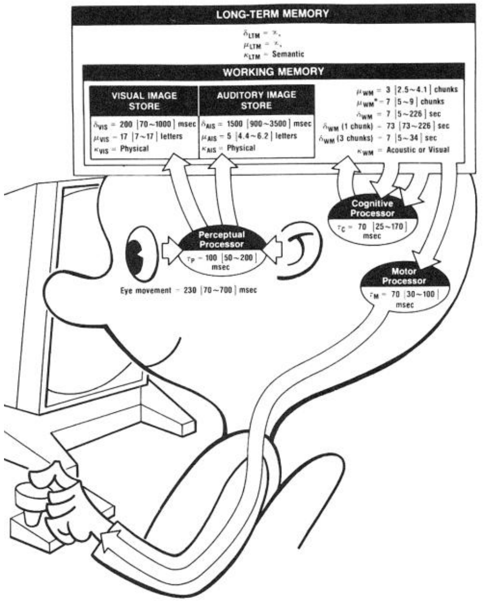
Questions?

- Project #1 – presentation in class next week
- Homework #4 due Thursday
- Hall of fame/shame presentations now scheduled

- NY Times article on Google and Marissa Mayer

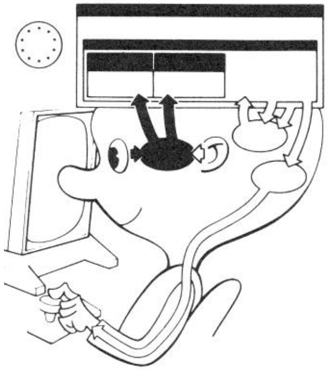
Human Information Processor (Card, Moran, Newell)



- Very influential
- Brought together several aspects of cognitive psychology
- Made accessible for computer scientists
- Practical model – **not** description of how things actually work

- What are the three components?

Perceptual Processor



- Physical sensing, here sight, into Visual Image Store
- Difference between **perceptual memory** and **working memory?**
- Decode for transfer to working memory
  - Progressive
    - *Example: 10ms/letter*
  - Selective
    - *Spatial*
    - *Pre-attentive: color, direction…*
    - *Not semantic (can't do "odd numbers")*

Perceptual Processor

- Capacity
  - Example: 17 letters
- Visual image store fades
  - Half-life: 200 ms [90 – 1,000ms]
- Cycle time
  - Initial impression to being available in visual image store
  - τ = what? 100 ms [50 – 200ms]
- What is Slowman, Middleman, and Fastman?
- Why do events separated by < 0.1sec seem causally related?
- Why are films shown at 24 fps then instead of 10 fps?

Pre-attentive perception: How many 3s?

85689726984689762689764358922659865986554897689269898

02462996874026557627986789045679232769285460986772098

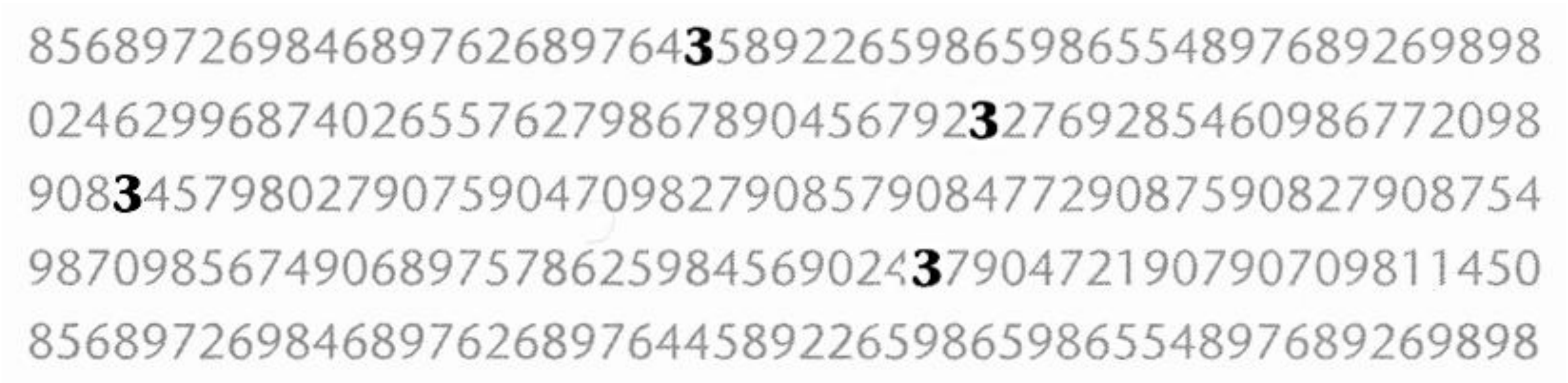
90834579802790759047098279085790847729087590827908754

