King Saud University

College of Engineering

IE – 341: "Human Factors Engineering"

Spring – 2025 (2nd Sem. 1446H)

Chapters 3. Information Input and Processing

Part – 2: Fitts's Law (Chapter 9)

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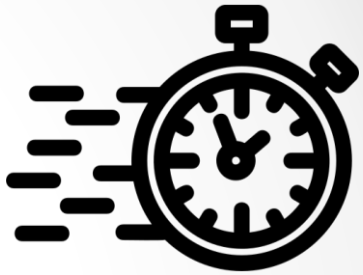
Chapter Overview

Information Processing and Compatibility

1. Information Display – Coding (Ch. 3)
2. Fitts' Law (Ch. 3, Ch. 9)
3. Hick Hyman Law (Ch. 3)
4. Signal Detection Theory (Ch. 3)
5. Memory - Attention (Ch. 3)
6. Compatibility - Part 1 - Spatial Compatibility (Ch. 10)
7. Compatibility - Part 2 - Movement - Modality Compatibility (Ch. 10, Ch.3)

Speed of Movements

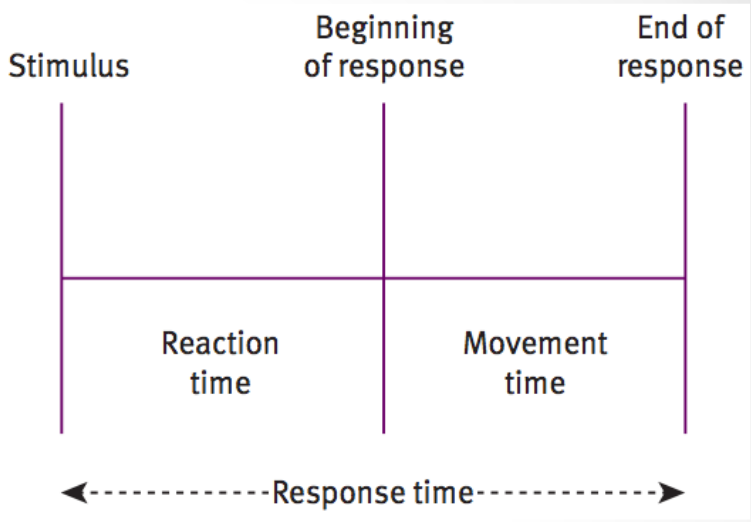
- Physical response is necessary as a result of stimuli:
  - e.g. visual displays, auditory signals
  - e.g. events



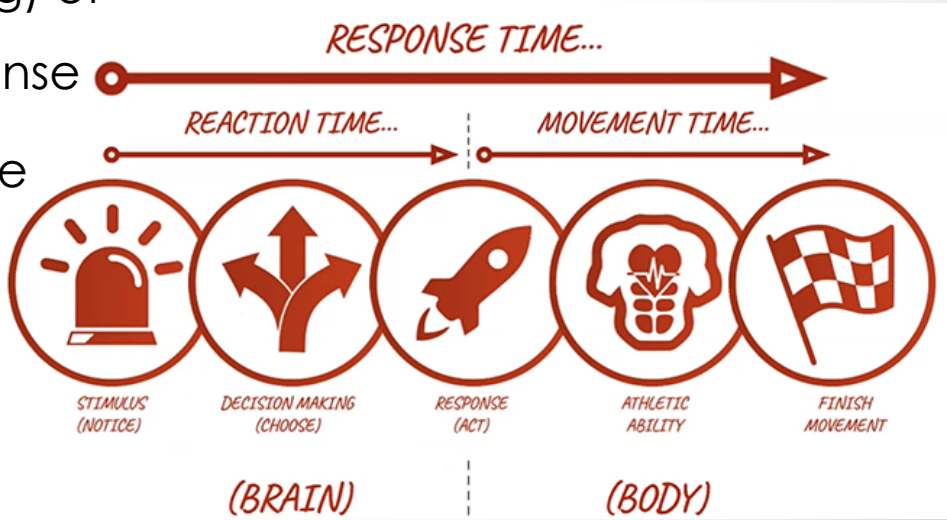
- Response in some cases must be done quickly:
  - e.g. applying brakes in emergency
  - e.g. athlete response during fight
  - i.e. rapid/critical response time is required
  - we examine variables involved in such cases
  - and effect on design of tasks and displays

Speed of Movements (Cont.)

