Vorlesung
Mensch-Maschine-Interaktion

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Chapter 3
Designing Systems for Humans

- 3.1 Design for humans
- 3.2 Space and territory
- 3.3 Visual perception and reading
- 3.4 Hearing, Touch, Movement
- 3.5 Cognitive abilities and memory
- 3.6 Emotion
- 3.7 Natural and intuitive interaction, Affordance

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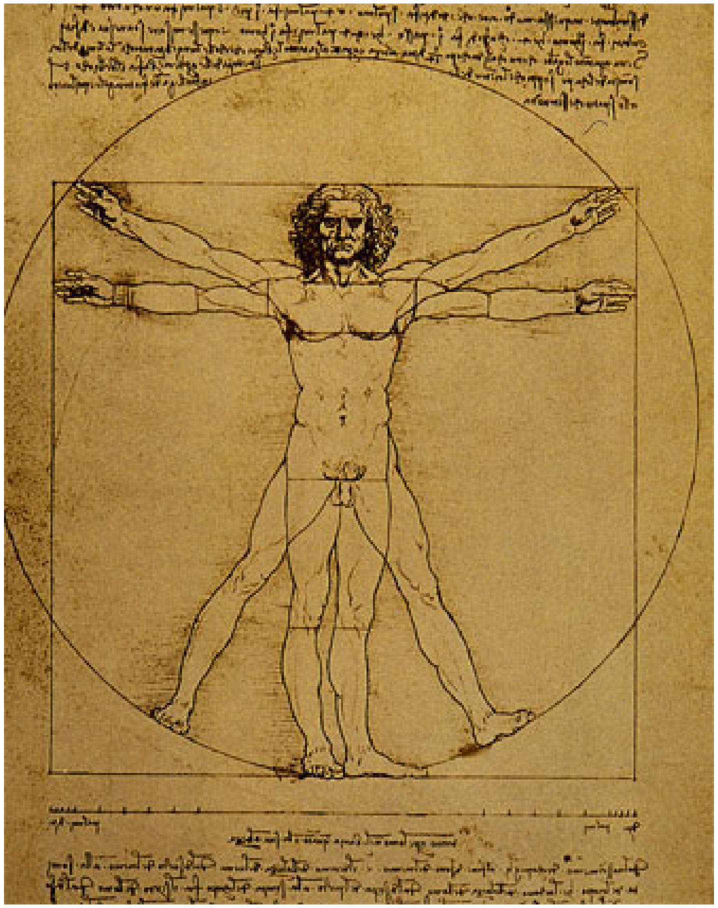
Designing for humans
What has to be considered?

- 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 Human Processor (1)

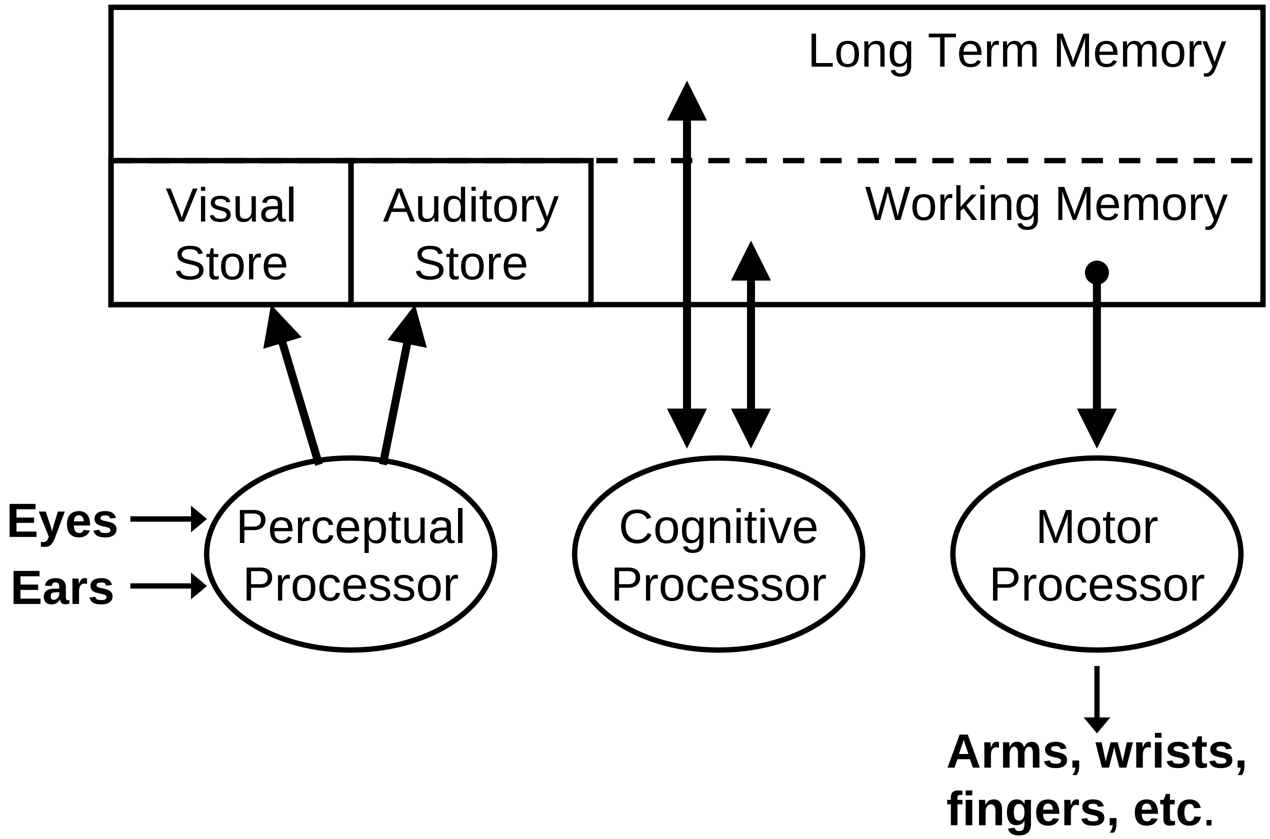
- Very simple "model" of a human interacting with a computer
- The model describes the human as three sub-systems
  - Perceptual system (acquire input from the real world)
  - Motor system (manipulate the real world)
  - Cognitive system (connection between input and output, basic processing and memory)
- Each subsystem includes
  - Processing
  - Memory

- See Card, Moran and Newell 1983, and Dix chapter 1

Model 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, …)

