Lecture 9
Models 1 – Hick's and Fitts' Laws

with reference to sections 7.4 and 7.6 of

The Resonant Interface
HCI Foundations for Interaction Design

First Edition

by Steven Heim

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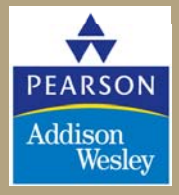


Chapter 7 Interaction Design Models

- Model Human Processor (MHP)
- Keyboard Level Model (KLM)
- GOMS
- **Modeling Structure**
- Modeling Dynamics
- **Physical Models**

Modeling Structure – *Hicks Law*

MAXIM

Hick's law (Hick-Hyman law) can help to optimize menu structures.

- One common case of Hick's law:
- Equation for the time it takes to choose one item from *n* alternatives, all having an equal probability of being chosen.
- the time it takes is proportional to the logarithm (base 2) of the number of choices, plus 1.

Hicks Law – The Hyman Experiment

Setup:

- n lights,
- next to them n buttons.
- A random light is lit.
- Test participant has to press button under lit light.
- Time T from lighting the light to pressing the button is measured.
- What is the average T depending on n?

Modeling Structure – *Hicks Law*

$$T = a + b \log2(n + 1)$$

- The coefficients *a* and *b* are arrived at from experimental data by linear regression, and depend on the person, training, other factors.
- Typical values for back-of-envelope calculations are a=50 and b=150.

Hicks Law – The Hyman Experiment 2

- n lights,
- next to them n buttons.
- Lights are lit with **different** probability.
- Test participant has to press button under lit light.
- Time T from lighting the light to pressing the button is measured.
- What is the average T depending on n?

Modeling Structure – *Hicks Law*

- The expected time is:

$$T = a + b\,\mathrm{H}$$

- Where H is the Shannon information content/ information-theoretic entropy of decision:

$$\mathrm{H} = \Sigma_{i=1}^{n}\, p_i \log2(1/p_i + 1)$$

- For n equal probabilities the formula is

$$\mathrm{H} = \log2(n + 1)$$

Hicks Law – The Hyman Experiment 3

- n lights,
- next to them n buttons.
- Lights are lit **dependent on previous light** (this is called stimulus dependencies)**.**
- Time T from lighting the light to pressing the button is measured.

- Conditional probabilities have to be used.
- Still same law!

Hicks Law – The Hyman Experiment 3

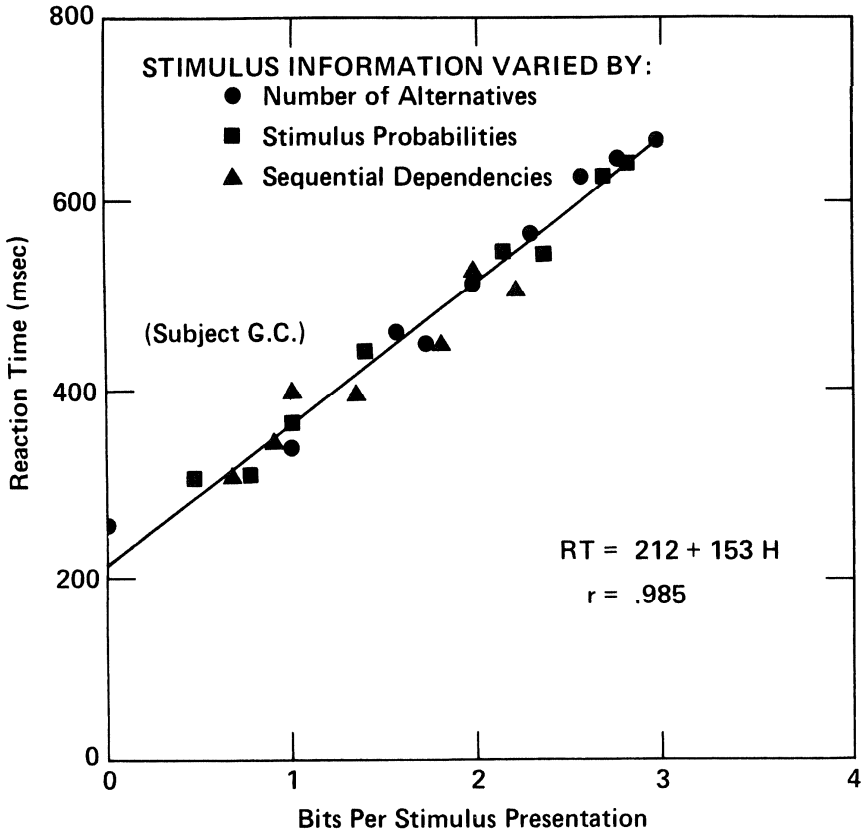


Figure 2.23. Choice reaction time for three different ways of manipulating the stimulus information *H*.
Data for a single subject. Hyman (1953, Figure 1, p. 192, subject G.C.).

