Human Capabilities

Human information processing
Model human performance

Hall of Fame or Shame

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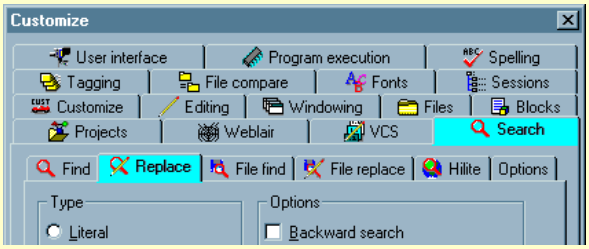
Hall of Fame or Shame



MultiEdit 8.0

Image from http://homepage.mac.com/bradster/iarchitect/tabs.htm

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Homework Presentation

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Human Information Processor

Psychological Science Base for HCI

Human mind is an information-processing system
- Memory
- Processor
- Parameters & interconnections

Simplified and limited model of psychological theory
- Practical, influential model

Useful for predicting gross human behavior

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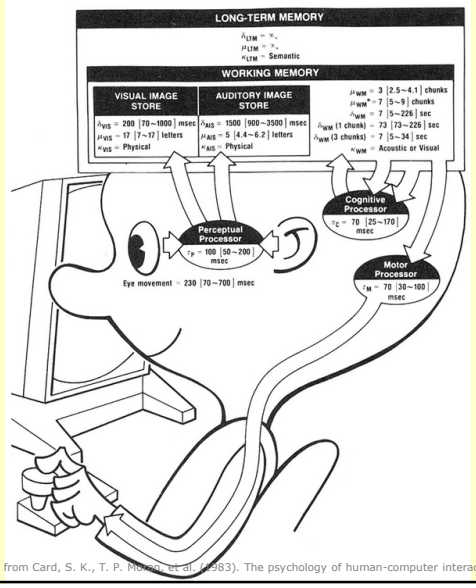
The Model Human Processor



Memories & Processors
- Perceptual Processor
- Cognitive Processor
- Motor Processor
- Working Memory
- Long-Term Memory

Principles of Operation
- Recognize-Act Cycle of the Cognitive Processor
- Variable Perceptual Processor Rate Principle
- Encoding Specificity Principle
- …

Image from Card, S. K., T. P. Moran, et al. (1983). The psychology of human-computer interaction. Hillsdale, N.J., L. Erlbaum Associates.

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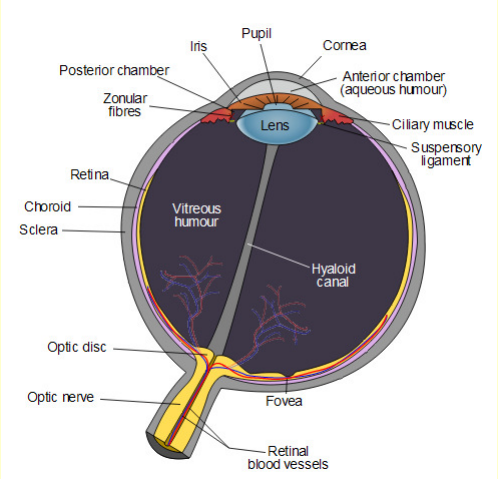
Perceptual System - Eye



Wikipedia

Retina
- Intensity
- Wave length
- Spatial distribution

- Peripheral vision for orientation

Fovea
- 2 degrees across
- Detail obtained

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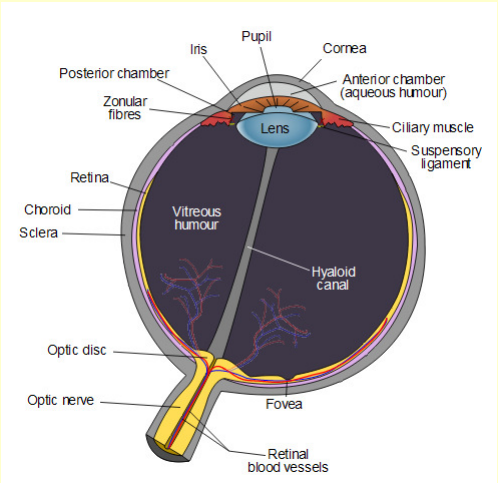
Perceptual System - Eye



