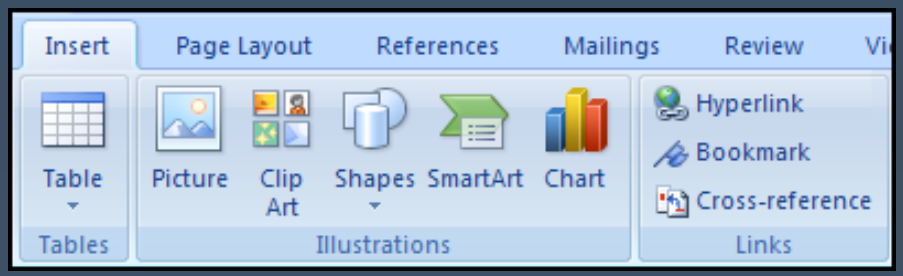
Windows 95: Missed by a pixel
Windows XP: Good to the last drop



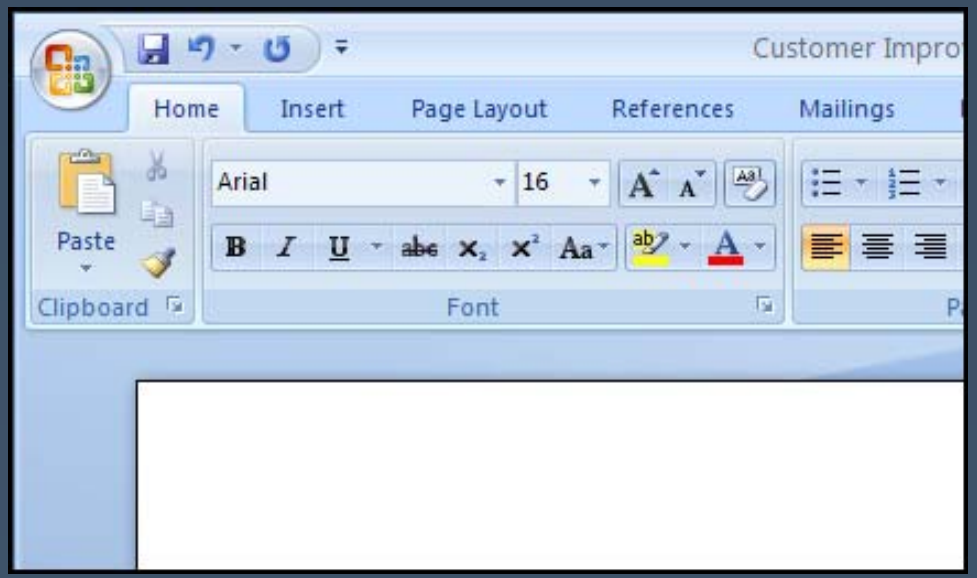
The Apple menu in Mac OS X v10.4 Tiger.

Source: Jensen Harris, An Office User Interface Blog : Giving You Fitts. Microsoft, 2007; Apple

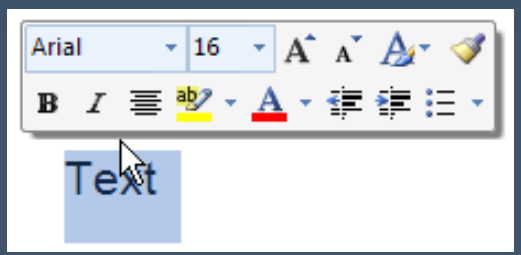
Fitt's Law in Microsoft Office 2007



Larger, labeled controls can be clicked more quickly



Magic Corner: Office Button in the upper-left corner



Mini Toolbar: Close to the cursor

Source: Jensen Harris, An Office User Interface Blog : Giving You Fitts. Microsoft, 2007.

CLASS FITT'S LAW CONTEST

- Need 5 volunteers

Principles of Operation (cont.)

- Power Law of Practice
  - task time on the nth trial follows a power law
    - $T_n = T_1 n^{-a} + c$, where a = .4, c = limiting constant
    - i.e., you get faster the more times you do it!
    - applies to skilled behavior (sensory & motor)
    - does not apply to knowledge acquisition or quality

