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Cognitive Background

I. Model Human Processor
   a. Empirically developed / verified
   b. Concept: The brain is like a CPU
   c. Four Pieces
      i. Perceptual: Eyes, Ears
      ii. Cognitive (CPU), Short-Term Memory (registers)
      iii. Long-Term Memory (disk – “long-term” meaning more than a few seconds)
      iv. Motor
   d. Perceptual
      i. Each perception has its own memory.
      ii. Information is always handled in “chunks”
      iii. After perception, information is transferred to Cognitive
      iv. If Cognitive is busy, it goes straight to long-term memory
      v. Visual
         1. Fonts are *perceived* automatically
         2. Details are all encoded in the data that’s sent to the rest of the brain
         3. Synaesthesia.
            a. Some people recognize color, letter before shape.
            b. About 1 to 3% of the population.
            c. Perhaps because those areas are adjacent in the brain?
         4. 17 chunks fit in short-term memory for about 200 milliseconds
         5. Broad special sense (of the entire room), narrow focus (6^o)
      vi. Auditory Perception
         1. Simpler
         2. Remember about five sounds for about 1.7 seconds
         3. The brain learns to ignore similar or repeated sounds. Audio processing never even reports these to the rest of the brain.
   e. Cognitive
      i. Chunk-based (variable-sized chunks)
      ii. Cognitive automatically brings up relevant long-term memories by chunk.
      iii. More recently accessed memories are accessed faster.
      iv. Working Memory
         1. Retains chunks for about seven seconds
         2. Works with about seven chunks
         3. There has to be *some* rule for chunking. In phone numbers it’s just three arbitrary digits and four arbitrary digits, but that’s enough to support chunking.
   f. Long-term Memory
      i. Unbounded size! It’s harder to *find* things as data are added to memory, but the brain won’t ever get “full.”
      ii. Memories are stored relative to context. The brain forgets “expected” details and then just fills them in during recall.
      iii. Time and success rate for recalling from long-term memory both vary. They generally vary together.
      iv. Remembering *uniqueness* is easier.
      v. Depends on associations.
   g. Motor
      i. Initiated by chunks in working memory.
      ii. Muscle Memory: Trained by repeated actions. Nerves “down the line” are doing the processing.

II. Information Processing Model
   a. Input goes to encoding, to comparison, to response selection, to response execution, to output. It’s a procedure.

b. Attention and Memory were added later, so at each step ("Comparison," for example) attention and memory are involved.
c. See diagrams on [CS-296-2005-01-SLIDES-03:09]
d. Mental Models
    i. People develop mental models of how things work.
    ii. Functional Model
        1. Describes *how to use it*.
        2. How the object actually works is a "black box."
        3. People know how to dial a telephone, but have no idea how the phone actually responds to the dialing process.
        4. Think "Heechee ship."
    iii. Structural Model
        1. Includes detail about how it works inside.
        2. Level of detail may be limited, but it's there.
        3. It's possible in many cases to "swap in" a structural model when something breaks down in order to analyze it. If dialing the phone isn't working, you may know enough about how it works to try to solve the problem.
    iv. For some things we keep both models and use whichever is appropriate. For some we keep only a functional model.

III. Uses of Cognitive Background
a. We want to do everything we can in UI design to make the user's job easier.
b. We can also predict response times for certain actions based on what we know.
c. Summary
    i. We only "know" seven things at once. Computers, on the other hand, are very good at remembering.
    ii. Aegis cruiser missile problem (shot down a civilian plane): the operator had to remember too much at once.
    iii. Remember chunking! When the user has to remember stuff, give clues about chunking (particularly if there are semantics to the chunks)
        1. Use graphical separation – graphical clues that imply semantics for chunking.
        2. Put more information into each chunk. Use font, color, size, shape, position. Faces, for example, have *tons* of information all at once. Is there a way for computers to exploit that?
    iv. Can easily overdo it!
        1. Don't give too much information at once.
        2. Reaction times that are too fast are uncomfortable.
        3. Color should be an *accent*, not a primary conveyor of information
        4. Can be really ugly with too much decoration.
        5. Balance between distinct pieces and combined whole – aesthetics.
d. Expected Sequences
    i. Our "thinking" is pattern matching.
    ii. More recent patterns (recently accessed) are matched faster.
    iii. Make pattern matching easier.
    iv. Don't use the beginning of a sequence the user has seen before and then give a "surprise ending" that breaks the pattern.
e. Flashing
    i. Sudden changes like flashing are *immediately* sent to consciousness. Each flash acts like an interrupt and generates a separate chunk.
    ii. "Might be a tiger, might be a tiger, might be a tiger."
f. Sounds
    i. Repeated sounds are ignored.
    ii. The *absence* of repeated sounds is noticed (e.g. doctors and nurses "listening" to an EKG machine – don't really hear beeps, but hear break in rhythm).
g. Motor Control

    i. Fine control is limited. It's almost impossible to drag something one pixel.
    ii. Put things in the same place on every page.

h. Decision-Making
    i. Make places with a required decision from the user obvious.
    ii. Make it easy to evaluate comparisons (what happens if I go down this path – am I cutting off some option I might have wanted?)

i. Structural vs. Functional
    i. Explicitly decide which model the user should be using.
    ii. If it's functional, make the *functions* obvious.
    iii. If users need more power, encourage a model of how it works under the hood. This model may also used to "debug" when something goes wrong.

j. GOMS
    i. We can use these models to estimate efficiency.
    ii. We build up empirical times for the number of cognitions, movements, et cetera.
    iii. GOMS and the Model Human Processor go hand in hand.
    iv. More on GOMS later.

k. Model Limitations
    i. People are much more complicated than the model suggests.
    ii. Culture, for example, has a *huge* impact on how the interface should work.
        1. Reading direction should lead to steps being laid out in that order.
        2. Colors and shapes have meaning. White is the funeral color in Japan.
    iii. Almost completely ignores learning
        1. Are some patterns easier to learn than others? We don't know!
        2. There's a difference between learning speed and accuracy.
    iv. Analogies are instinctive
        1. The model doesn't include that at all.
        2. What makes a good analogy? How can we exploit that?
    v. Sociality!
        1. People are fundamentally social.
        2. We're interacting with "someone" when we're at the computer
        3. We learn socially. Could we learn by watching the computer?
        4. The brain is just really good at social interaction (e.g. recognizing faces).

l. Dangers
    i. Too much understanding can be dangerous.
    ii. Imagine what subliminal advertising would be like if the computer were reacting "too much" subconsciously with people!