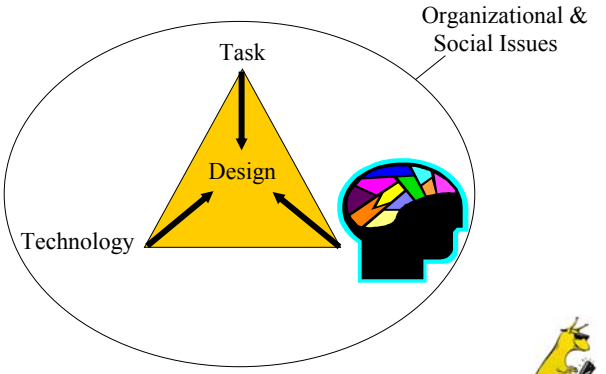
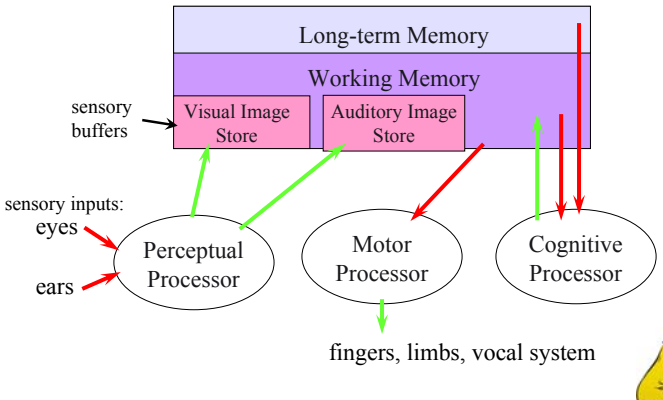
HCI Foundations: Human



1. Model Human Processor (MHP)

- Card, Moran & Newell: *The Psychology of HCI* (1983)
- Based on years of basic psychology experiments found in the literature
- Models the information processes of a user interacting with a computer
  - Most likely serial in action & parallel in recognition
  - Skilled performance differs from novice performance
- Enables calculations to be made of how long a user will take to carry out a task
- Three interacting subsystems
  - Perceptual, motor, cognitive
  - Each with its own processor, components, memory
- Focus on a single user interacting with some entity
  - Neglects effect of other people

1. MHP Diagram



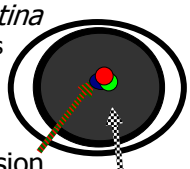
2 Senses

2.1 Vision
2.2 Audition
2.3 Haptic/motor

Additional reading:
http://www.hhmi.org/senses/

2.1 Vision: the eyes

- Lens focuses light to the *retina*
  - Light passes through the lens
  - Focused on the retina
  - Rod cells (periphery)
  - Cone cells (fovea)



- Central 1-2° gives *foveal* vision
- Remaining 180° gives *peripheral* vision
- Cone cells
  - Detect color and hi-res images
  - X-ganglia (wires from the cell to the brain) provide early pattern detection.
- Rod cells
  - Good for low levels of luminance
  - Y-ganglia permit early movement detection
  - Sense shades of grey but can't detect colors.

Add: How we see the world

2.1.1. Visual disability

- Normal: 20/20: the ability to read letters of a certain size (the norm for one's age) from the eye chart placed 20' away
- 20/40 = You need twice the size to read at 20'
- Registered blind = 20/200
- At least 1.5M blind and visually impaired Americans use computers
- Only 10% blind people read Braille
- The most common AT: screen magnifier/reader


Myopia (short-sighted) Hypermetropia (far-sighted)

Cataracts

Glaucoma

2.1.1. Visual disability

Color Blindness

- *8-10% male and 0.5% female populations experience some form of color deficiency*
- Protanope
  - 1% males, "red-weakness"
- Deuteranope
  - 5% males, "green-weakness"
- Tritanope
  - blue/yellow deficit

Ageing-related

- Macular Degeneration

- Retinopathy (mostly caused by diabetes)

2.1.1 Visual Disability

Normal vision

Protanope

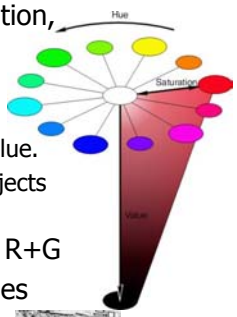
Simulated using Vischek (http://www.vischeck.com/vischeck/vischeckURL.php)

