Human-Computer Interaction

2. Termin: Design basics & the human

Human-computer interaction

is concerned with the *design**, *evaluation* and *implementation* of interactive systems for *human* use.

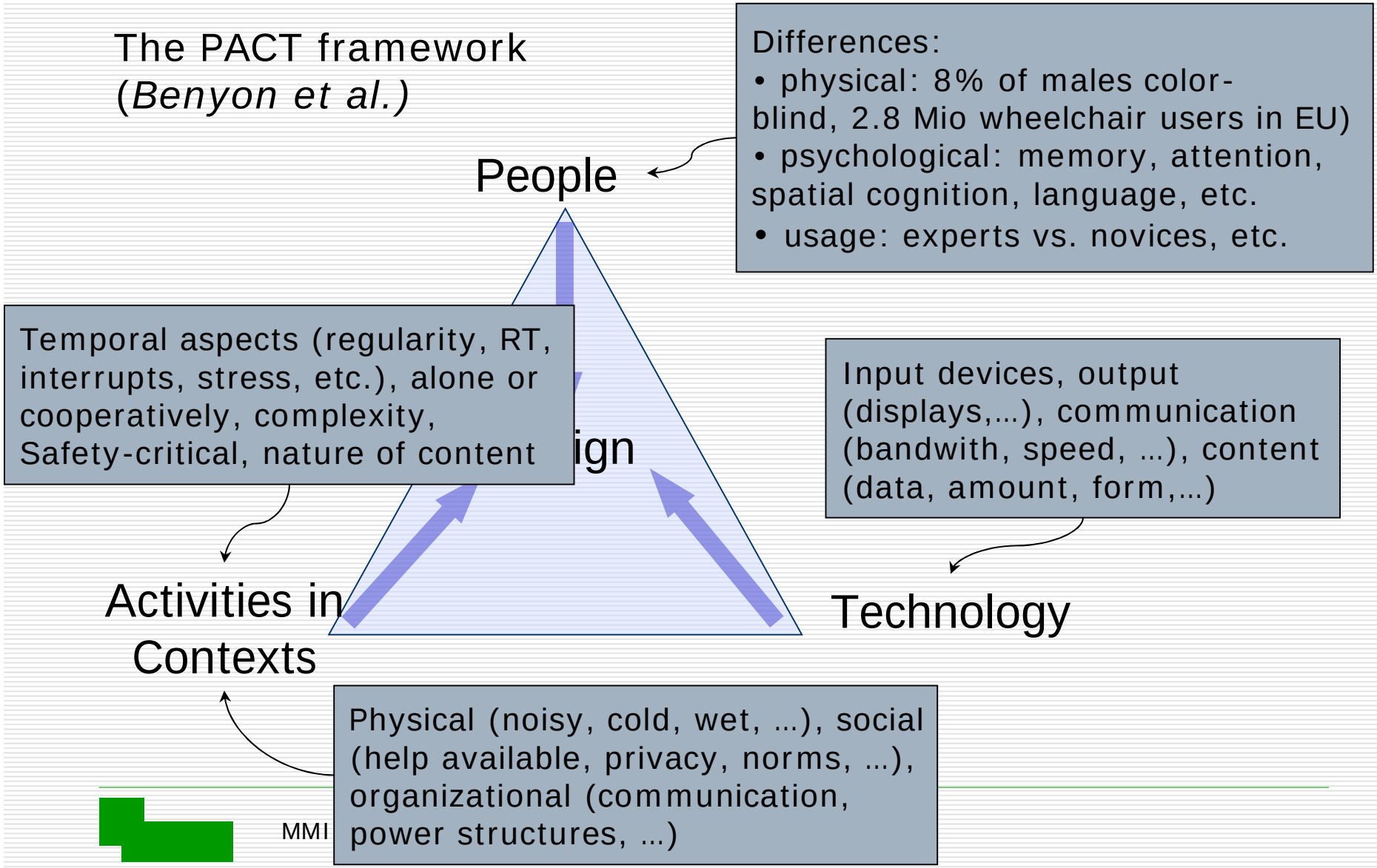
*Design: refers both to the creative process of building a new interactive system and to the representations produced during the process. Here, the former is meant!