- Total **response time** consists of two components:
  - **reaction time** and
  - **movement time**



- Reaction time:
  - time from onset (i.e. beginning) of signal/stimulus requiring response
  - until beginning of the response
- Movement time (*MT*):
  - time from the beginning of the response
  - until its completion

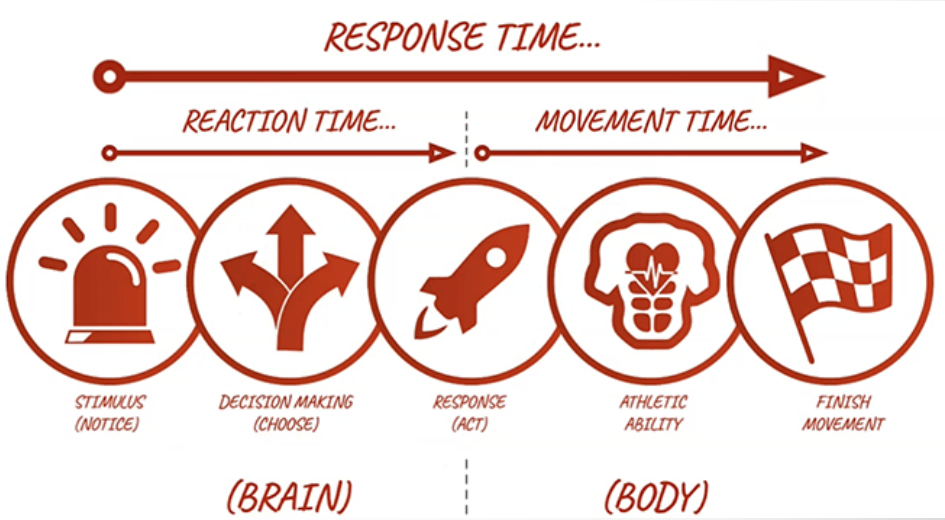


Speed of Movements (Cont.)

Movement Time (Cont.):

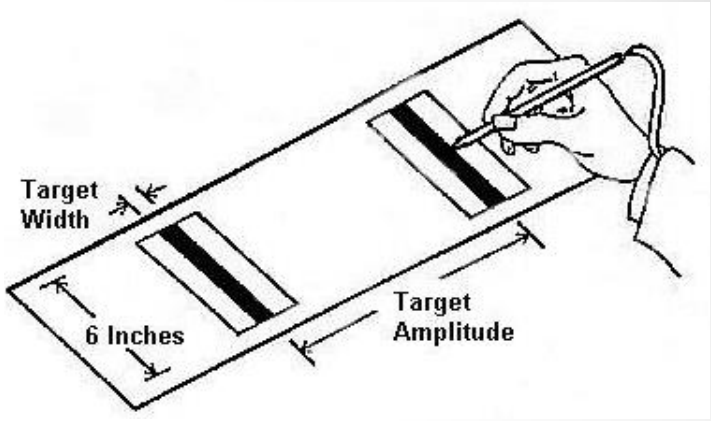
- Time to complete a movement depends on:
  - nature/direction of the movement (not discussed) and
  - degree of accuracy required

- Movement time is affected by:
  - distance moved and
  - precision demanded by the size of the target

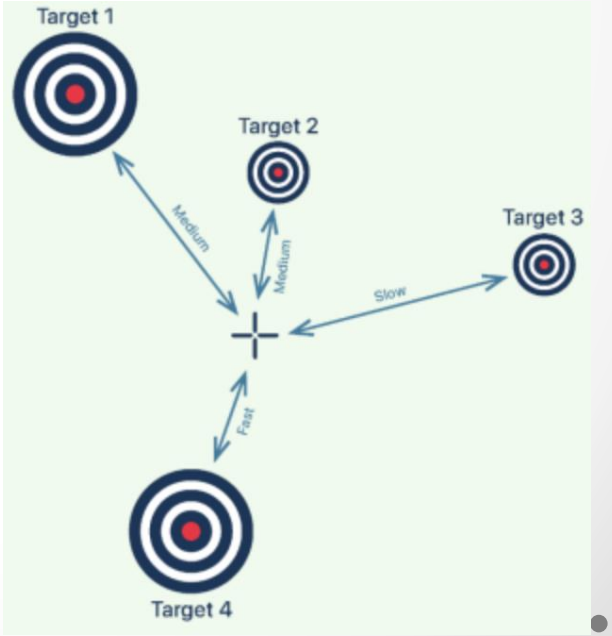


Fitts's Law

- Fitts's Law is used to reach a relation between
  - **size** of, as well as **distance** to target
  - and speed (or **response time**)
    to reach target

