

# Predicting Manual Motor Movement Times Using Fitts' Law

Edited by A. Hornof  
October, 2018

Materials from El-Glaly and Kuehl <http://www.se.rit.edu/~swen-444/00/index.html>;  
Agrawala, Canny, Guimbretiere, and Hearst; and Kieras.

# Major stages of human information processing:

- Perceptual
- Cognitive
- Memory
- Motor

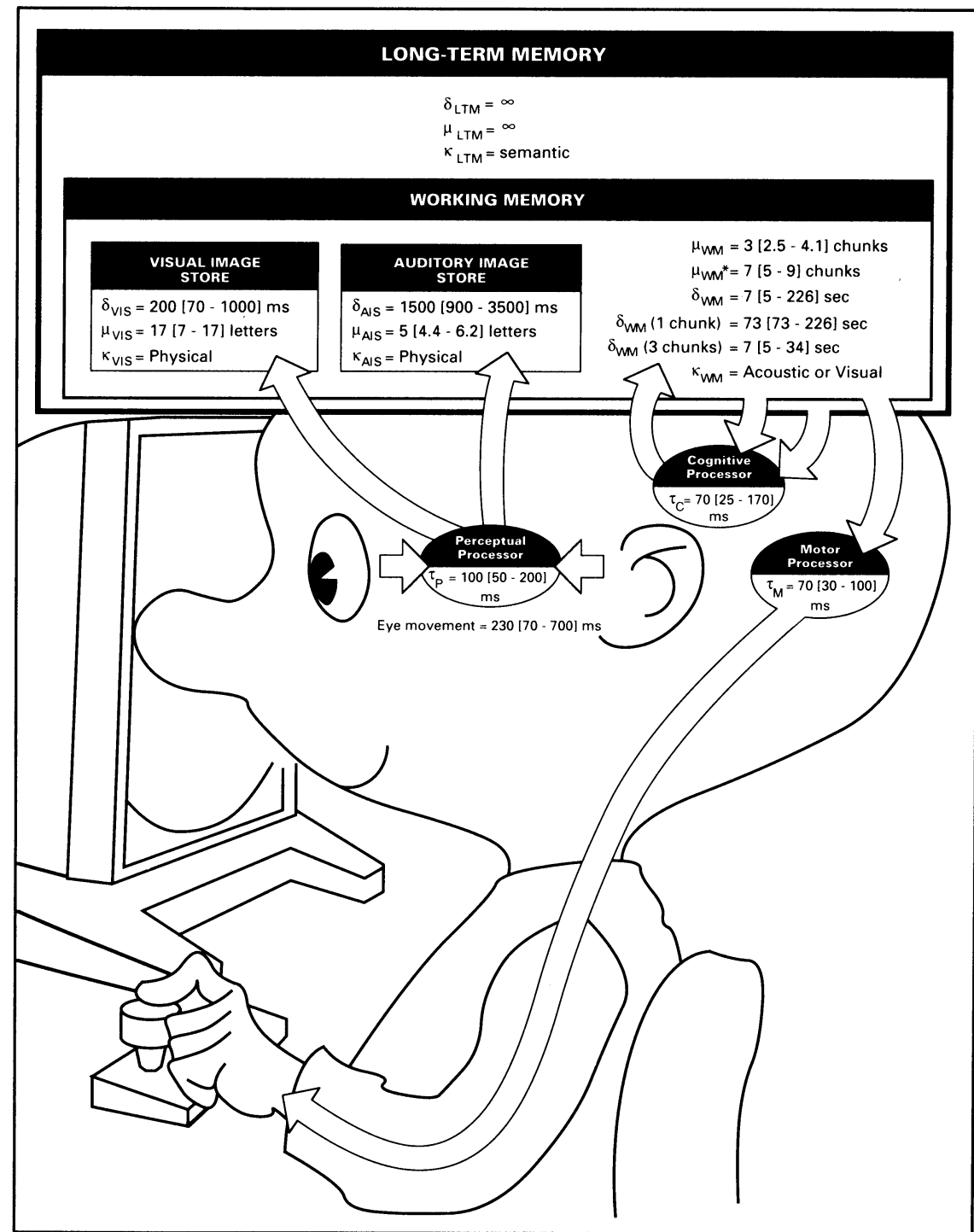


Figure 1-9. The Model Human Processor (MHP) block diagram (adapted from Card, Moran, & Newell, 1983).

