


HCI Abilities (I)

Understanding the user
- mainly perception/motion



Human Capabilities

- Why do we care? (better design!)
- Want to improve user performance

Time and effort expended to complete tasks

- Knowing the user informs the design

1. Senses
2. Information processing systems
3. Physical responding

}

}

}


input

processing

output

From the user's point of view


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What Makes a System Usable

Human considered to be a...	Usability results when the system...
Sensory processor	Fits within human limits
Interpreter/Predictor	Fits with knowledge
Actor in environment	Fits with task and social context

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Overview

I. Senses

- a. Vision
- b. Hearing
- c. Touch
- d. Smell

Part I

II. Information processing


1. Perception
2. Cognitive
 - a. Memory
 - i. Short term
 - ii. Working mem.
 - iii. Long term
 - b. Processing
 - c. Selection/attention
 - d. Learning
 - e. Problem solving
 - f. Language
3. Motor system

PART III

III. Motor system



Part II

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I. Senses

- Sight, hearing, touch important for current HCI
 - ❖ smell, taste ???
- Abilities and limitations affect design

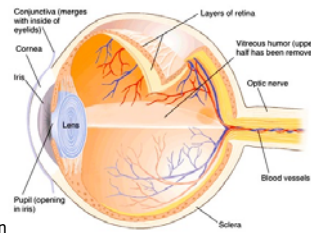



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Vision

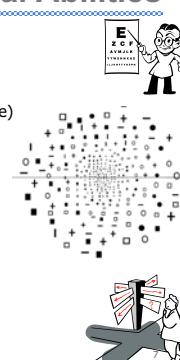
- Visual System
 - ❖ Eye
 - ❖ Retina
 - ❖ Neural pathway
 - ~ 80% of brain's operation



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Visual Abilities

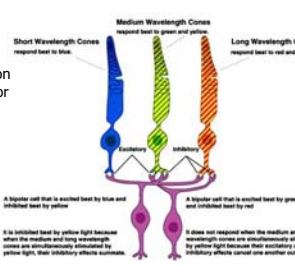
- **Sensitivity**
 - ❖ luminance: $10^{-6} \sim 10^7$ mL (see notes)
- **Acuity**
 - ❖ detection, alignment, recognition (visual angle)
 - ❖ retinal position: fovea has best acuity
 - And best color perception
- **Movement**
 - ❖ Tracking (continuous) vs. reading (saccadic)
- **Note:** Vision decreases with age
- **Implications (??)**
 - ❖ Font size & location depends on task
 - ❖ Much done by context & grouping



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Color Vision

- **Color & the retina**
 - ❖ 380 (blue) ~ 770nm (red)
 - ❖ Problems with cones or ganglion cells causes problems with color perception
 - ❖ (not really "color blindness")
 - ❖ 8% males, 0.5% females
- **Implications (??)**
 - ❖ avoid saturated colors
 - ❖ color **coding** should be **redundant** when possible



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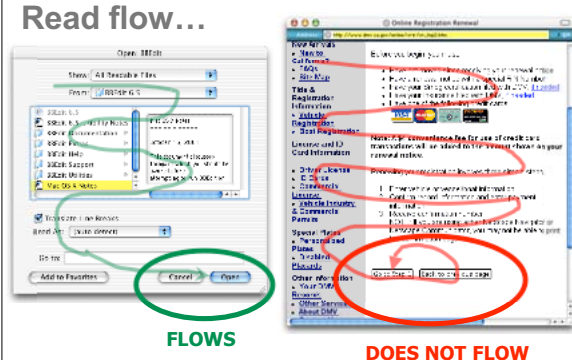
A Visual Guideline...

- **Read-flow principle:**
 - ❖ Action items (buttons, links) should support the flow of the user in the same way as reading occurs.
 - ❖ The last action should be the most-likely action to avoid backtracking.
 - ❖ Left=back, stop, quit, cancel, previous
 - ❖ Right=next, continue, submit

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Read flow...