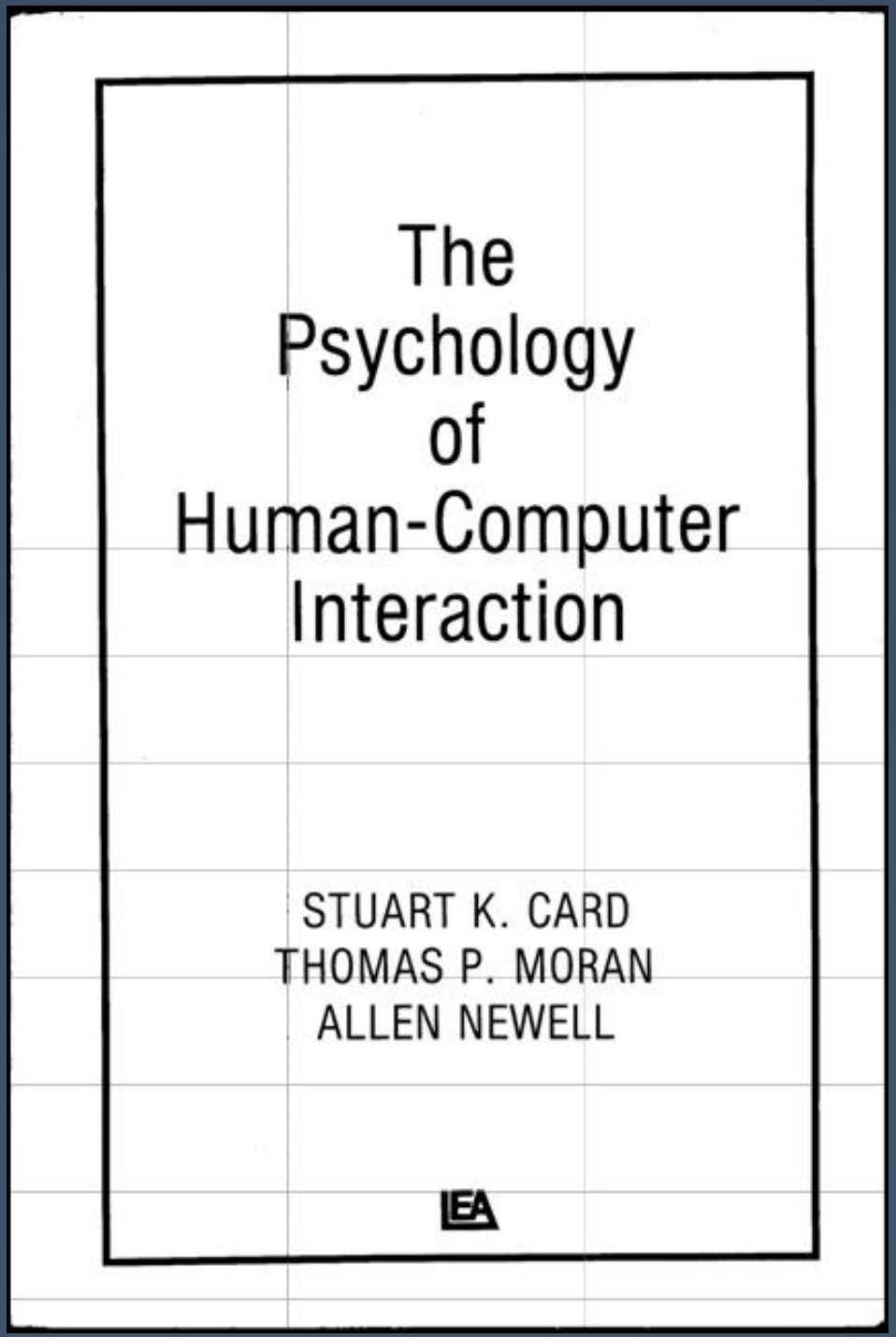
Source: Landay, James. “Human Abilities”. CS160 UC Berkeley.

Implications for mobile design

- Nokia N95 interface designs?
- iPhone?

- What might happen to mobile device “inputs” in the future?

