Human Abilities

“Design” in HCI

- Note: Differences with “design” in software engineering
  - Design in HCI = create a new concept
  - Design in SE = given concept, create an architecture/schema for the system being built
- Design includes two different aspects
  - Low level aspects of UI that help people interact more efficiently
  - High level representation of concepts in UI that help people understand and interact with software

“Design” in HCI

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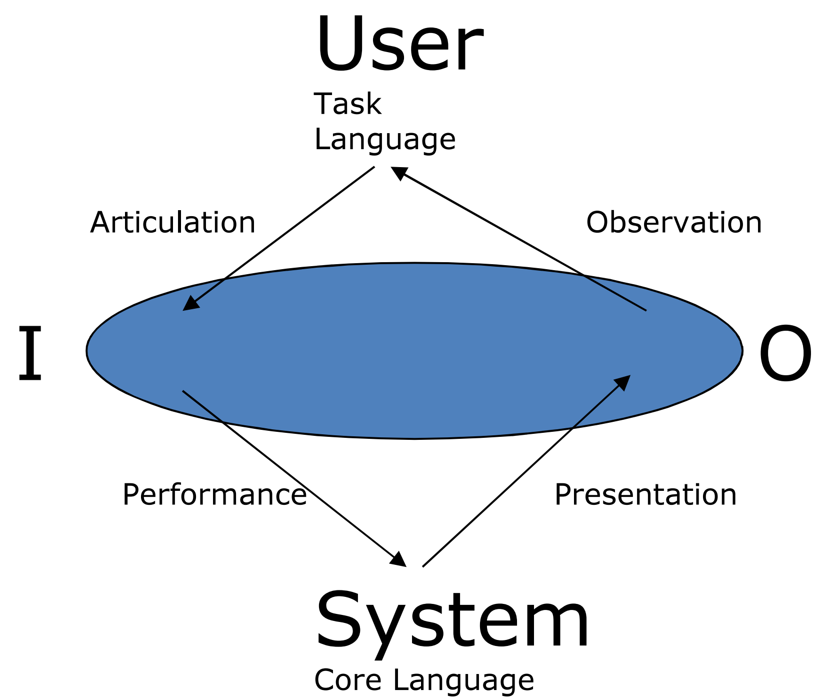
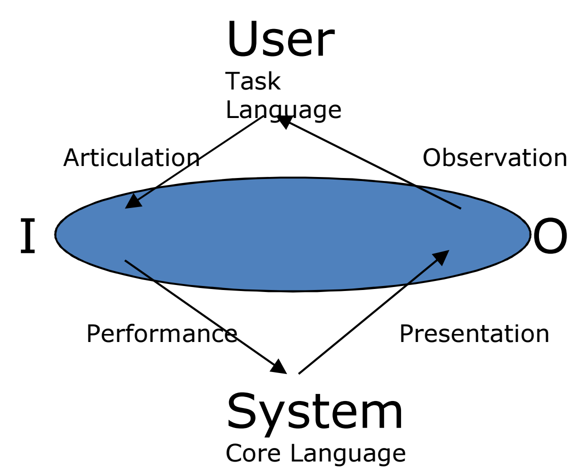


Both the widgets that instantiate the UI and the representation of information are informed by characteristics of people