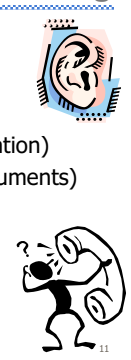


FLOWS
DOES NOT FLOW

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Hearing

- **Capabilities** (best-case scenario)
 - ❖ pitch - frequency (20 - 20,000 Hz)
 - ❖ loudness - amplitude (30 - 100dB)
 - ❖ location (5° source & stream separation)
 - ❖ timbre - type of sound (lots of instruments)
- **Implications (??)**



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Several auditory guidelines

- **Duration:** 100 ms minimum
- **Loudness:** 10-15 dB over ambient; max 90 dB
- **Onset ("attack") rate:** 1-5 dB per second; 20 ms minimum
- **Frequency:** 300 - 3000 Hz. Varies with age.
- **Levels of data in a dimension:**
 - ❖ Intensity (pure tones) 4-5
 - ❖ Frequency 4-7
 - ❖ Duration 2-3

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More auditory guidelines...


- **Appropriate spectrum**
 - ❖ Complex spectral features for warning or detection; transients for localization; simple spectrum for discrimination
- **Avoid similar frequencies**
 - ❖ (Leads to "beating", poor discrimination)
- **Use population expectancies for mappings**
 - ❖ Louder, brighter, faster, higher pitch = "more" or "up"
 - ❖ Rising pitch = "moving up" or "getting full"
 - ❖ Major key, bright spectrum = "happy" or "good"

Note: Make sure you know which population stereotypes apply (e.g., sighted vs. blind listeners)

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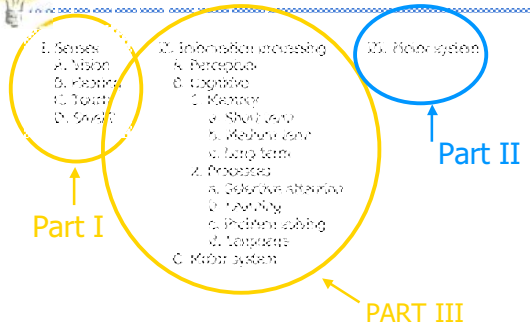
Touch

- **Three main sensations handled by different types of receptors:**
 - ❖ Pressure (normal)
 - ❖ Intense pressure (heat/pain)
 - ❖ Temperature (hot/cold)
- **Sensitivity, Dexterity, Flexibility, Speed**
- **Where important?**
 - ❖ Mouse, Other I/O, VR, surgery



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- I. Senses
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 - b. Hearing
 - c. Touch
 - d. Smell
- II. Information processing
 - k. Perception
 - l. Cognitive
 - 1. Memory
 - a. Short term
 - b. Medium term
 - c. Long term
 - 2. Processes
 - a. Selective attention
 - b. Learning
 - c. Problem solving
 - d. Language
 - C. Motor system
- III. Motor system

Part I, Part II, PART III

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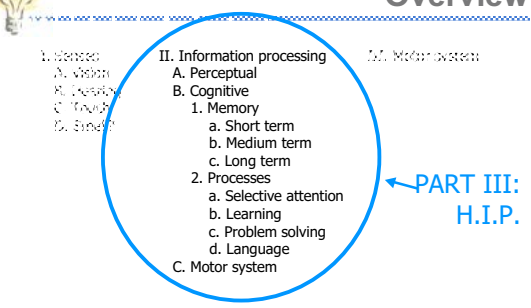
III. Motor System

- **Capabilities**
 - ❖ Range of movement, reach, speed, strength, dexterity, accuracy
- **Often cause of errors**
 - ❖ Wrong button
 - ❖ Double-click vs. single click
- **Principles**
 - ❖ Feedback is important
 - ❖ Minimize eye movement



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Overview



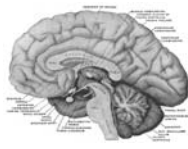
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PART III: H.I.P.