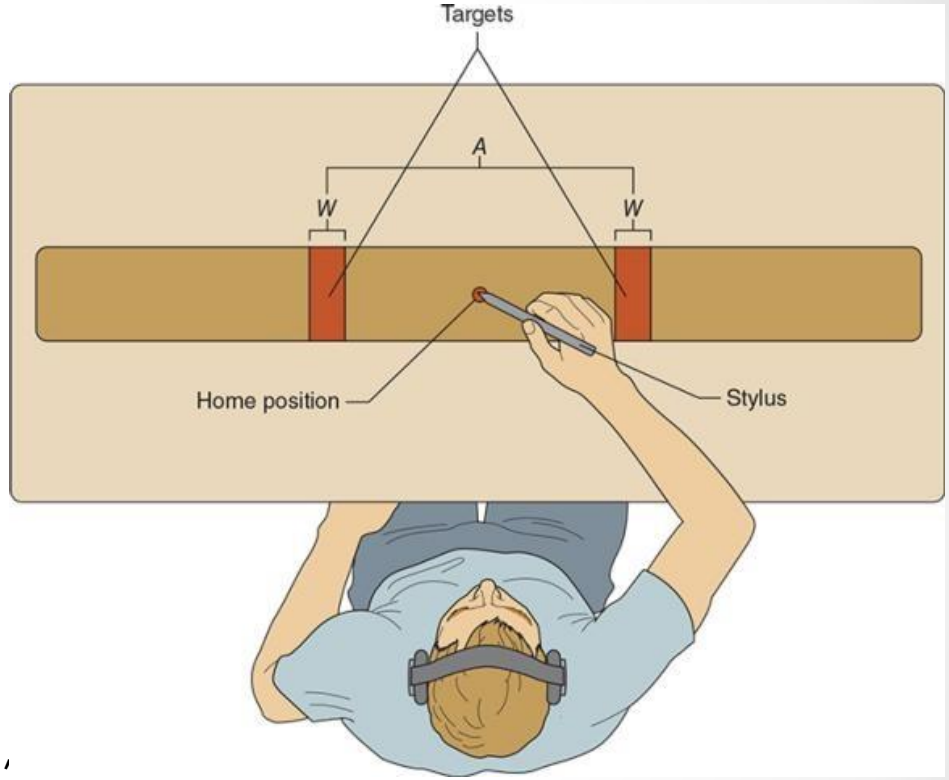


- *Fitts* and *Peterson** found that:
  - the longer the distance (***D***)
  - and/or the smaller the target (***W***)
  - ⇒ the longer the movement will take



Fitts's Law

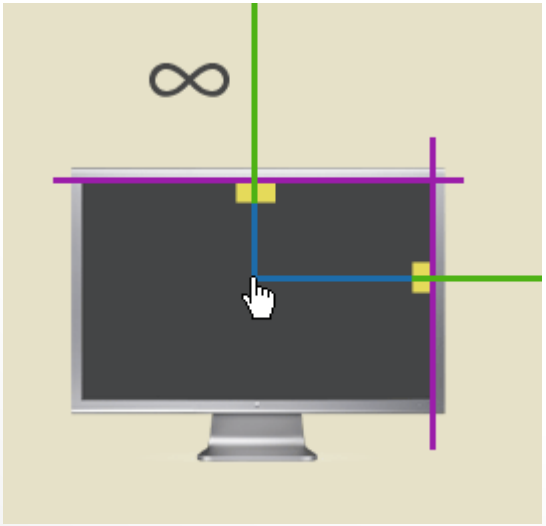
- Fitts's tapping task:
  - participant taps between two targets
  - targets have varying width (*W*),
  - and varying amplitude between them (*A*)
  - participant attempts to move as rapidly as possible between targets,
  - while keeping the number of target misses to a minimum

