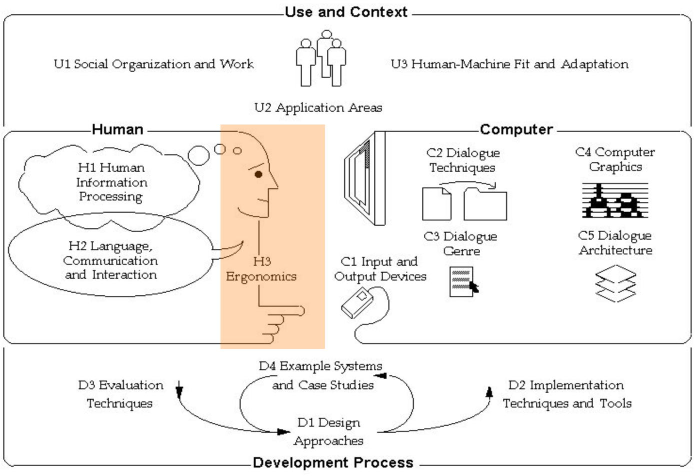
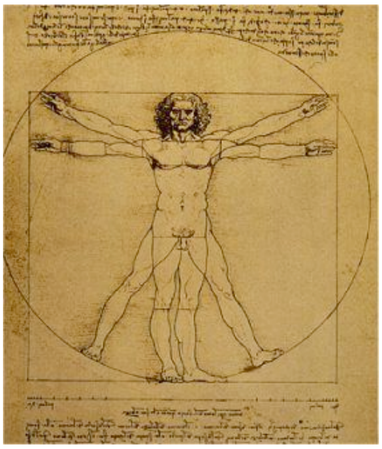
3 Capabilities of Humans and Machines



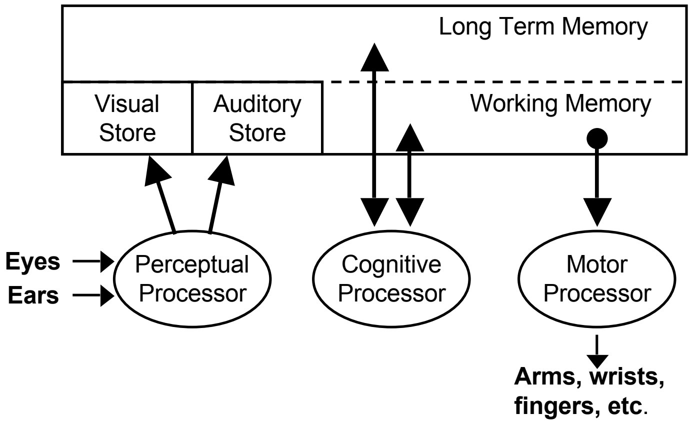
What are the prerequisites on the human side?

Designing for humans
What has to be considered?

- Humans are very complex! Even psychology only explains parts…
- Physiology (e.g. size, strength, degrees of freedom, fatigue)
- Psychology (e.g. memory, perception, cognition)
- Variety (e.g. gender, abilities and disabilities)
- Soft factors (e.g. aesthetics, motivation, pleasure, experience) related to psychology and physiology



Model of the Human "Processor" (1)



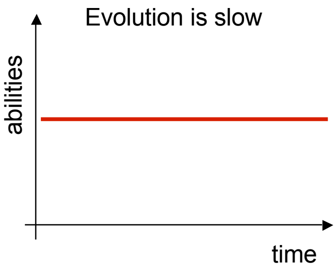
- From Brian P. Bailey, Computer Science 498bpb, Psychology of HCI http://www-faculty.cs.uiuc.edu/~bpbailey/teaching/2004-Fall/cs498/
- See also Card, Moran and Newell 1983, and Dix chapter 1

Model of the Human "Processor" (2)

- Reaction/processing time, example
  - Perception (stimulus); typical time: TP ~ 100ms
  - Simple decision; typical time: TC ~ 70ms
  - Minimal motion; typical time: TM ~ 70ms
    (example for complex motor action see Fitts' law, KLM)
- Overall time for operation where there is a sequential processing
  - pressing a button when a light comes on is about 240ms
    T = TP + TC + TM
  - Matching a symbol and then pressing one of two buttons is about 310ms (2TC because there is comparison and decision)
    T = TP + 2TC + TM
- Processing can also be parallel
  (e.g. phoning while writing, talking while driving, …)