From: Card et al. The Psychology of Human-Computer Interaction, Lawrence Erlbaum, 1983

Hicks Law – One Proposed Mechanism

- Test participants group lights intuitively into a hierarchy of groups.
- On each level roughly the same number of groups:
  - 3 top-level groups,
  - for each top-level group 3 subgroups,
  - and so on…
- This yields a logarithmic relationship.
- In case of varying probabilities, groups are of different size, or might even change.

Physical Models

- Physical models can predict efficiency based on the physical aspects of a design.

- They calculate the time it takes to perform actions such as targeting a screen object and clicking on it.

Physical Models – *Fitts' Law*

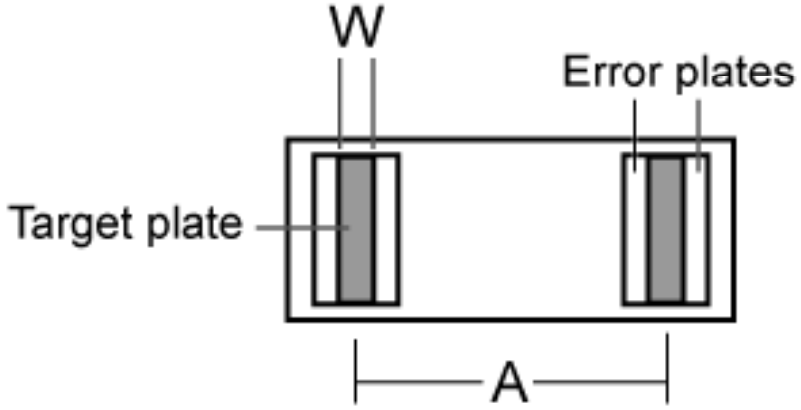
- Fitts' law states that the **time** it takes to **hit** a target is a function of
  - the **size** of the target and
  - the **distance** to that target.

MAXIM

Fitts' law can help to optimize the size and location of a screen object.