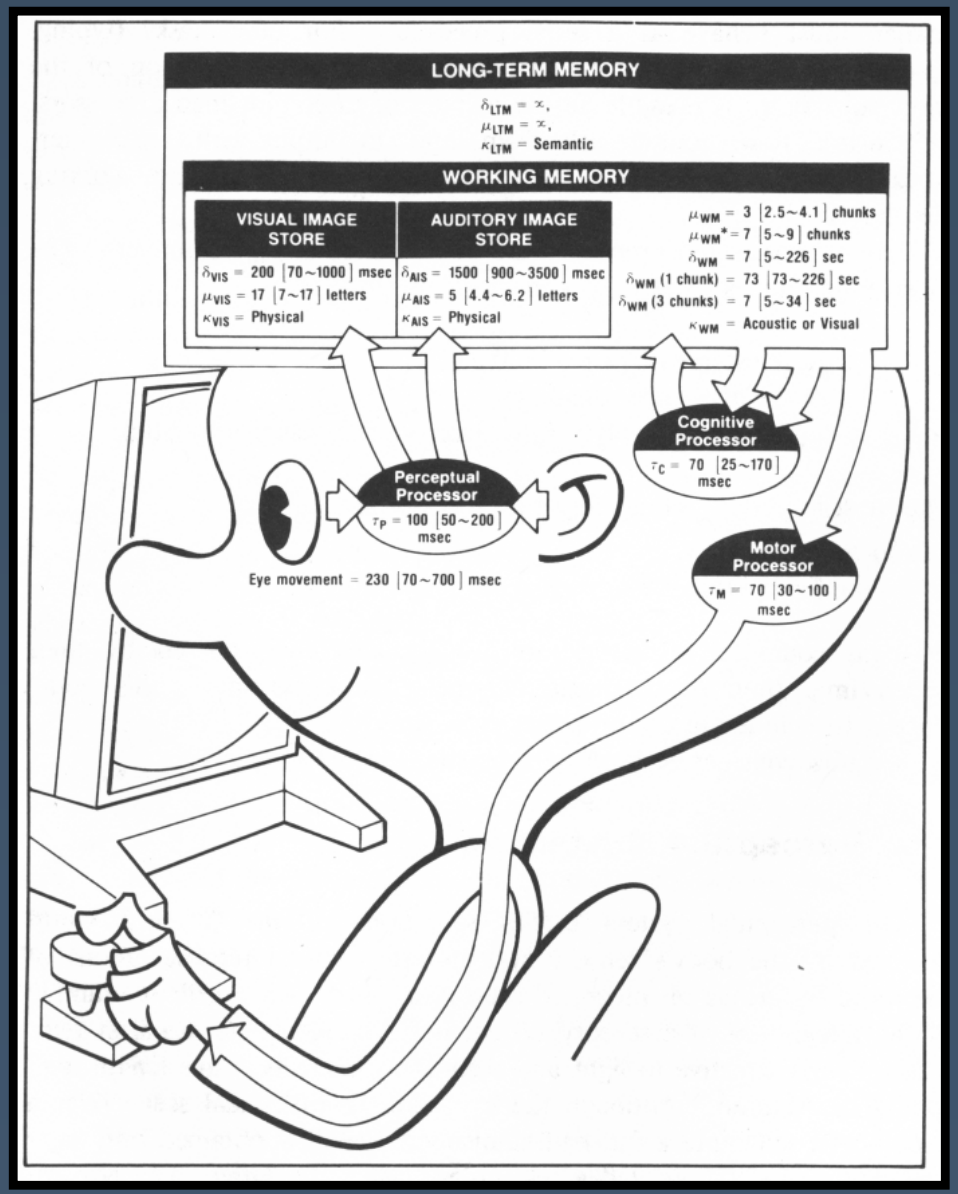
CMN



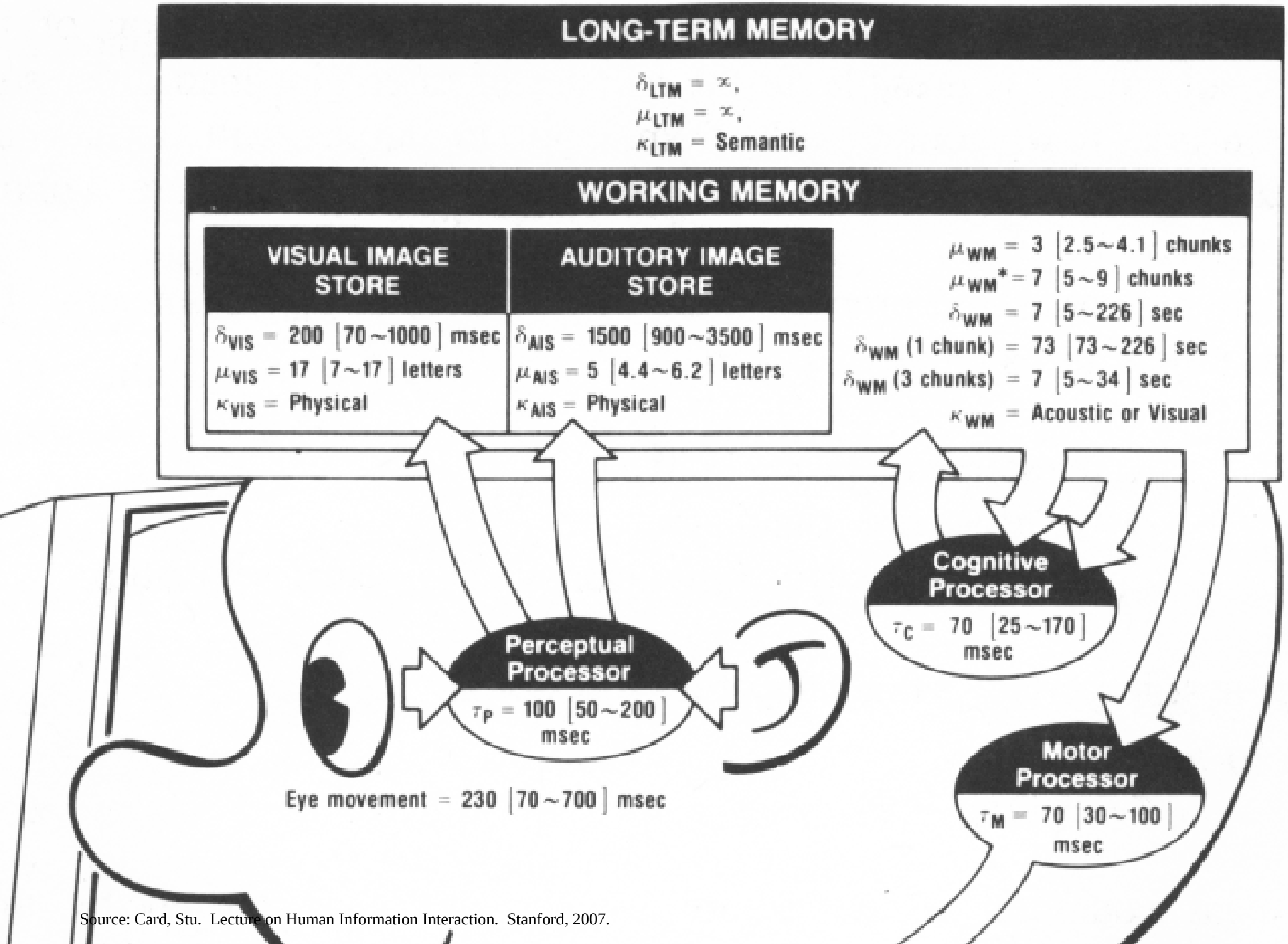
Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

MODEL HUMAN PROCESSOR

- Processors and Memories applied to human
- Used for routine cognitive skill [and learning and forgetting!]