Human abilities

- Abilities of un-augmented users in general do not change a lot over time, e.g.
  - ability to cope with cognitive load
  - willingness to cope with stress
  - time one can concentrate on a particular problem
- Abilities between individual users vary a lot
  - long term, e.g. gender, physical and intellectual abilities
  - short term, e.g. effect of stress or fatigue
- Abilities of one individual users changes over time (e.g. getting old)



Physiology

- Examples
  - Size of objects one can grasp
  - Weight one can lift or hold
  - Reach while seated or while standing
  - Optical resolution of the human vision system
  - Frequencies humans can hear
  - Conditions people can life in
  - …
- How does this relate to computer science?
  - Device and systems that are built
  - Processes we expect humans to perform
- If we ignore it…
  - People may not be able to use it
  - Performance will be suboptimal

Discussion
3D-Mouse vs. Physiology?

www.vrealities.com

Discussion
Gesture Input vs. Physiology?

- From the movie Minority Report
  http://www.minorityreport.com/

3 Capabilities of Humans and Machines

Corresponding extension topic:
E3 Advanced Interface Technologies

Types of Distance

Category	Approximate Distance	Kind of interaction
Intimate distance	Up to 0.5 meters	Comforting, threatening
Personal distance	0.5-1.25 meters	Conversation between friends
Social distance	1.25-3.5 meters	Impersonal business dealings
Public distance	More than 3.5 meters	Addressing a crowd

Hall, E.T. (1966). *The Hidden Dimension: Man's Use of Space in Public and Private.* Garden City, N.Y.: Doubleday.

Cited according to Nicolas Nova, Socio-cognitive functions of space in collaborative settings: a literature review about Space, Cognition and Collaboration (http://tecfa.unige.ch/perso/staf/nova/CRAFT_report1.pdf)

Territories at a table

- Humans have territories
- Example for territories at a table for a single person and for groups
  - Scott, S.D. (2003). Territory-Based Interaction Techniques for Tabletop Collaboration. *Conference Companion of the ACM Symposium on User Interface Software and Technology UIST'03*, November 2-5, 2003.

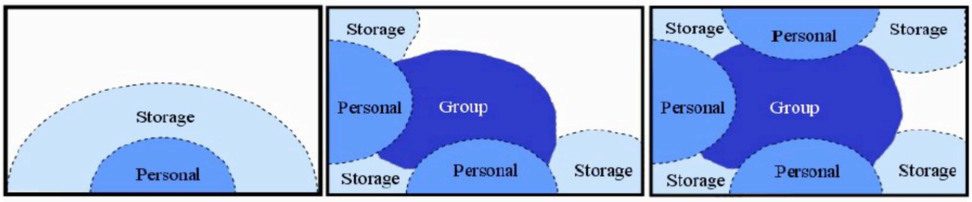
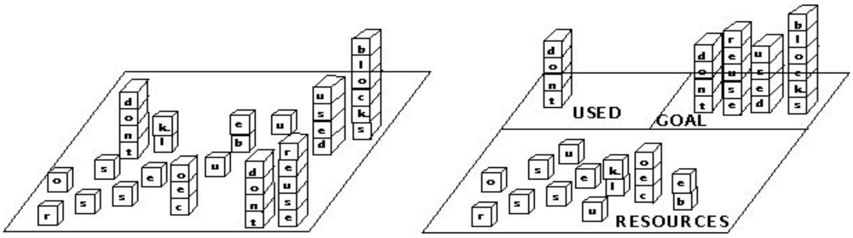


Figure 4. Territories on a tabletop display. The left picture illustrates an arrangement of territories with only one user located at the table, thus no group territory is necessary. The centre and right pictures illustrate 2 and 3 users at the tabletop, respectively.