Golden rule of design

understand your materials

Designing interactive systems

The PACT framework
(*Benyon et al.)*



For Human–Computer Interaction

- understand people
  - capabilities, psychological & social aspects, etc.
  - human error
- understand computers
  - limitations, capacities, tools, platforms, devices
- understand interaction

Human-centred view:

- *Psychically*
  pressing buttons, moving mouse, adjusting levers, haptic feedback, etc.
- *Perceptually*
  see information on display, hear audio feedback, etc.
- *Conceptually*
  from the feedback we get, try to understand what the system does and what we should be doing

Now...

- Focus on the human from Cognitve Science and Cognitive Psychology
- capabilities & limitations of humans

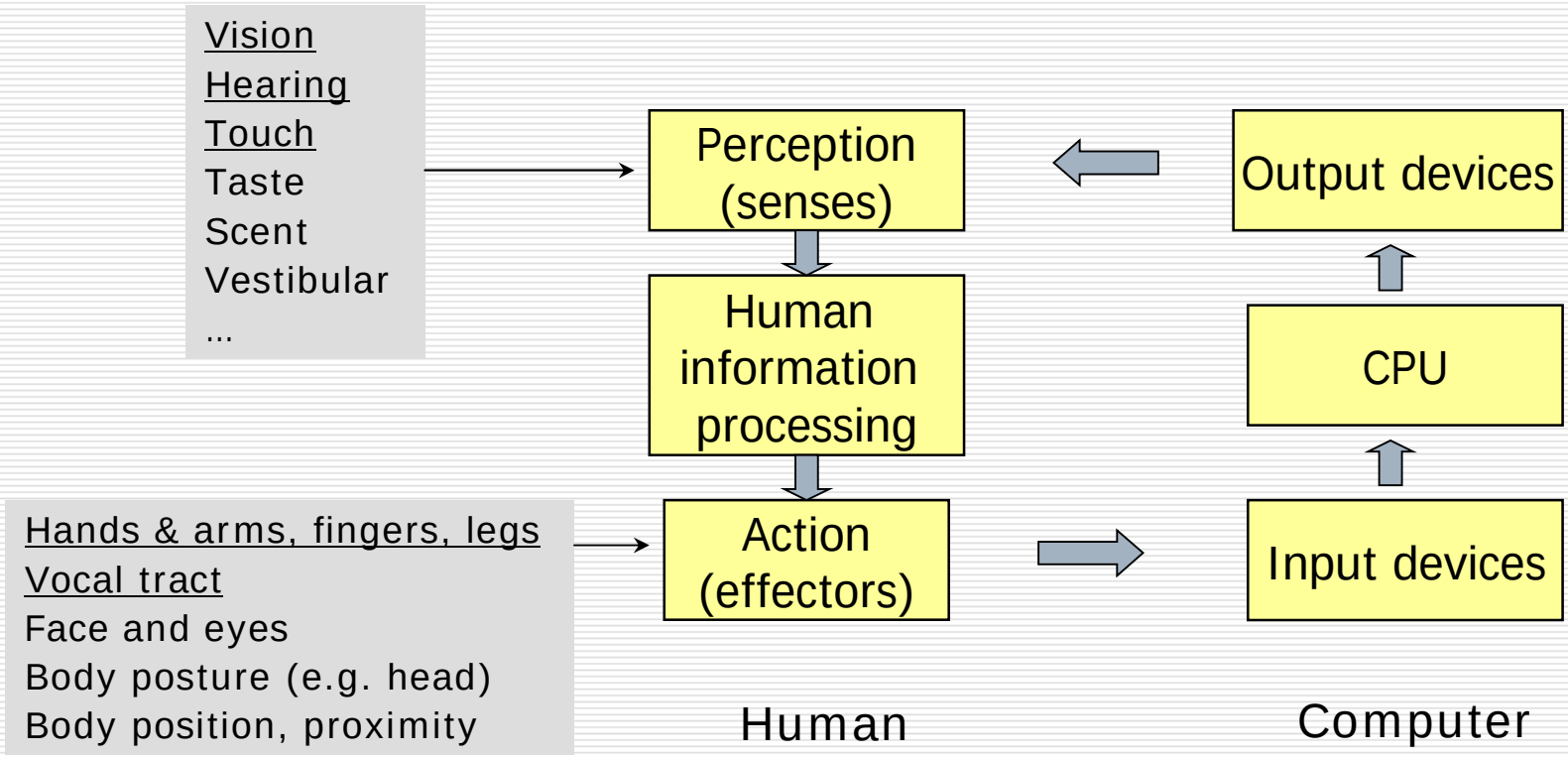
Recommended readings:

- 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

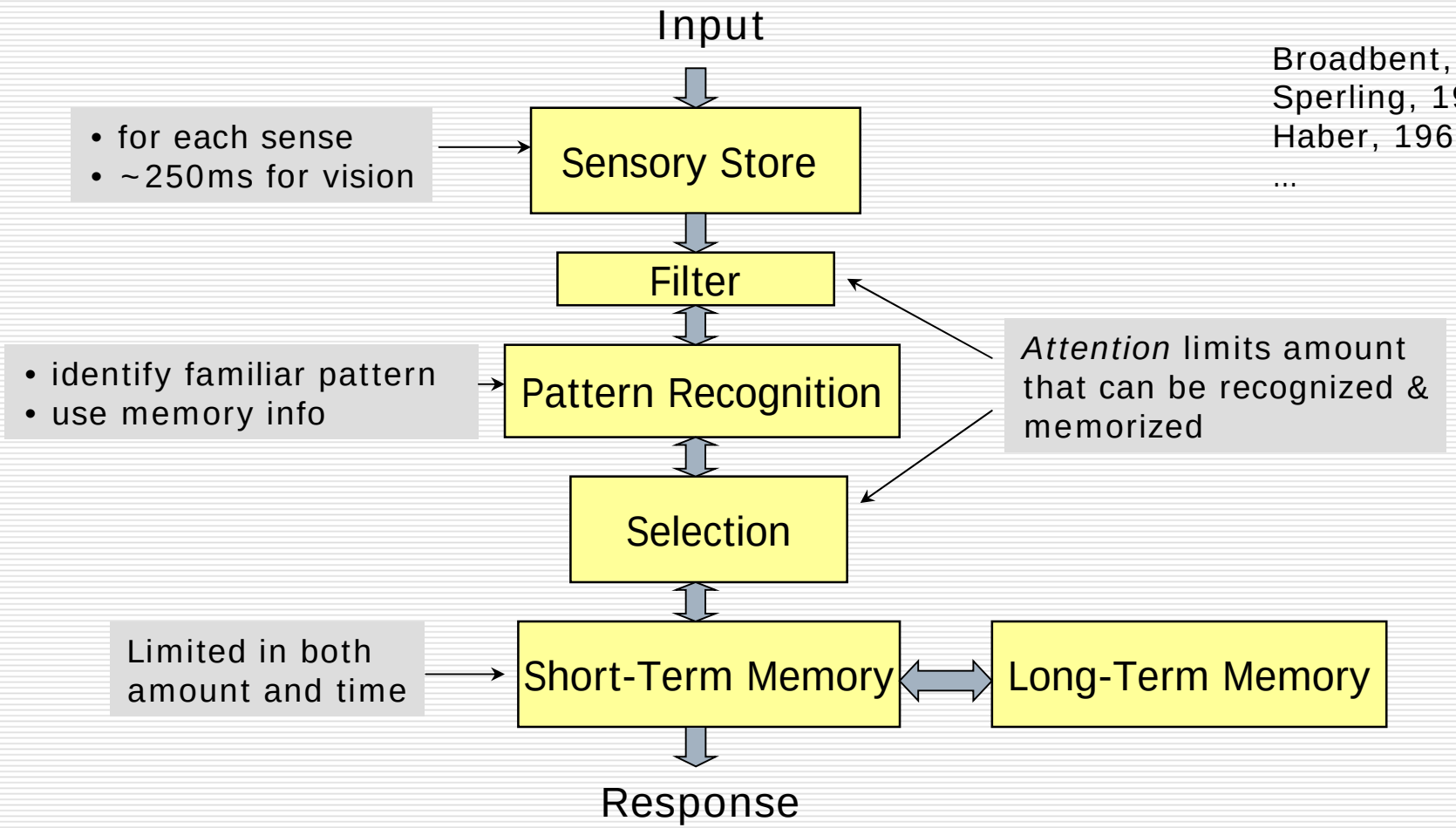
The human

- Information i/o ...
  - visual, auditory, haptic, movement
- Information stored in memory
  - sensory, short-term, long-term
- Information processed and applied
  - reasoning, problem solving, skill, error
- Emotion influences human capabilities
- Each person is different

Early model (Card, Moran, Newell, (1983), Psychology of HCI)



Human Information Processing



Broadbent, 1958;
Sperling, 1963;
Haber, 1969;
...