Deuteranope

Tritanope

2.1.2. Vision: color

- Cone cells detect color (hue, saturation, value) through photo-pigments.
  - mainly reds (64%) & very few blues (4%).
  - Center of retina (high acuity) has no blue.
  - Means disappearance of small blue objects you fixate on.
- Brightness is determined mainly by R+G
- Shapes are detected by finding edges
  - combine brightness & color differences for sharpness
  - harder to deal w/ blue edges & blue shapes



2.1.2 Vision: color

- Different wavelengths of light focused at different distances behind eye's lens
  - need for constant refocusing → fatigue
  - be careful about color combinations
- More saturated colors = more focusing
  - don't use saturated colors in UIs unless you really need something to stand out (warning)
  - pastel colors are cleaner
- Stereoscopic vision (slightly different image to each eye) gives excellent depth perception
- Color picker: http://www.visibone.com/colorlab/

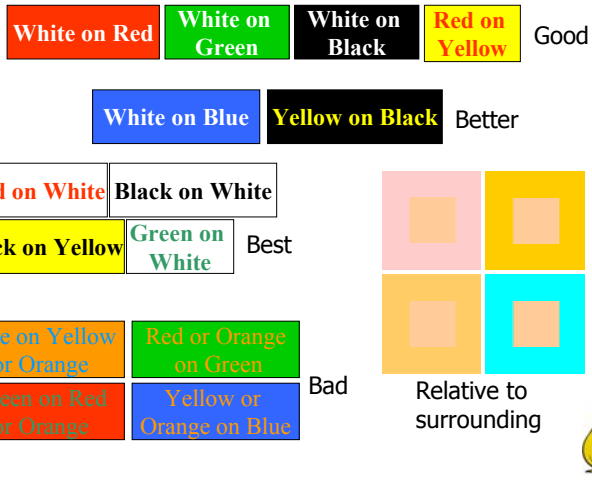
2.1.3. Designing with color

- Before designing with colors, ask:
  - Does color add something that cannot be provided by black and white?
  - Is the chosen color appropriate for the text or object?
  - Does the color provide cues to improve understanding or memory?
  - Are there any visual problems that may make the information less legible (dyslexia, color blindness, aging)?
- On-screen color varies widely from device to device for two reasons
  - Device calibration (gamma setting, 1.8 for PC, 2.2 for Mac)
  - Inability to display certain color (color replacement)

2.1.3. Designing with color

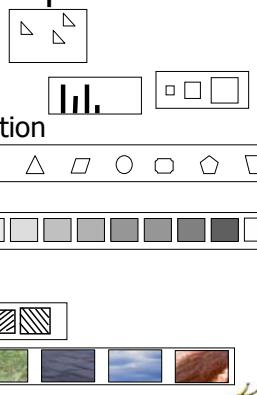
- http://websitetips.com/colortools/sitepro/
- Use contrast for structure & hierarchy
- Color palettes
  - Monochromatic
  - Complementary
  - Analogous

2.1.3. Designing with color

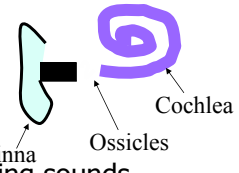


2.1.4 What are the options?

- position
  - changes in the x, y (z) location
- size
  - change in length, area or repetition
- shape
  - infinite number of shapes
- value
  - changes from light to dark
- orientation
  - changes in alignment
- texture
  - variation in pattern
- motion



2.2 Audition (hearing)



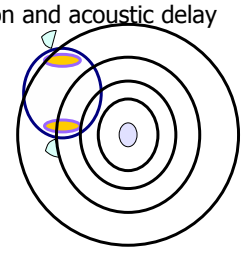
- Receiving vibrations and perceiving sounds
  - Outer ear protects inner/middle ear and amplifies sound
  - Middle ear transmits sound waves as vibrations to inner ear
  - Pinna → canal → ear drum → ossicles (amplifier) → cochlea (detection)
- Conduction deficit: Impairment in transfer of sound through outer and middle ear
- Neural deafness: Impairment in the neural transmission of sound

2.2.1 Auditory Characteristics

- Pitch
  - 20Hz – 15KHz frequency
  - Human is less accurate in distinguishing high frequencies than low ones
  - Tuned to 3KHz by shape of outer ear
- Timbre
  - 'signature' of sound source
  - complex set of resonance overlaying the fundamental frequency
- Amplitude and loudness
  - *Loudness* is a psychological property of sound
  - Our ears are capable to cope with 0 to 160db (pain at 130db!)