98709856749068975786259845690243790472190790709811450

85689726984689762689764458922659865986554897689269898

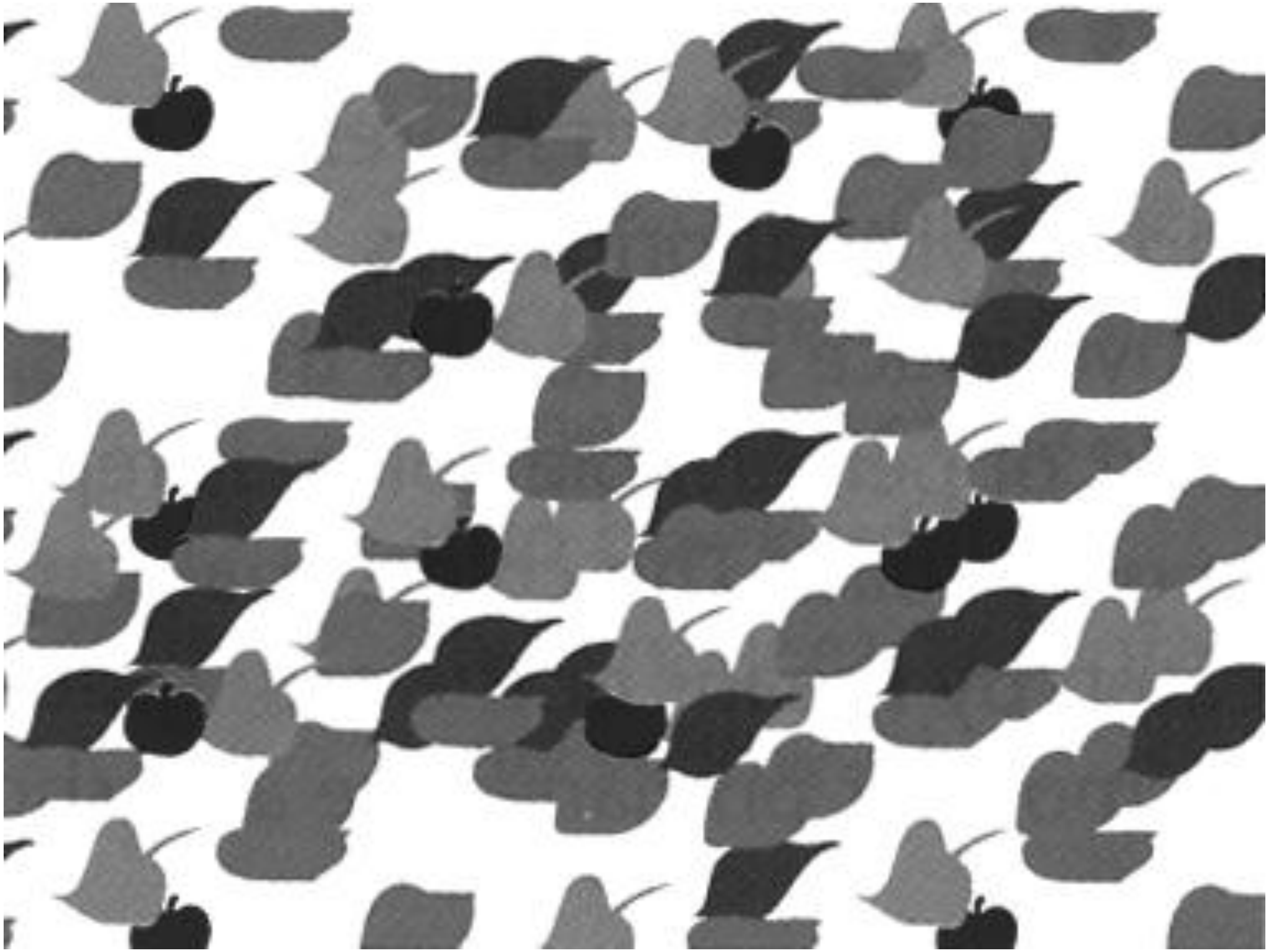
From Information Visualization, C. Ware

Pre-attentive perception: How many 3s?



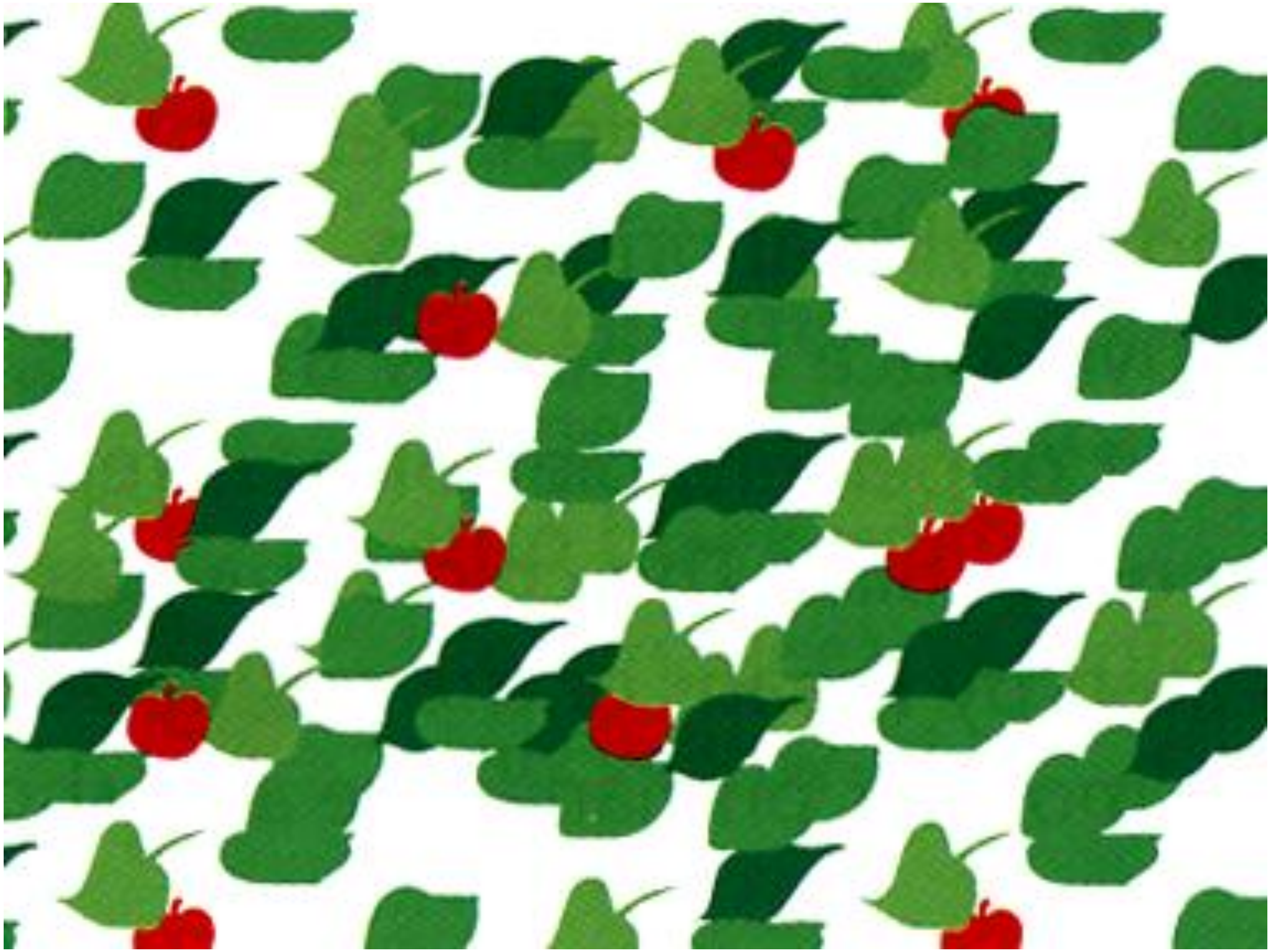
From Information Visualization, C. Ware

Where are the cherries?