The intelligent use of space (1)
Motivation



- Space matters
  - Humans use space to ease tasks
  - Computer systems often do not support this well
- “**How we manage the spatial arrangement of items around us is not an afterthought: it is an integral part of the way we think, plan, and behave.**”

  David Kirsh. The Intelligent Use of Space. Artificial Intelligence (73), Elsevier, p31-68, 1995.
  http://adrenaline.ucsd.edu/kirsh/articles/space/intelligent_useof_space.pdf

The intelligent use of space (2)

- Space is used to
  - Simplify choice
  - Simplify perception
  - Simplify internal computation
- Some effects
  - Reduce cognitive load (space complexity)
  - Reduce number of steps required (time complexity)
  - Reduce probability of errors (unreliability)

Designing with space
Example: assembly line

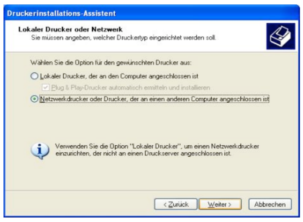
- Pre-structured environment
- serially decomposed tasks
- dividing task into subtasks
- Subtasks are done in a certain space
- Limited availability of tools and parts in a space

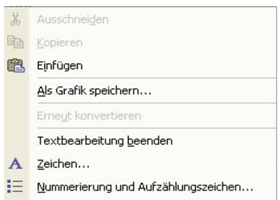
- *"…by regionalizing subtasks we restrict the kind of actions an agent will consider undertaking. Only certain inputs find their way into each region, only certain tools are present, and so only certain actions are afforded.* " (Kirsh, Intelligent Use of Space)

Equivalent to an assembly line in computer science / software?

- Wizards
- Guided tours
- (Distributed) workflow
- Tools that have support for different roles
- User interfaces that restrict choice as appropriate for a given context
- Different applications for different tasks
- Different work environments for different tasks (e.g. CAD workstation, video editing station, POS terminal)
- …

When designing systems and solutions
- – Utilize space as much as possible
- – Use space in the physical world and on screen
- – Allow users to customize special arrangements
- – Provide interactive means for manipulation of objects in space



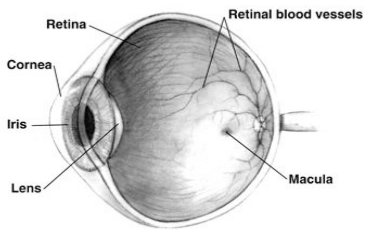


3 Capabilities of Humans and Machines

3.1 Designing Systems for Humans
3.2 Space and Territory
3.3 Visual Perception and User Interfaces
The Human Eye and Vision
Gestalt Perception
Change Blindness
3D Vision

The human eye

- See *Digitale Medien (Grundstudium)*
- Basics again
  - Very high dynamic range
  - Bad color vision in dark conditions
  - Best contrast perception in red/green
  - Limited temporal resolution (reaction speed)
  - Good resolution and color in central area (macula)
  - Maximum resolution and color only in the very center (fovea)
    - » Eye does not see the full picture but scans the scene by jumping from detail to detail



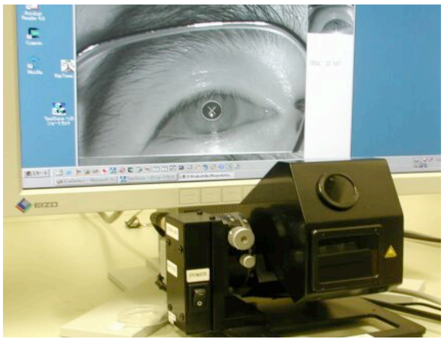
Images from wikipedia

Reception and Interpretation

Two stages in vision
- physical reception of stimulus
- processing and interpretation of stimulus

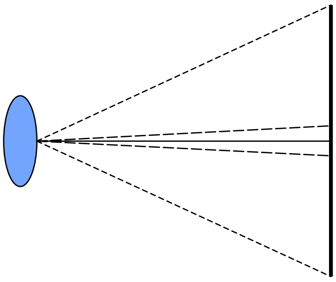
Interpreting the signal
- Size and depth
  - visual angle indicates how much of view object occupies
  - visual acuity is ability to perceive detail (limited)
  - familiar objects perceived as constant size
  - cues like overlapping help perception of size and depth
- Brightness, Colour
  - visual acuity increases with luminance as does flicker
  - blue acuity is lowest
  - 8% males and 1% females colour blind
- The visual system compensates (e.g. for movement, changes in luminance)
  - Context is used to resolve ambiguity
  - Optical illusions sometimes occur due to overcompensation