2.2.2 Auditory characteristics

- Sound filtering
  - Can attend to sounds over background noise
  - E.g. the cocktail party phenomenon
- Location
  - Horizontal plane
  - Pinnae separation and acoustic delay

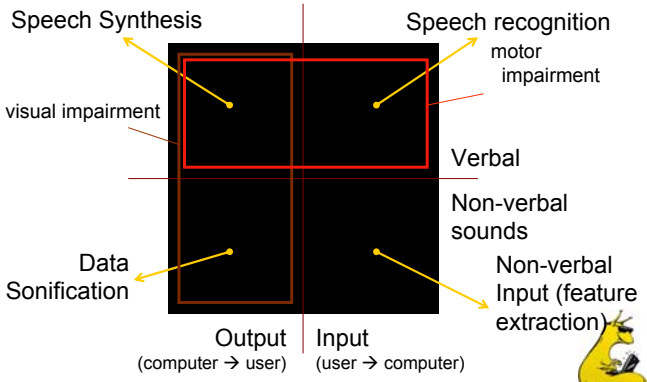


2.2.3 Auditory Impairment

- Marginal, mild, and moderate losses: 2-60 dB loss
- Profoundly impaired/deaf: 60-75 decibel loss in hearing capacity in the better ear
- Causes: 50-75 percent prenatal
  10-20 percent perinatal (rubella)
  20-30 percent postnatal (aging)

- Presbyacusis: aging-related progressive hearing loss of higher frequency, more common in men
  - Check mosquito ringtone → annoying for under 30
- Noise-induced hearing loss (NIHL): results from exposure to high-intensity sounds, over a long period of time

2.2.4 Designing with Sounds



2.2.4 Designing with Sounds

- Earcons
  - Synthetic sounds used to convey information
  - Structured combinations of notes (motives) represent actions and objects

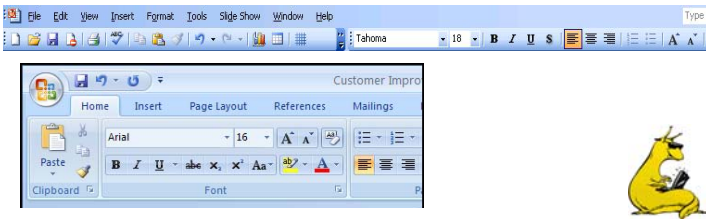
- Auditory icons
  - Natural sounds with associated semantics which can be mapped onto similar meanings in the interaction
    e.g. throwing something away
    ~ the sound of smashing glass

2.3.1 Haptics (touch)

- Receiving thermomechanical forces and perceiving physical properties of things
- Three kinds of *cutaneous* receptor (skin)
  - Thermoreceptors (temperature)
  - Mechanoreceptors (pressure)
  - Nocioceptors (pain)
- Kinaesthetic sense - body pose
  - Two kinds of *proprioceptor* in joints
- Reaction times depend on fitness
  - Practice improves
  - Deteriorate with age

2.3.2 Motor subsystem: Fitts' Law

- Fitts' Law predicts that the time to point at an object using a device is a function of the distance from the target object & the object's size.
- The further away & the smaller the object, the longer the time to click on it.
- Fitts' Law is useful for designing systems for which the time to click on an object is important



2.3.2 Motor subsystem

- Fitts' Law $MT = a + b \log_2\left(\frac{2A}{W} + c\right)$
  - *MT* is the movement time
  - *a* and *b* are empirically determined constants, that are device dependent.
  - c is a constant of 0, 0.5 or 1
  - *A* is the distance of movement from start to target centre
  - *W* is the width of the target, which corresponds to "accuracy"
  - It has an assumption that the most time used is for homing (i.e. better to locate objects on the edges of the screen even if it's further)
  - BUT, only accounts for *direct line* movements