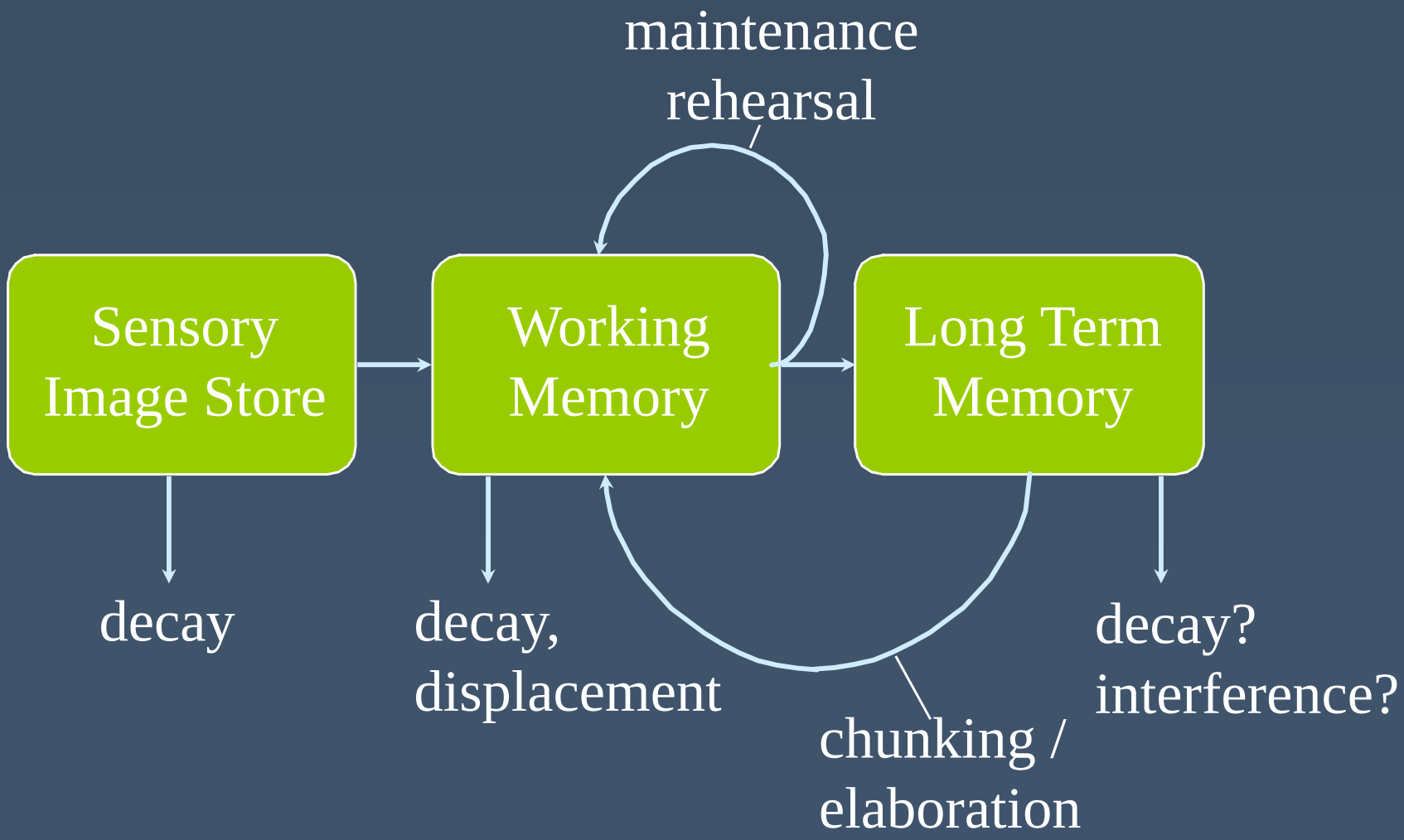


Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

Stage Theory



Source: Landay, James. “Human Abilities”. CS160 UC Berkeley.

Stage Theory

- Working memory is small
  - temporary storage
    - decay
    - displacement
- Maintenance rehearsal
  - rote repetition
  - not enough to learn information well
- Answer to problem is organization

Source: Landay, James. “Human Abilities”. CS160 UC Berkeley.

MHP Principles of Operation

- Recognize-Act Cycle of the CP
  - on each cycle contents in WM initiate actions associatively linked to them in LTM
  - actions modify the contents of WM
- Discrimination Principle
  - retrieval is determined by candidates that exist in memory relative to retrieval cues
  - interference by strongly activated chunks

Source: Landay, James. “Human Abilities”. CS160 UC Berkeley.

Principles of Operation (cont.)

- Variable Cog. Processor Rate Principle
  - CP cycle time T_c is shorter when greater effort
  - induced by increased task demands/information
  - decreases with practice

Source: Landay, James. “Human Abilities”. CS160 UC Berkeley.

Implications for Designing from MHP

- Recognition over recall
- Relate interface to existing material
- Recode design in different ways
- Organize and link information
- Use visual imagery and auditory enhancements

Source: Landay, James. “Human Abilities”. CS160 UC Berkeley.

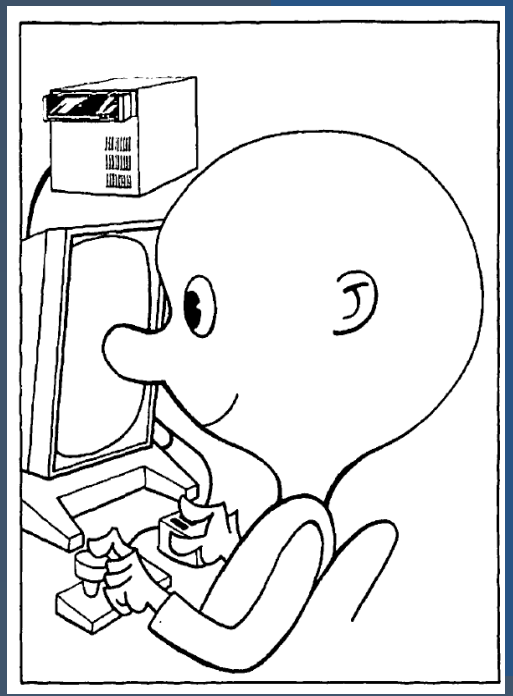
CLASS MHP CONTEST

- Need 4 volunteers

TASK ANALYSIS: GOMS (GOALS, OPERATORS, METHODS, SELECTION RULES)