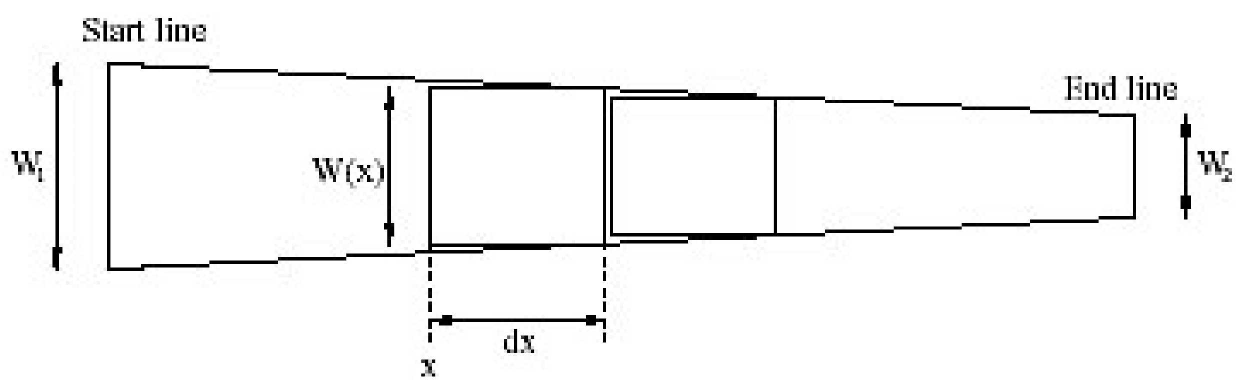
Understanding People

- Movement
  - Fitt's Law
  - Steering Law
- Memory
- Reasoning



Movement

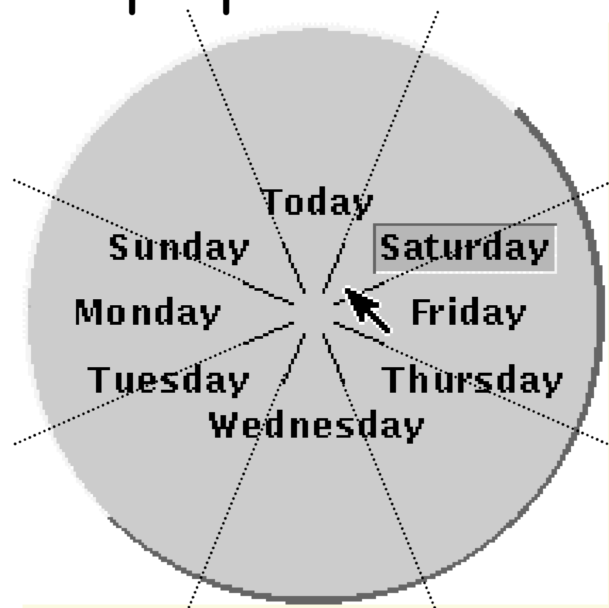
- Fitt's Law
  - $T = a + b \log_2 (A / W + 1)$
- Steering Law
  - $T = a + b \int_c (1/W(s)) \, ds = a + b \, (A/W)$