2.3.3. Motor Impairment

- Paralysis – usually due to spinal injury, the higher the damage the greater the degree of paralysis
  - tetraplegia/quadriplegia – all four limbs
  - paraplegia – lower limbs only
- Lack of strength (aging = reduced grip strength)
- Tremor/lack of accuracy (Parkinson's disease)
- Slowness (age-related)
- Cerebral palsies: a group of disorders in the development of postural control and mobility
- Some input devices to address motor impairment:
  - HMD and eye-trackers
  - Blow-suck tube, tongue joystick
  - Voice recognition systems
  - Sticky keys, slow keys, gravity well

3 Cognition

3.1 Why study cognition

3.2. Attention, memory and problem solving

3.3 Cognitive impairment

3.1 Why study cognition?

- Interacting with technology is cognitive
- We need to take into account cognitive processes involved and cognitive limitations of users
- We can provide knowledge about what users can and cannot be expected to do
- Identify and explain the nature and causes of problems users encounter
- Supply theories, modelling tools, guidance and methods that can lead to the design of better interactive products

3.1. Core cognitive aspects

- Attention
- Perception and recognition
- Memory
- Reading, speaking and listening
- Problem-solving, planning, reasoning and decision-making, learning
- Most relevant to HCI are attention, perception and recognition, and memory

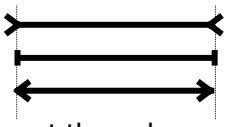
3.2.1 Attention

- Selecting things to concentrate on at a point in time from the mass of stimuli around us
- Two states:
  - Focused attention: ability to attend to stimulus in presence of distracters
  - Divided attention: ability to attend simultaneously to lots of things
- Driven by meaning and by change
  - Voluntary: Examine an object, directing gaze etc.
  - Captured by salience and grouping: spatial, intensity, color, size, timbre, pitch, *convention*
  - Involuntary *capture* and movement: Perceptual filters "trigger" attention capture (cocktail party effect, buzzing light)

3.2.1 Designing for attention

- Make things salient: use colour, larger font, white space, underlining, animation, noises
- Presenting supporting information that is relevant to goal (google's advertisement)

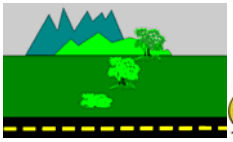
3.2.2 Sensation and Perception



- Sensation = sensing our environment through touch, taste, sight, sound, and smell
- Perception = the way we interpret these sensations and therefore make sense of everything around us

3.2.2 Perception: "knowing"

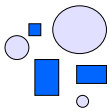
- Gestalt psychology
  - Perceptions are formed by grouping of stimuli based on prior knowledge
- Object constancy
  - When landing, you just "know" that the houses are real
- Depth perception
  - Motion parallax, interposition, perspective

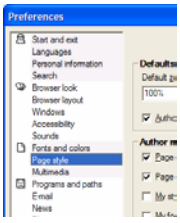


3.2.2: Gestalt Psychology – Law of Perceptual Organization

1) Proximity (grouping)

2) Similarity (color/shape)