## LONG-TERM MEMORY

$$\delta_{LTM} = \infty$$

$$\mu_{LTM} = \infty$$

$$\kappa_{LTM} = \text{semantic}$$

## WORKING MEMORY

### VISUAL IMAGE STORE

$$\delta_{VIS} = 200 [70 - 1000] \text{ ms}$$

$$\mu_{VIS} = 17 [7 - 17] \text{ letters}$$

$$\kappa_{VIS} = \text{Physical}$$

### AUDITORY IMAGE STORE

$$\delta_{AIS} = 1500 [900 - 3500] \text{ ms}$$

$$\mu_{AIS} = 5 [4.4 - 6.2] \text{ letters}$$

$$\kappa_{AIS} = \text{Physical}$$

$$\mu_{WM} = 3 [2.5 - 4.1] \text{ chunks}$$

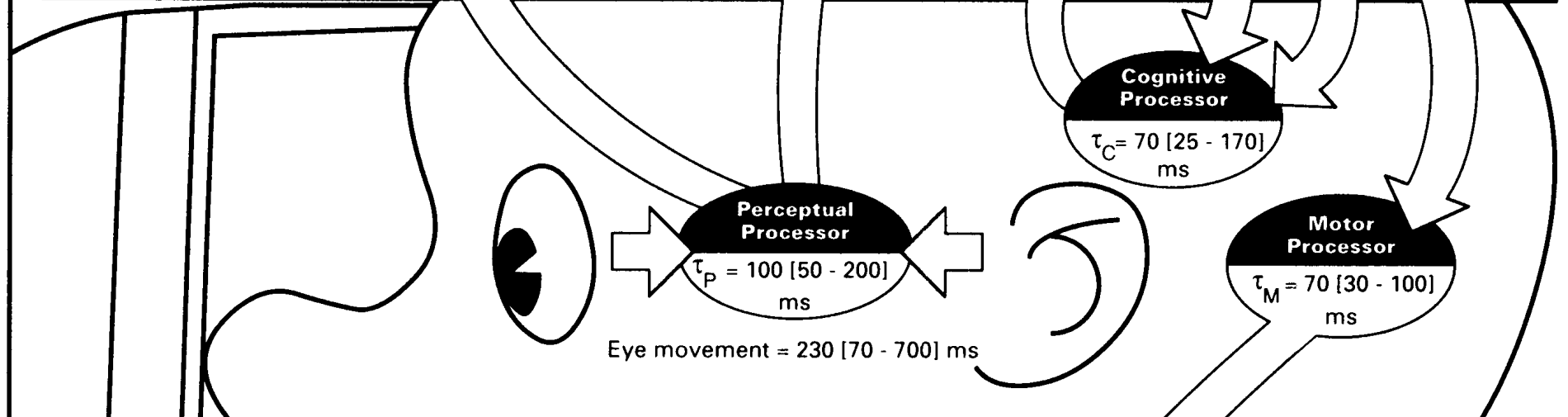
$$\mu_{WM}^* = 7 [5 - 9] \text{ chunks}$$

$$\delta_{WM} = 7 [5 - 226] \text{ sec}$$

$$\delta_{WM} (1 \text{ chunk}) = 73 [73 - 226] \text{ sec}$$

$$\delta_{WM} (3 \text{ chunks}) = 7 [5 - 34] \text{ sec}$$

$$\kappa_{WM} = \text{Acoustic or Visual}$$



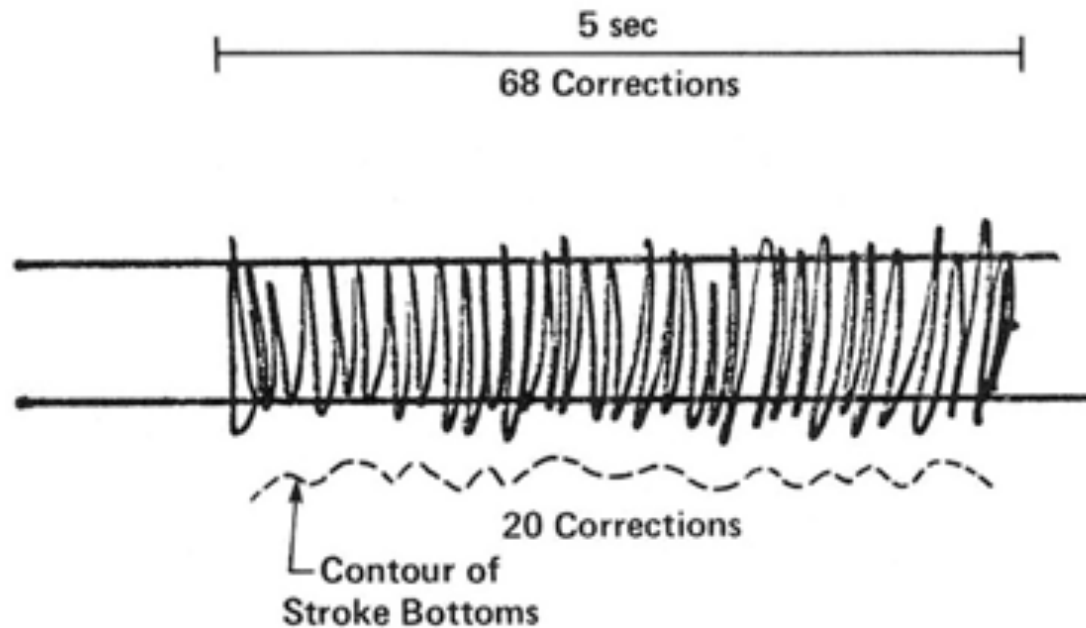
An early decomposition aimed at predicting human performance. Science permits engineering models to be constructed to predict aspects of human performance such as task execution time. Such as motor....