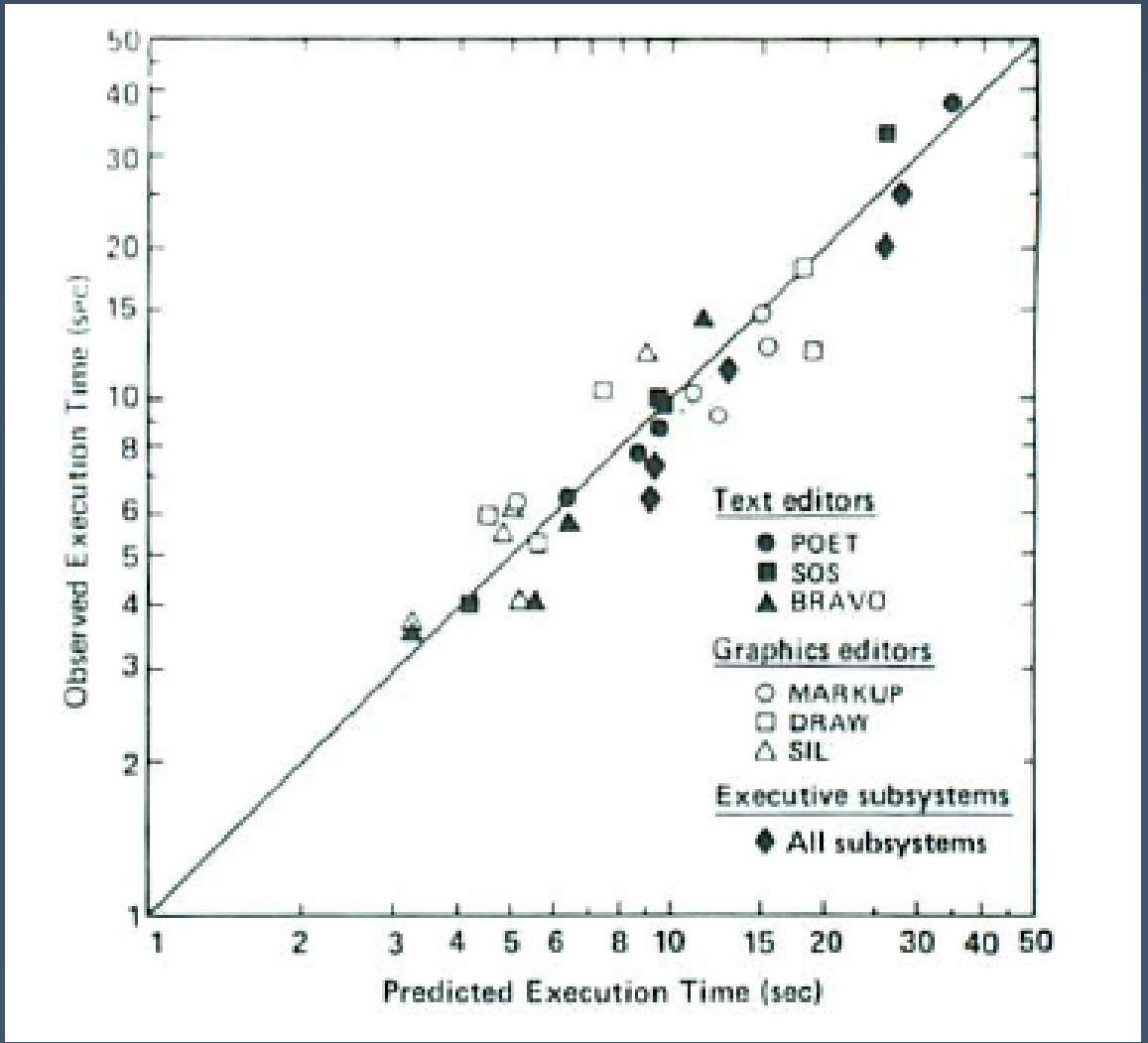
task analysis

GOAL: EDIT-MANUSCRIPT • repeat until done
  GOAL: EDIT-UNIT-TASK
    GOAL: ACQUIRE-UNIT-TASK • if not remembered
      GET-NEXT-PAGE • if at end of page
      GET-NEXT-TASK • if an edit task found
    GOAL: EXECUTE-UNIT-TASK
      GOAL: LOCATE-LINE • if task not on line
        [select : USE-QS-METHOD
          USE-LF-METHOD]
      GOAL: MODIFY-TEXT
        [select USE-S-COMMAND
          USE-M-COMMAND]



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

PREDICTS TIME WITHIN ABOUT 20%



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

GOMS Example: for Mac Finder

- Method for goal: delete a file.
- Step 1. Accomplish goal: drag file to trash.
- Step 2. Return with goal accomplished.
- Method for goal: move a file.
- Step 1. Accomplish goal: drag file to destination.
- Step 2. Return with goal accomplished.
- Method for goal: delete a directory.
- Step 1. Accomplish goal: drag directory to trash.
- Step 2. Return with goal accomplished.
- Method for goal: move a directory.
- Step 1. Accomplish goal: drag directory to destination.
- Step 2. Return with goal accomplished.