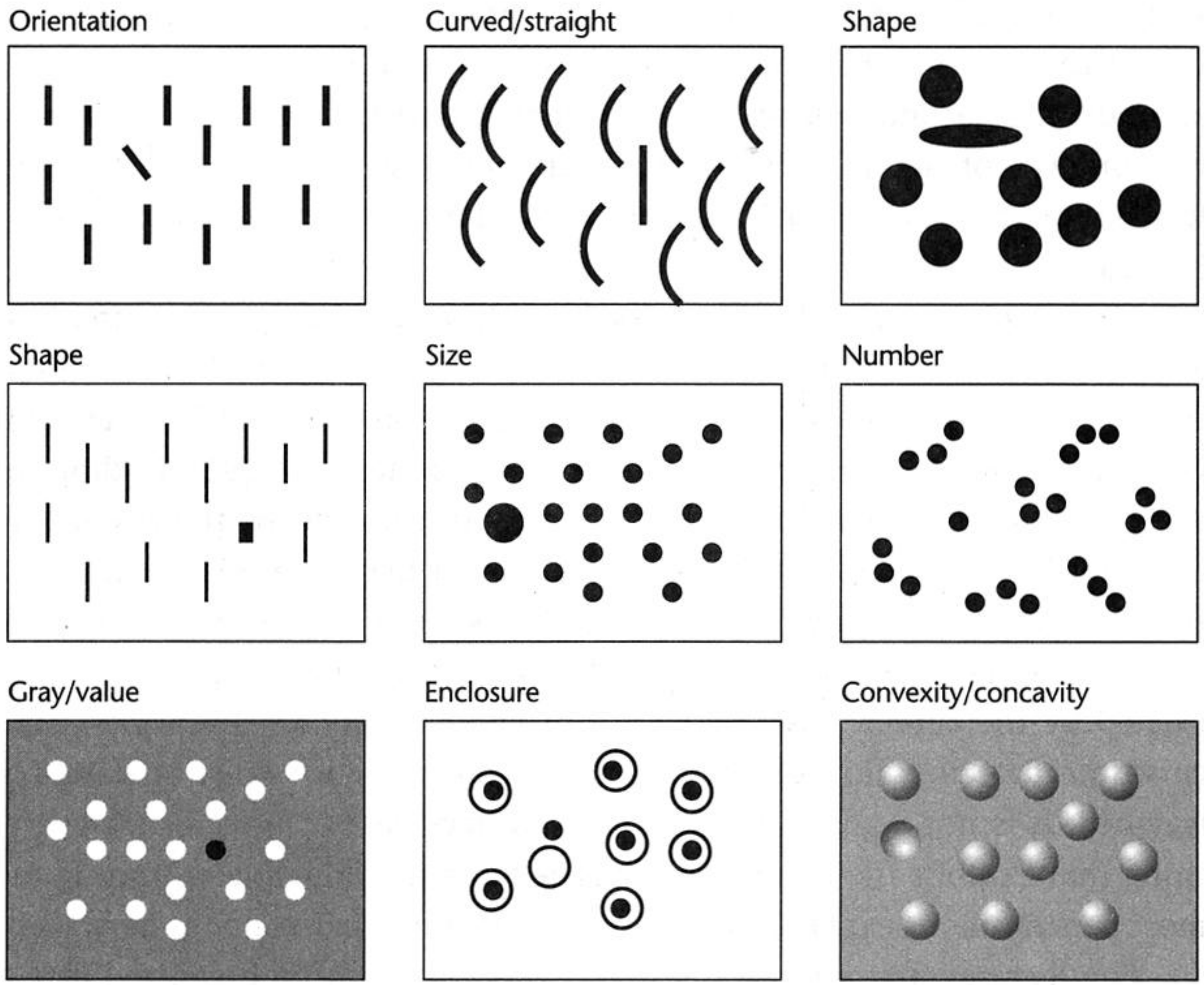
From Information Visualization, C. Ware

Where are the cherries?