Wikipedia

Central Vision
- fovea

Peripheral Vision
- retina

Eye Movement
- 70~700 ms duration

Head Movement
- If >30° away from fovea

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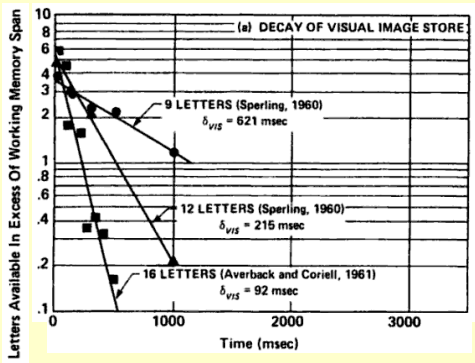
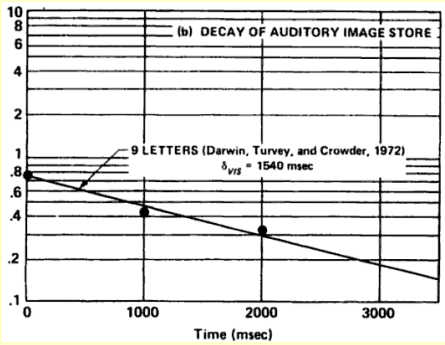
Perceptual Memory – Decay Time

Half-life: time after which probability of retrieval < .5



Visual Image Store: 200 [90~1000]ms



Auditory Image Store: 1500 [900~3500]ms

Charts from Card, S. K., T. P. Moran, et al. (1983). The psychology of human-computer interaction. Hillsdale, N.J., L. Erlbaum Associates.

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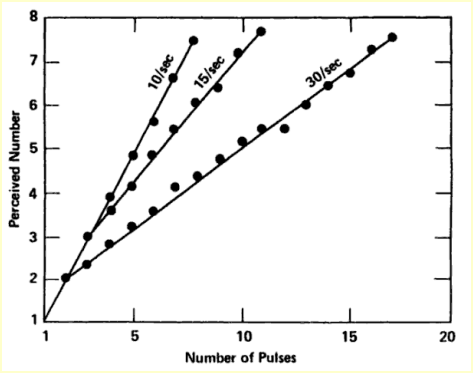
Perceptual Processor – Cycle Time

Cycle Time = Unit impulse response

- Time response of the visual system to a very brief pulse of light
- Time that takes before human claims to see it after impulse
- 100 [50~200] ms



Charts from Card, S. K., T. P. Moran, et al. (1983). The psychology of human-computer interaction. Hillsdale, N.J., L. Erlbaum Associates.

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Perceptual Processor – Cycle Time

Bloch's Law (1885): $I \cdot t = k$, $t < \text{cycle time}$

- I: intensity of stimulus
- t: lasting time of stimulus
- Pulse of light lasting 10 ms with 50 has the same appearance as a pulse of 20 ms with intensity of 25

Cycle time could vary according to conditions

- "Variable Perceptual Processor Rate Principle"
- The perceptual processor cycle time varies inversely with stimulus intensity

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Perceptual Processor – Cycle Time

Example 1. Compute the frame rate at which an animated image on a video display must be refreshed to give illusion of movement.

Frame rate > 1/(cycle time) = 1/100 =10 frame/sec

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Perceptual Causality

Perceptual Fusion: Two stimuli within a perceptual processor cycle appear ***fused***
→ the first event appears to ***cause*** the other

UI responses < PP cycle time
→ appear instantaneous

1/(PP cycle time) fps = 10 fps (frame per second)
→ perceived as a moving picture