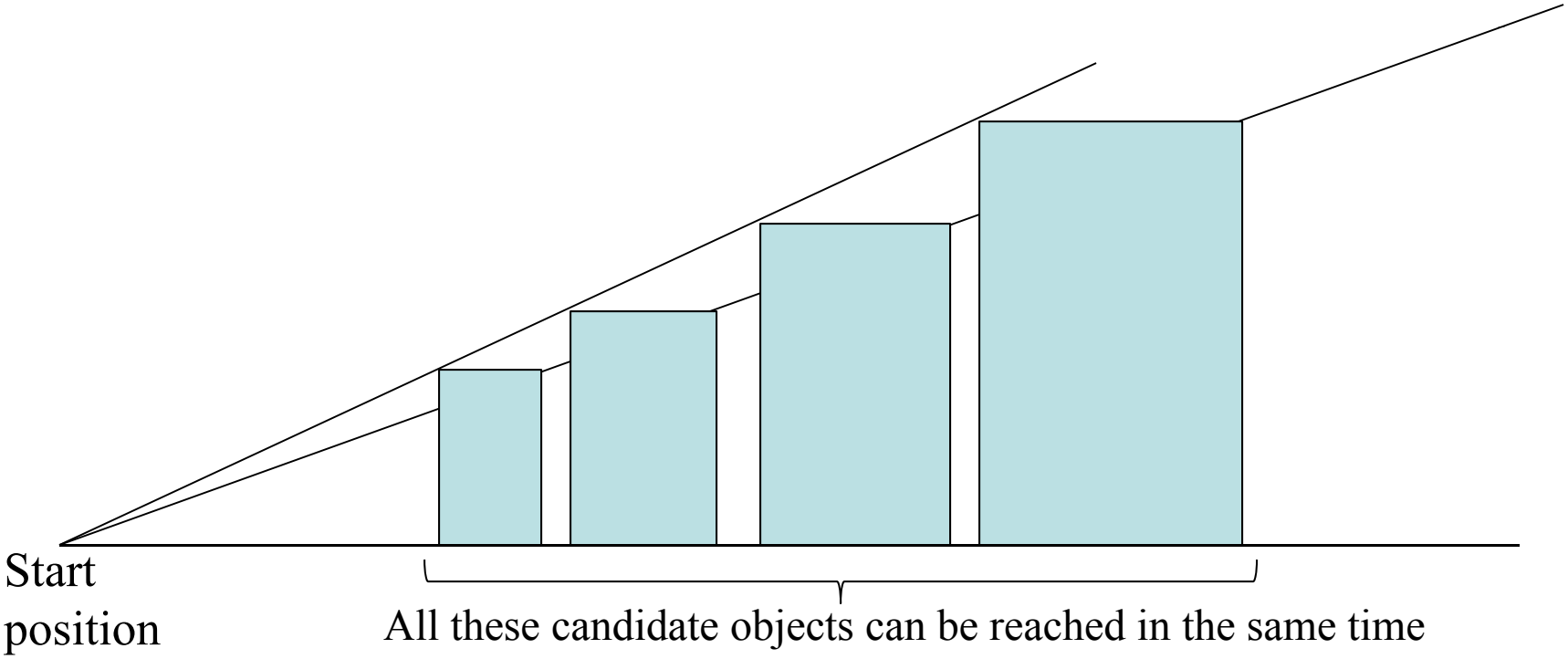
Fitts' Law – The Experiment

- Fitts described "reciprocal tapping"
  - Subjects were asked to tap back and forth on two 6-inch-tall plates with width *W* of 2, 1, 0.5, and 0.25 inches



Fitts' Law – **Example observation**

- The time needed does not change if the target is moved outward and resized proportionally.



Physical Models – *Fitts' Law*

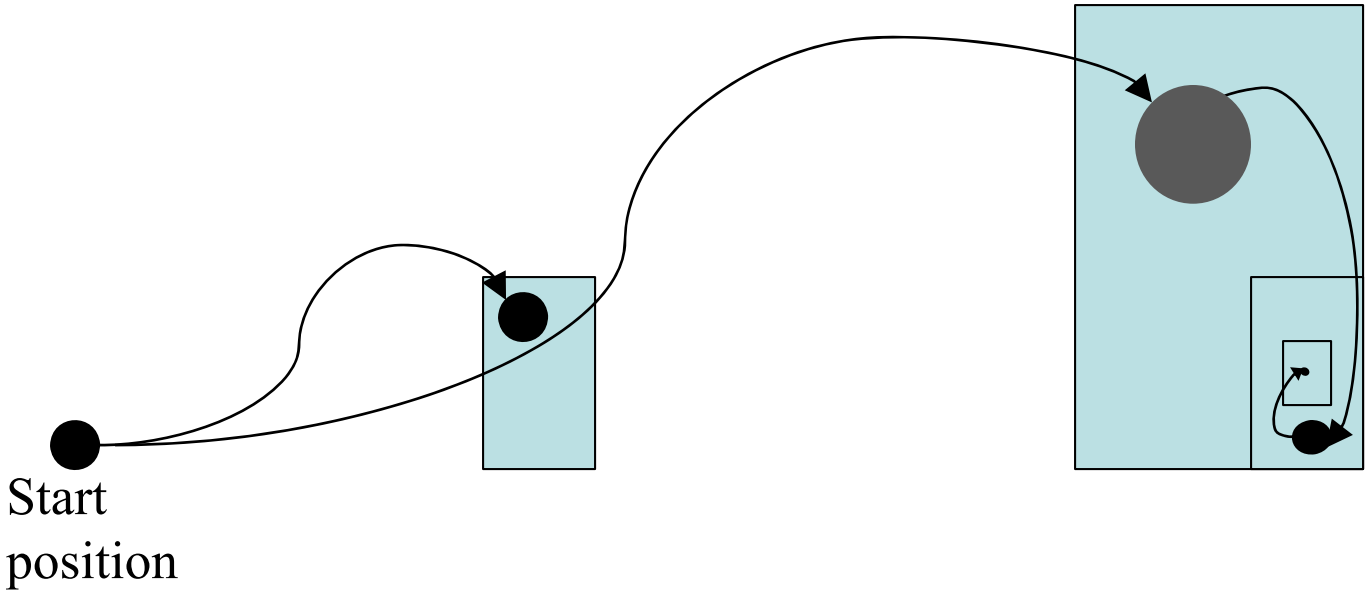
- The average time for the completion of any given movement task can be calculated by the following equation:

$$T = a + b \log2(A/W + 1)$$

- Coefficients *a* and *b* are arrived at from experimental data by linear regression, and depend on the pointing device and the person.
- Typical values for back-of-envelope calculations are a=50 and b=100.