- Method for goal: drag item to destination.
- Step 1. Locate icon for item on screen.
- Step 2. Move cursor to item icon location.
- Step 3. Hold mouse button down.
- Step 4. Locate destination icon on screen.
- Step 5. Move cursor to destination icon.
- Step 6. Verify that destination icon is reverse-video.
- Step 7. Release mouse button.
- Step 8. Return with goal accomplished.

Source: Abowd, Gregory. CS 4753. Human Factors in Software Development. Georgia Tech.

Comparison: for DOS

- Method for goal: delete a file.
- Step 1. Recall that command verb is "ERASE".
- Step 2. Think of directory name and file name and retain as first filespec.
- Step 4. Accomplish goal: enter and execute a command.
- Step 6. Return with goal accomplished.
- Method for goal: move a file.
- Step 1. Accomplish goal: copy a file.
- Step 2. Accomplish goal: delete a file.
- Step 3. Return with goal accomplished.
- Method for goal: copy a file.
- Step 1. Recall that command verb is "COPY".
- Step 2. Think of source directory name and file name and retain as first filespec.
- Step 3. Think of destination directory name and file name and retain as second filespec.
- Step 4. Accomplish goal: enter and execute a command.
- Step 5. Return with goal accomplished.
- Method for goal: delete a directory.
- Step 1. Accomplish goal: delete all files in the directory.
- Step 2. Accomplish goal: remove a directory.
- Step 3. Return with goal accomplished.
- Method for goal: delete all files in a directory.
- Step 1. Recall that command verb is "ERASE".
- Step 2. Think of directory name.
- Step 3. Retain directory name and "*.*" as first filespec.
- Step 4. Accomplish goal: enter and execute a command.
- Step 5. Return with goal accomplished.
- Method for goal: remove a directory
- Step 1. Recall that command verb is "RMDIR".
- Step 2. Think of directory name and retain as first filespec.
- Step 3. Accomplish goal: enter and execute a command.
- Step 4. Return with goal accomplished.
- Method for goal: move a directory.
- Step 1. Accomplish goal: copy a directory.
- Step 2. Accomplish goal: delete a directory.
- Step 3. Return with goal accomplished.
- Method for goal: copy a directory.
- Step 1. Accomplish goal: create a directory.
- Step 2. Accomplish goal: copy all the files in a directory.
- Step 3. Return with goal accomplished.
- Method for goal: create a directory.
- Step 1. Recall that command verb is "MKDIR".
- Step 2. Think of directory name and retain as first filespec.
- Step 3. Accomplish goal: enter and execute a command.
- Step 4. Return with goal accomplished.
- Method for goal: copy all files in a directory.
- Step 1. Recall that command verb is "COPY".
- Step 2. Think of directory name.
- Step 3. Retain directory name and "*.*" as first filespec.
- Step 4. Think of destination directory name.
- Step 5. Retain destination directory name and "*.*" as second filespec.
- Step 6. Accomplish goal: enter and execute a command.
- Step 7. Return with goal accomplished.

- Method for goal: enter and execute a command.
- *Entered with strings for a command verb and one or two filespecs.*
- Step 1. Type command verb.
- Step 2. Accomplish goal: enter first filespec.
- Step 3. Decide: If no second filespec, goto 5.
- Step 4. Accomplish goal: enter second filespec.
- Step 5. Verify command.
- Step 6. Type "<CR>".
- Step 7. Return with goal accomplished.
- Method for goal: enter a filespec.

- *Entered with directory name and file name strings.*
- Step 1. Type space.
- Step 2. Decide: If no directory name, goto 5.
- Step 3. Type "\".
- Step 4. Type directory name.
- Step 5. Decide: If no file name, return with goal accomplished.
- Step 6. Type file name.
- Step 7. Return with goal accomplished.

Source: Abowd, Gregory. CS 4753. Human Factors in Software Development. Georgia Tech.