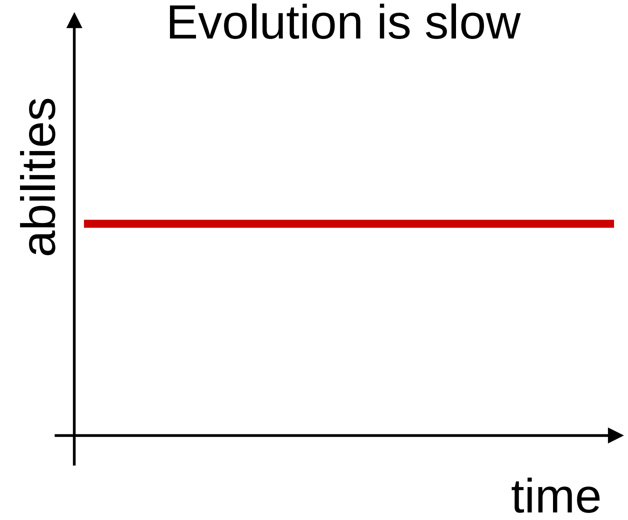
Model Human Processor (3)



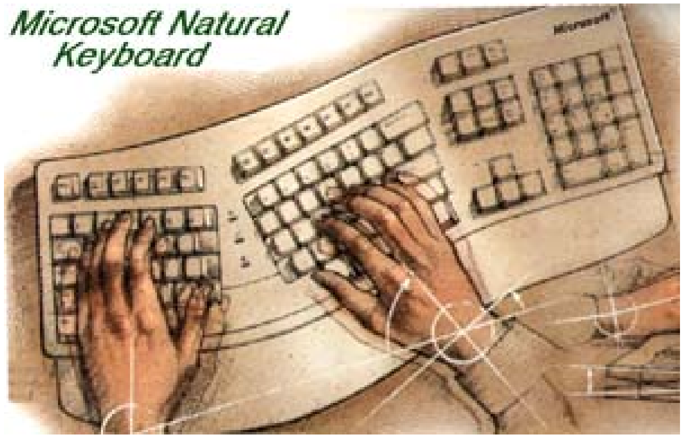
- From Brian P. Bailey, Computer Science 498bpb, Psychology of HCI http://www-faculty.cs.uiuc.edu/~bpbailey/teaching/2004-Fall/cs498/

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
  - Weigh 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 build
  - Processes we expect humans to perform

- If we ignore it…
  - People may not be able to use it
  - Performs will be sub optimal

Discussion
3D-Mouse vs. Physiology?

www.vrealities.com

Discussion
Gesture Input vs. Physiology?

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

Example: Wearable Computing

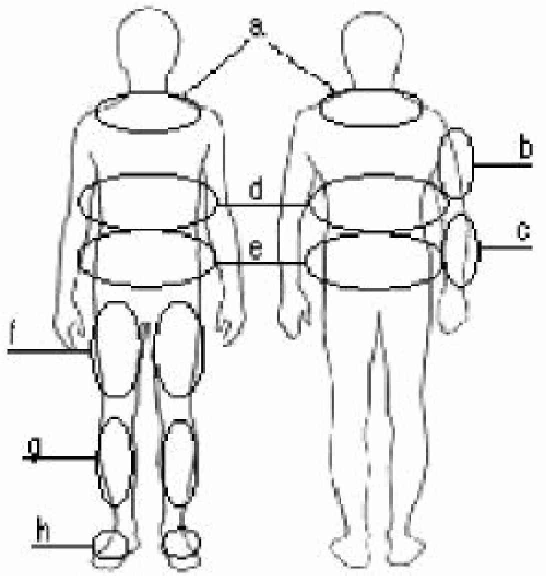


Fig. 1, The general areas we have found to be the most unobtrusive for wearable objects are: (a) collar area, (b) rear of the upper arm, (c) forearm, (d)rear, side, and front ribcage, (e) waist and hips, (f) thigh, (g) shin, and (h) top of the foot.

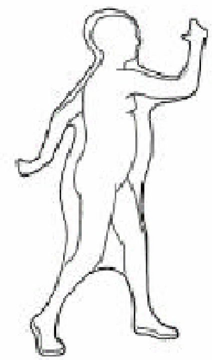
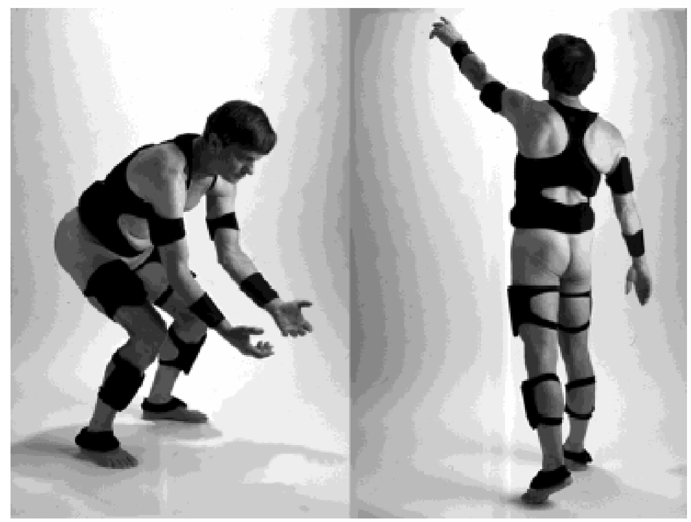


Figure 4, Aura around the human body that the brain will perceive as part of the body.



- F. Gemperle, C. Kasabach, J. Stivoric, M. Bauer, and R. Martin. *Design for wearability*. In IEEE International Symposium on Wearable Computers, Pittsburgh PA, USA, October, 1998.
- http://www.ices.cmu.edu/design/wearability

General Principle
Designing for humans

- Design systems that fit humans
  - Physiological
  - Psychological
  - Emotional
- Augment the human intellect and the human capabilities
- Basic design guideline
  - Let the computer do what the computer is good at
  - Let the human do what the human is good at
  - Consider human and computer always as one system *(Sheiderman: concentrating on what people can do with computers)*

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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.