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Memory

- **Four "types" and functions**
 - ❖ **Perceptual "buffers"**
 - Orientation of eye movements
 - ❖ **Short-term memory**
 - Organization of conscious thought, calculations
 - ❖ **Intermediate**
 - Storing intermediate results, future plans
 - ❖ **Long-term**
 - Personal knowledge & autobiography



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Perceptual Store

- Visual and auditory "subliminal" memory
 - ❖ visuospatial sketchpad, phonological loop
- Very brief, but *veridical* representation of what was perceived
 - ❖ Details decay quickly (~.5 sec)
 - ❖ Rehearsal prevents decay
 - ❖ Another task prevents rehearsal
- Uses include
 - ❖ word recognition during reading
 - ❖ use of syntax/morphology/prosody during speech understanding

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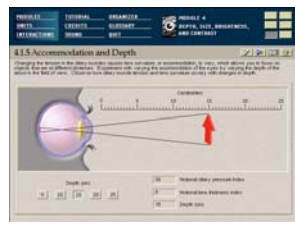
Short-term memory

- STM has a limited capacity
 - ❖ Uses "chunks": 4 ± 5 units (not 7 ± 2 !)
 - ❖ Chunking requires *long-term* knowledge
- Display format should match memory subsystem used to perform task
 - ❖ E.g. auditory confusions can be common with words/letters
- New information can interfere with old information
 - ❖ Retroactive interference
 - New information can't displace old information
 - ❖ Proactive interference (more common)
 - Old information is displaced by new

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HCI Guideline: Flow vs. chunking

- Continuous vs. Discrete data -- match display to content type
 - ❖ Does data "flow" or is it displayed in "chunks"?
 - (the interface needs to reflect the appropriate interaction style)

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Long-term Memory

- Seemingly permanent & unlimited
 - ❖ Access is harder, slower (Activity helps)
- Episodic memory
 - ❖ Events & experiences in serial form
 - Helps us recall what occurred
- Semantic memory
 - ❖ Structured record of facts, concepts & skills
 - One theory says it's like a network
 - Another uses frames & scripts (like record structs)
 - ❖ Skills include memorization, so metamemory is a form of strategic memory
 - Where *could* I have left those keys?

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Memory Characteristics

- Things move from STM to LTM by use
 - ❖ (1) rehearsal & practice
 - ❖ (2) use in context

Unclear if we ever really forget something

↑

➤ We "forget" things due to decay and interference

↓

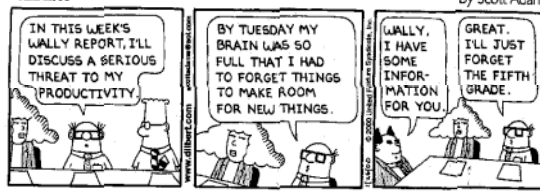
Similar gets in way of old

Lack of use

↑

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Forgetting as *interference*



By Scott Adams

...buffer overflow!


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Cognitive Processing

- Four main processes of cognitive system:
 - ❖ Selective Attention
 - Task switching and focus
 - ❖ Learning
 - Skill acquisition and conceptual knowledge
 - ❖ Problem Solving
 - Convergent (structured) and divergent
 - ❖ Language
 - Understanding and production
 - Phonology, syntax, semantics and pragmatics


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Selective Attention

- We can focus on one "thing" at a time
 - ❖ Cocktail party conversations
- "Things" attended to are visual or auditory streams
 - ❖ Streams form after a few seconds
- Salient visual/auditory cues facilitate attention switching
 - ❖ Examples
 - Boldface, blinking and beeping
 - ❖ Undesired facilitation = distraction

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Learning

<ul style="list-style-type: none"> ➤ Procedural Learning <ul style="list-style-type: none"> ❖ How to <i>do</i> something <ul style="list-style-type: none"> • Knowing <i>how</i> ❖ Tacit or implicit knowledge ❖ Involves <ul style="list-style-type: none"> • Acquiring motor and cognitive skills • Automatization 	<ul style="list-style-type: none"> ➤ Declarative Learning <ul style="list-style-type: none"> ❖ Facts <i>about</i> something <ul style="list-style-type: none"> • Knowing <i>that</i> ❖ (Mainly) explicit knowledge ❖ Involves <ul style="list-style-type: none"> • Memorization • Understanding concepts & rules
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expertise as chunking