Eye movement



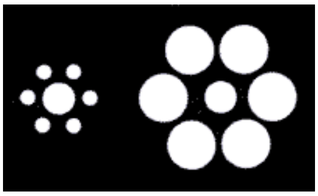
- Eye movement can be visually detected and used for eye-tracking
- You can tell where someone looks

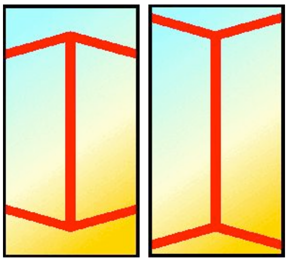
How much resolution do we need?

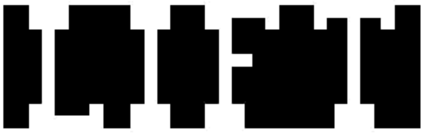


- Assumption: viewing distance = horizontal image width
- Horizontal view angle = 2*atan 0.5 = 53 degrees
- Max. angular resolution of the eye = 1/60 degree
- ➔ Max. horizontal resolution = 53 * 60 = 3.180 pixels
- Viewing distance of A4 paper = 10 inch ➔ 300dpi

Optical Illusions

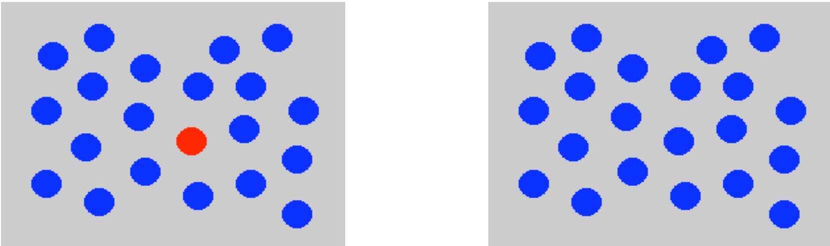






www.eyetricks.com

Example: Color Selection



Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in color.

Hearst, 2003

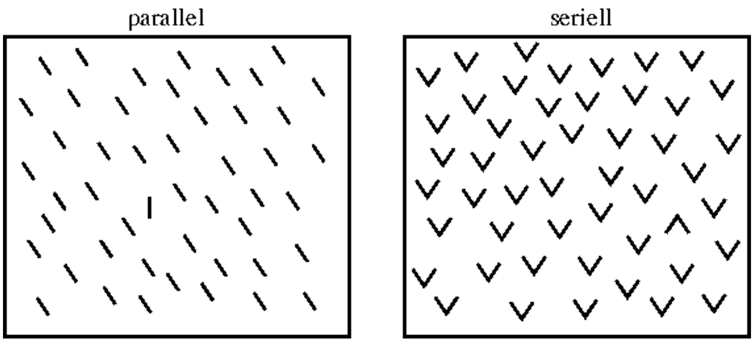
Pre-attentive processing:

Processed without focusing attention

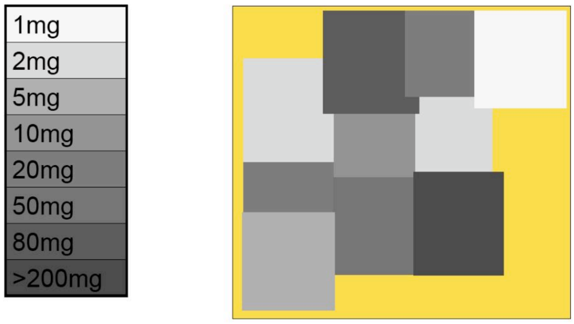
Constant time < 200-250 ms independent of number of distractors

(Eye movements take 200 ms)