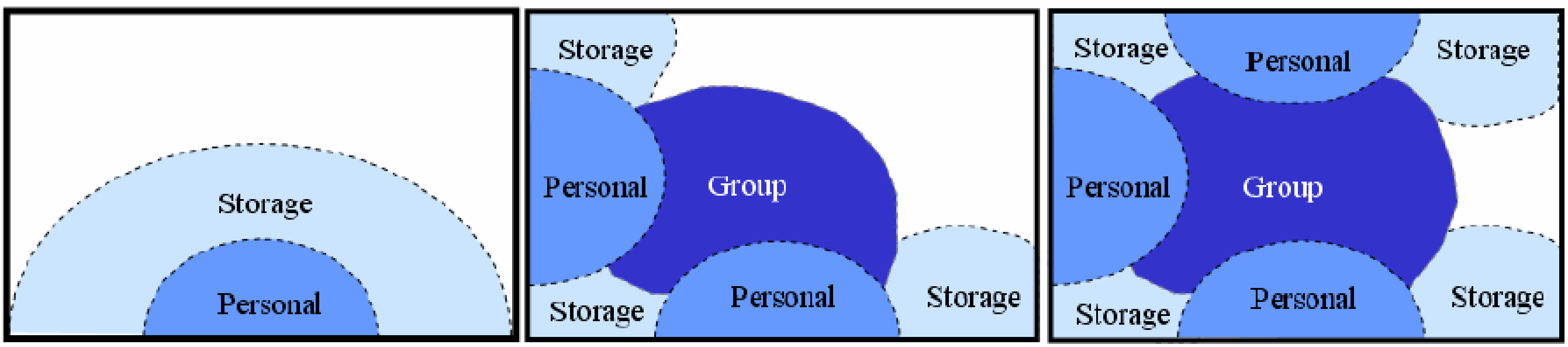


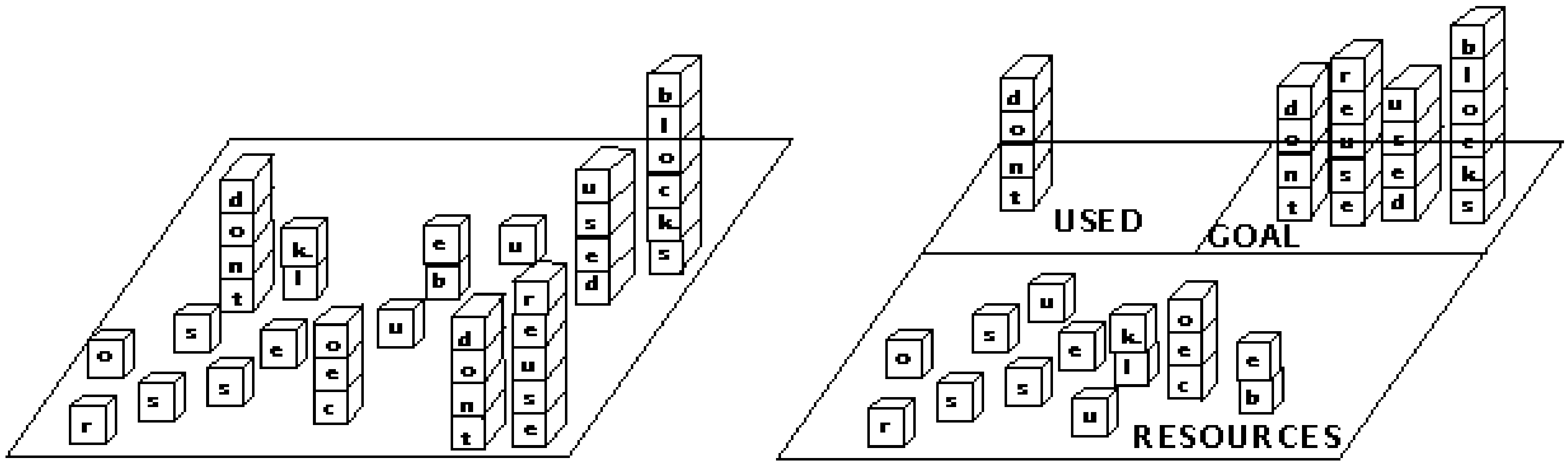
Figure 4. Territories on a tabletop display. The left picture illustrates an arrangement of territories with only one user located at the table, thus no group territory is necessary. The centre and right pictures illustrate 2 and 3 users at the tabletop, respectively.

Space matters

- Humans use space to ease tasks
- Computer systems often do not support this well

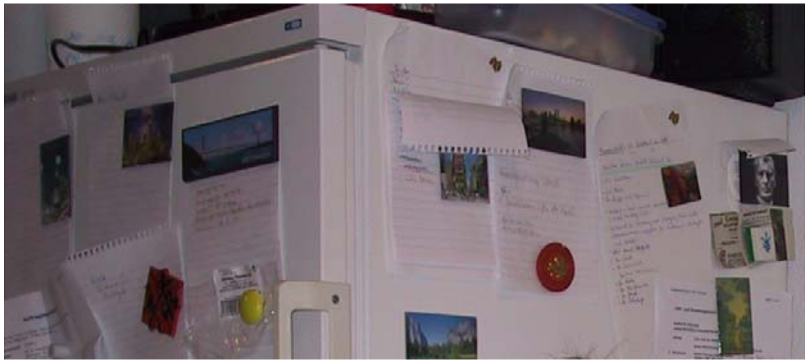
- "**How we manage the spatial arrangement of items around us is not an afterthought: it is an integral part of the way we think, plan, and behave.**"
  David Kirsh. The Intelligent Use of Space. Artificial Intelligence (73), Elsevier, p31-68, 1995.
  http://icl-server.ucsd.edu/~kirsh/Articles/Space/AIJ1.html

The intelligent use of space
Motivation



- David Kirsh. The Intelligent Use of Space. Artificial Intelligence (73), Elsevier, p31-68, 1995. http://icl-server.ucsd.edu/~kirsh/Articles/Space/AIJ1.html

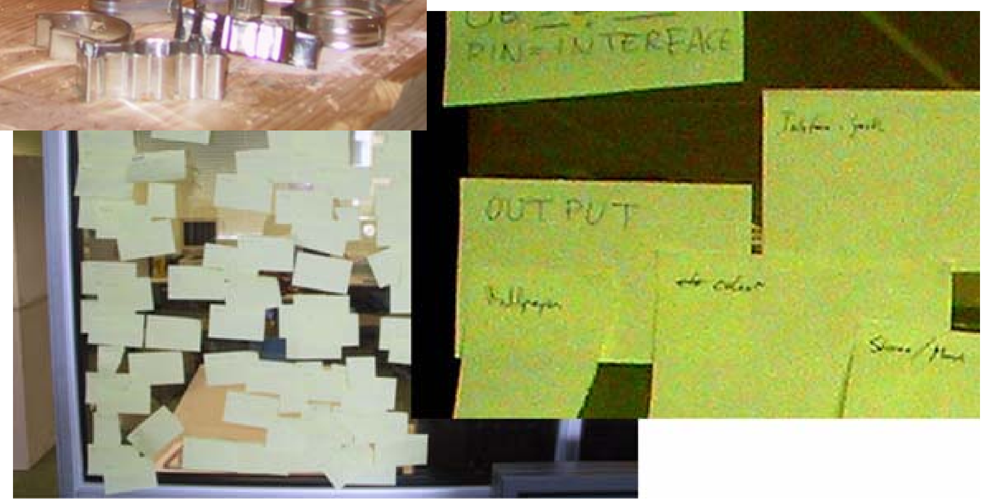
The intelligent use of space (1)



- 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)

- David Kirsh. The Intelligent Use of Space. Artificial Intelligence (73), Elsevier, p31-68, 1995. http://icl-server.ucsd.edu/~kirsh/Articles/Space/AIJ1.html
- 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

Use of space



- Organizing storage
- Arranging tools
- Easing processing (e.g. sorting)

