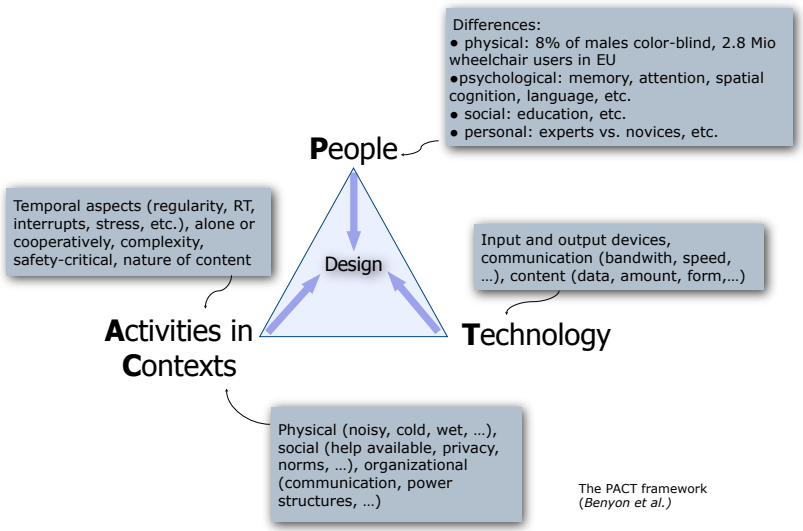
Human-Computer Interaction

2. Termin: Design basics & the human

What is Human-Computer-Interaction?

- HCI aims at making interactions between people and machines less stressful and less error-prone, and thus to increase efficiency of tasks that involve the human and the computer
- HCI is concerned with the *design*, *evaluation* and *implementation* of interactive systems for human use
- HCI involves research on the human, the technology, the interaction, and the context in which everything takes place



The PACT framework (*Benyon et al.*)

Now...

focus on the human (user)

Recommended readings:

- Dix et al.: "Human-Computer Interaction", Kap. 1, S. 12-26
- Matlin & Foley: "Sensation and Perception" (3rd ed.), Needham Heights: Allyn & Bacon, 1992.
- Reed: „Cognition" (5th ed.), Wadsworth, 2000, Kap. 1-5
- Benyon et al.: „Designing Interactive Systems", 2005, Kap. 5, 15, 16

The *human-centred* view on HCI

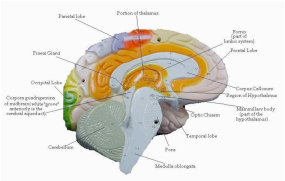
In HCI, the human processes information...

- **Physically**:
  pressing buttons, moving mouse, adjusting levers, haptic feedback, etc.
- **Perceptually**:
  see information on display, hear audio feedback, feel touch feedback, etc.
- **Conceptually**:
  try to understand system from the feedback provided, plan what should be done next

The human centred view in HCI

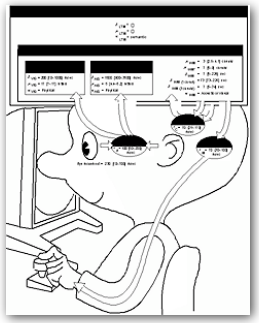
Heavily influenced by Cognitve Science and Cognitive Psychology viewpoint:

Human as information processor

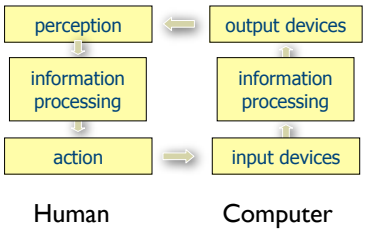


- input/output: visual, auditory, haptic, movement, force
- memories: sensory, short-term, long-term, working
- processing: reasoning, problem-solving, skills and routines, experiences, errors
- regulated and influenced by emotions

Psychology of HCI (Card, Moran & Newell; 1983)



Two information processors coupled in goal-directed action.



