Understanding Impairment

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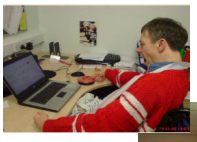
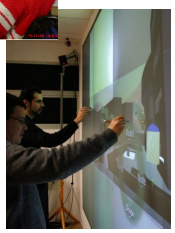
University of Cambridge

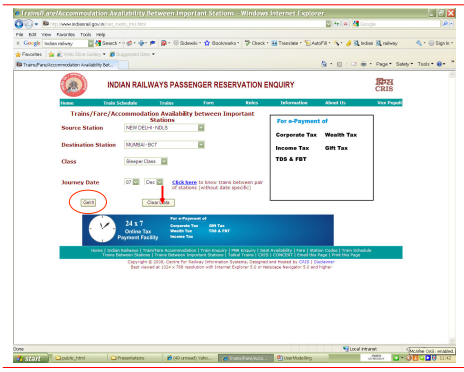
- 800 years old
- 31 Colleges
- 150 departments, faculties, schools and other institutions
- Total Students: 18,306
- Total staff: 9,140
- 89 Nobel Prizes

What we get





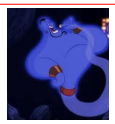
What we get – usability evaluation



Users

Vision

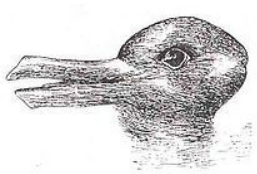
Cognition

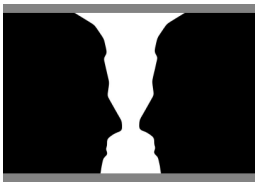


Hearing

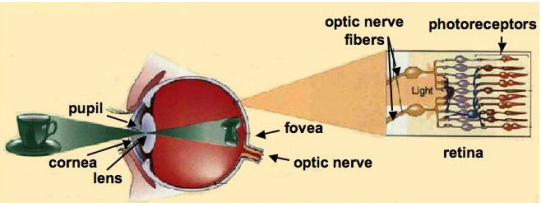
Motor action

Vision





Eye

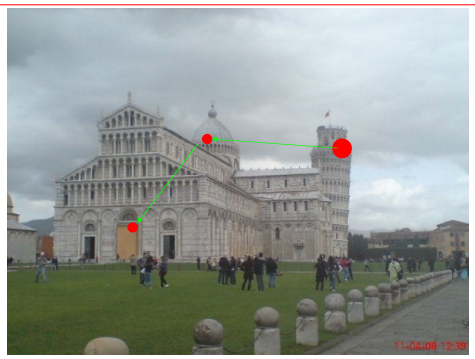


Principle of Vision

- Top down theory: You perceive what you want to
- Bottom up theory: You decompose & reconstruct
- Visual Search
  - –Serial (search time ∞ number of items)

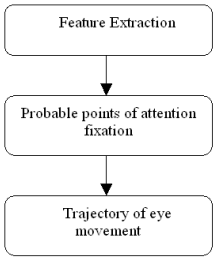
  - –Parallel (pop out effect)

Basic Strategy



Recording from an eye tracker

Modelling Vision

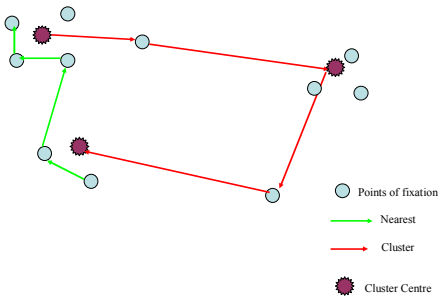


Spotlight metaphor of attention

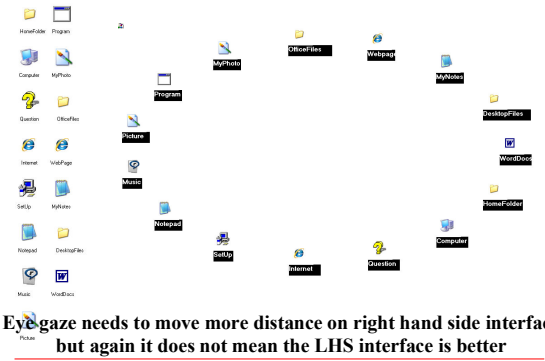
Icon design

Right hand side icons are more distinctive, but not necessarily 'better'

Eye Movement Strategies



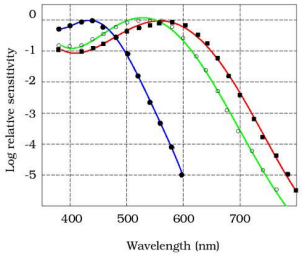
Eye movement in interfaces



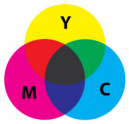
Eye gaze needs to move more distance on right hand side interface but again it does not mean the LHS interface is better