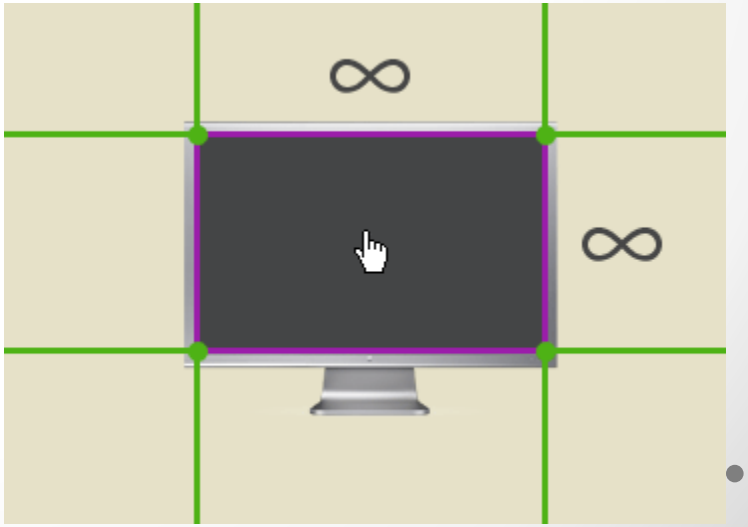


Fitts's Law

- Target can be button on screen or break pedal, etc.

- This has many (increasing) applications in HCI (human-computer interaction)
- Important finding: edges of a screen are easiest (i.e. shortest time) to reach: can you show how?





Fitts's Law

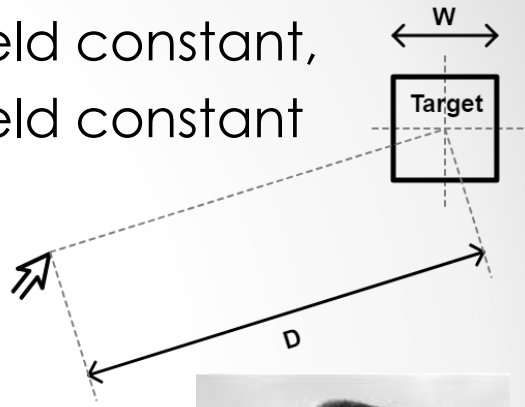
- Watch the following video on Fitts' (or Fitts's) Law:

"Mouse Pointers & Fitts's Law - Computerphile"

https://youtu.be/E3gS9tjACwU

Fitts's Law

- Fitts found that:
  - *MT* was a log. function of *D* when *W* was held constant,
  - *MT* was a log. function of *W* when *D* was held constant



1. Fitts's Law (1954), first version:

$$MT = a + b \log_2 \left(\frac{D}{W} \right)$$


Paul Fitts

  - ***MT***: movement time (ms)
  - ***D***: distance to target (aka amplitude)
  - ***W***: width of target (i.e. target size, e.g. button)
  - ***a***, ***b***: empirically derived constants (depend on the type of movement), measured in ms
  - note, $\log_2$ is used since MT is related to info. (in bits) contained in the movement (Ch. 3)

Fitts's Law

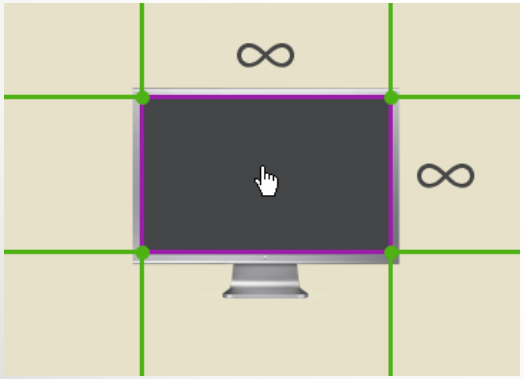
Alternative versions of Fitts's Law:

2. (2*D*/*W*) vs. (*D*/*W*): to avoid -ve log when *W* > *D*:

$$MT = a + b \log_2 \left(\frac{2D}{W} \right)$$

3. What happens if $D \approx 0$? or if $W \to \infty$? What does that mean (i.e. any useful implications?):

$$MT = a + b \log_2 \left(\frac{2D}{W} + 1 \right)$$



Fitts's Law

To show effect of constants *a*, *b*:

- Figure 9-10: data from movements of the,
  - arm,
  - wrist (hand), and
  - finger

