cs465

principles of user interface design, implementation and evaluation

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1. Principles of Design

   Design of Everyday Things

2. Reaction Time and Motor Skills

   Predictive Models
   - *Hick's Law*
   - *KLM*
   - *Fitts' Law*

   Descriptive Models
   - *KAM*
   - *Three-state Model of Graphical Input*
   - *Guinard's Model of Bimanual Skill*

Reaction Time, Motor Skills

Predictive Models (*engineering models, performance models*)

In HCI, they allow metrics of human performance to be determined analytically without undertaking time-consuming and resource-intensive experiments.

Hick's Law

$$RT = a + b \log_2(n)$$

Where *a* and *b* are empirically determined constants.

Given *n* stimuli

Used for:

- Telephone operator selecting among 10 buttons when the light behind a button comes on.
- Measuring and predicting the time to select items in hierarchical menus (found that breadth should be favored over depth in hierarchical menus.
- Text-entry rates on soft keyboards with non-QWERTY layouts.

Keystroke-Level Model (KLM by Card et al)

Goal is to predict the time to accomplish a task on a computer system.
The model predicts expert error-free task-completion times, given the following parameters:

- a task or series of subtasks
- method used
- command language of the system
- motor-skill parameters of the user
- response-time parameters of the system

$T_{execute} = t_k + t_p + t_h + t_d + t_m + t_r$

Sum of subtask times

4 motor control operators (k is keystroking, p = pointing, h = homing, d = drawing) +

one mental operator (m) +

one system response operator (r)

t_k ranges from .08s for highly skilled to 1.20s for a typist working with an unfamiliar keyboard.

Fitts' Law

One of the most robust and highly adopted models of human movement. The model is, arguably, the most successful of many efforts to model human behavior as an information-processing activity (From John Carroll Text).

Fitts applied information theory to measure the difficulty of movement tasks and the human rate of information processing as tasks are realized.

amplitude of aimed movement ~ electronic signal

spatial accuracy of movement ~ electronic noise

human motor system ~ communication channel

Shannon's Theorem

$C = B \log_2 (S /N +1)$

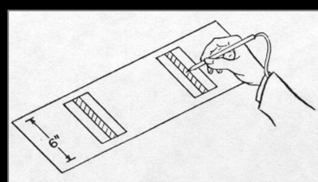
S is signal power, N is noise power

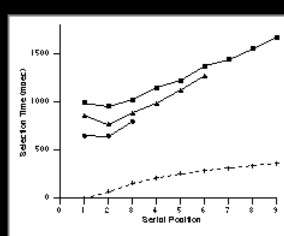
$ID = \log_2(2A / W)$ where ID is the index of difficulty by the metric of bits

To improve the analogy, this became $ID = \log_2(A / W + 1)$

$MT = a + b * ID$ where MT is movement time

Through empirical tests and linear regression…..





$ID = \log_2(A / W_e + 1)$

$TP = ID_e / MT$

$ID = \log_2(A / W_e + .5)$

For ID < 3 bits

Measured A(pixels), W(pixels), ID(bits), ER(%), MT(ms) for 2 devices

$W_e = 4.122 * SD_x$ where SD_x is the standard deviation in the selection coordinates over a block of trials. Replacing target W with the effective target width.

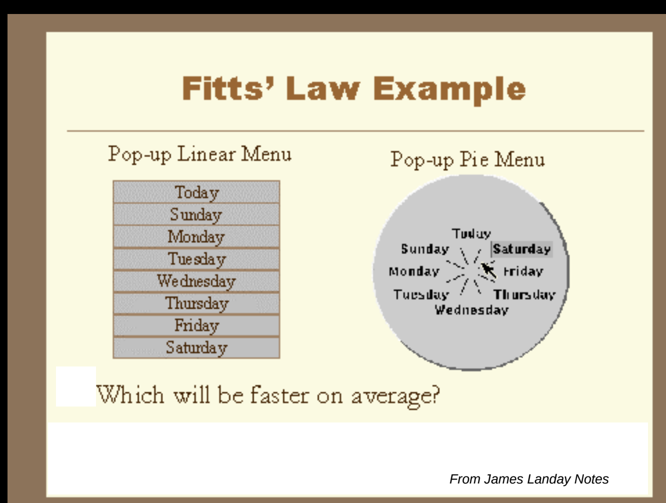
Good for predicting text entry rates on mobile phone.