Design Implications – Fitts' Law

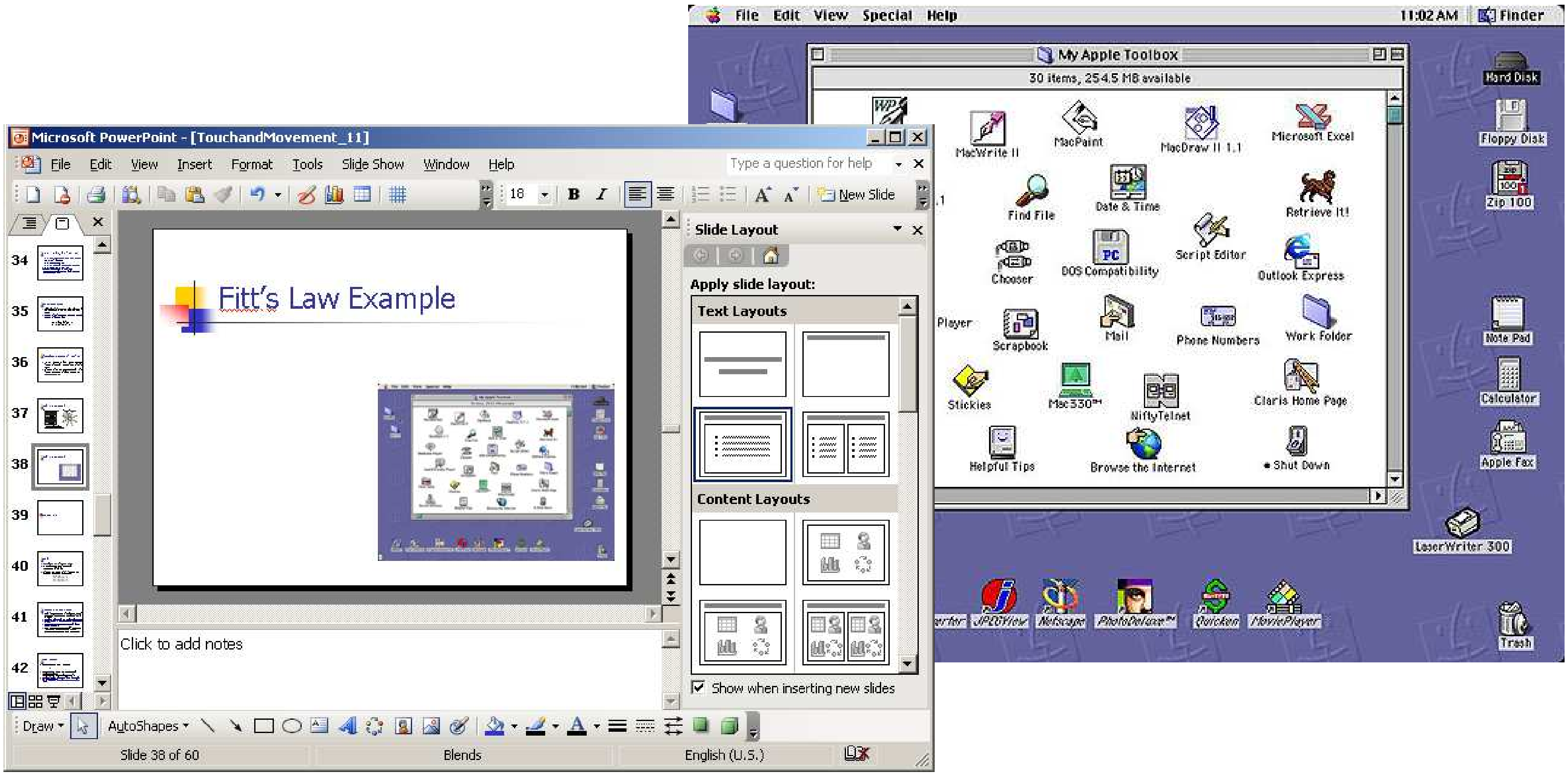
Pop-up Linear Menu

Pop-up Pie Menu



From Landay's HCI slides
I'm still not sold on Pie menus

Design Implications – Fitts' Law



Expect-K

- ..\Videos\uist.avi
- ..\Videos\ThickButtons _ finger text input for touchsreen smartphones.flv
- ..\Videos\YouTube - iPhone Typing Demonstration.flv

Design Implications – Steering Law

- hierarchical menu item selection

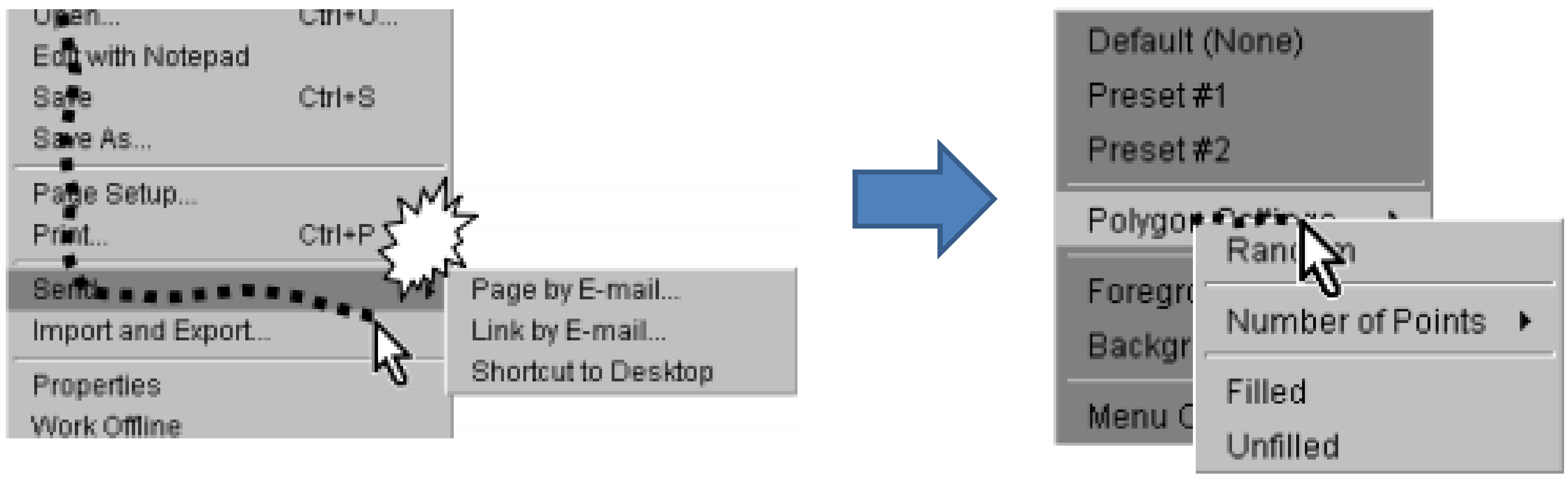
  $$T_n = a + b\,\overbrace{(nh/w)}^{\text{Vertical}} + a + b\,\overbrace{(w/h)}^{\text{Horizontal}}$$