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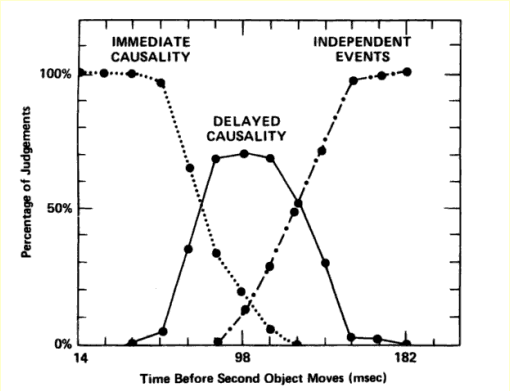
Perceptual Causality

Perceptual Fusion: Two stimuli within a perceptual processor cycle appear ***fused*** → the first event appears to ***cause*** the other



Charts from Card, S. K., T. P. Moran, et al. (1983). The psychology of human-computer interaction. Hillsdale, N.J., L. Erlbaum Associates.

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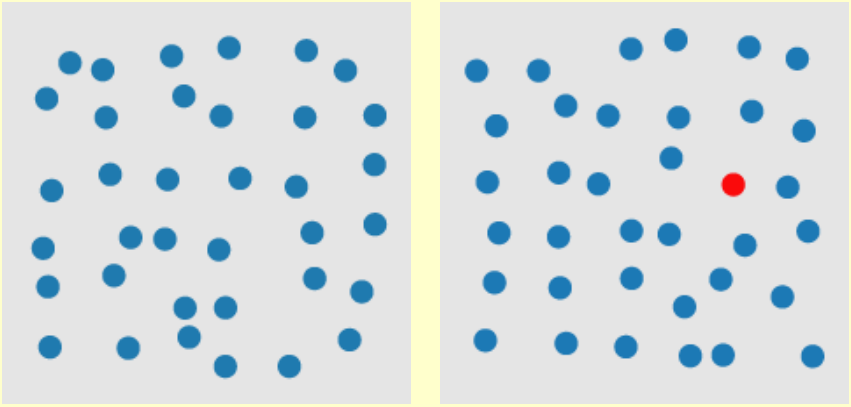
Preattentive Features: Color



http://www.csc.ncsu.edu/faculty/healey/PP/index.html

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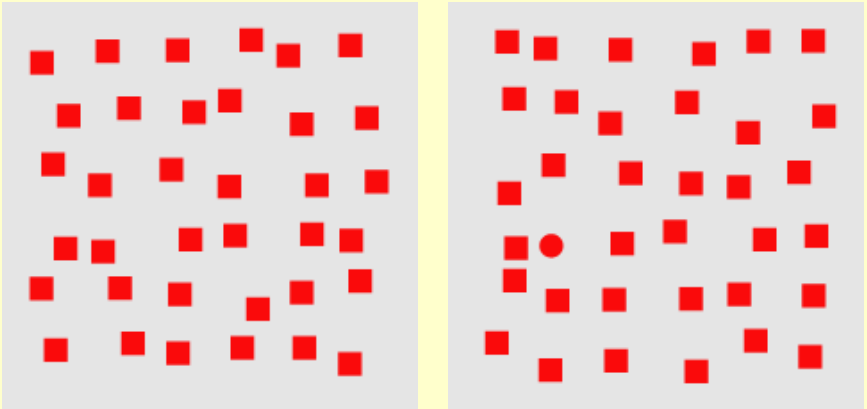
Preattentive Features: Shape



http://www.csc.ncsu.edu/faculty/healey/PP/index.html

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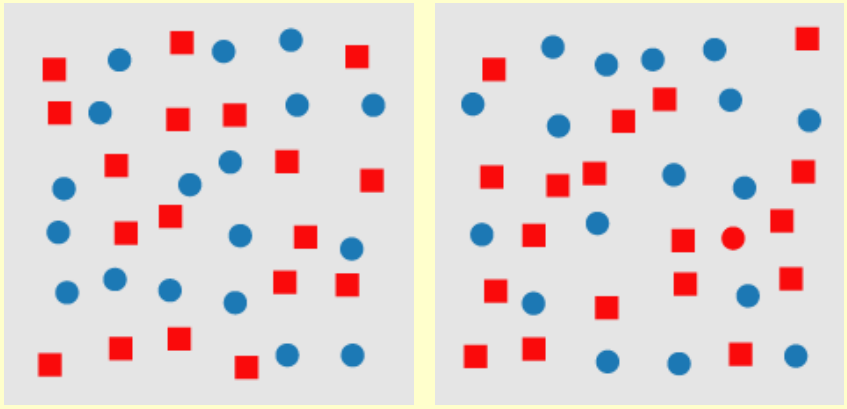
Non Preattentive : Conjunctions