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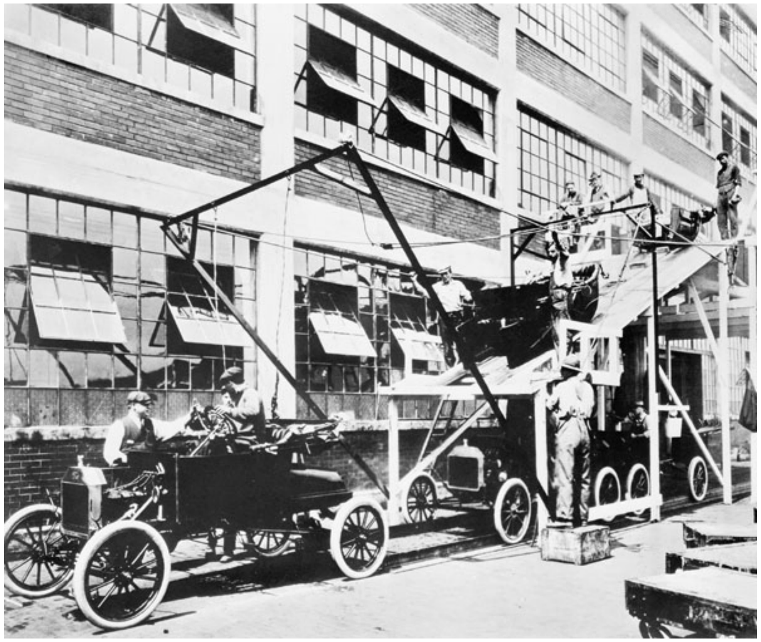
Designing with space Example: assembly line

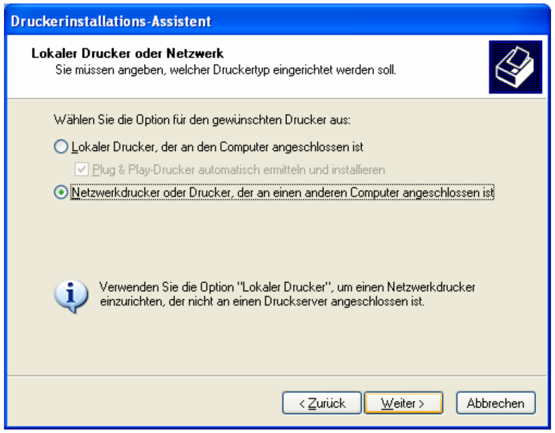
- Pre-structured environment
- serially decomposed tasks
- dividing task into subtasks
- Subtasks are done in a certain space
- Limited availability of tools and parts in a space

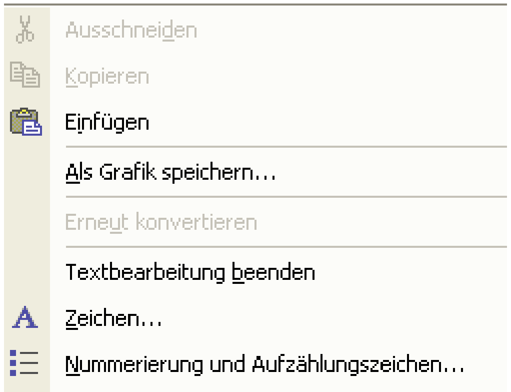


- *"…by regionalizing subtasks we restrict the kind of actions an agent will consider undertaking. Only certain inputs find their way into each region, only certain tools are present, and so only certain actions are afforded.* " (Kirsh, intelligent use of space)

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)
- …





General principles
Designing with space

- 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
- The physical space and spatial arrangement
  - provides constraints and guidance
  - implies behavior
  - eases categorization
  - Search and retrieval
  - Allows to make (internal human) computation easier
- Segment problems and task
  - Spatial
  - Temporal

Think of the assembly line

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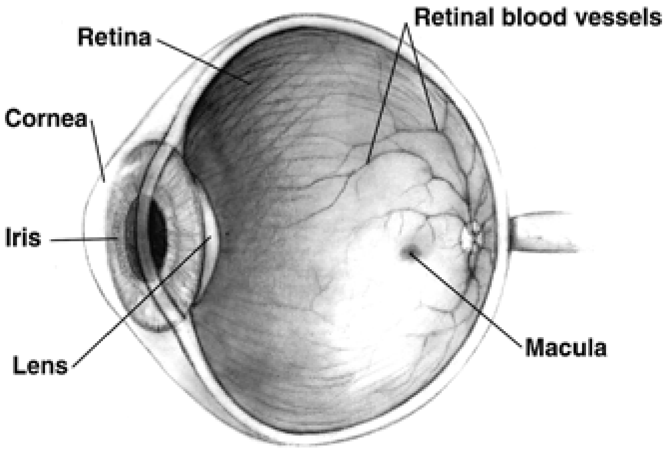
The human eye

- 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)



Images from wikipedia

Temporal resolution of visual perception

- Images to movie
- Flicker

Vision

Two stages in vision

- physical reception of stimulus
- processing and interpretation of stimulus

The Eye - physical reception

- mechanism for receiving light and transforming it into electrical energy
- light reflects from objects
- images are focused upside-down on retina
- retina contains rods for low light vision and cones for colour vision
- ganglion cells (brain!) detect pattern and movement

Interpreting the signal

- Size and depth
  - visual angle indicates how much of view object occupies

    (relates to size and distance from eye)
  - visual acuity is ability to perceive detail (limited)
  - familiar objects perceived as constant size

    (in spite of changes in visual angle when far away)
  - cues like overlapping help perception of size and depth

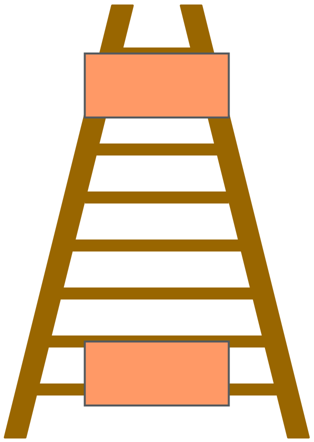
Interpreting the signal (cont)

- Brightness
  - subjective reaction to levels of light
  - affected by luminance of object
  - measured by just noticeable difference
  - visual acuity increases with luminance as does flicker
- Colour
  - made up of hue, intensity, saturation
  - cones sensitive to colour wavelengths
  - blue acuity is lowest
  - 8% males and 1% females colour blind

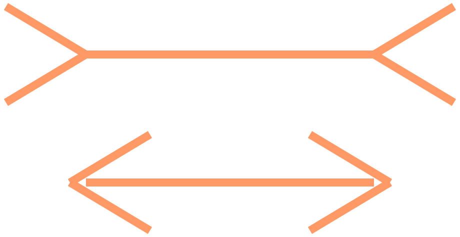
Interpreting the signal (cont)

- The visual system compensates for:
  - movement
  - changes in luminance.
- Context is used to resolve ambiguity
- Optical illusions sometimes occur due to over compensation