Human Information Processing

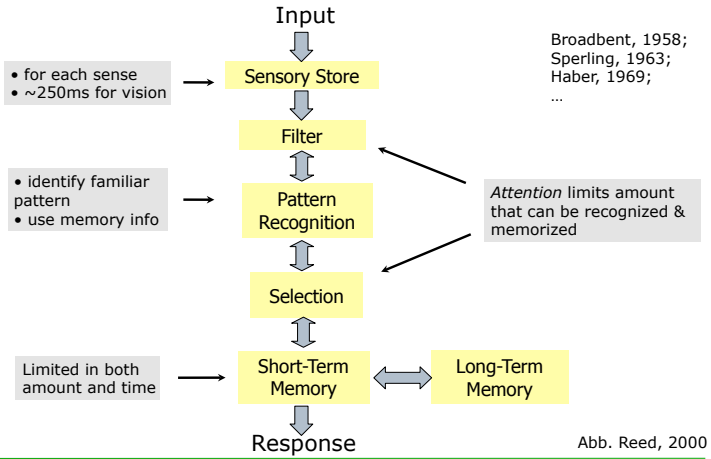
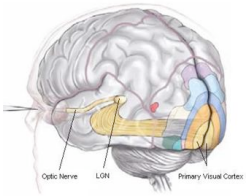


Abb. Reed, 2000

Perception

Vision & visual perception

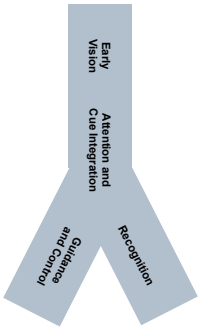


- Roughly a two-stage process:

1. Physical reception of stimuli
   - Light sensation by optical appartus of the eye
   - Transformation into neural impulses in photo receptors of the retina

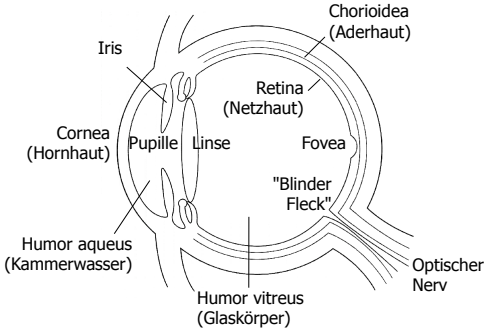
2. Processing & interpretation
   - Processing starts right in the retina
   - Further processing and interpretation in brain structures (visual cortex)

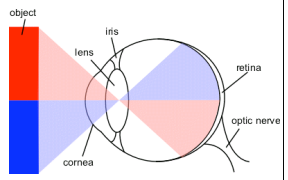
Visual perception steps

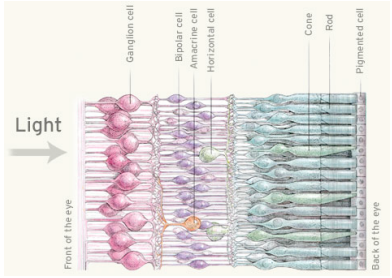


- **Early = Preattentive vision:**
  - Generates image-like "maps" for depth, color, texture, contrast, and motion
  - Parallel processing
  - Perceptual learning
- **"Middle Vision"**
  - Serial processing within a focus of attention
  - Cue integration
  - Figure and ground segmentation
- **Recognition**
  - Generates judgements ("names")
  - Invariance with respect to position, pose, illumination, etc
  - Learning of categories
- **Guidance and Control**
  - Eye-hand coordination
  - Body posture
  - Movement control and stabilization