# Motor Processor

Receive input from the cognitive processor

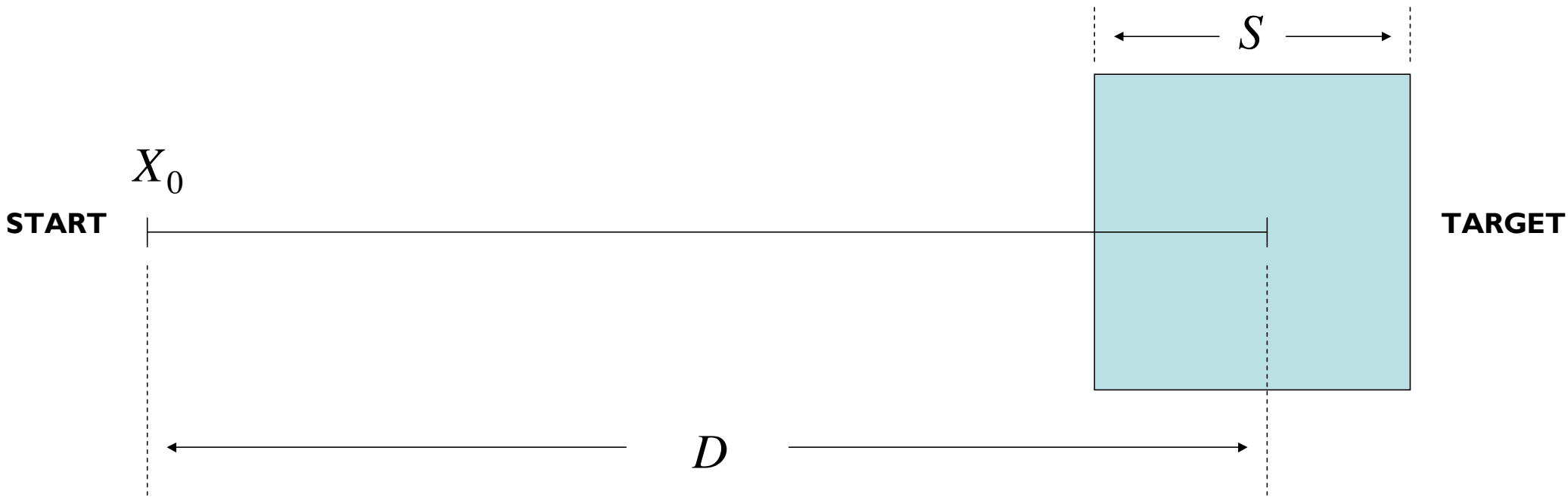
Execute motor programs

- Pianist: up to 16 finger movements per second
- Point of no-return for muscle action



(Agrawala et al.)

Predict the time to move a cursor or a finger distance  $D$  to click on a target of size  $S$ .



# Fitts' Law

$$T = a + b \log_2(D / S + 1)$$

a, b = constants (empirically derived)