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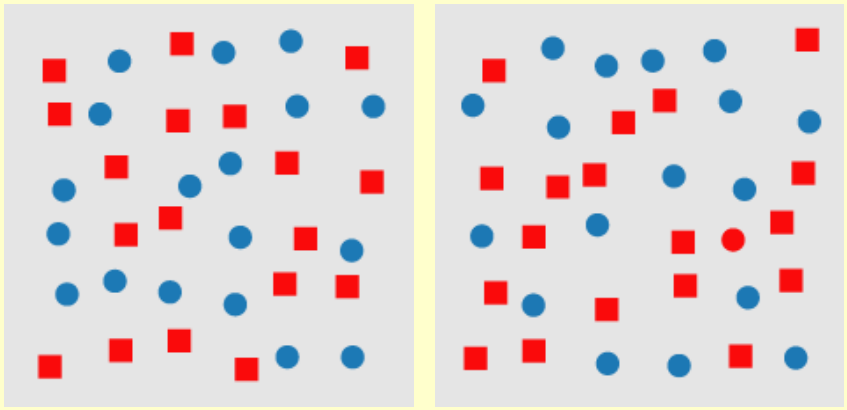
Non Preattentive : Conjunctions



http://www.csc.ncsu.edu/faculty/healey/PP/index.html

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Feature	Author
line (blob) orientation	Julész & Bergen [1983]; Wolfe [1992]
length	Triesman & Gormican [1988]
width	Julész [1985]
size	Triesman & Gelade [1980]
curvature	Triesman & Gormican [1988]
number	Julész [1985]; Trick & Pylyshyn [1994]
terminators	Julész & Bergen [1983]
intersection	Julész & Bergen [1983]
closure	Enns [1986]; Triesman & Souther [1985]
colour [hue]	Triesman & Gormican [1988]; Nagy & Sanchez [1990]; D'Zmura [1991]
intensity	Beck et al. [1983]; Triesman & Gormican [1988]
flicker	Julész [1971]
direction of motion	Nakayama & Silverman [1986]; Driver & McLeod [1992]
binocular lustre	Wolfe & Franzel [1988]
stereoscopic depth	Nakayama & Silverman [1986]
3-D depth cues	Enns [1990]
lighting direction	Enns [1990]

Figure 3: A list of two-dimensional features that "pop out" during visual search, and a list of authors who describe preattentive tasks performed using the given feature.

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Cognitive System

Connect perceptual system to motor system
Most complicated

Cognitive Memories
- *Working memory* for holding information under current condition
- *Long-Term memory* for storing knowledge for future use

Cognitive Processor
- Recognize-act cycle
- Fetch-execute cycle of computers

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Working Memory: Chunks

chunks

- Activated elements in Long-Term memory
- Unit of memory or perception
- Depends on presentation and what you already know

- "BCSBMICRA" vs. "CBSIBMRCA"

Activation spread → interfere with old ones

- ROBIN ROBERT BIRD WING FLY ···

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Working Memory: Interference

Say the color of each words

Tree
Computer
Baby
Cat
Graph
Clock

Yellow
Green
Red
Blue
Purple
Black

Slide idea from slides by Prof. Robert Miller

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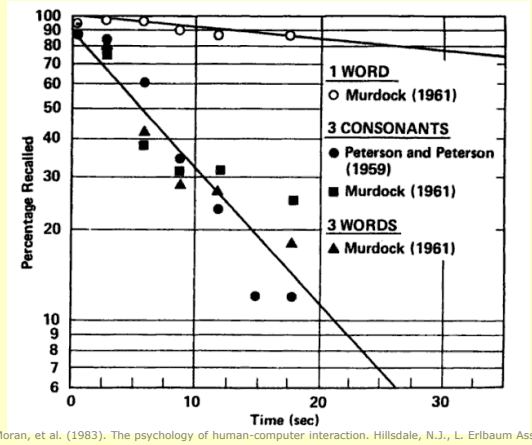
Working Memory : Decay Rate

Effect of interference

7 [5~226] sec half-life



Charts from Card, S. K., T. P. Moran, et al. (1983). The psychology of human-computer interaction. Hillsdale, N.J., L. Erlbaum Associates.