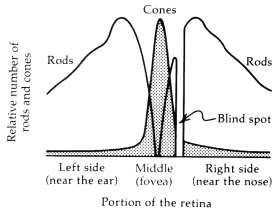
The human eye





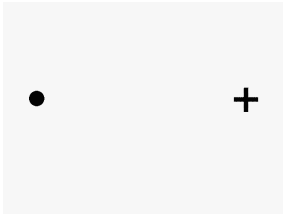


	Cones	Rods
Function	Color sight	Black-white sight
Number	7 Millions	125 Millions
Distribution	everywhere, conentrated at Fovea	not at Fovea
Lighting conds.	well illuminated	dark
Resolution	very good	weak
Sensitivity	weak	very good



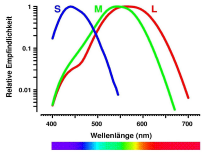
- Rods dominate peripheral vision
- details better seen in foveal region
- more sensitive with peripheral vision
- visual system compensates blind spot

The blind spot

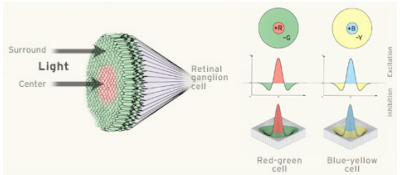


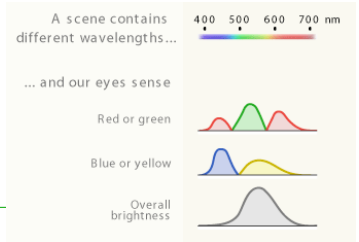
Cover your left eye, look directly at the dot from some distance, move towards it. At some point the cross will disappear!
To check, cover your right eye and do the same - no blind spot! That's because your left eye's blind spot is to the left of the dot.

Vision: color



- Receptors
  - Three cone types with preferred wave lengths
    - S: blue, M: green-yellow, L: yellow-red
  - Humans can distinguish 150 colors, with varying saturation and brightness ca. 7 Mio colors
  - More M and L receptors in fovea than S type (bad color perception)
- Ganglion cells





Vision: depth perception

- Visual angle (~size of image projected on retina) depends on size & distance of object
- But even at different distances, same objects are perceived as being of same size ("*Größenkonstanz*")

→ brain needs to take *depth information* into account

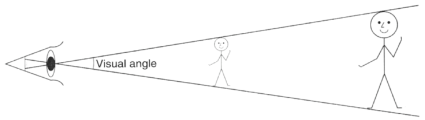
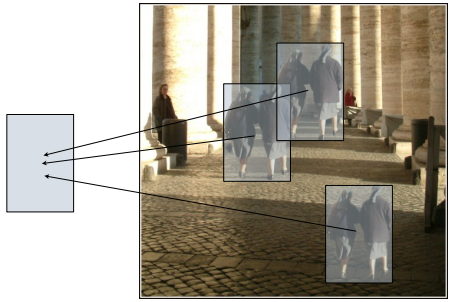


Abb.: Dix et al., 1998

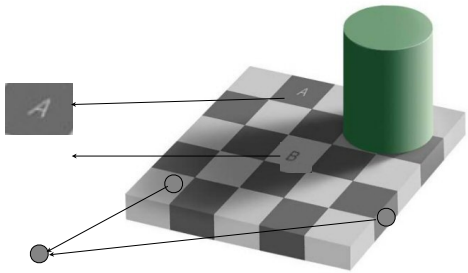
Perceiving size & depth

- Primary depth cues
  - difference of left-/right-eye images (close-up range)
  - process of combining these images
  - process of shaping the lens to create sharp image
  - inward movement of eyes to focus (2-7m)
- Secondary depth cues
  - Light & shade
  - Linear perspective
  - Height over horizontal plane: distant objects higher above horizont
  - Motion parallax: images of things at different distances vary differently when moving
  - Overlap & occlusion
  - Relative size: small objects tend to be further away
  - Texture gradient

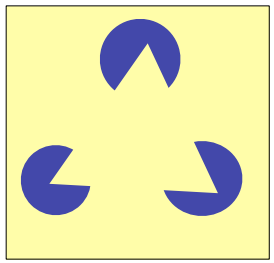
Relative size



Light & shade



Feature Integration and Perceptual Organization



Kanizsa triangle:

Subjective contours are perceived at the boundary between the triangle and the background.