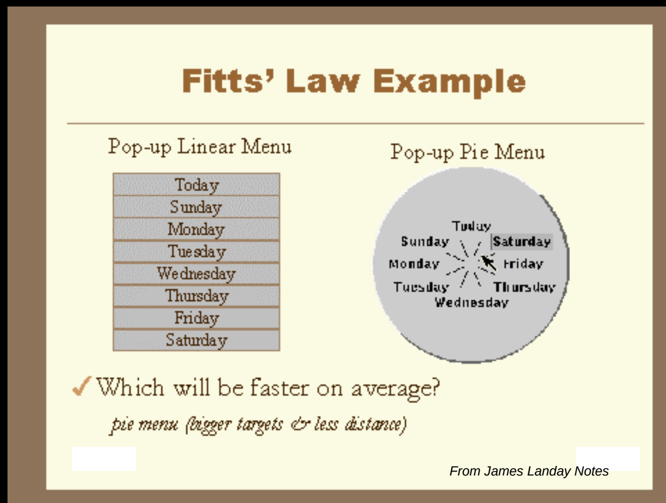
Example empirical data using mouse:

- Data on the Microsoft 2.0 mouse
- Data gathered using 240 observations
  (12 participants x 20 trials per condition)
- Via regression, A was determined to be 545; B was 420
- Therefore, MT = 548 + 420 * ID
- ID = $\log_2$(A / W + 1)

Combining the above 2 equations, one can solve for MT.

You can use standard pixel sizes for menu target areas.





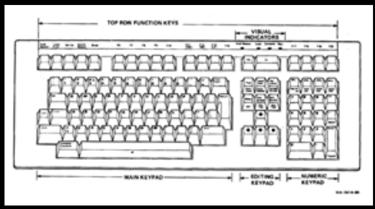
Power Law of Practice

$T_n = T_1 * n^{(-\alpha)}$

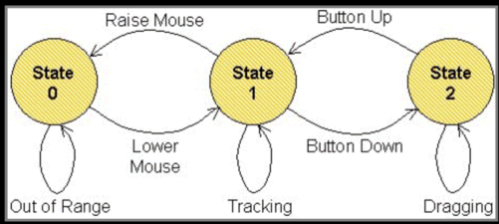
where α is learning constant (usually about 0.5),
n is the number of trials

Descriptive Models

- Key Action Model (KAM)

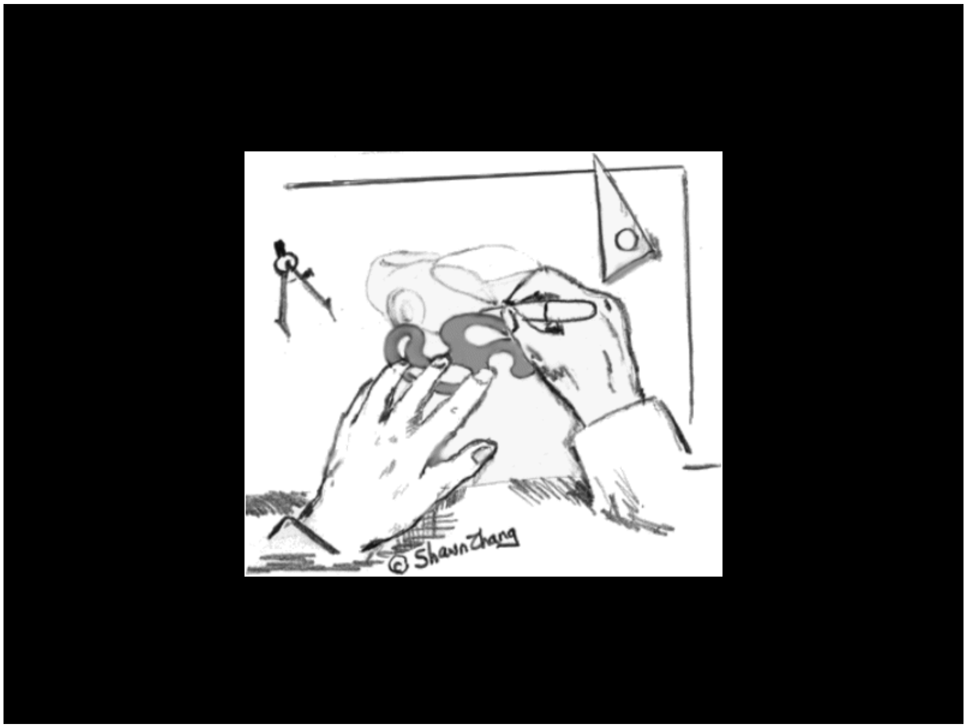


- Three-State Model of Graphical Input



Guinard's Model of Bimanual Skill

Hand	Role and Action
Nonpreferred	• Leads the preferred hand • Sets the spatial frame of reference for the preferred hand • Performs course movements
Preferred	• Follows the nonpreferred hand • Works within the established frame of reference set by the nonpreferred hand • Performs fine movements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