D = distance

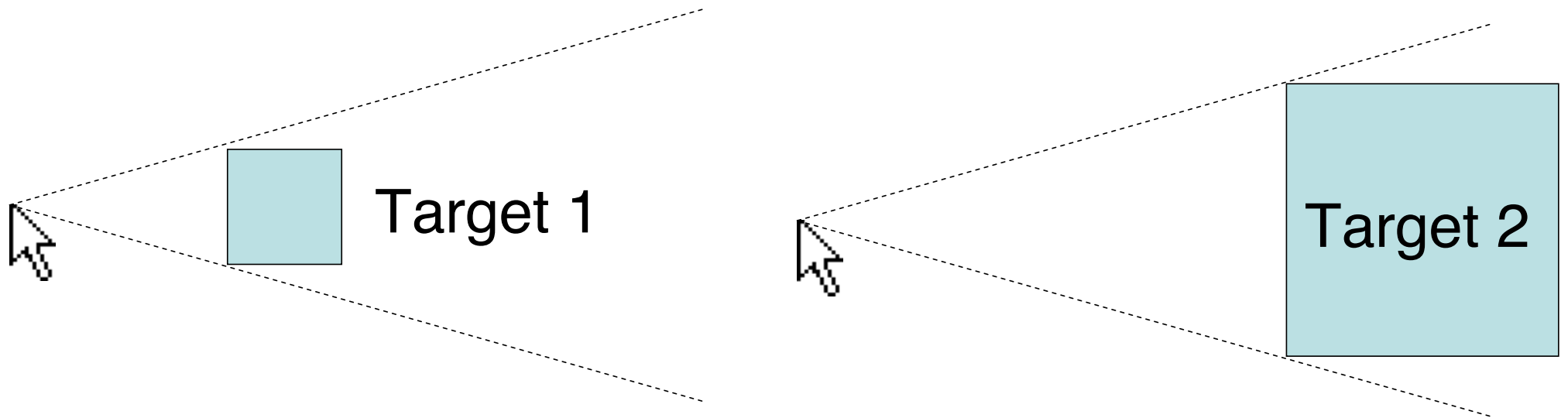
S = size

ID is Index of Difficulty =  $\log_2(D/S+1)$

- Models well-rehearsed selection task
- T increases as the **distance** to the target increases
- T decreases as the **size** of the target increases