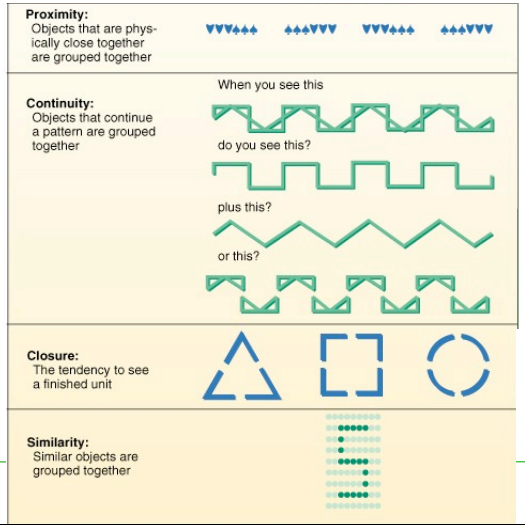
Gestalt "laws".

„Gestalt laws“ of visual perception

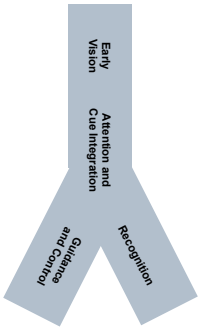
- The brain strives to make visual impressions clearer, simpler, better understandable
- Gestalt psychology assumes „Prägnanz“ to be a basic principle of perception, such that more concise forms provide better conditions for perception and memory
- „Gesetz der guten Gestalt“: Gestalt qualities given, if some order is recognizable that eases perception
  - the more difficult the order, i.e. the harder to group elemens together, the more reduced the Gestalt and perceptive qualities

(Max Wertheimer)

Gestalt principles (examples)



Visual perception steps



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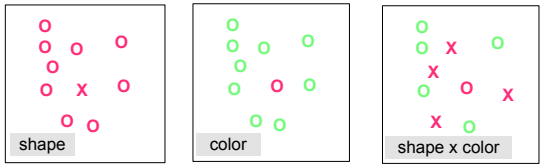
Attentive vs. Preattentive Vision:



- Task: find deviating element ("odd man out")
  - Within one "feature dimension", search time is independent of number of distractors (parallel search)
  - Conjunctions involving different feature dimensions require serial search, search times grows with number of distractors.
- Feature integration theory (Treisman & Gelade, Cogn. Psychol 1980): Binding of feature maps by *focus of attention*

How is form recognized?

- Comparison with patterns stored in LTM
- Processed & stored in terms of …?
  - Templates (Philipps, 1974)
  - Features (Gibson, 1969; Egeland, 1975; …)
  - Features + structure (Marr, 1978; Biederman, 1987)

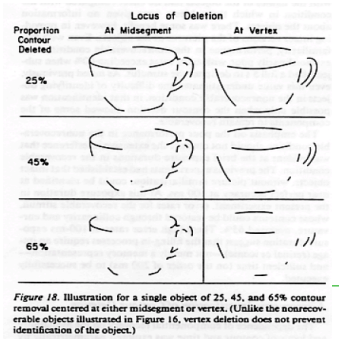


Figure 18. Illustration for a single object of 25, 45, and 65% contour removal centered at either midsegment or vertex. (Unlike the nonrecoverable objects illustrated in Figure 16, vertex deletion does not prevent identification of the object.)

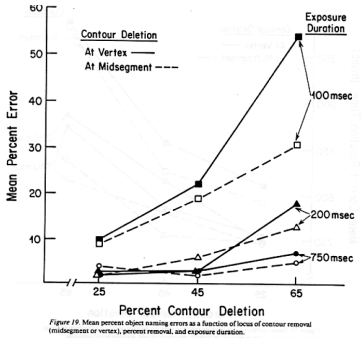
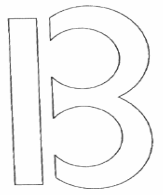


Figure 19. Mean percent object naming errors as a function of locus of contour removal (midsegment or vertex), percent removal, and exposure duration.