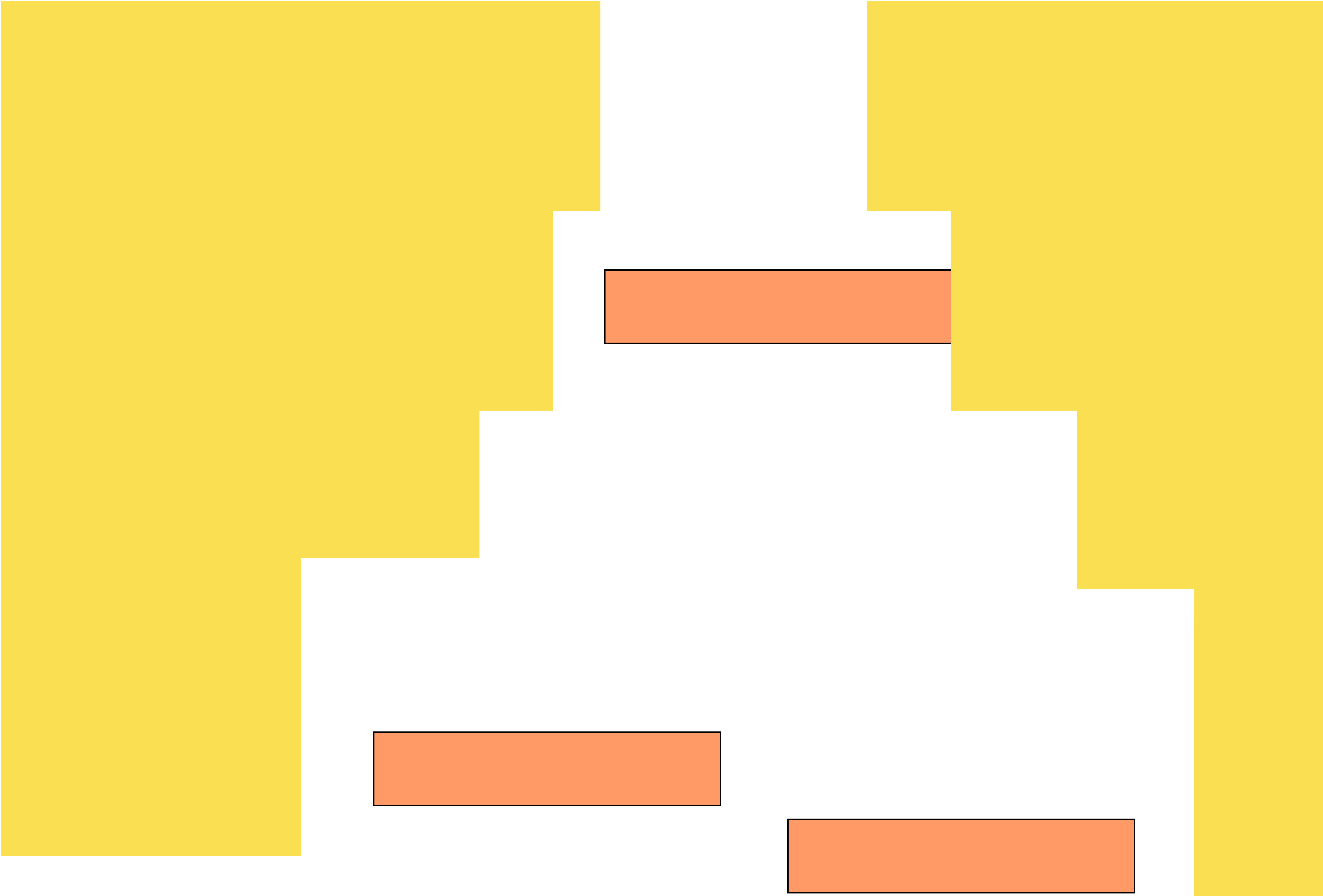
Optical Illusions



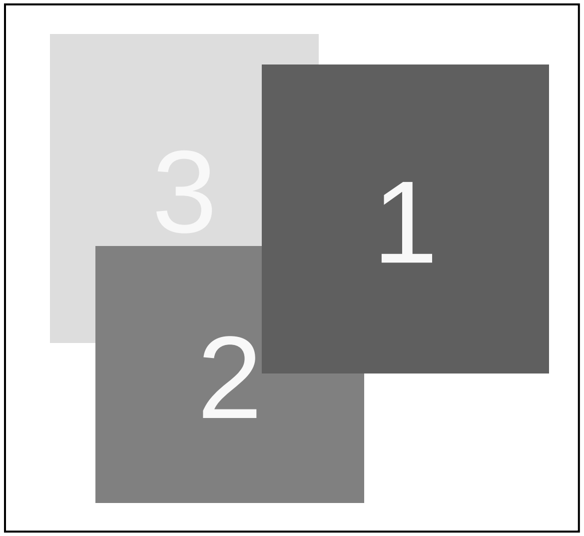
the Ponzo illusion

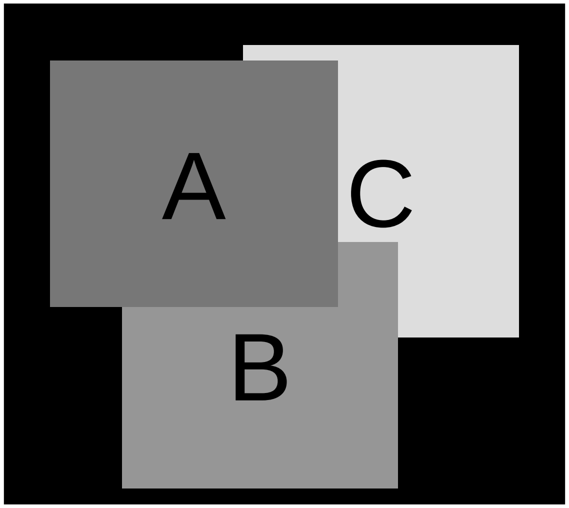


the Muller Lyer illusion



Match the gray squares





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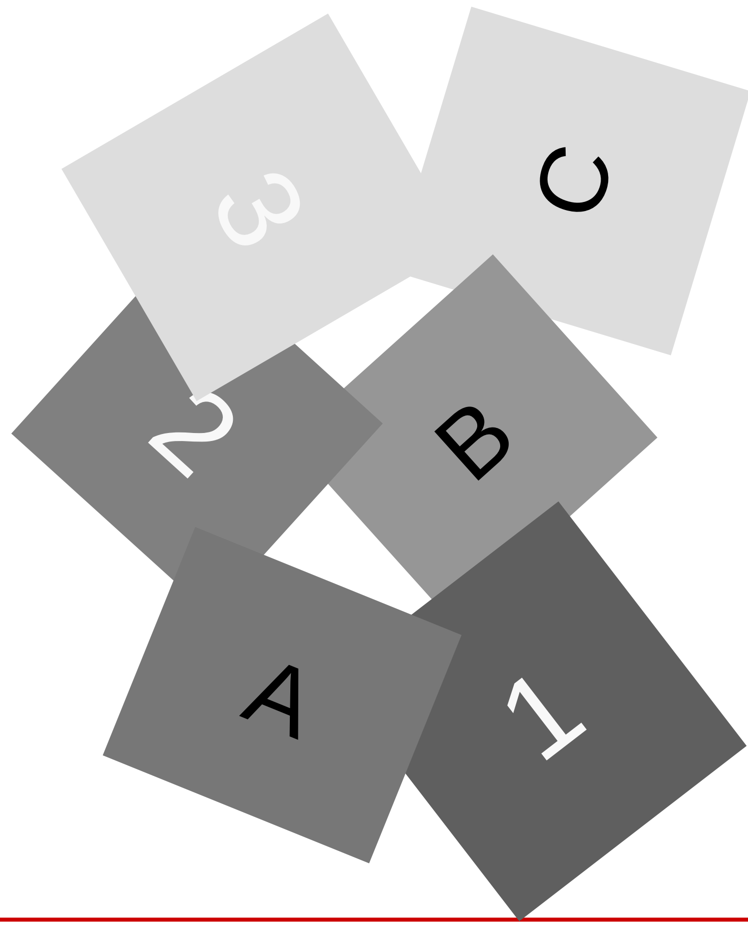
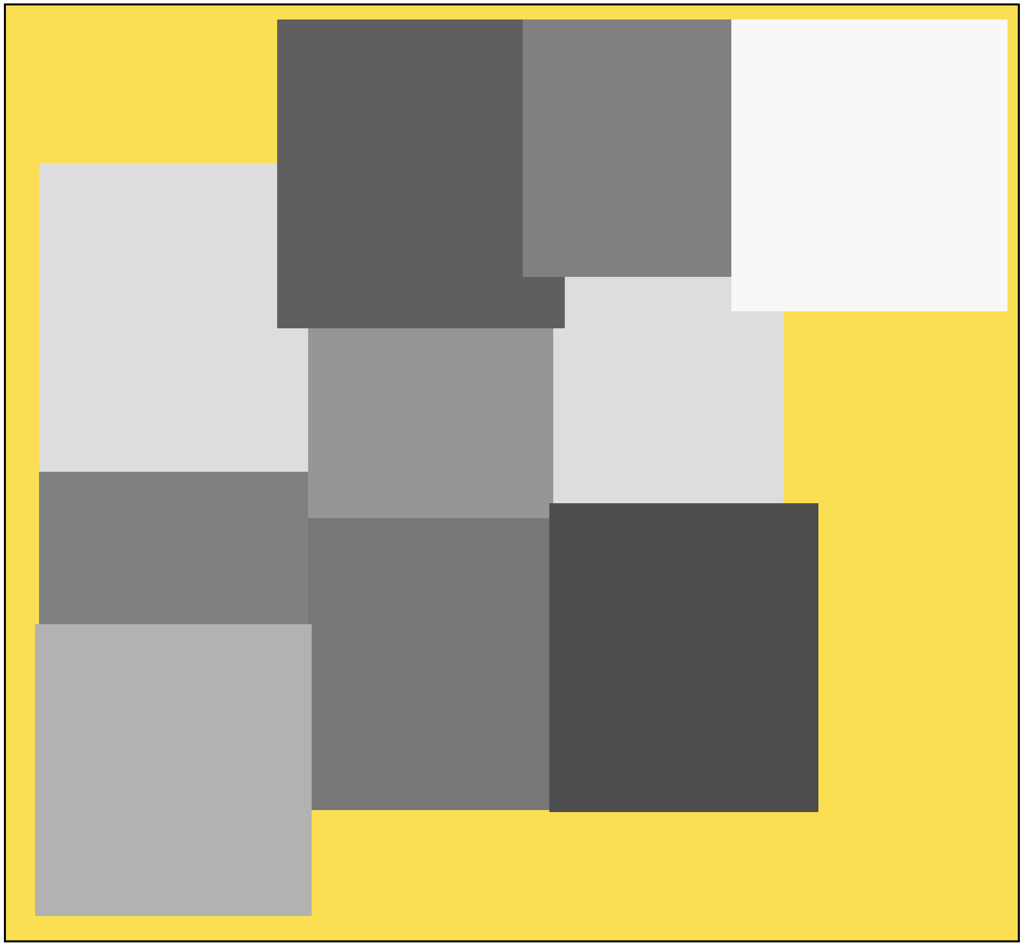


A != 1
B != 2
C = 3

Color keys can be really difficult

1mg
2mg
5mg
10mg
20mg
50mg
80mg
>200mg



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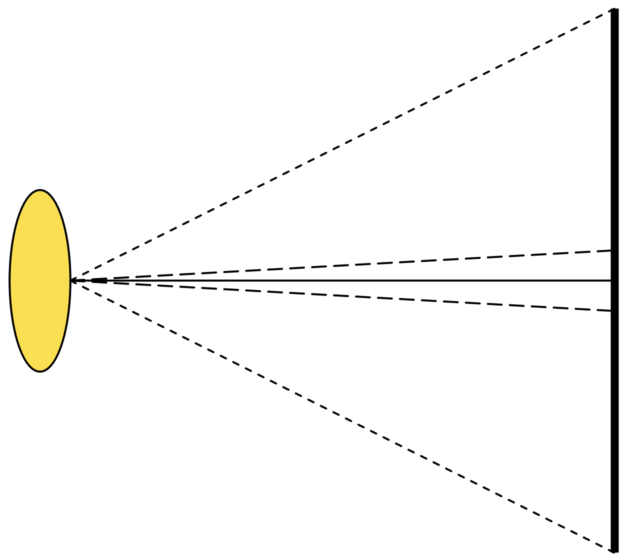
Eye movement

- 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 = horiz. image width