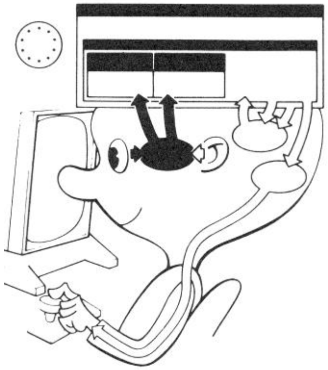
From Information Visualization, C. Ware

Other examples of pre-attentive variables

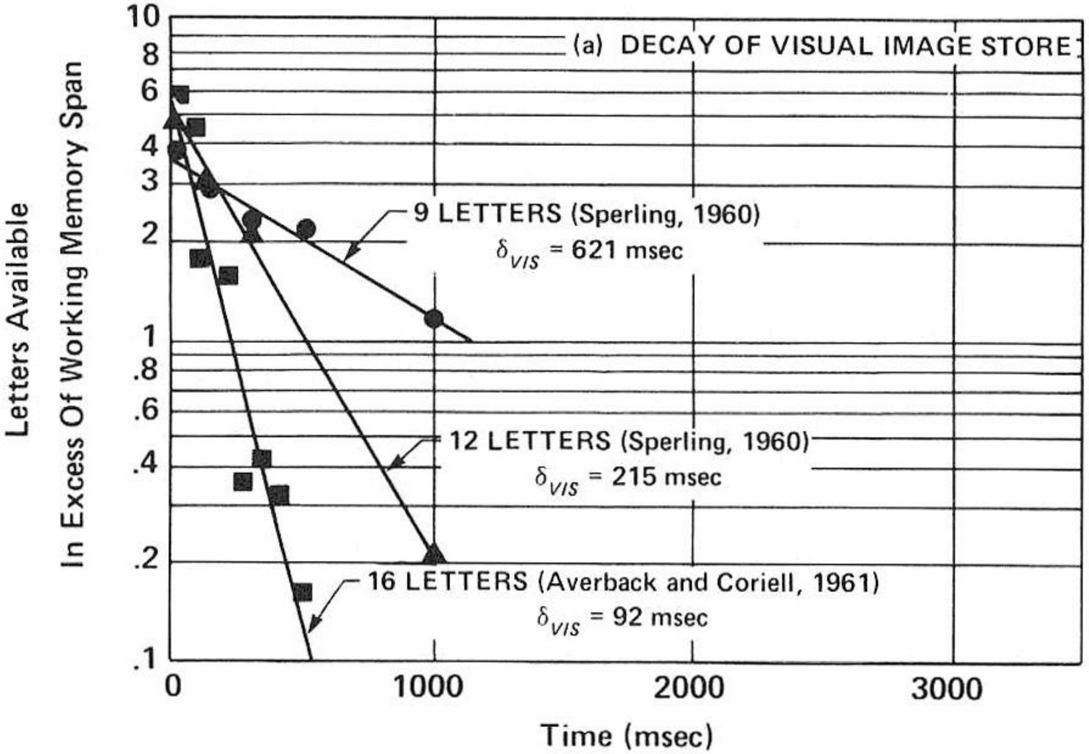


From Information Visualization, C. Ware

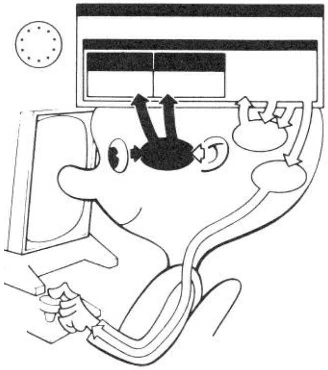
Perceptual Processor



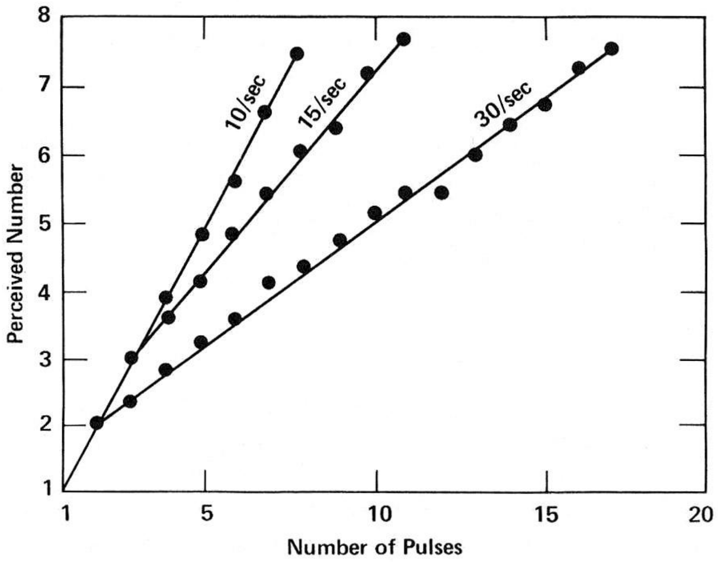
- Decay: 200ms

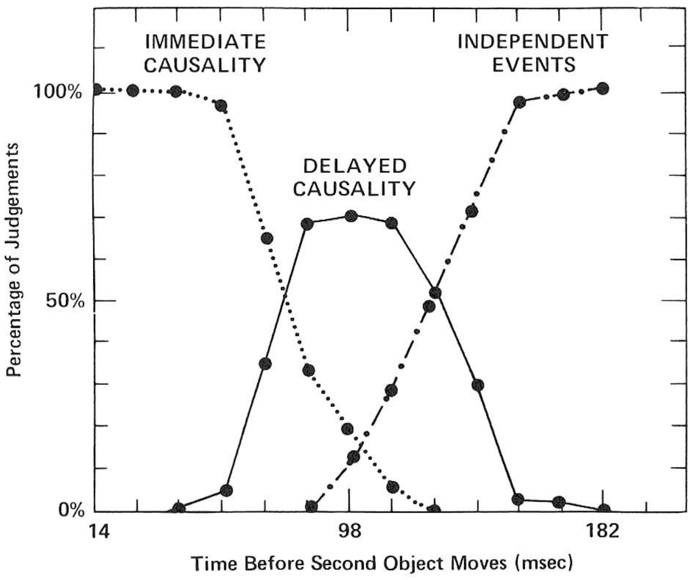


Perceptual Processor

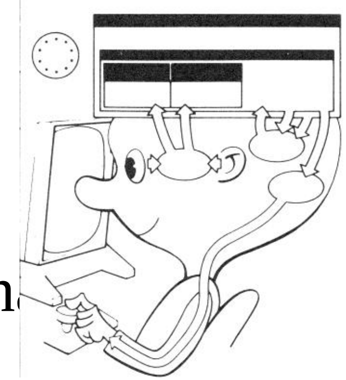


- Cycle time
  - Quantum experience: 100ms
    - *Percept fusion*
    - *Causality*

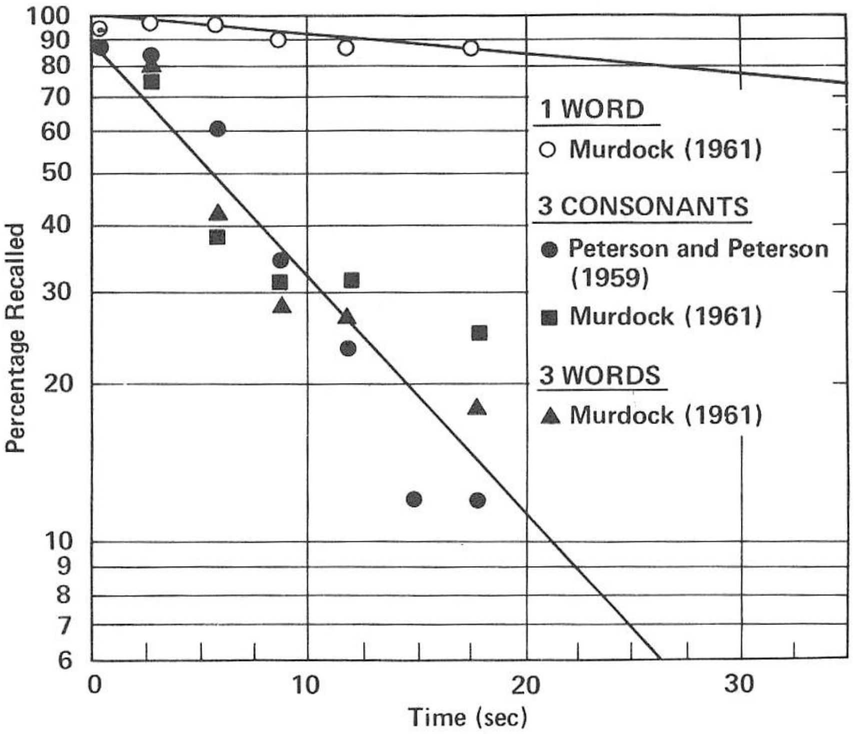




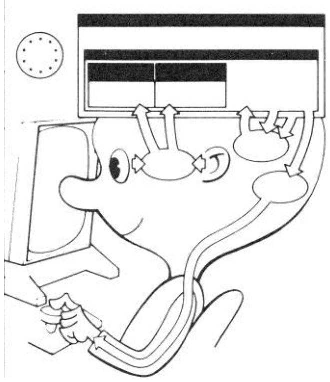
Working Memory



- Why is "UMDMSNBC" much easier to remember th "MCUSMBDN"?
- Access in chunks
  - Task dependent construct
  - 7 +/- 2 (Miller)
- Decay
  - Content dependant
  - Limit attention span
  - Half-life ~7 secs

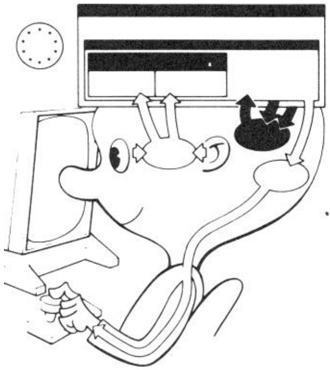


Long term memory

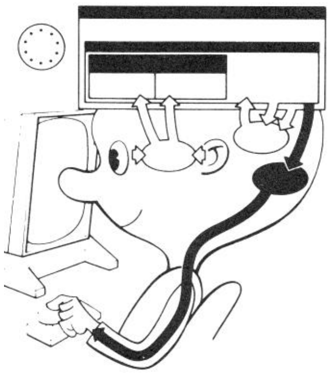


- Very large capacity
  - Semantic encoding
- Associative access
  - Fast read: 70ms
  - Expensive write: 10s
    - *Several Rehearsal and/or recall,*
- Context at the time of acquisition key for retrieval
- Noisy
- What is half-life?
  - Infinity!
  - But retrieval might fail if:
    - *No associations can be found*
    - *Associations to other items interfere*