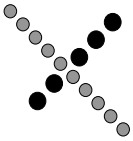




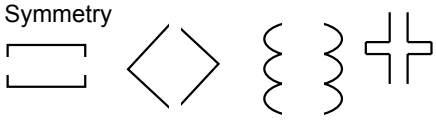
3) Closure

3.2.2: Gestalt Psychology – Law of Perceptual Organization

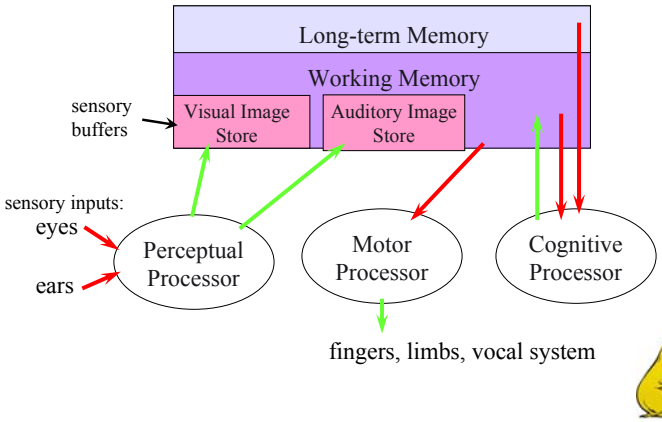
4) Continuity



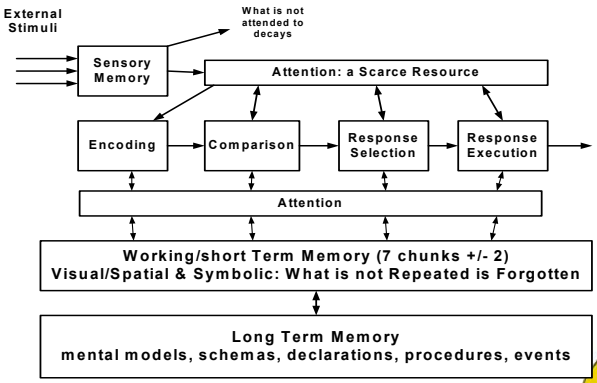
5) Symmetry



1. MHP Diagram



Human Information Processing Model



3.2.3. Sensory buffers/memory

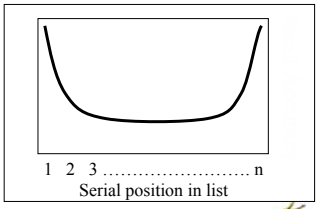
- Very brief, but accurate representation of what was perceived
  - Details decay quickly (70 - 1000 ms visual; 0.9 - 3.5 s auditory)
  - Limited capacity (7 - 17 letters visual; 4 - 6 auditory)

3.2.3 Short-term memory

- Dynamics
  - Decay 5-226 sec, rehearsal prevents decay, interference speeds up decay
  - Rapid access
- Serves as "working memory"
  - Permits combination of sensory and memory information

3.2.3 Short-term memory

- Limited capacity
  - 7 ± 2 chunks (Miller) – often misinterpreted
  - A chunk is a meaningful grouping of information – allows assistance from LTM (individual differences)
- Early and late best
- Applies to 'raw' content (strategies & meaning affect memory)
- Can you memorize these?
  - HEC ATR ANU PTH ETR EET
  - 746335892147530
- Easier when grouped
  - THE CAT RAN UP THE TREE
  - 746 335 892 147 530



3.2.4 Long-term memory

- The sum of all we know
  - Slow access (100ms to days) – tip-of-the-tongue
  - Limitless capacity, stable content
- "facts" (knowing that)
  - Cows have four legs, red is a color
- Skills (knowing how)
  - Cook rice or drive a car
- Stories or episodes
  - Personal, history, fictitious

3.2.4 Long-term memory

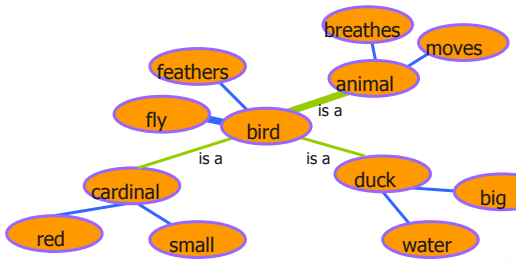
- Semantic memory
  - Memory for meaning
    - Facts and skills
  - Relationships between things
    - Conceptual connections
    - Massively distributed networks
- Built up by association
  - Experience and exposure

3.2.4 Long-term memory

- More connections:
  - more "anchors" for new learning
  - more "routes" for recall
- "Hebbian learning" to strengthen neural links → how neuronal connections are enforced in mammalian brains
  - Simultaneous activation of neural pathways
  - Intermittent coactivation (exposure) most effective