- Horiz. Viewangle = 2*atan 0.5 = 53 degrees
- Max. angular resolution of the eye = 1/60 degree
- ➔ Max. horiz. resolution = 53 * 60 = 3.180 pixels
- Viewing distance of A4 paper = 10 inch ➔ 300dpi

Reading

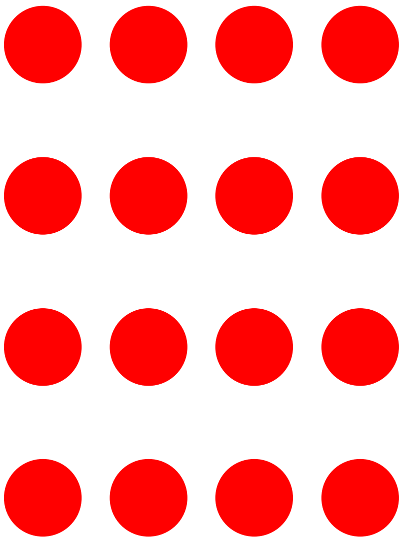
- Several stages:
  - visual pattern perceived
  - decoded using internal representation of language
  - interpreted using knowledge of syntax, semantics, pragmatics
- Reading involves saccades and fixations
- Perception occurs during fixations
- Word shape is important to recognition
- Negative contrast improves reading from computer screen