  $= 2a + b\,(n/x + x)$ with $x = w/h$

  h = height of sub menu

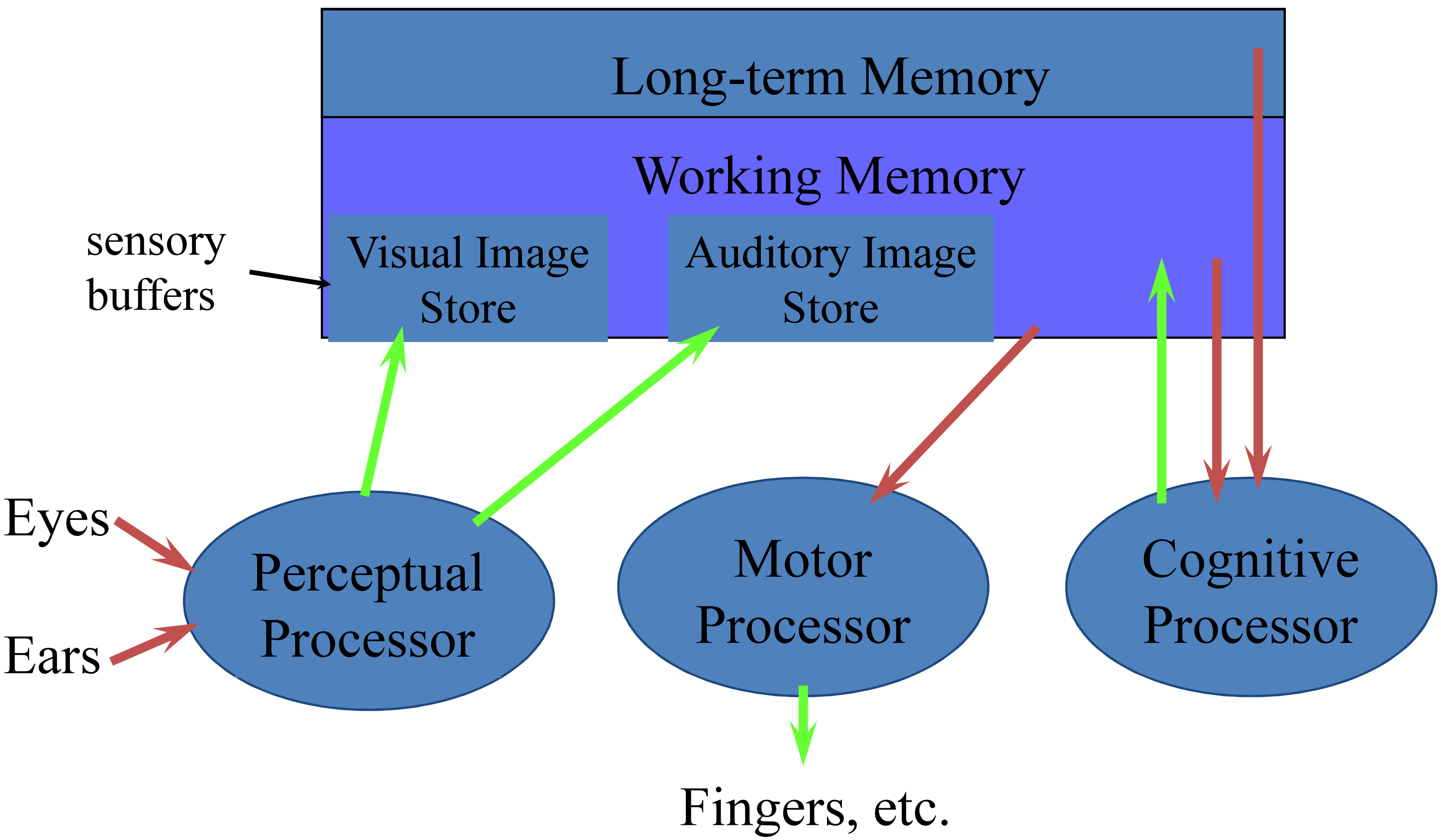
  n = submenu level
- So T is minimal when $x = \sqrt{n}$ or $w = \sqrt{n} * h$
  - the greater the number of menu items there are, the greater the quotient w/h is
- Can be used to compare designs, i.e. linear hierarchical menus and hierarchical pie menus