# Considers Distance and Target Size

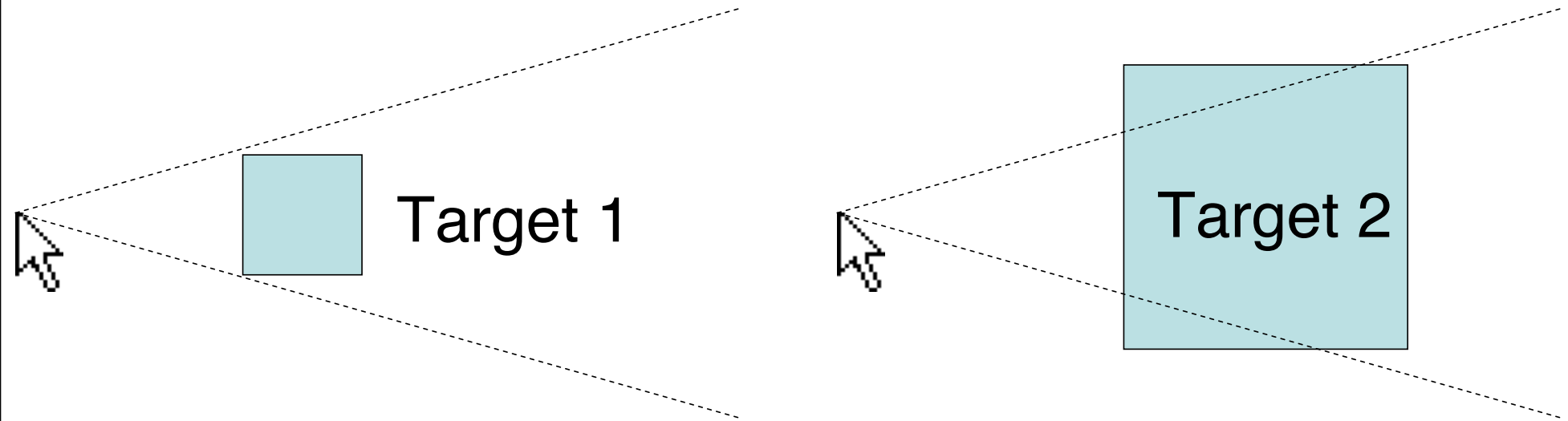
$$T = a + b \log_2(D/S + 1)$$



Same ID → Same Difficulty

# Considers Distance and Target Size

$$T = a + b \log_2(D/S + 1)$$

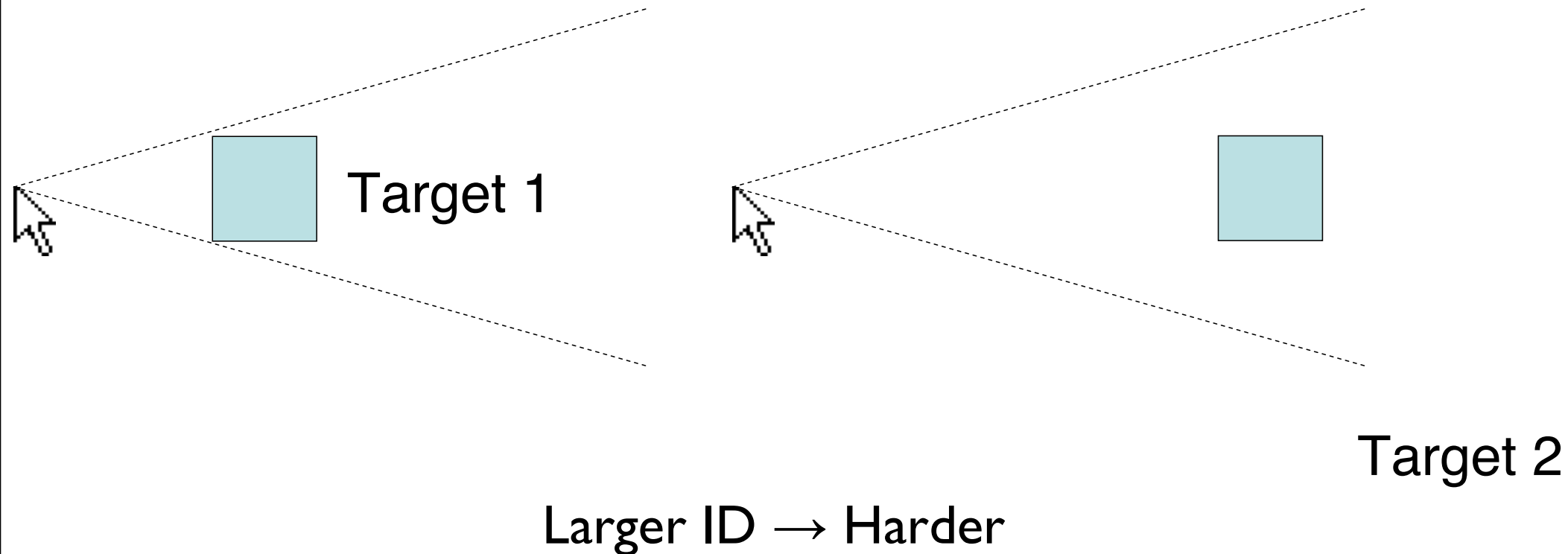