Comparison

- Mac Finder: only 3 methods to accomplish these user goals, involving a total of only 18 steps.
- DOS requires 12 methods with a total of 68 steps.

- Consistency in Mac Finder
- A major value of a GOMS model is its ability to characterize, and even quantify, this property of *method consistency*.

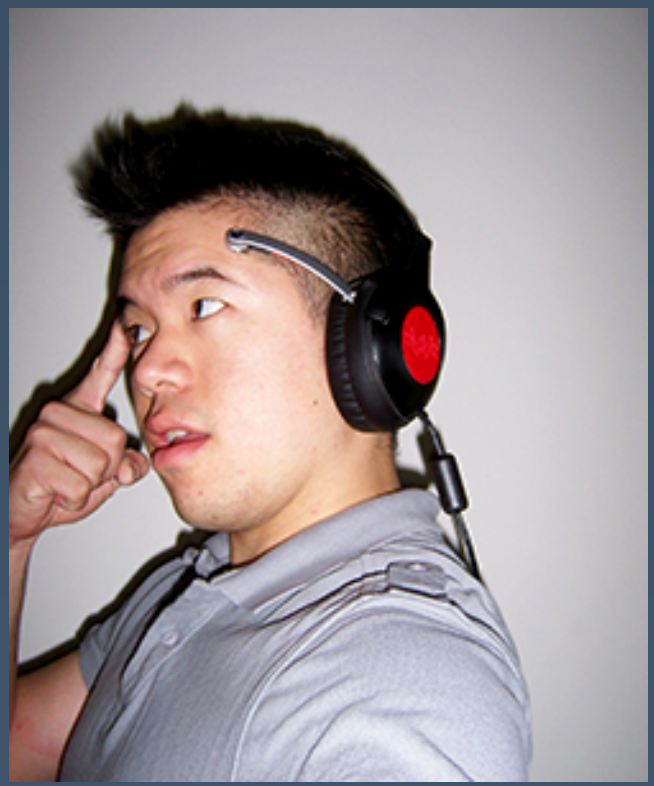
Source: Abowd, Gregory. CS 4753. Human Factors in Software Development. Georgia Tech.

Implications for interface design

- GOMS not often used formally
- But thinking through consistency of sub-tasks very useful!
- Good for comparing different systems

Eye to the Future: Brain Computer Interfaces

- Your brain might be your next videogame controller.
- http://www.youtube.com/watch?v=hQWBfCg91CU

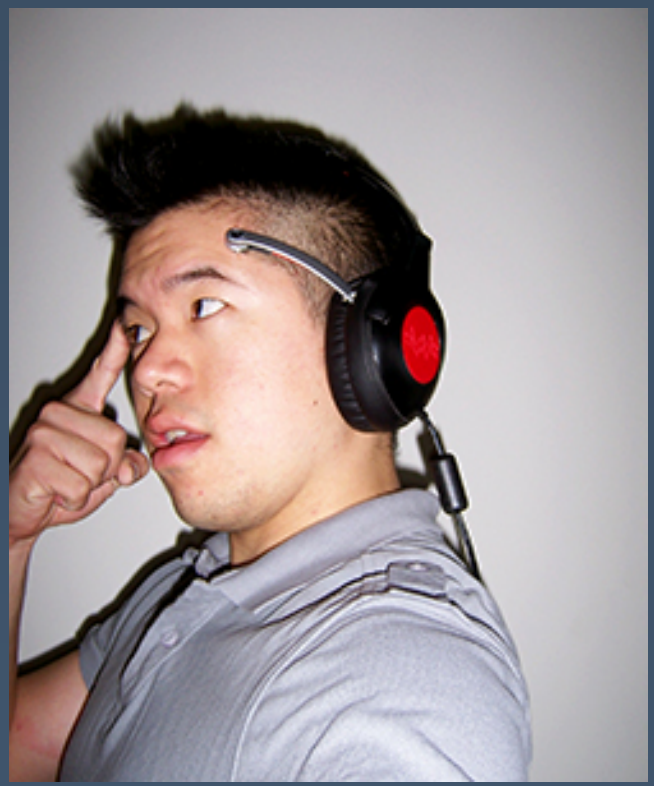


NeuroSky

Source: NeuroSky, “Direct Brain-to-Game Interface Worries Scientists”, Wired Magazine, 2007

Eye to the Future: Brain Computer Interfaces WARNING!

- ... the devices sometimes force users to slow down their brain waves. Afterward, users have reported trouble focusing their attention.



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Source: NeuroSky, “Direct Brain-to-Game Interface Worries Scientists”, Wired Magazine, 2007