Preattentive and Attentive Pattern Recognition



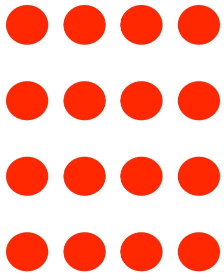
Color Keys Can be Misleading



3 Capabilities of Humans and Machines

Gestalt Perception

- Grouping items into group based on
  - Proximity
  - Similarity



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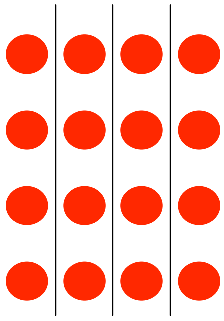

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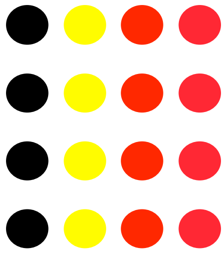


Gestalt Perception Example

- Keep red
- Off line
- ???

Gestalt Perception Example

- Keep off red lines
- !!!

3 Capabilities of Humans and Machines

Change Blindness

- Phenomenon in visual perception
  - Relatively recently discovered (1996+)
- Large changes in a scene are not noticed
  - Up to a fifth of the whole picture
- Happens when there is a short distraction, e.g.
  - "mud splashes"
  - "brief flicker"
  - "cover box"
  - eye blink

http://nivea.psycho.univ-paris5.fr/ECS/ECS-CB.html

Change blindness example

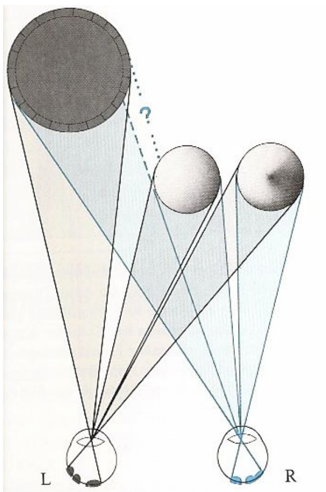
Ronald Rensink, University of BC, Vancouver, Canada

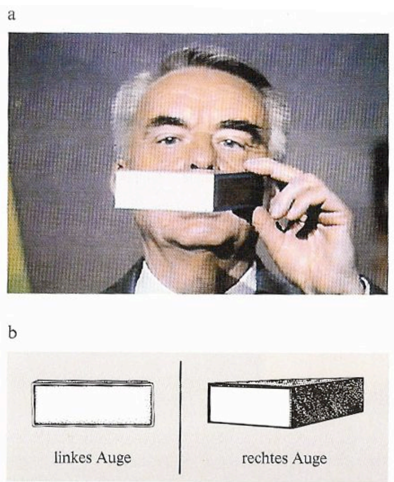
3 Capabilities of Humans and Machines

Seeing in 2D and 3D
Views and Displays

- Everything on a 2D display is 2D!
  - If we see it 3 dimensional we imagine it…
  - Expectations and experience as basis
  - Displaying a projection of a 3D model
- “Real” 3D needs requires a image for each eye
  - Happens naturally when looking at 3D objects in physical space
  - Can be simulated by providing a separate image for each eye using technology
- Options to visualize 3D graphics
  - Create a 2D image that the user translates in 3D in his head
  - Provide images (that represent a 3D model from a particular view point) for both eyes
  - Create 3D structures (static or dynamic)