Cognitive Processor

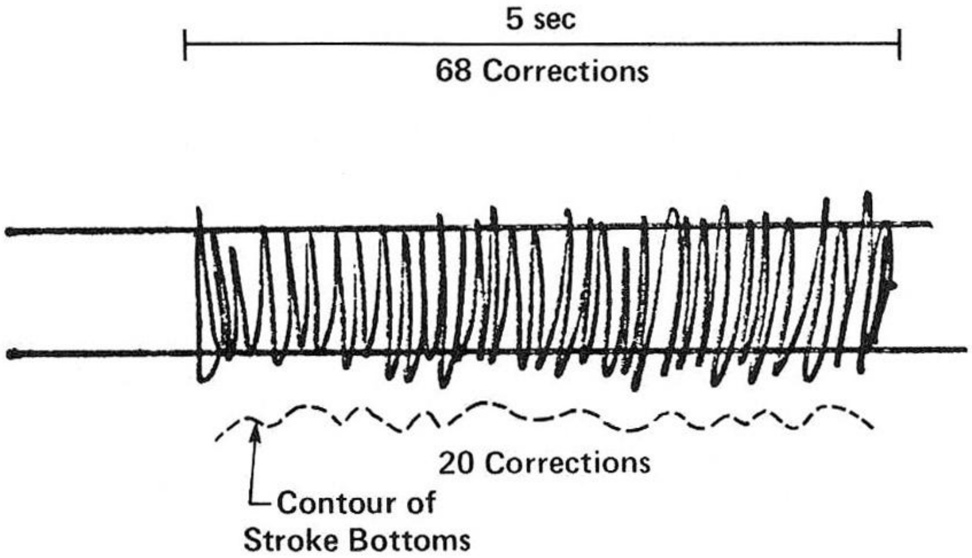


- Cycle time: 70ms
  - Can be modulated
- Typical matching time
  - Digits: 33ms
  - Colors: 38ms
  - Geometry: 50ms…
- Fundamentally serial
  - One locus of attention at a time
    - *Eastern 401, December 1972*
      - Crew focused on checking the landing gear indicator bulb,
      - Meanwhile the aircraft is loosing altitude (horn, warning indicator…),
      - Aircraft crashed in the Everglades
      - see "The Humane Interface" by Raskin, p25
    - *But what about driving and talking?*



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



Questions?

- HW#3 due Wednesday
- Project #1 presentation next Monday

Human Information Processor
(Card, Moran, Newell)

Perceptual Processor

Cycle time: 100 ms

Cognitive Processor

Cycle time: 70 ms

Motor Processor

Cycle time: 70 ms

It is a model – understandable by computer scientists

Predictive, but simplistic

Does not describe actual underlying mechanisms

Put it together: Do two letters have same name?

a A

Perceive first letter

Start clock

Perceive second letter (τ_P)

Recognize letter (τ_C)

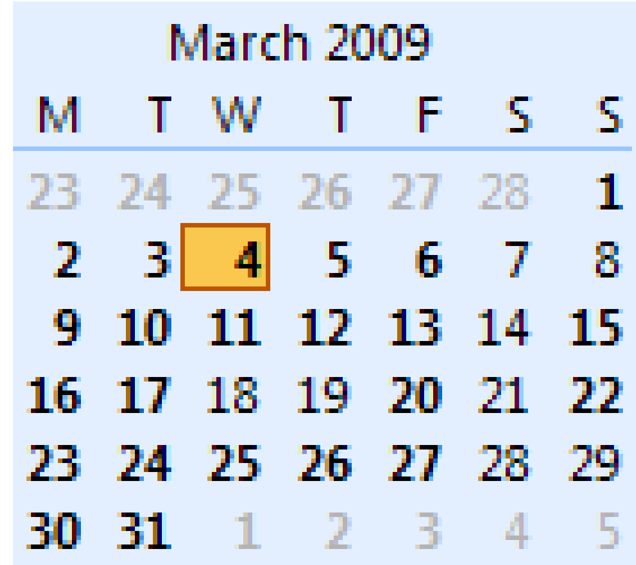
Match (τ_C)

Initiate response (τ_C)

Respond (τ_M)

=> $\tau_P + 3\tau_C + \tau_M$ = 100 + 3*70 + 70 = 380ms

You try it



How many days are in March, 2009:

Perceive calendar (τ_P)

Recognize last day (τ_C)

Decide to move eye to last day (τ_C)

Move eye to last number (τ_M)

Perceive number (τ_P)

Recognize number(τ_C)

Initiate response (τ_C)

Respond (τ_M)

=> $3\tau_P + 3\tau_C + 2\tau_M = 3*100 + 3*70 + 2*70 = 650ms$

Eye movement

- Eye movement time
  - 230 ms [70 – 700ms]
- If you move one saccade per phrase while reading, and one phrase is 2.5 words, then
  (60 sec/min)/(.230 sec/saccade x 1/2.5 saccade/word)
  = 652 word / minute

⇒ So, speed readers (2,500 words / minute) don't see all words

Putting it together: Reading Speed

How can you speed up reading?

$\Rightarrow$ RSVP

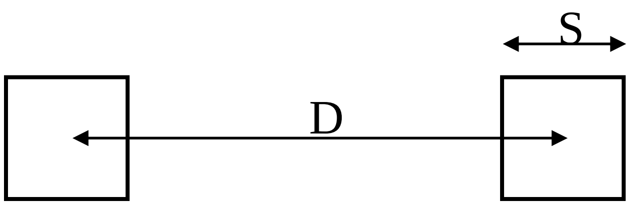
$\tau p + \tau c = 100ms + 70ms$

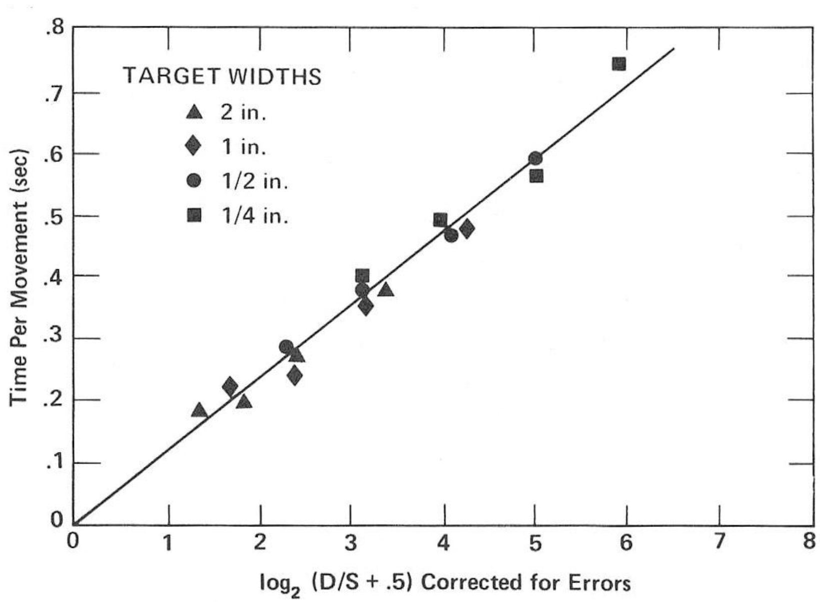
(2.5 word / phrase) x (60 sec / min) / (.170 sec / phrase)