- Slope of line (*b*):
  - decreases from arm to finger
  - as slope ↓
    ⇒ effect of (*D*/*W*) ratio ↓
  - ⇒ control becomes easier
  - ⇒ $\log_2\left(\frac{2D}{W}+1\right)$ is usu. referred to as: **index of difficulty** (**ID**)

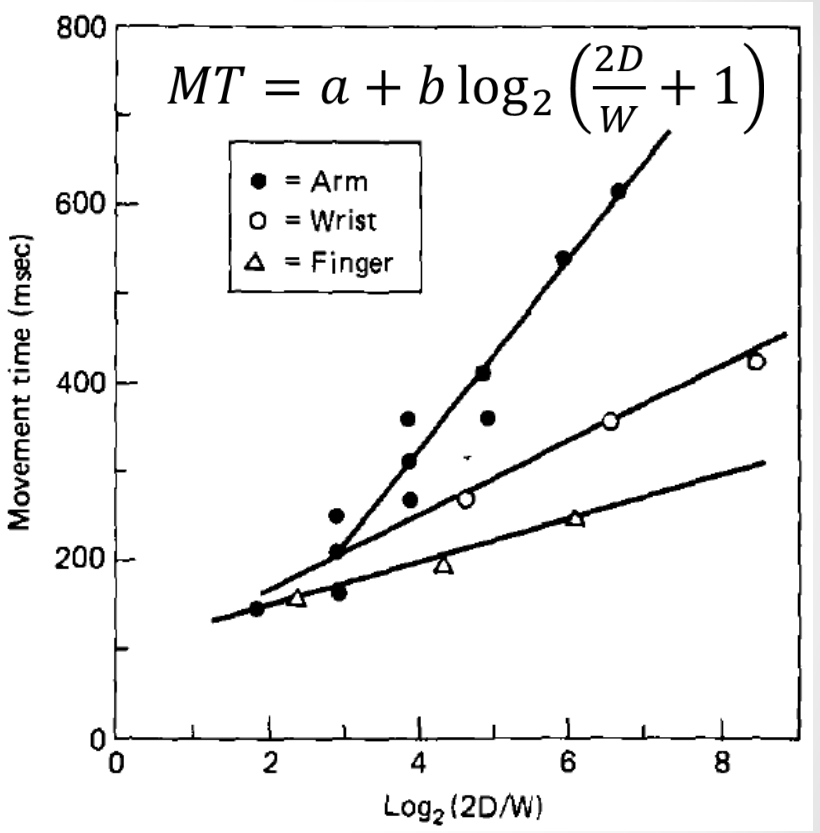


FIGURE 9-10
Example of Fitts' law for arm, wrist, and finger movements. The slopes of the functions are: for arm, 105 ms; for wrist, 43 ms; and for finger, 26 ms. (*Source: Based on data from Langolf, Chaffin, and Foulkes, 1976.*

Fitts's Law

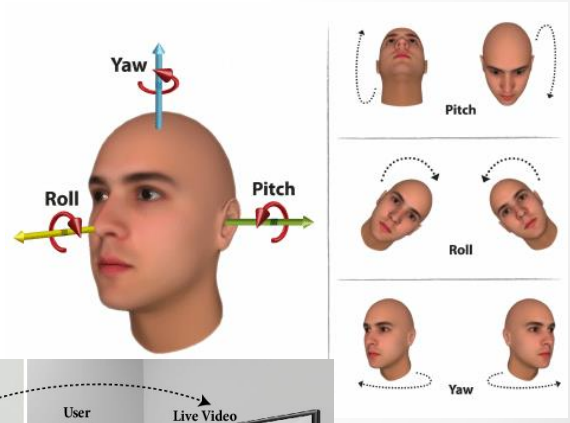
Alternative versions of Fitts's Law (cont.):