Smaller ID → Easier

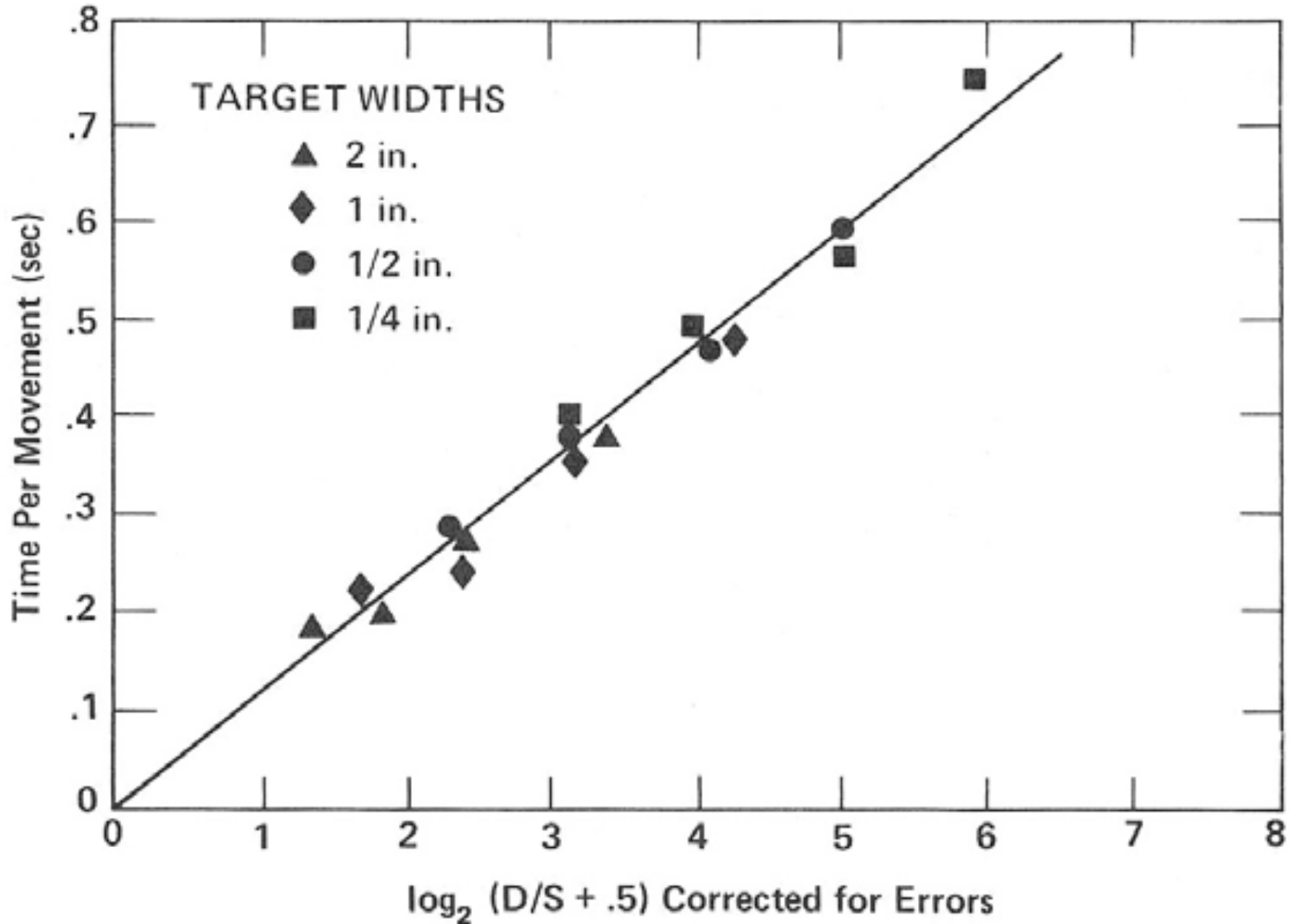


# Considers Distance and Target Size

$$T = a + b \log_2(D/S + 1)$$

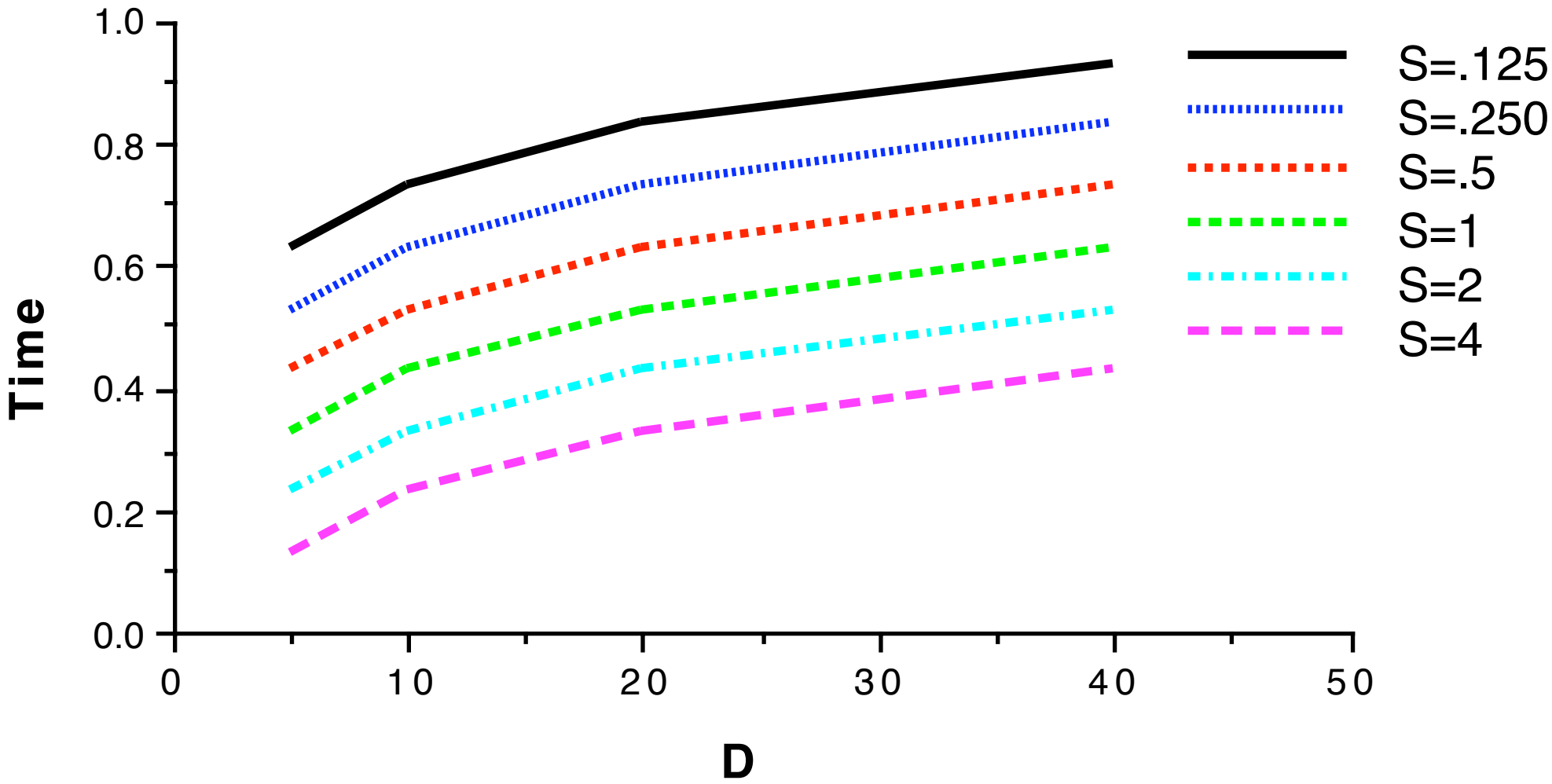


# Experimental Data



# Movement Time as a function of