3.2.4 Long-term memory

- Link strength
  - Affects ease of access
  - Function of usage frequency



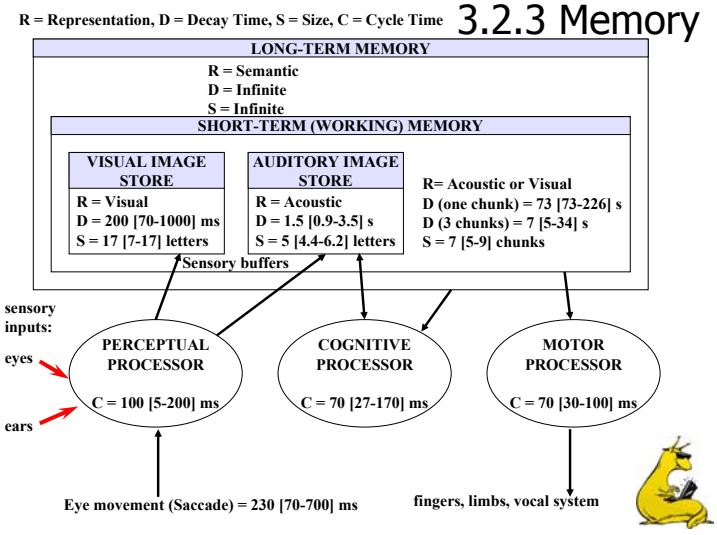
3.2.4 Long-term memory

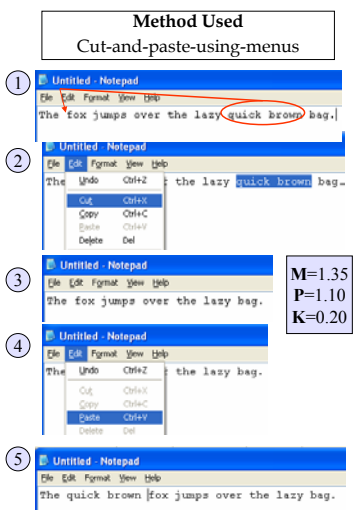
- Scripts and frames for concepts
  - Typical sequences of events
  - Part of semantic memory, used by episodic memory
- Episodic memory
  - Story memory
  - Reconstruction rather than replay
    - Built on 'key events'
    - Filling in the gaps

3.2.4 Long-term memory

- Forgetting
  - Destruction or inaccessibility?
    - Both e.g. concussion and stroke damage
  - Interference
    - Not "running out of space"
    - Referential confusion and masking
  - Lack of use
    - Connections partially overwritten
    - They possibly last forever!

3.2.3 Memory

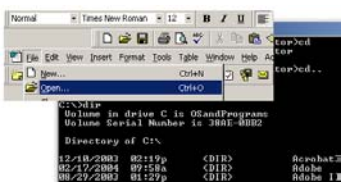




Description	Opr	Dur (s)
Mentally Prepare	M	1.35
Move cursor to "quick"	P	1.10
Double-click mouse button	K	0.40
Move cursor to "brown"	P	1.10
Shift-click mouse button	K	0.40
Mentally Prepare	M	1.35
Move cursor to Edit menu	P	1.10
Click mouse button	K	0.20
Move cursor to Cut menu	P	1.10
Click mouse button	K	0.20
Mentally Prepare	M	1.35
Move cursor to before "fox"	P	1.10
Click mouse button	K	0.20
Mentally Prepare	M	1.35
Move cursor to Edit menu	P	1.10
Click mouse button	K	0.20
Move cursor to Paste menu item	P	1.10
Click mouse button	K	0.20
TOTAL PREDICTED TIME		14.90

3.2.5. Designing for Memory

- Recall
  - info reproduced from memory
- Recognition
  - presentation of info provides knowledge that info has been seen before
  - easier because of cues to retrieval
- We want to design UIs that rely on recognition!



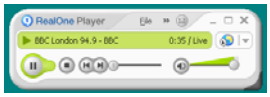
3.2.6 Reasoning

- *Usage* of domains of knowledge and understanding
  - Within domains
    - Familiar structures (an individual's scripts again)
    - Common concepts
  - Application of (pseudo)logic
    - Combination of rules and experience
    - Rationality within sets of knowledge

3.2.6 Reasoning

- Deduction
  - Derive logical conclusion from given premises
    - Vegetables are healthy, potatoes are vegetables, chips are potatoes → chips are healthy.
- Induction
  - Generalisation from instances
    - The swans (I've seen) are white → Swans are white
- Abduction
  - Reasoning from event to cause
    - When Sam is drunk, he drives fast. Sam passes my car with 90 mph → he is drunk.