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Working Memory : Capacity

3 [2.5~4.1] chunks

Effective capacity (augmented by the use of LTM)

- e.g., Longest number that can be repeated back
- 7 [5~9] chunks
- Fastman can do 81 chunks

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Long-Term Memory

Knowledge repository

Unlimited capacity and little decay (no erasure)

Retrieval could fail:
- No effective associations
- Interference by similar associations (light/dark vs. light/heavy)

To remember something later
- Associate it with items already in LTM in novel ways
- Elaborative Rehearsal vs. Maintenance Rehearsal (repetition)

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Cognitive Processor

Recognize-act cycle
- Recognize actions in LTM → modify contents of WM (act)
- Parallel in recognition, serial in action

Cycle time: 70 [25~170] ms

- Digits: 33 ms
- Colors: 38 ms
- Letters: 40 ms
- Words: 47 ms
- Geometrical shapes: 50 ms

- Silent counting rate: 167 ms

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Hick-Hyman Law of Reaction Time

Given *n* equally probable choices, the average decision time *T*

$$T = b \log_2 (n+1)$$

Time to make a decision as a function of choices
Binary Search (not linear)

In general, the number of cycles of cognitive processor is proportional to amount of information in the stimulus

Adapted from slides by Prof. Robert Miller

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Human Performance

To address uncertainties in parameters of Model Human Processor

- Slowman : worst performance
- Fastman : best performance
- Middleman : nominal performance

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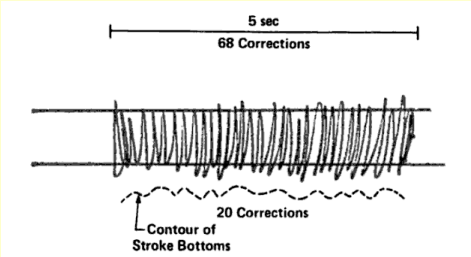
Motor System



Closed Loop vs. Open Loop Control

Perception + Decision + Motor cycle times
= (5 sec)/(20 corrections) = 250 ms

Cycle time: 70 [30~100] ms

Image from Card, S. K., T. P. Moran, et al. (1983). The psychology of human-computer interaction. Hillsdale, N.J., L. Erlbaum Associates.

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Fitts's Law

$$T = I_M \log_2(2D/S)$$

T: movement time
S: target width
D: distance to target

I_M: 22~122 ms/bit, (fastman~slowman)

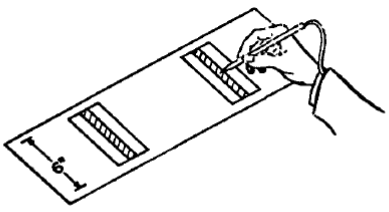

Figure 1. Reciprocal tapping apparatus. The task was to hit the center plate in each group alternately without touching either side (error) plate.

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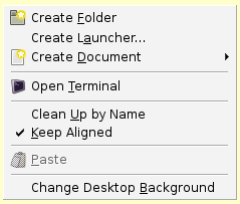
Fitts's Law

Relies on "Closed Loop" control of Motor System

Implications:

- Larger (Closer) targets are easier to click
- Macintosh menu bar is faster to use (correction time)
- Pie menu is faster than popup menu



Images from Wikipedia

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Power Law of Practice

$$T_n = T_1 n^{-\alpha}$$

The time to do a task decreases with practice

The rate of decrease is proportional to a power of the amount of practice

Typical values for α are [.2~.6]

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Reading

Card, S. K., T. P. Moran, et al. (1983). The psychology of human-computer interaction. Hillsdale, N.J., L. Erlbaum Associates.