Distance

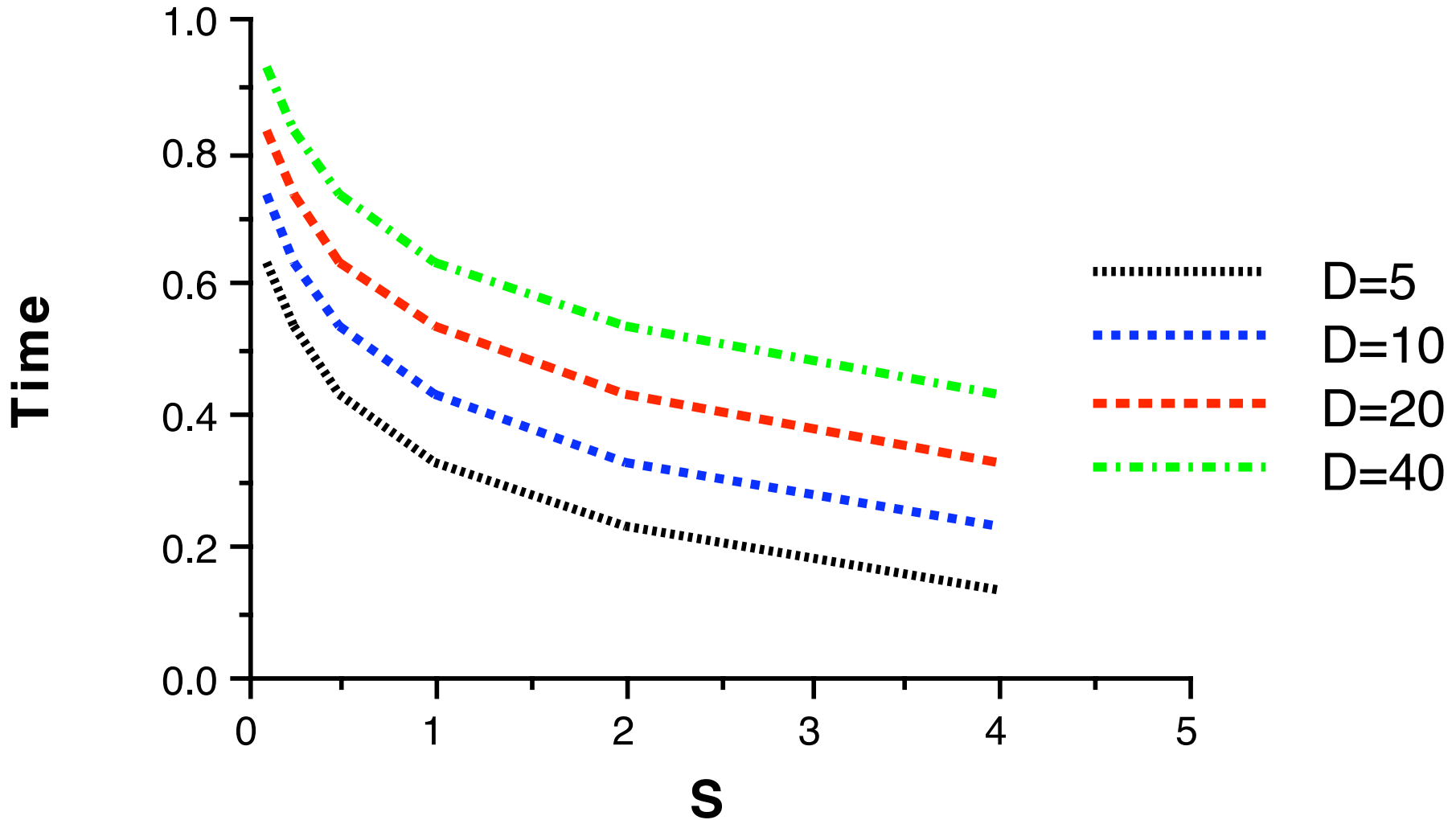
Time is less than linear with D



Big moves are relatively fast

# Movement Time as a function of Target Size

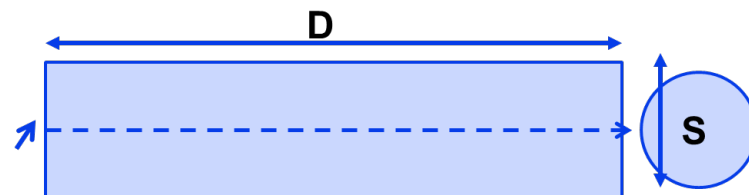
Time is worse than linear as S gets small