Importance of visual context



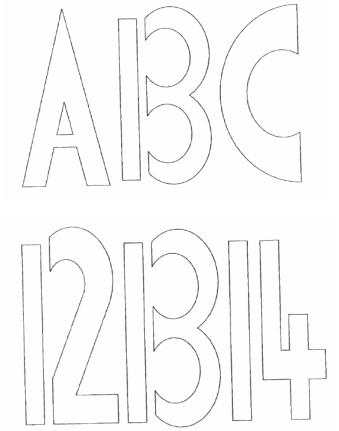


Abb.: Dix et al., 1998

Reading - applied pattern recognition

- Not a sequential process of building words from letters
  - Saccades & fixations (depend on text complexity), perception occurs during fixations
  - Words are patterns too, can be recognized as quickly as letters
  - Recognition on three interacting levels in parallel: features, letters, words (McClelland & Rumelhardt, 1981; Massaro & Cohen, 1991)
- *Word superiority* effect (Reicher, 1969):
  - Stimulus: 1 letter, 4-letter word, 4-letter non-word
  - Task: which of 2 alternative characters was at a certain pos.?
  - Result: most accuracte in word condition
- Speed: about 250 words per minute
  - Dark characters on light backround easier to read
  - negative contrast improves reading from screen

Reading

- Perception is both bottom-up *and* top-down
- guided by context and expectation

"Luat enier sidtue an eienr elgnhcsien uvrsnäiett, ist es eagl in wcheler rhnfgeeloie die bstuchbaen in eniem wrot snid. das eniizg whictgie ist, dsas der etrse und der lztete bstuchbae am rtigeichn paltz snid. der rset knan tatol deiuranchnedr sien und man knan es ienrmomch onhe porbelm lseen. das legit daarn, dsas wir nhcit jeedn bstuchbaen aeilln lseen, srednon das wrot als gzanes."

The quick brown

fox jumps over the

the lazy dog.

Anm.: Der Effekt wurde schon 1976 im Rahmen einer linguistischen Studie beschrieben

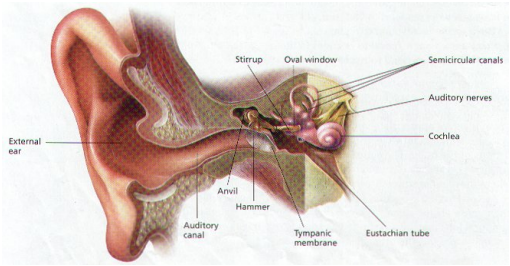
Hearing & auditory perception

A four-stage process:

1. **Transduction**
   - translation of sound waves into neural impulses
2. **Auditory grouping**
   - segregation & integration of sound streams
3. **Scene analysis**
   - extraction of perceptual properties
4. **Interpretation**
   - experience of the auditory environment

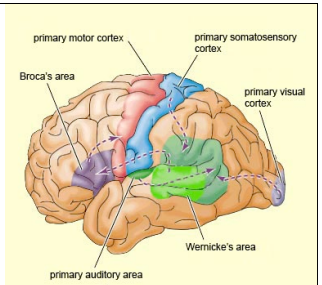
(McAdams & Bigand, 1993)

Human ear



- Transduction
  - Sound wave travels through ear canal
  - Transformation of ear drum vibrations into bone movements (ossicls) and amplification
  - Transmission into cochlea (inner ear), filled with liquid
  - Delicate hair cells bend and cause neural impulses