= 882 word / minute

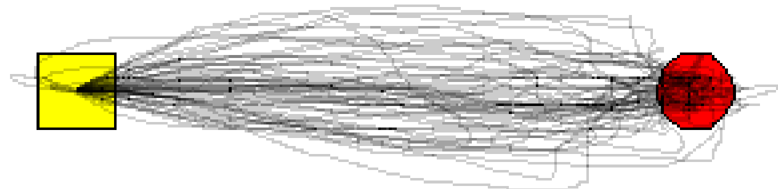
Put it together: Fitts' law (tapping task)

$$T = I_M \log_2(D/S + 0.5)$$





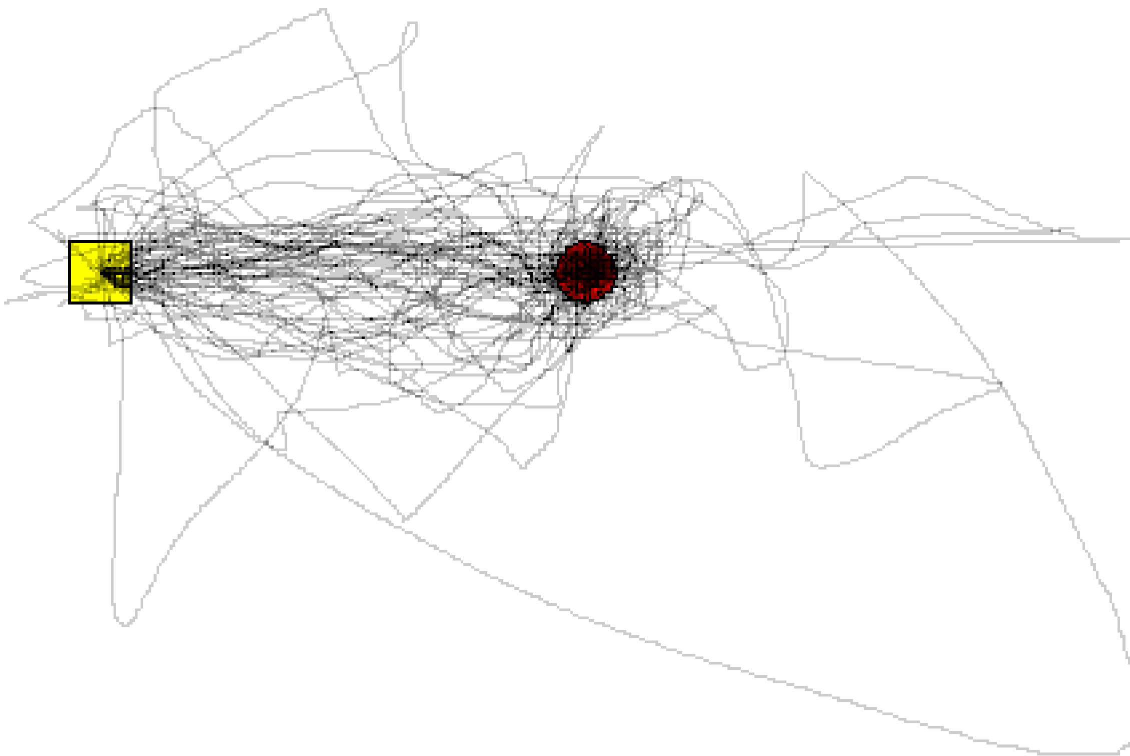
Implications: Fitts' Law



All paths taken by adult participants to click on a 32 pixel target at a distance of 256 pixels.

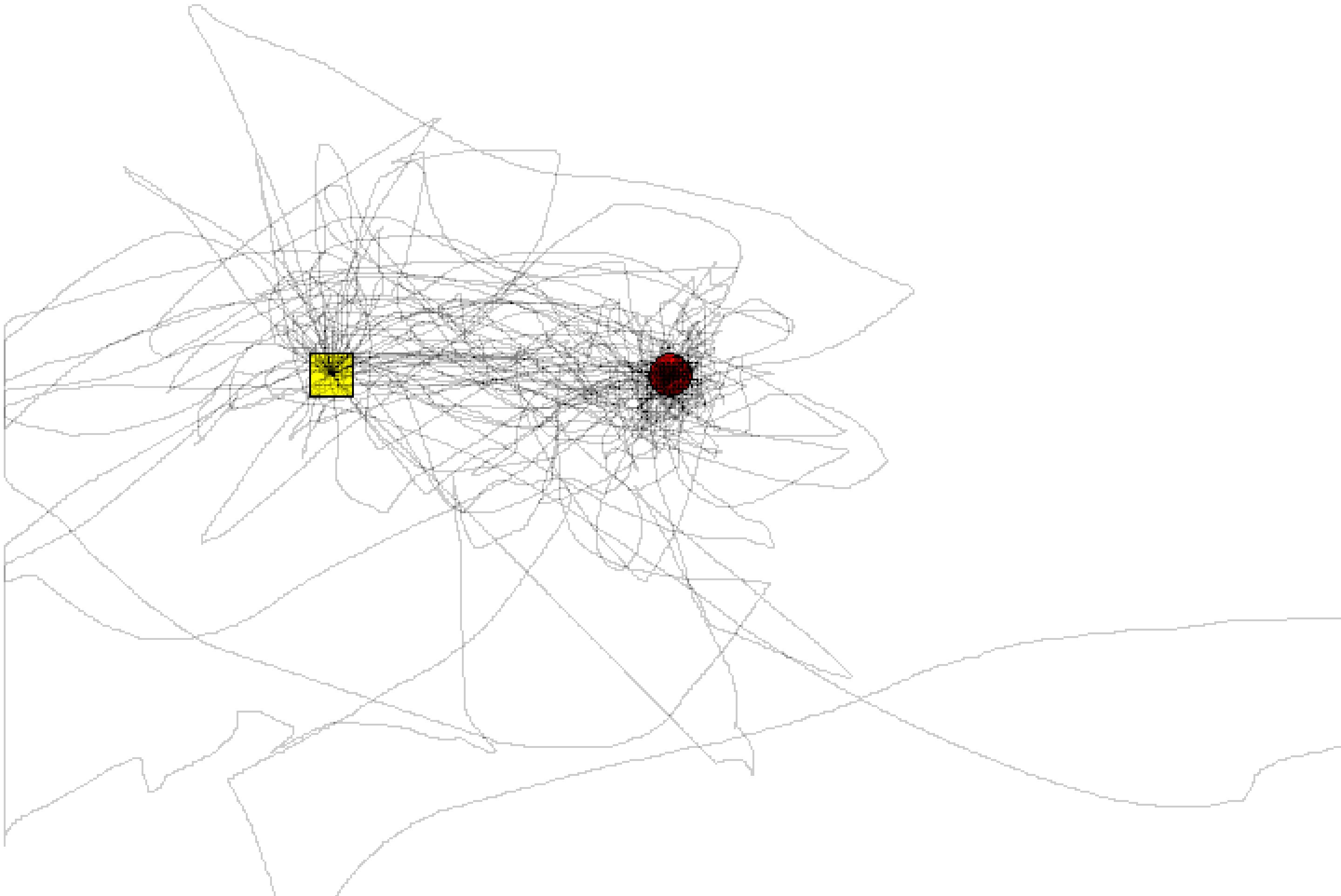
Hourcade, J. P., Bederson, B. B., Druin, A., & Guimbretière, F. (2004) **Accuracy, Target Reentry and Fitts' Law: Performance of Preschool Children Using Mice**, *Transactions on Computer-Human Interaction*, New York: ACM, 11 (4), pp. 357-386.