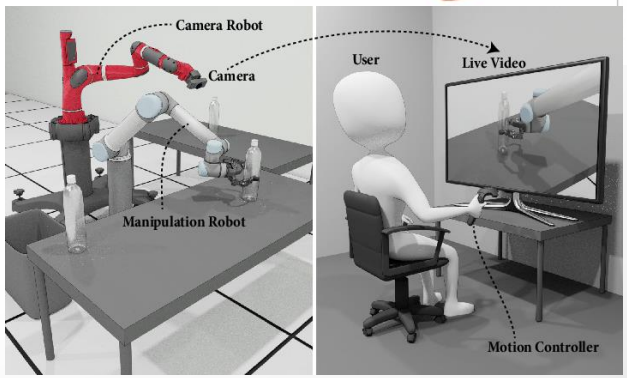
4. Introduce ID into Fitts's law ("Shannon's correction"):

$$MT = a + b \cdot ID$$

- note, ID is usually less than five
- also note, for older adults: $MT = 1.75 * MT$

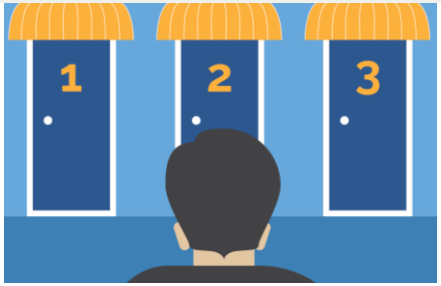
- Note, Fitts' law also applies to:
  - movements of the feet
  - movements of the head
  - movements made underwater
  - remotely manipulated movements

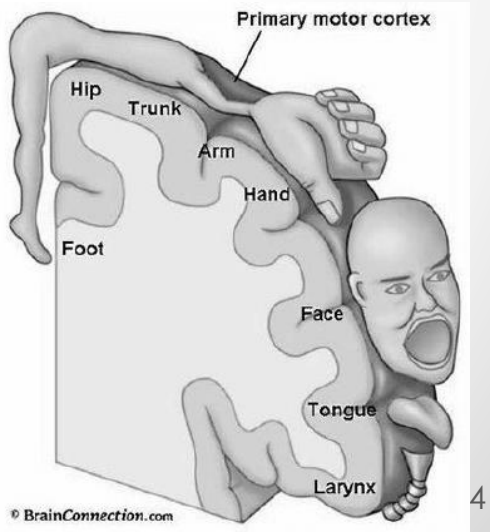




Fitts's Law

- Ways to assist people in responding rapidly to stimuli:
  1. use sensory modalities with shortest reaction time
  2. present stimuli in a clear manner
  3. minimize number of alternatives from which to choose
  4. give advance warning of stimuli (if possible)
  5. use body members that are close to the cortex (i.e. brain), to reduce neural transmission time
  6. use control mechanisms that minimize response time
  7. train the individuals





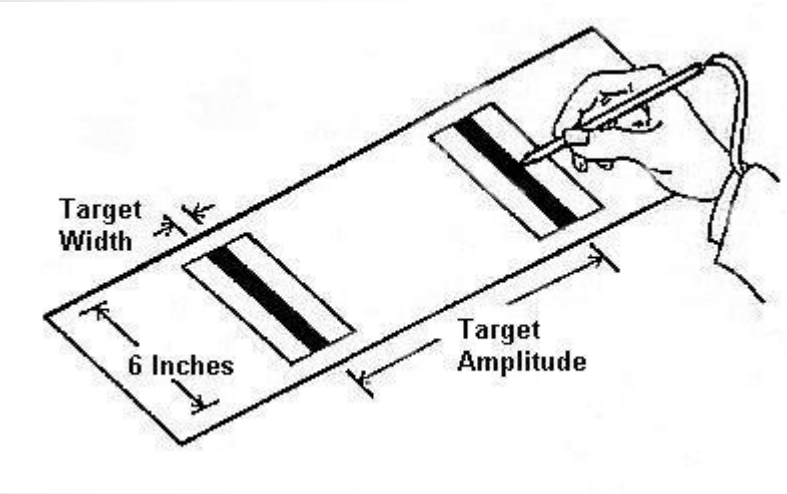
Fitts's Law

- Interactive Exercise on *Fitts's Law*
  http://fww.few.vu.nl/hci/interactive/fitts/