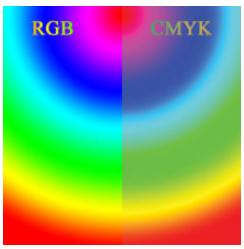
Colour vision

Cone spectral sensitivities



Colour in computers and printers





Colour blindness

Original Image **Protanopia** **Deuteranopia**

Ishihara test

Plate 16

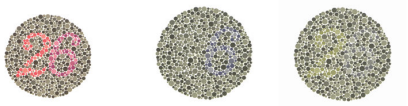
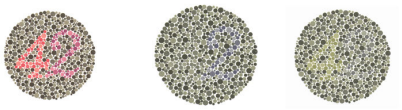


Plate 17

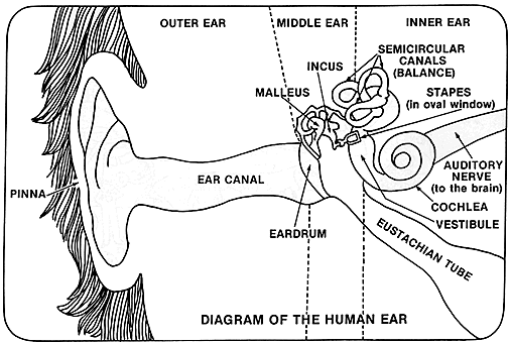


Designers' points

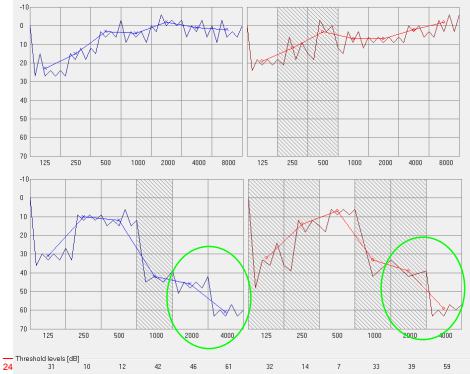
- Keep similar interface items together
- Use distinctive symbols but keeping in mind consistency
- Remember how a colour will be rendered, considering colour blind users
- Remember top down theory, means users' expectation from an interface

Hearing

Ear



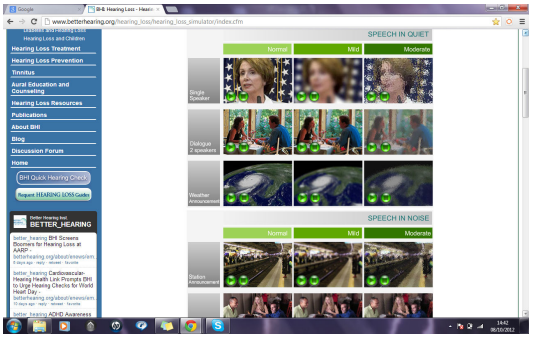
Audiogram



Hearing impaired users

- Difficult to listen soft sound
- Loud sound may seem louder (Loudness recruitment)
- Reduced response to spectral contrast (like blurring of an image)

Hearing impairment examples

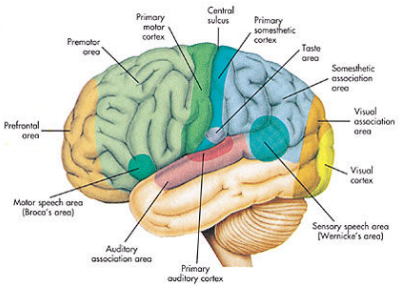


Designers' points

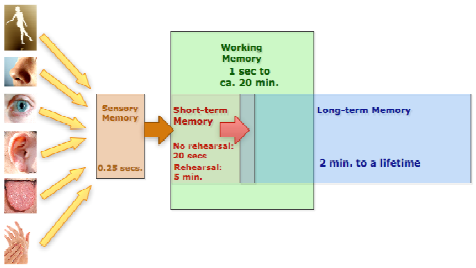
- Increasing volume cannot solve the problem
- Background noise and music may reduce audibility
- Certain words or syllabi have higher chances to be confused, which should be taken care of during designing audio based dialog system

Cognition

Brain



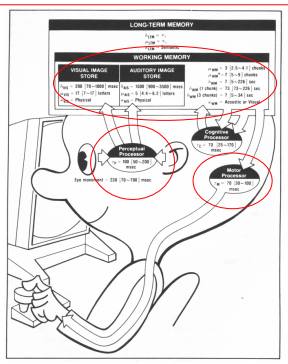
Memory



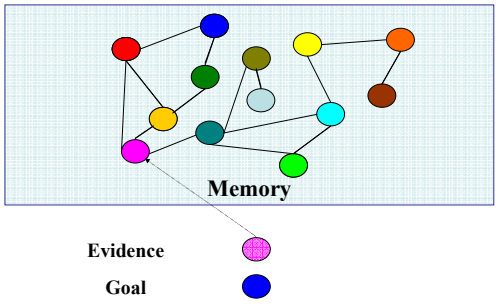
Time scale of action

TIME SCALE OF HUMAN ACTION		
SCALE (sec)	SYSTEM	STRATUM
10^{7} 10^{6} 10^{5}		SOCIAL
10^{4} 10^{3} 10^{2}	Task Task Task	RATIONAL
10^{1} 10^{0} 10^{-1}	Unit Task Operations Deliberate Act	COGNITIVE
10^{-2} 10^{-3} 10^{-4}	Neural Circuit Neuron Organelle	BIOLOGICAL