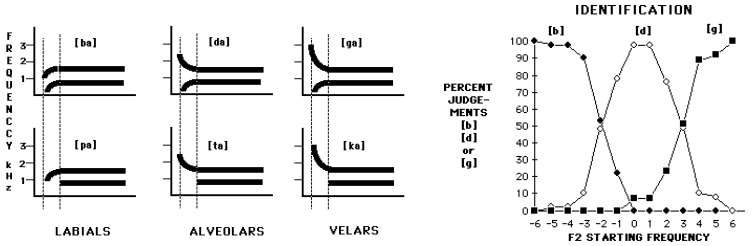
Auditory perception



- Features processed:
  - Loudness (= amplitude)
    - Whisper (15 dB), conversation (60), car horn (110), rock concert (120+)
  - Frequency (= pitch)
    - Human hearing range: 20 Hz - 15.000 Hz
  - Timbre (type or quality of sound)
- Final perception created in auditory cortex
  - Directed hearing: temporal and intensity differences at the two ears
  - Filtering of background noise („cocktail party effect")
  - Impression of non-existent sounds (tinitus)

Categorical (sound) perception

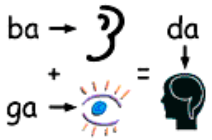
When hearing similar sounds (ba, da, ga), that differ slightly in starting frequency of an harmonic (2nd formant F2), speakers seem to discriminate between learned categories



Audio-visual perception

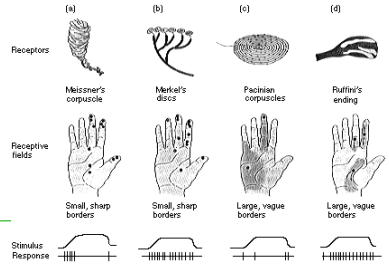
- Integration in dedicated brain areas

„McGurk-Effekt": What does he say?



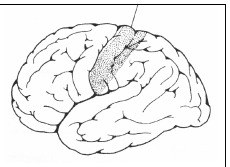
Touch perception

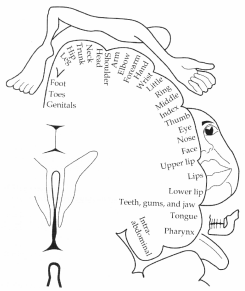
- Receptors underneath the skin and in muscles and joints
- Almost everywhere, ca. 2qm receptive skin surface, but not equally distributed
- Three types of skin receptors
  - thermoreceptors: heat and cold
  - nocireceptors: intense pressure, heat, pain
  - mechanoreceptors:
    - respond differently to immediate or continuous pressure
    - more sensitive in females than in males
    - differences among skin areas (e.g. fingers)



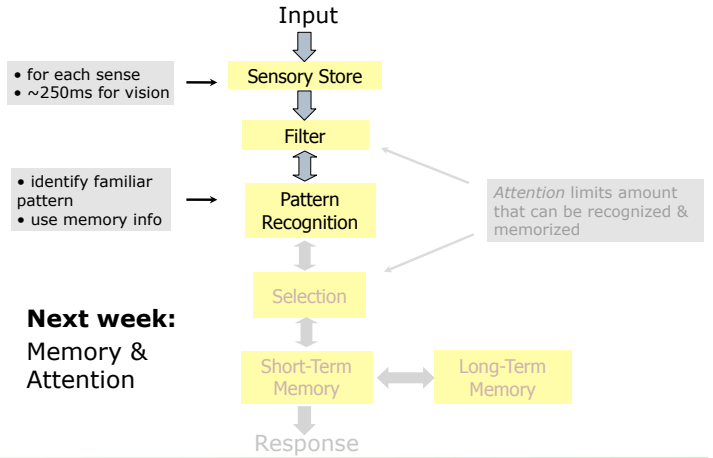
Touch perception

- Somatosensory cortex processes representations of skin receptors
- Brain area size (~ #neurons) proportional to the sensitivity of the respective skin area





Human Information Processing



Next week:
Memory & Attention