Implication: Fitts' Law



All paths taken by 5 year-old participants to click on a 32 pixel target at a distance of 256 pixels.

Implication: Fitts' Law



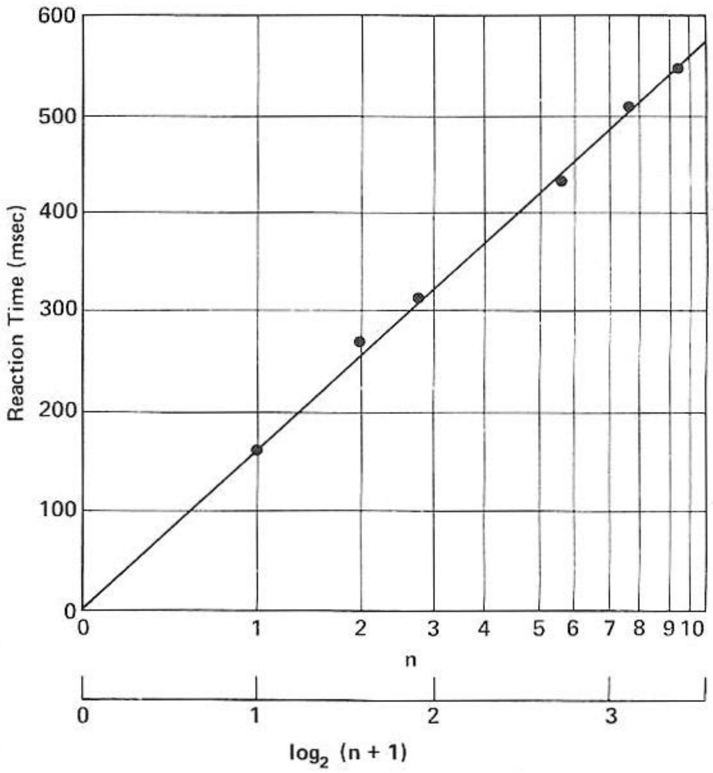
All paths taken by 4 year-old participants to click on a 32 pixel target at a distance of 256 pixels.

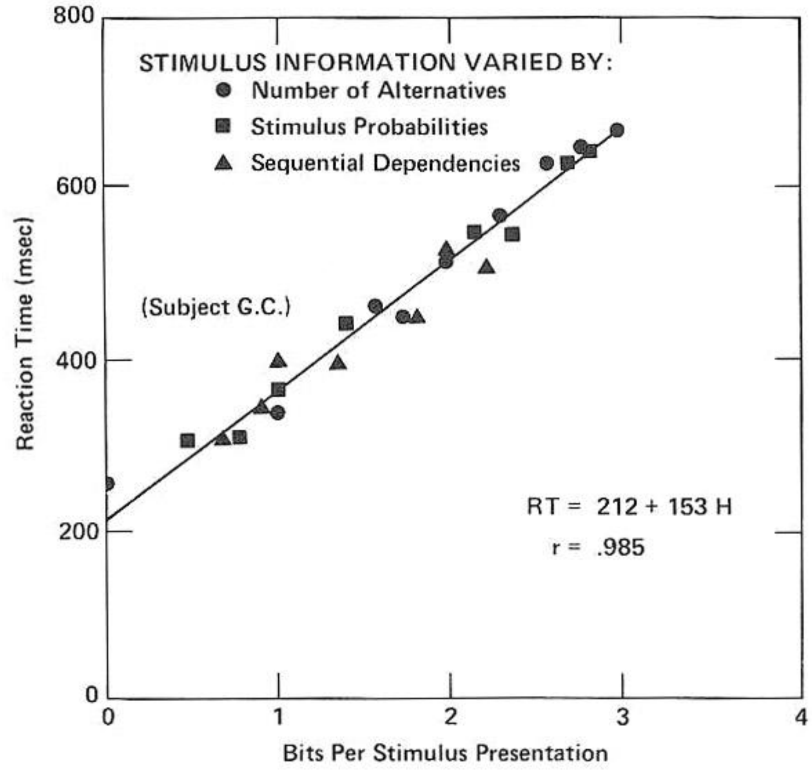
Implication: Fitts' Law

- Location of buttons on screen
  - Windows vs. Mac
  - Borders around buttons
  - Pull-down menus vs pie menus
  - What are the best locations on the screen?
- Size/distance trade-off. Which is faster?

Hick's law

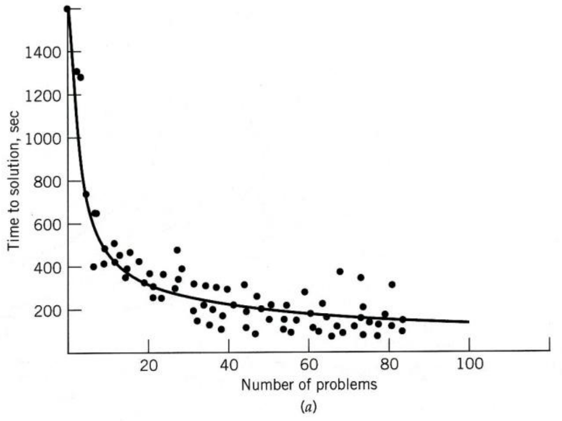
- Cost of taking a decision: $H = \log_2(n + 1)$
- Why log rather than linear?

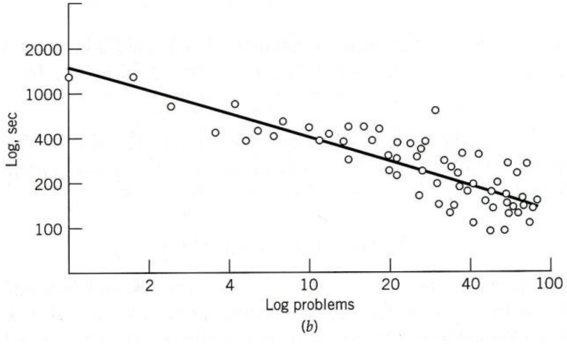




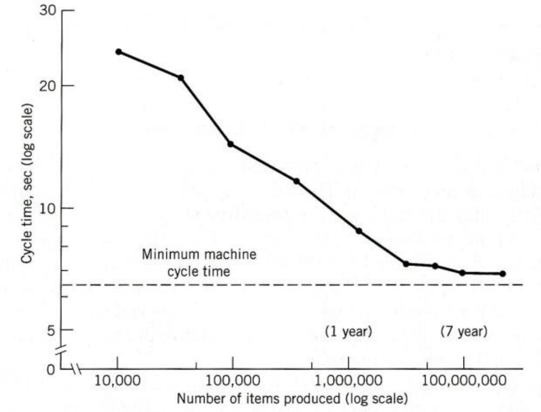
Learning
("Learning and memory" Anderson)