Reading is a central activity when using a computer

- Reading: controls, labels, information chunks
- Background on reading and online reading
  - http://en.wikipedia.org/wiki/Reading_%28activity%29
  - http://www.medien.ifi.lmu.de/fileadmin/mimuc/mmi_ws0304/exercise/aufsaetze.html
- Some basic facts
  - Typical reading speeds are 100 (memorizing) to 1000 (scanning) words per minute
  - Reading skills differ to a great extend (according to PISA more than 20% have difficulties in reading)
  - Reading speed has for many tasks a significant impact on overall user performance
  - Good readers “recognize” words (they do not read them letter by letter)
  - Providing a visual presentation that supports reading is important (font, size, color, length of lines, structure, …)
  - Reading from a computer screen is in general slower than from paper

Gestalt Perception

- Grouping items into group based on
  - Proximity
  - Similarity



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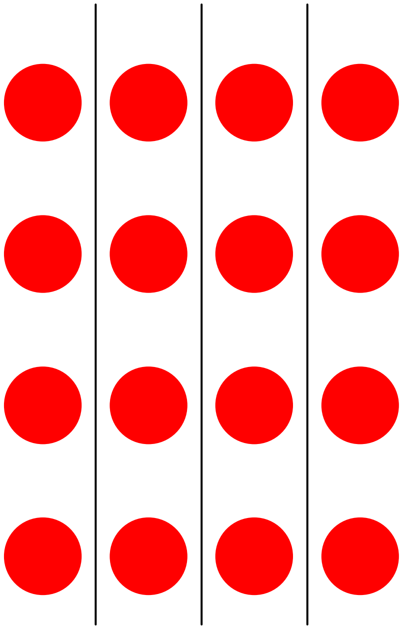

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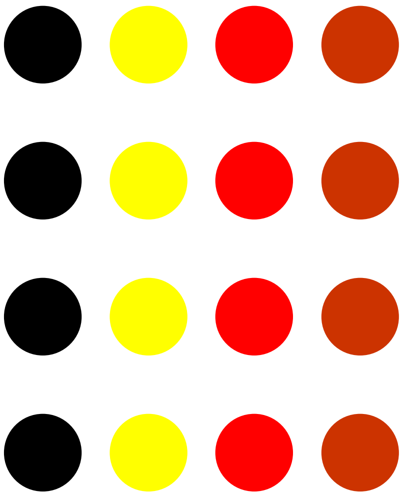


Gestalt Perception Example

- Keep red
- Off line
- ???

Gestalt Perception Example

- Keep off red lines

- !!!


Baggage Claim
International Arrivals
Foreign Exchange
荷物受取／全てのゲート
Elevator
S10
Sunshine Foundation
CAUTION
KEEP OFF
RED LINES
KEEP
RED
OFF
LINE