Fitts' Law – **Proposed mechanism**

- The movement is not a single movement, but a series of similar movements: The second and following movements are corrections.



Physical Models – *Fitts' Law*

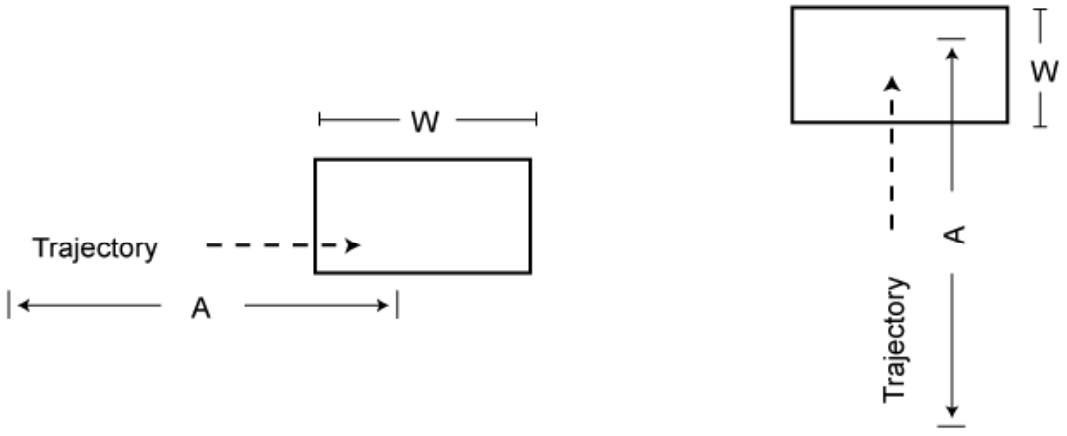
- Implications of Fitts' Law
  - Large targets and small distances between targets are advantageous.
  - Screen elements should occupy as much of the available screen space as possible.
  - The largest Fitts-based pixel is the one under the cursor.
  - Screen elements should take advantage of the screen edge whenever possible.

Physical Models – *Fitts' Law*

- Limitations of Fitts' Law
  - It does not model errors.
  - It only models continuous movements.
  - It is not suitable for all input devices, for example, isometric joysticks.
  - It does not address two-handed operation.
  - It does not address the difference between flexor and extensor movements.
  - It does not address cognitive functions such as the mental operators in the KLM model.

Physical Models – *Fitts' Law*

- *W* is computed on the same axis as *A*.



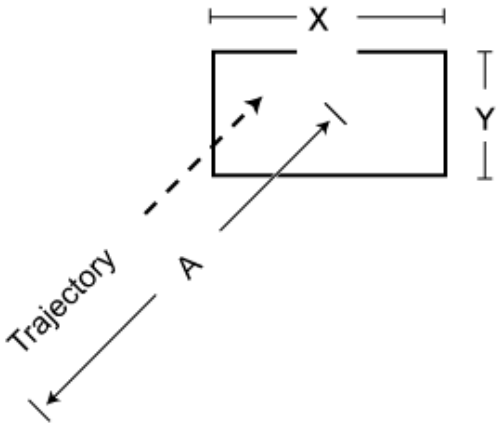
Horizontal and vertical trajectories

Targeting a circular object

Physical Models – *Fitts' Law*

- Bivariate data
  - Smaller-Of—The smaller of the width and height measurements:

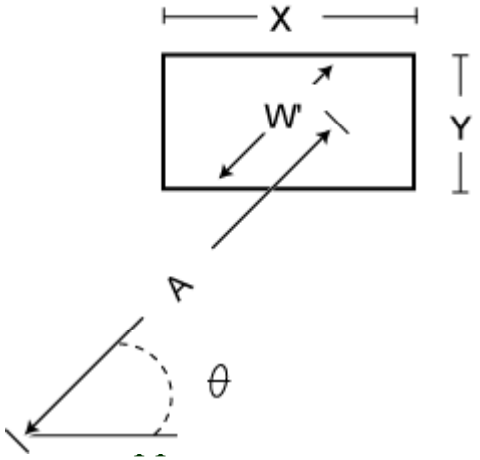
$$W \sim \min(W, H)$$



Targeting a rectangular object.