Very small targets are quite difficult

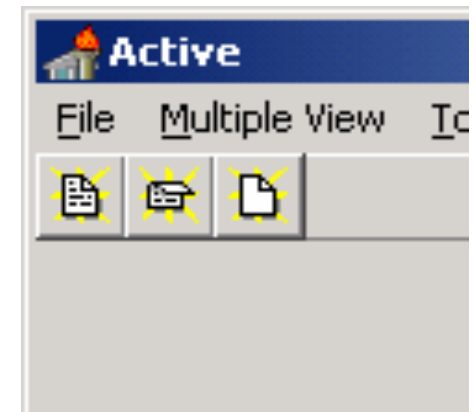
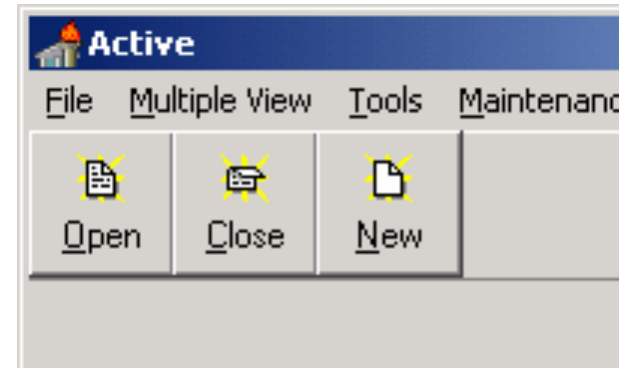
# Implications of Fitts' Law

- Large targets and small distances between targets are advantageous
- Screen elements should occupy as much of the available screen space as possible
- The largest Fitts-based pixel is the one under the cursor (why?)
- Screen elements should take advantage of the screen edge whenever possible
  - The edges of the screen have infinite depth and no targeting required
- Steering tasks – moving linearly in a “tunnel” of length  $D$  and size  $S$  is more difficult than pointing



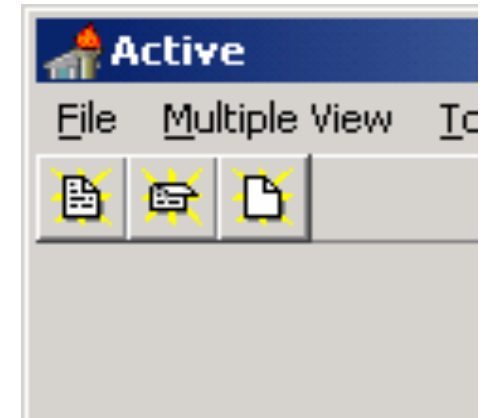
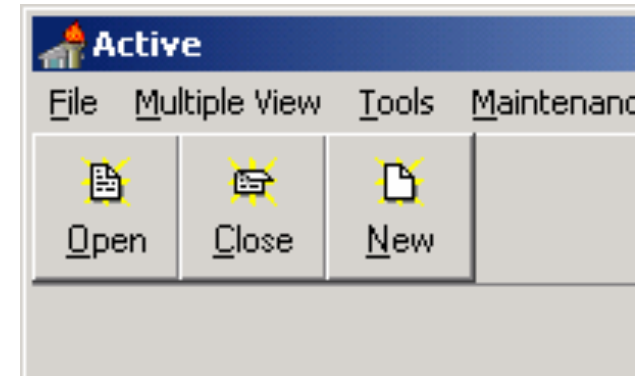
# Toolbar Example

*Microsoft Toolbars offer the user the option of displaying a label below each tool. Name at least one reason why labeled tools can be accessed faster. (Assume, for this, that the user knows the tool.)*



# Toolbar Example

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





# Tool Matrix Example

*You have a palette of tools in a graphics application that consists of a matrix of 16x16-pixel icons laid out as a 2x8 array that lies along the left-hand edge of the screen. Without moving the array from the left-hand side of the screen or changing the size of the icons, what steps can you take to decrease the time necessary to access the average tool?*





# Tool Matrix Example

1. Change the array to  $1 \times 16$ , so all the tools lie along the edge of the screen.
2. Ensure that the user can click on the very first row of pixels along the edge of the screen to select a tool. There should be no buffer zone.

# Fitts Law - Summary

- Many aspects of human information processing and performance can be understood—*and predicted*—by decomposing human behavior into its component processes.
- The major components of human information processing are: perceptual, cognitive, memory, and motor.
- Fitts' law predicts human performance for time-minimizing pointing tasks in which the target (including its boundaries) has been identified.
- Understanding Fitts' law helps you to make better decisions for interactive designs that require pointing movements.
- Fitts' law provides a basis for comparing the efficiency of different pointing devices or pointing techniques.
  1. Design an experiment with a range of  $D$ s,  $S$ s, and  $ID$ s.
  2. Bring participants to accurate and practiced performance.
  3. Collect consistently accurate time-minimizing performance.
  4. Plot the best-fitting (logarithmic) regressions.
  5. Compare the  $a$  and  $b$  coefficients across the devices or techniques.
  6. The device or technique with the lower coefficients wins.