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Facilitating Learning

<ul style="list-style-type: none"> ➤ Using structure <ul style="list-style-type: none"> ❖ Analogy <ul style="list-style-type: none"> • Common structure w.r.t. existing knowledge. • Use user's previous knowledge in interface ❖ By structure & organization <ul style="list-style-type: none"> • Structural cues as cognitive affordances • Make (expected) mental model visible in interface 	<ul style="list-style-type: none"> ➤ Over time <ul style="list-style-type: none"> ❖ Repetition <ul style="list-style-type: none"> • Practice makes perfect (automatization) • But practice can make imperfect (hard to unlearn poor skills) ❖ Presented in incremental units <ul style="list-style-type: none"> • Gradual introduction • Previously learned features "scaffold" new • E.g. "training wheels" interfaces
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Learning: Observations

- Users focus on getting task done, not learning to use system effectively
 - ❖ But power tools enable many users to learn the task itself for the first time (e.g. desktop publishing)
- Users apply analogy even when it doesn't apply
 - ❖ Beware the unintended metaphor
 - ❖ Theory that *all* conceptual thinking is metaphorical/analogical
 - Lakoff & Johnson
 - Fauconnier & Turner


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Problem Solving

- Storage in LTM, then application
 - ❖ Knowledge used *in* problem solving
 - ❖ Knowledge *of* problem-solving skills
- Reasoning
 - ❖ Deductive
 - Inference from concepts to facts
 - All men are mortal, Socrates is a man, so Socrates is mortal.
 - ❖ Inductive
 - Generalizing from facts to concepts
 - Socrates is a man, Socrates is mortal (and so are Plato, Aristotle, et al.), so I guess all men are mortal
 - ❖ Abductive
 - Reasoning from a fact back to the action or state that caused it
 - All men are mortal, Socrates is mortal, so Socrates is probably a man


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Problem Solving: Observations

- People adopt problem-solving heuristics
 - ❖ Use rules of thumb rather than algorithms
 - ❖ *Bounded rationality* (Simon): Resources are not available for algorithmic solution
 - ❖ It's better to have a workable but incorrect solution than the correct solution that comes too late
- People often choose suboptimal strategies, esp. for low priority problems
 - ❖ Try a few plausible shots and choose the best
 - ❖ *Satisficing* (Simon): The best is the enemy of the good enough
- People learn better strategies with practice
 - ❖ But these are generally domain-specific


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Implications

- Allow flexible shortcuts
 - ❖ Forcing plans will bore user
- Have active rather than passive help
 - ❖ Recognize waste


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Language

- Language is mainly rule-based with learned facts for the many irregular cases
 - ❖ E.g. How do you make plurals?
 - ❖ Syntax is both word/morpheme-based and position-based
 - Word order is widely used in artificial languages
 - Inflection and prepositions/particles are not used much
- Open questions:
 - ❖ When should systems have natural language interfaces, given that artificial NLP is *brittle*?
 - ❖ Should artificial command languages mimic natural language ordering?
 - Is it "chmod a+r foo.dat" or "chmod foo.dat a+r"?

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Observations: H.I.P.

<ul style="list-style-type: none"> ➤ <u>People: abilities</u> <ul style="list-style-type: none"> ❖ Effectively unbounded LTM ❖ Long LTM duration & high organizational complexity ❖ Very effective unsupervised learners ❖ Flexible attention switching ❖ Powerful pattern recognition 	<ul style="list-style-type: none"> ➤ <u>People: limitations</u> <ul style="list-style-type: none"> ❖ Limited capacity STM ❖ Limited duration STM ❖ Unreliable access to LTM ❖ Error-prone and distractible ❖ Very, very slow!
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**Computer is opposite!
Allow one who does it
best to do it!
(Function allocation)**

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