- The time T_n to perform a task on the nth trial follows a power law: $T_n = T_1 n^{-\alpha}$

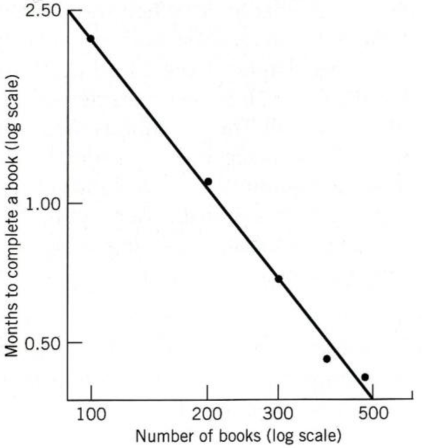




Problem solving



Manual skill



Writing books

Problem Solving

1. States – Characteristics of a situation
2. Goals – The state you are trying to achieve
3. Operators – The steps you can follow to change states
4. Search – Find a sequence of operators that transforms state from current state to goal state

Learning consists (roughly) of:

- Learning operators
- Optimizing search

Difference Reduction

- “Greedy” algorithm
  Transform state to move closer to goal
- Optimizes simple metric

=> get stuck in local minima

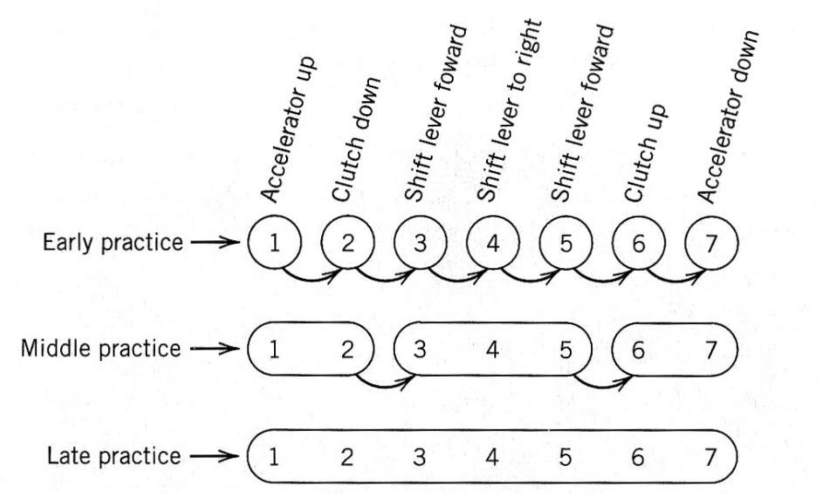
Operator Subgoaling

- <= Working backward from goals
- Requires memory for state
- Like AI-style “planning”

Stages of skill acquisition
("Learning and memory" Anderson)

Example: Using a manual transmission

- Cognitive
  - Verbal representation of knowledge
- Associative
  - Proceduralization
    - *From rehearsal to recognition*
- Autonomous
  - More and more automated
  - Faster and faster
  - No cognitive involvement
    - *Difficult to describe what to do*
  - **The importance of motor program**



Production Rules

- Condition-action pairs represent procedural knowledge
- Can be applied with less memory

- Can recognize directly what to do without having to think through all the possibilities.

- (i.e., linear search replaced with immediate recognition)

- How does this apply to counting?
- How does this relate to long-term memory?

Experts

- Practice
- Knowledge
- Rules

=> Automatized Skills

- Doesn’t engage cognitive system
  - No working memory load
  - Not interruptible
  - Perception goes away as system goes open-loop

Closed Loop vs. Open Loop

Closed Loop

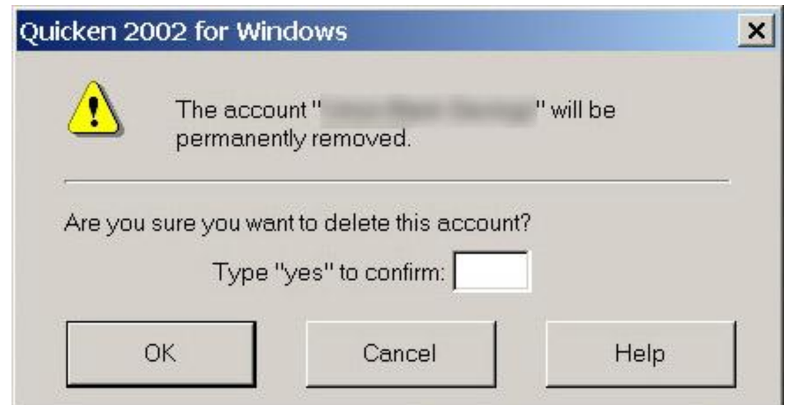
- Feedback from perception through cognitive to motor
- Examples?

Open Loop

- Control is planned in advance and motor executes without perception or cognitive
- Examples?

Implications: confirmation steps

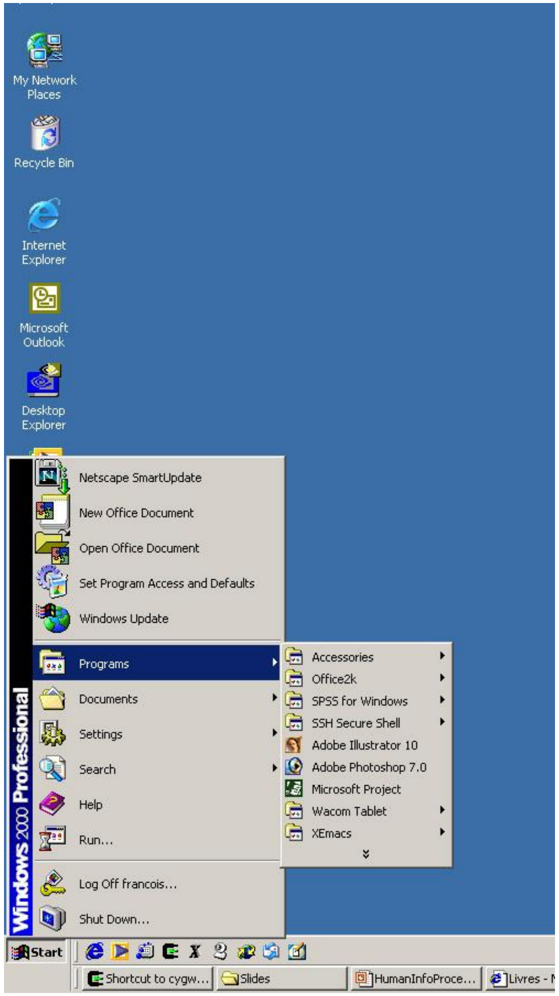
- Pros and Cons?



- See also “The humane interface” Raskin, p23

Implications: dynamic menus

- Pros and Cons



Midterm

- Covers everything up to and including today
- Last year’s midterm available online