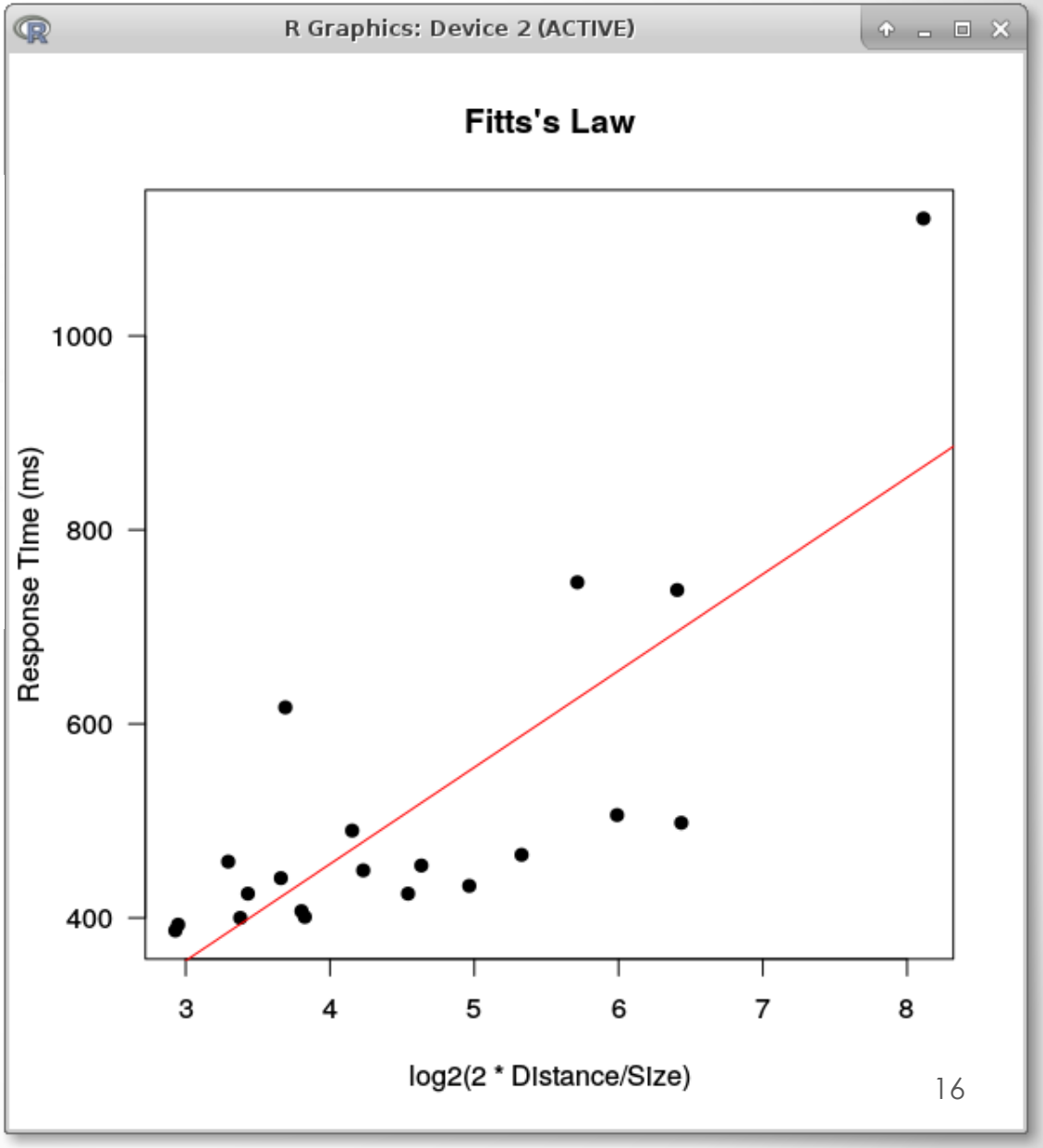
- Another interactive exercise and further explanation:
  http://www.psytoolkit.org/lessons/fitts.html

- Another interactive exercise:
  http://simonwallner.at/ext/fitts/

Fitts's Law



- Q: where does the red line cross the y-axis? What do you think this means?*



References

- ***Human Factors in Engineering and Design***. Mark S. Sanders, Ernest J. McCormick. 7th Ed. McGraw: New York, 1993. ISBN: 0-07-112826-3.
- ***Movement time prediction in human-computer interfaces***. MacKenzie, I. S. (1995). In R. M. Baecker, W. A. S. Buxton, J. Grudin, & S. Greenberg (Eds.), Readings in human-computer interaction (2nd ed.) (pp. 483-493). Los Altos, CA: Kaufmann. [reprint of MacKenzie, 1992]