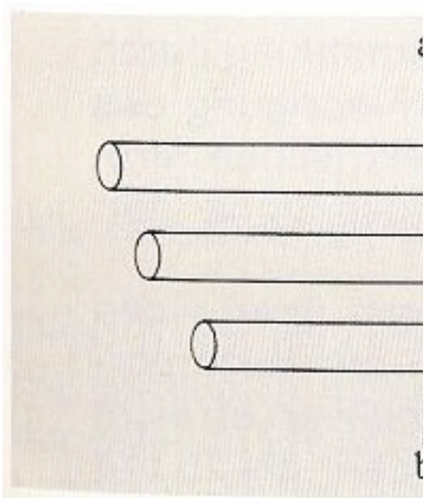
Stereo 3D Vision Basics



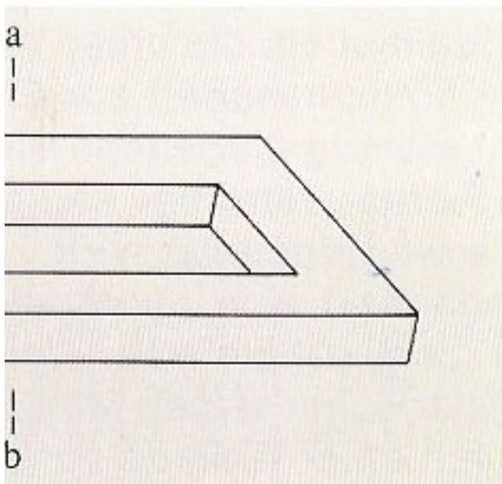


From A. Maelicke, Vom Reiz der Sinne, VCH 1990

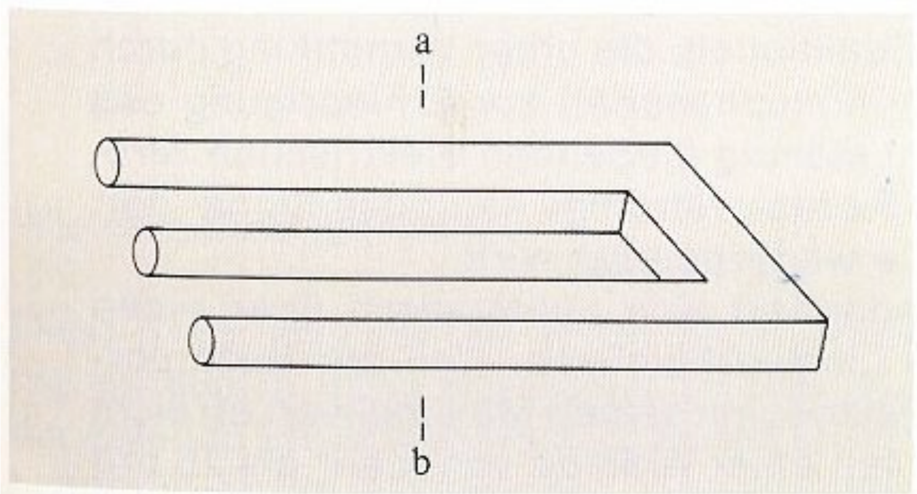
2D drawing: Make it conclusive… (1)



2D drawing: Make it conclusive… (2)



2D drawing: Make it conclusive… (3)



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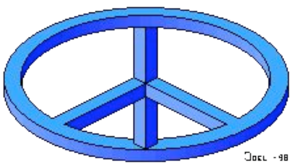
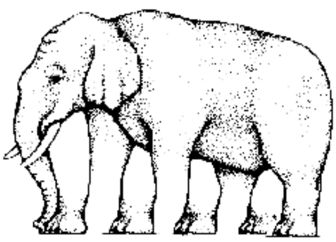
Optical Illusions Based on 3D Constructions

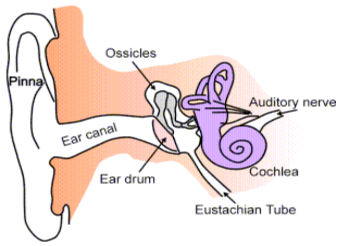




www.eyetricks.com

3 Capabilities of Humans and Machines

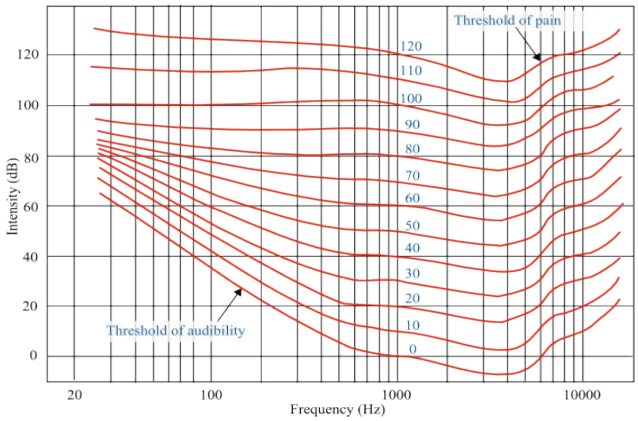
Human Hearing



- Two Ears
  - information about the environment
  - type of sound source
  - distance and direction
- Physical apparatus:
  - outer ear – protects inner ear and amplifies sound
  - middle ear – transmits sound waves as vibrations to inner ear
  - inner ear – chemical transmitters are released and cause impulses in auditory nerve
- Sound
  - Pitch (Tonhöhe) – sound frequency
  - Loudness (Lautstärke) – amplitude
  - Timbre (Klangfarbe) – type or quality