Design Implications – Steering Law



Memory

Model Human Processor



MHP basics

- Based on empirical data
  - years of basic psychology experiments in the literature
- Three interacting subsystems
  - perceptual, motor, cognitive
- Sometimes serial, sometimes parallel
  - serial in action & parallel in recognition
    - pressing key in response to light
    - driving, reading signs, & hearing at once
- Parameters
  - processors have cycle time (T) ~ 100-200 ms
  - memories have capacity, decay time, & type

Memory

- Three types of memory

1. Sensory memory

   Focusing attention transfers to

2. Short term (working) memory

   Practice/rehearsal transfers to

3. Long term memory

Sensory memory

- Short term buffers
- Different channels have different buffers:
  - Iconic memory for visual stimuli
  - Echoic memory for auditory stimuli
  - Haptic memory for touch
  - New information overwrites old information
- Existence demonstrated in a couple of ways:
  - After images
  - Direction from which sound emanates and recall of question you didn't think you knew
- Collects information all the time
  - Need some way to filter
  - We do this by attention and focus

Short-term memory

- Think about a task like reading:
  - Need to keep info from first of a sentence in order to get meaning
  - Meaning is what's stores, not words
  - Implies a need for temporary "working" storage
- Accessed rapidly: ~70ms
- Limited capacity
  - Two ways this has been tested:
    1. Lengths of sequences: 7 +/- 2 digits
    2. Free recall of info in any order

Short-term memory exercises

- Here is a sequence of numbers:
  - 2653797620853261823

Short-term memory exercises

- Here is a sequence of numbers:
  - 871 392 567 481 28 10 21 37

Short-term memory exercises

- Here is a sequence of numbers:
  - 871 392 567 481 28 10
- We remember best when information is "chunked"

Long-term memory

- Stores factual information, experiential knowledge, and rules of behavior
- Huge, if not unlimited
- Slow access time (100 ms)
- Two types:
  - Episodic memory
    - Our memory of events
  - Semantic memory
    - Structured record of facts
- Use rehearsal to move info from short term to long term memory

LTM Processes

- Getting info into long term memory:
  - How do I learn?
  - Optimizations include:
    - Total time hypothesis: Amount learned is proportional to time spent learning
    - Distribution of practice effect: Learning works best if spread out
  - Learning well includes understanding
    - Build models of information
    - Structure, familiarity, concreteness
    - Particularly for devices – why is a VCR hard to program?

LTM Processes

- Forgetting
  - Decay or interference:
    - Decay:
      - Theory that over time, information degrades
      - Actually plotted logarithmic scale
    - Interference:
      - New info. Over-writes old info.
  - Now a debate about whether forgetting ever happens or if it’s a retrieval problem
    - Old information breaking through
    - Tip of tongue phenomenon

LTM Processes

- Recall vs. recognition
  - Recall
    - Information is reproduced from memory
  - Recognition
    - Presentation of information cues us to fact we’ve seen this before
  - Should stress recognition over recall
    - Why?