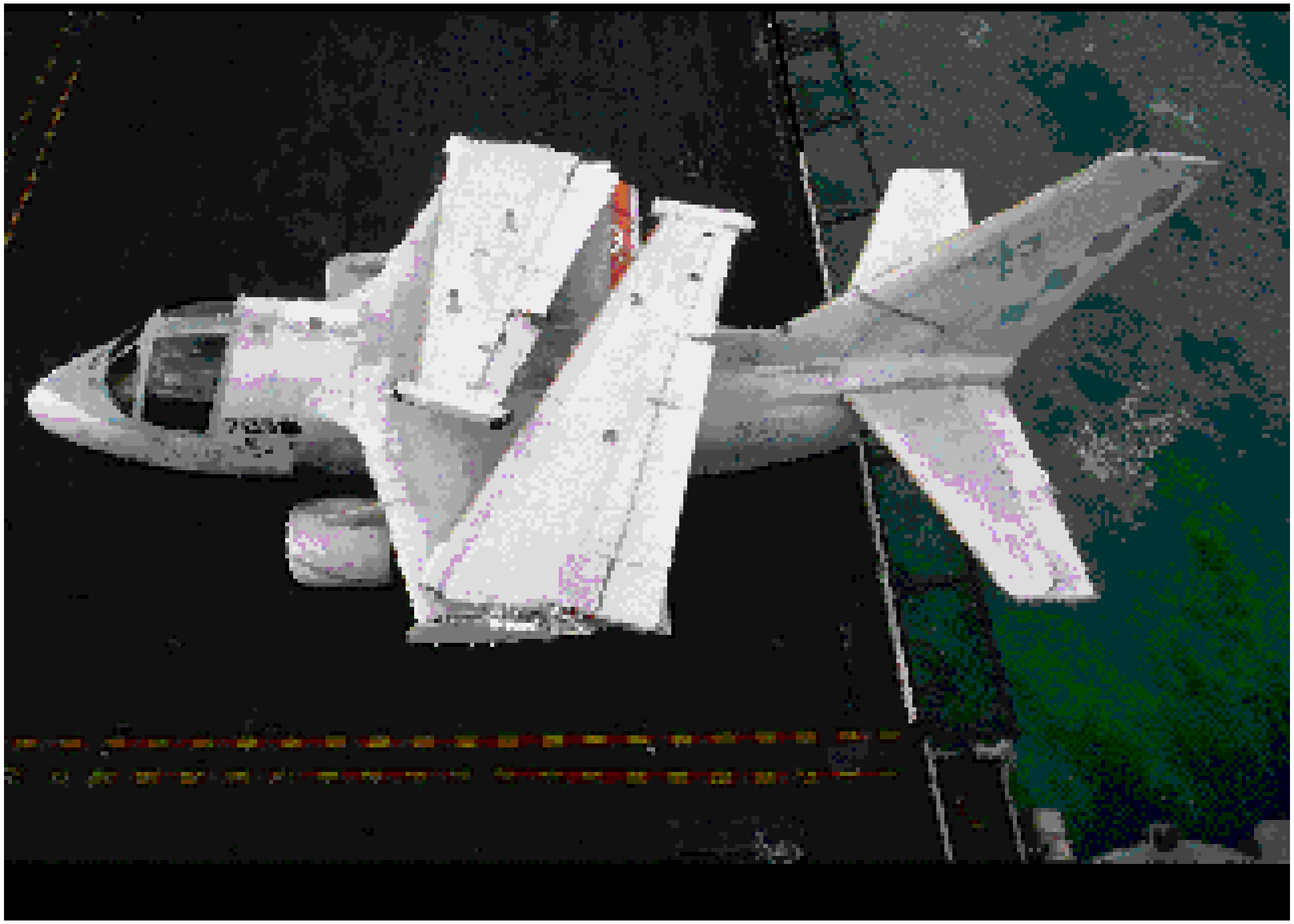
Change Blindness

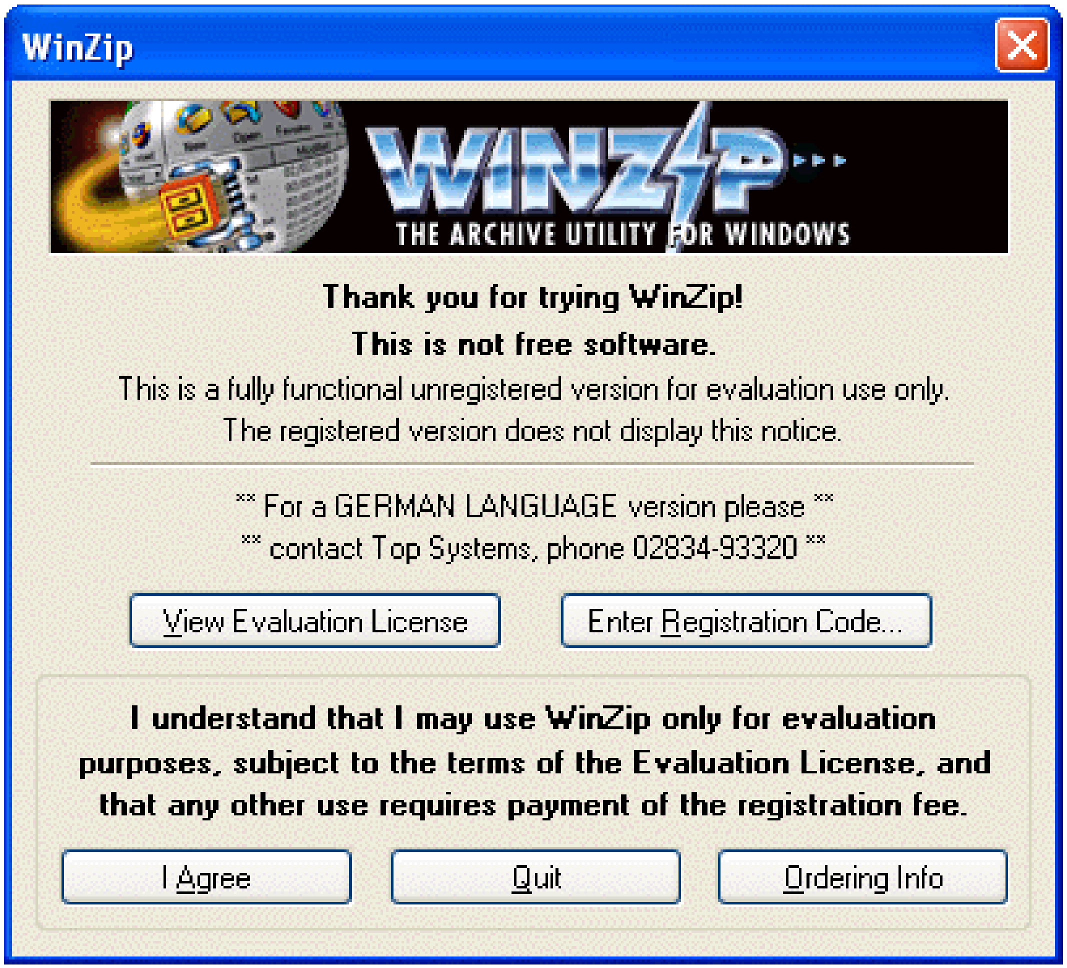
- phenomenon in visual perception
- large changes in a scene are not noticed
- Happens when there is a short distraction, e.g.
  - “mud splashes”
  - “brief flicker”
  - “cover box”

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

Change blindness example: mud splashes

Change blindness example: flicker

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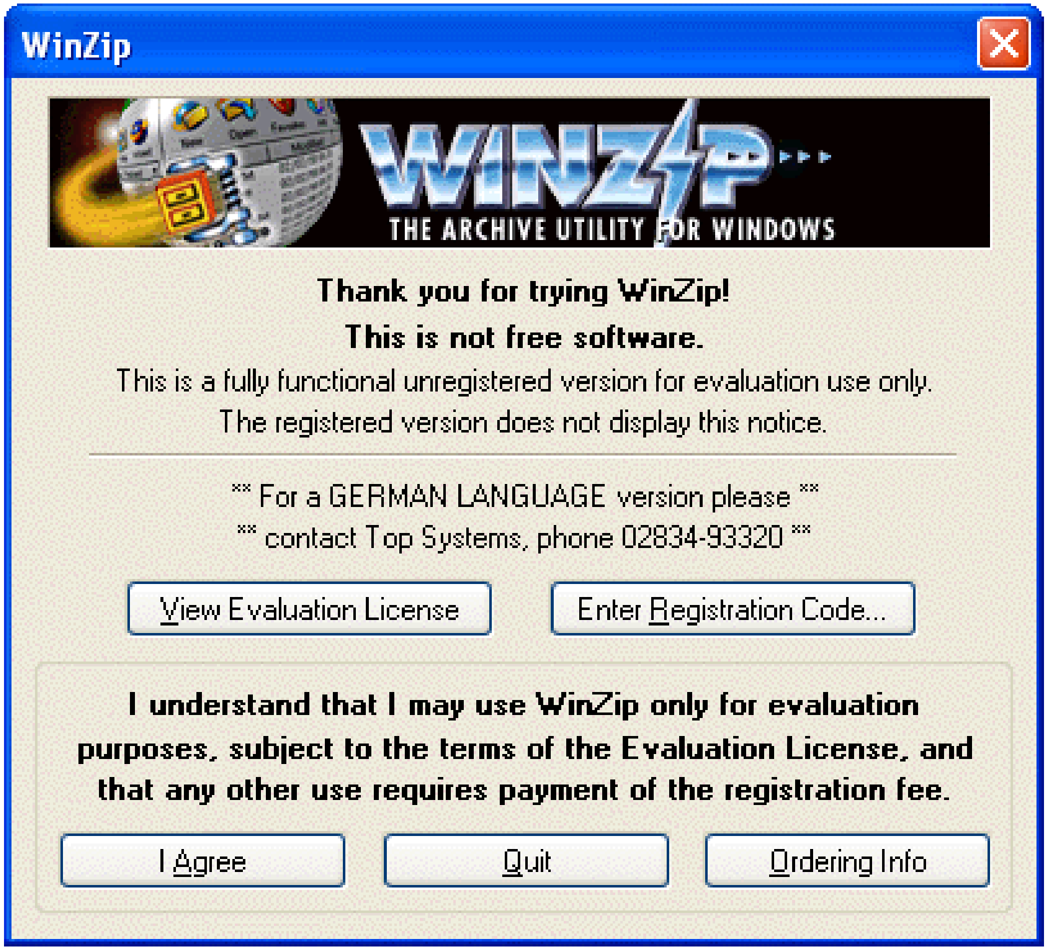
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- Distributed Cognition, Coordination and Environment Design. David Kirsh http://icl-server.ucsd.edu/~kirsh/Articles/Italy/published.html
- Interactivity and MultiMedia Interfaces http://icl-server.ucsd.edu/~kirsh/Articles/Interactivity/brock-single.html
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- 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
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