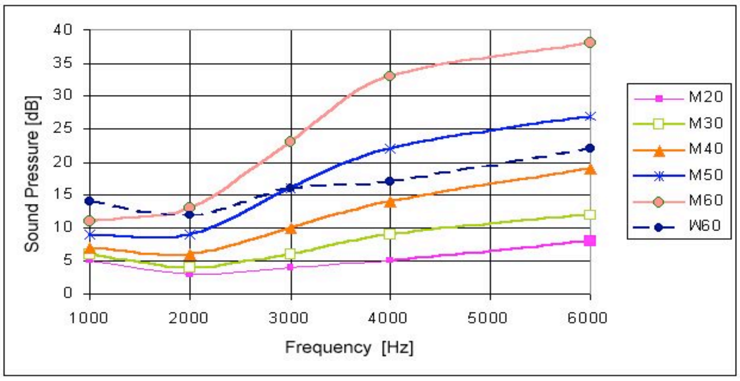
Source:
Wikipedia
and Dix et al.

Threshold of hearing/pain



- Fletcher-Munson equal-loudness contours
  (image from http://en.wikipedia.org/wiki/Absolute_threshold_of_hearing)

Threshold of hearing for different age groups

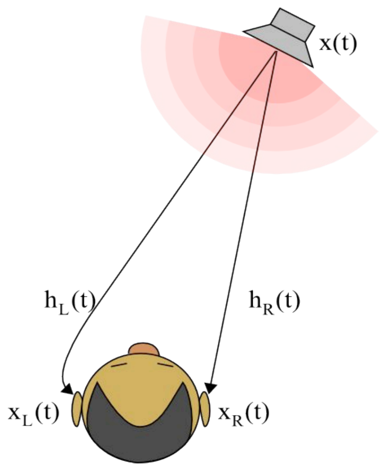


Thresholds of hearing for male (M) and female (W) subjects between the ages of 20 and 60
(for details see http://en.wikipedia.org/wiki/Absolute_threshold_of_hearing)

Hearing – Words and Conversations

- Examples:
  - *You are in a noisy environment like a crowded underground train and you can still have a conversation. You can even direct your attention to another conversation and "listen in".*
  - *You are in a conversation and somewhere else someone mentions your name. You realize this even if you have not been listening actively to this conversation before.*
- The auditory system filters incoming information and allows selective hearing
  - Selectively hearing sound in environment with background noise
  - Spotting keyword
  - "Cocktail party phenomenon"

Spatial hearing



- Caused by:
  - Interaural time difference (ITD)
  - Interaural intensity difference (IID)
  - Head related transfer functions (HRTF)
- Better for high than for low frequencies

Touch

- Provides important feedback about environment.
  - May be key sense for the visually impaired.
- Stimulus received via receptors in the skin:
  - Thermoreceptors – heat and cold
  - Nociceptors – pain
  - Mechanoreceptors – pressure
    (some instant, some continuous)
  - Some areas more sensitive than others e.g. fingers.
- Proprioceptors:
  - Signal status of muscles and joints
  - Proprioception: unconscious perception of movement and spatial orientation
  - Kinesthesis: the ability to feel movements of the limbs and body

(see http://www.isr.syr.edu/course/neu211/lecture_notes/lec14.html)

Movement

- Time taken to respond to stimulus:
  reaction time + movement time
- Movement time dependent on age, fitness etc.
- Reaction time - dependent on stimulus type:
  - visual ~ 200ms
  - auditory ~ 150 ms
  - pain ~ 700ms
- Increasing reaction time decreases accuracy in the unskilled operator but not in the skilled operator.
  - See Fitts' law

(experiment for visual reaction time see:
http://biology.clc.uc.edu/fankhauser/Labs/Anatomy_&_Physiology/A&P202/Nervous_System_Physiology/Visual_Reaction.htm)