3.2.7 Designing for reasoning



- Affordance: the properties that things (are perceived to) have and how these relate to how the things could be used
- Metaphor: describing a first object as being or equal to a second object in some way
- Mapping: the set of possible relations between objects

Southwest Airlines Home Gate

3.2.8 Mental model

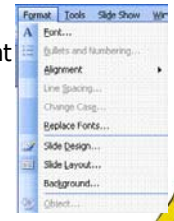
- A person's understanding of the world
  - Partial, informal, unstable
- Properties, interactions, forces, effects
  - E.g. cooking with a gas oven, way a can opener works
- Forged by experience
  - Trial and *error*
  - Consistent with model = believe in model
- Deep versus shallow models (e.g. how to drive a car and how it works)

Case 1: You arrive home hungry, frozen pizza instruction says heat in 350F oven. Set oven to max to speed up?

Case 2: In desperate need hot shower, open tap to the max to speed up hot water?

3.2.9 Designing for mental model

- People have preconceived models that you may not be able to change – so adapt
  - Disconnecting = pulling the wire out, not eject
- Interface must communicate model
  - Help/documentation to communicate your model
  - Visually – make things visible
  - Constraint – restrict what is irrelevant



3.2.10 Error

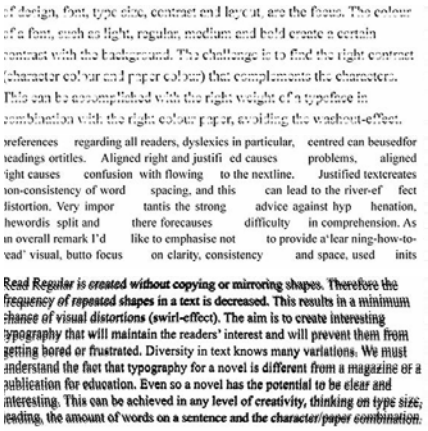
- There are two types of error
  - Mistakes
    - Wrong intention caused by "wrong" model
  - Action slips
    - Right intention but failed to do it right
- We should design to minimize error

Mac OS X

3.3. Cognitive impairments

- Speech and language disorders
  - Receptive: Do not respond as they should to familiar names, questions, or directions
  - Expressive: Have spoken language skills far below their peers
  - Articulation disorders: Disorders of precision, clarity, and accuracy of speech sounds
- Learning disabilities
  - Disorders of reading, spelling, writing, and mathematics
  - Dyslexia: Umbrella term for reading disabilities (includes letter reversal, sound retrieval and production in the written word, and word misusage)

3.3.1. More on Dyslexia



of design, font, type size, contrast and layout, are the frame. The colour of a font, such as light, regular, medium and bold create a certain contrast with the background. The challenge is to find the right contrast (character colour and paper colour) that complements the characters. This can be accomplished with the right weight of a typeface in combination with the right colour paper, avoiding the washout-effect.

preferences regarding all readers, dyslexics in particular, centred can beusedfor readings ortitles. Aligned right and justifi ed causes problems, aligned right causes confusion with flowing to the nextline. Justified textcreates non-consistency of word spacing, and this can lead to the river-ef fect distortion. Very impor tantis the strong advice against hyp henation, hewordis split and there forecauses difficulty in comprehension. As an overall remark I'd like to emphasise not to provide a'lear ning-how-to-read' visual, butto focus on clarity, consistency and space, used inits

Read Regular is created without copying or mirroring shapes. Therefore the frequency of repeated shapes in a text is decreased. This results in a minimum chance of visual distortions (swirl-effect). The aim is to create interesting typography that will maintain the readers' interest and will prevent them from getting bored or frustrated. Diversity in text knows many variations. We must understand the fact that typography for a novel is different from a magazine or a publication for education. Even so a novel has the potential to be clear and interesting. This can be achieved in any level of creativity, thinking on type size, leading, the amount of words on a sentence and the character/paper combination.

Washout effect

River effect

Swirl effect

Summary

- A well-designed interface/interaction supports:
  - User's mental model
    - of the underlying behavior of the device
  - Mapping: makes the relationship obvious between
    - the actual action of the device and
    - the action of the user
  - Affordances
    - makes each operation visible
  - Recognition rather than recall
    - users don't need to remember everything