LTM Processes

- Recall vs. recognition
  - Recall
    - Information is reproduced from memory
  - Recognition
    - Presentation of information cues us to fact we’ve seen this before
  - Should stress recognition over recall
    - Provide strong cues for recall if used

Reasoning

Reasoning

- Deductive
  - Uses logic to derive conclusions from premises
    - If it is Friday then she will go to work.
    - It is Friday, therefore she will go to work
- Inductive
  - Generalizes from cases we have seen
    - Can disprove simply by producing counter-example.
    - Scientific method.
- Abductive
  - Reasons about causes from events
    - I pressed a button and the window closed.

Reasoning

- Problem Solving
  - Gestalt theory
    - Restructuring and insight to perform productive problem solving
      - Pendulum example
  - Problem space theory
    - Problem solving looks at problem space as state space and moves from initial to goal state using operators
      - Math example
  - Using analogy
    - Solving novel problems involves mapping previous knowledge – analogical mapping
      - Medical example

Problem solving - continued

- Characteristics of experts
  - Chess – don't consider more moves, consider better ones.
  - Reading diagrammatic notations (grouping)
- Better encoding of knowledge as skill increases
  1. General purpose rules (slow)
  2. Rules specific to task
  3. Rules are tuned to boost performance

Mental Models – enabling problem solving

- A model of how device works
- Based on cognitive psychology
- Consider ATM card
  - What information does it contain?
- Problem with mental models is that term is over-used
  - Any argument about need for understanding of the device or application

Mental Models

- Debate about the importance …
  - For example, “success of a computer system is almost totally controlled by how well it fits into user’s work practice” – Stephen J. Payne (Mental Models researcher)
- But, an understanding of differing theories of models can help you understand user’s problem solving approach
- Differing theories as to how mental models are formed

Mental Models: Theories

- Naïve physics
  - Mechanics or electricity
- Problem spaces
  - Accomplish tasks by searching a space of possible actions
- Representational artifacts
  - Reading text versus understanding meaning
- Homomorphisms
  - Directions by reading a map versus from someone with experience with Toronto

Mental Models – differing theories

- Mental Models as Naïve physics
  - People understand the physical world based on their (imperfect) understanding of mechanics or electricity
  - Theorize about the physical world based on their mental model of the world
  - Mental models look at systems in the large
  - HCI often concerned with discrete phenomena
  - ATM cards … Study by Payne showing that discrete behaviors can be explained by models even if overall system is poorly understood

Mental Models – differing theories

- Mental models as problem spaces
  - Methods for achieving tasks
  - Problem solving involves searching a problem space of possible states
  - Skilled behavior involves remembering sequences of states to accomplish tasks
  - Problem: perfect skill is never reached
    - Always some aspect of search to solve problems
  - Behavior is either problem solving or learned
    - Learned behavior is either skill-based (controlled)/rule-based (automatic)
  - Examples of this include learning reverse-polish notation
    - (1+2)*3 => 1 2 + 3 * (rote procedures) vs. stack representation (model: an operator is entered, top of stack is popped)

Mental Models – differing theories

- Models as representational artifacts
  - Reading text -> understanding the meaning
  - To know what's on these slides, you don't need to remember the text
  - To search and find something in these slides, you need to remember the text
  - Payne proposes a "yoked state space" for software
    - Using software requires some representation of domain of software
      - User's goals are states in the domain
    - Using software also requires knowledge of the operations to transform states
      - This is the "device space"
    - These spaces have to be connected for user

Mental Models – differing theories

- Mental models as homomorphisms
  - Basically, the model is an analog
    - A verbal description of a picture vs. the picture itself
    - Picture is much more constrained.
  - Consider a map vs. experience with Toronto
    - People who have extensively studied the map vs. people who have lived here for a long time
    - Both can give good directions based on experience
    - Contrast with new-comers with no map
  - People with experience with software develop a cognitive map of the software

Take-Away Points

1. Know what people are going to do with your software and **how** they will do their task
2. People have characteristics and limitations
   - Biological in nature
   - Seeing, touch, movement, and thinking must all be considered.

- Overall, the design of software should consider characteristics of individuals