Physical Models – *Fitts' Law*

- *W*—The "apparent width" calculated along the approach vector

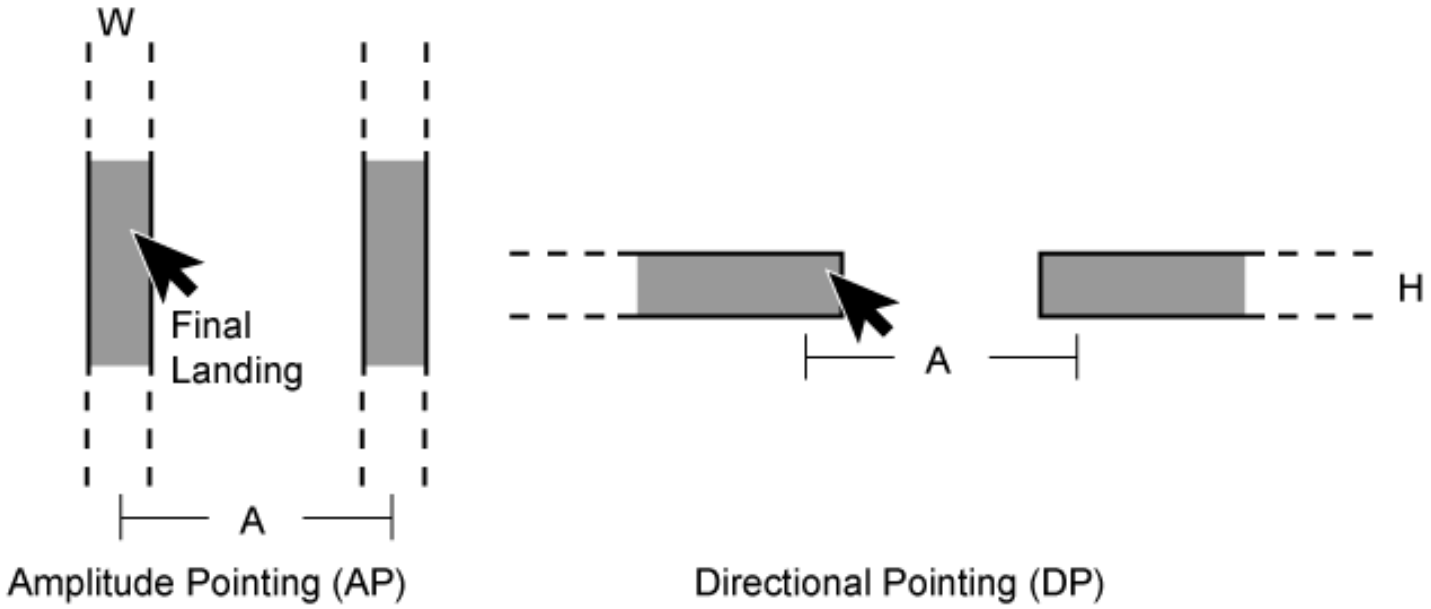


Physical Models – *Fitts' Law*

- **Amplitude Pointing (AP)**: One-dimensional tasks
  - Only the target width (whether horizontal or vertical) is considered.
  - The constraint is based on *W*, and target height (*H*) is infinite or equal to *W*
  - AP errors are controlled at "the final landing"

- **Directional Pointing (DP):** If *W* is set at infinity then *H* becomes significant
  - The constraint is based on *H*.
  - DP errors are corrected incrementally during the pointing movement (Accot & Zhai, 2003).

Physical Models – *Fitts' Law*



Physical Models – *Fitts' Law*

- Implications for interaction design:
  - Overly elongated objects hold no advantage (*W*/*H* ratios of 3 and higher).
  - Objects should be elongated along the most common trajectory path (widgets normally approached from the side should use *W*, those approached from the bottom or top should use *H*).
  - Objects should not be offset from the screen edge (consistent with the Macintosh OS).
  - Objects that are defined by English words generally have *W* >> *H* and should be placed on the sides of the screen. (However, greater amplitude measurements may be significant on the normal "landscape"-oriented screens.)

(Accot & Zhai, 2003)

Fitts' Law Use - Summary

- Fitts' Law can be used at two levels
  - As the basis for design decisions (just generally try to make your layout give good performance according to Fitts' Law)
  - To provide specific task time estimates for dialog modelling
- For the 2nd use, Fitts' Law works well with the Keyboard-Level Model (KLM), comes later.