Model Human Processor



Memory retrieval



A node with more connections will be retrieved quicker and with higher probability of retrieval

Errors

Table 8.2 A catalogue of errors

Skill-based performance	
Inattention	Overattention
Double-capture slips	Omissions
Omissions following interruptions	Repetitions
Reduced intentionality	Reversals
Perceptual confusions	
Interference errors	

Rule-based performance	
Misapplication of good rules	*Application of bad rules*
First exceptions	Encoding deficiencies
Countersigns and nonsigns	Action deficiencies
Informational overload	Wrong rules
Rule strength	Inelegant rules
General rules	Inadvisable rules
Redundancy	
Rigidity	

Knowledge-based performance

Selectivity
Workspace limitations
Out of sight out of mind
Confirmation bias
Overconfidence
Biased reviewing
Illusory correlation
Halo effects
Problems with causality
Problems with complexity
Problems with delayed feedback
Insufficient consideration of processes in time
Difficulties with exponential developments
Thinking in causal series not causal nets
Thematic vagabonding
Encysting

Source: Based on Reason, 1990

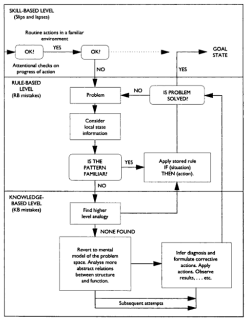


Figure 8.3 The Generic Error Modelling System (GEMS). (Based on figure 3.1, Reason, 1990)

Designers' points

- More connections → Easy retrieval
  - –Try to make interface elements familiar to users
  - –Use analogy to users' known objects, actions
- Identify and categorize prospective errors by end users
- Think about short term / working memory load while designing an interface
  - –Restrict amount of items in a single screen

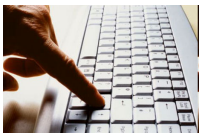
Motor action

Rapid Aiming Movements

Quick

Accurate

Preprogrammed



Woodworth's study

Eye open – visual feedback

Error ∝ Speed

Eye close – no visual feedback

Accuracy does not depend on Speed

Two phases of movement

- Initial impulse
- Current control

Fitts' Law

264

$$T = a + b\log_2\left(1 + \frac{D}{W}\right)$$

PAUL M. FITTS

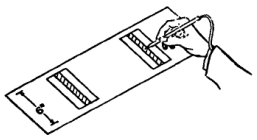


Figure 1. Reciprocal tapping apparatus. The task was to hit the center plate in each group alternately without touching either side (error) plate.

Applications

- Moving cursor in a screen using mouse or joystick
- Transferring pegs into hole
- Aiming movement under water
- Manipulating objects under a microscope

Computer input device

Card's first home run came when he used a then-little-known law called "Fitts' law" to examine input devices such as joy sticks, a head-motion detector, and a newfangled controller that hung by a cable from the computer called a "mouse." Fitts' law analyzes how easily a human can hit any given target - in this case, moving a cursor to a specific point on a screen - and Card measured the mouse to be almost as simple as if one could move the cursor around on the screen with one's hand. After Card's work, Xerox began manufacturing mice, Apple soon followed, and now they're practically de rigueur

Motor impaired users

Fitts' Law

Smits-Engelsman [2007]

Gajos [2007]

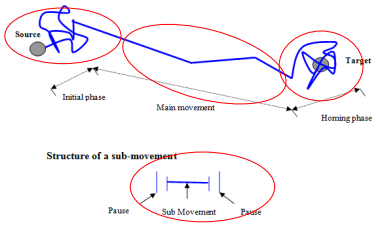
Bravo [1993]

Gump [2002]

Trewin and Pain, 1999
Keates, Clarkson and Robinson, 2000
Keates and Trewin, 2005
Keates, Trewin and Paradise, 2005

Hand strength

Model



Linear regression model predicts number of sub-movements and movement time in each phase

Designers' points

- It takes more time to point if
  - Target is away from source
  - Target is small in size
- Movement occurs in multiple sub-movements
- Sub movements in homing phase may be random due to physical or situational impairment
  - Increase inter-button spacing to avoid wrong selection

Take away points

- Understanding users
- Understanding impairments
- Design strategies to address
  - Visual
  - Hearing
  - Cognitive and
  - Motor impairment