Abb. Reed, 2000

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

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)

The perceptive apparatus

The human eye

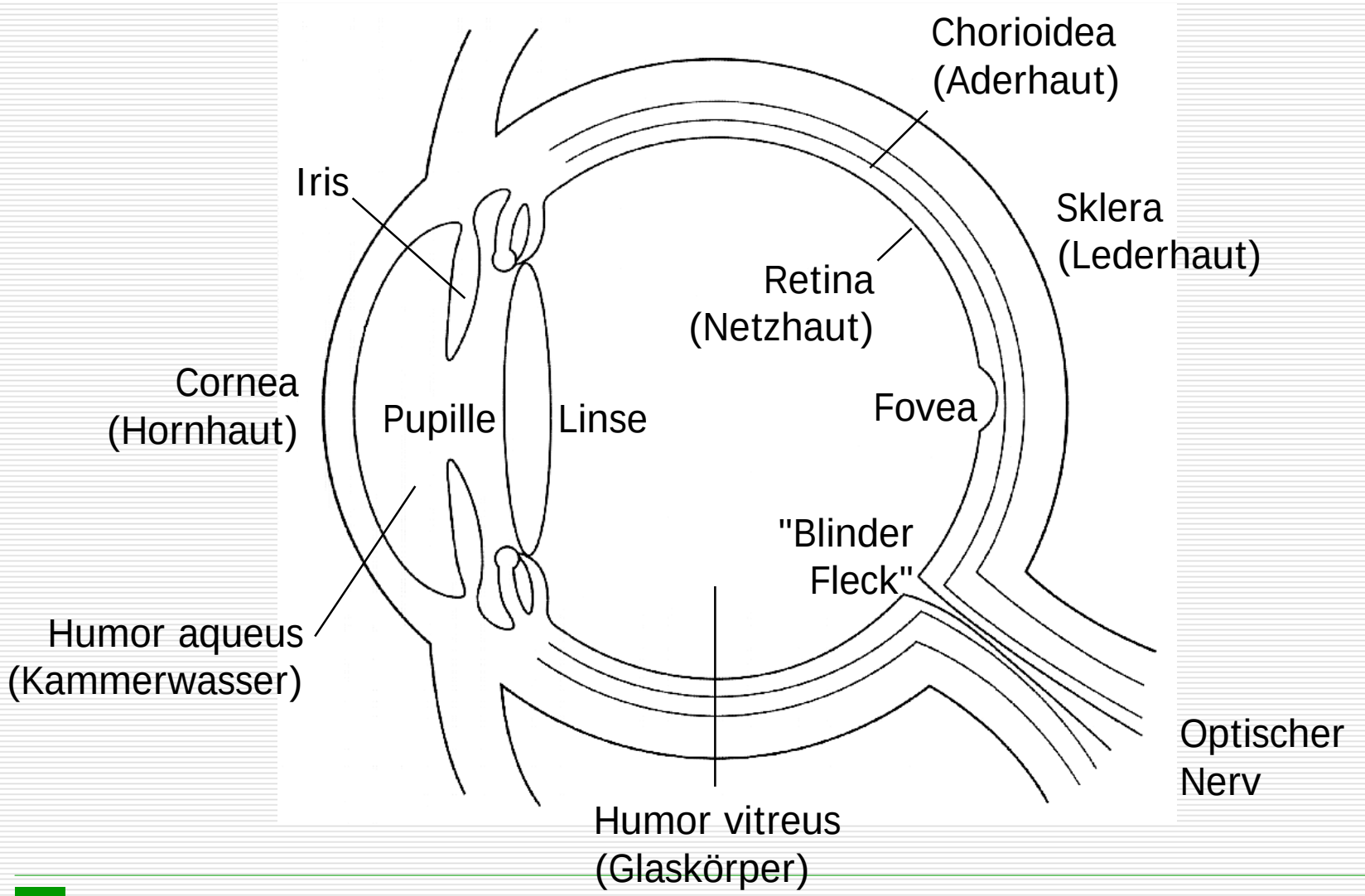
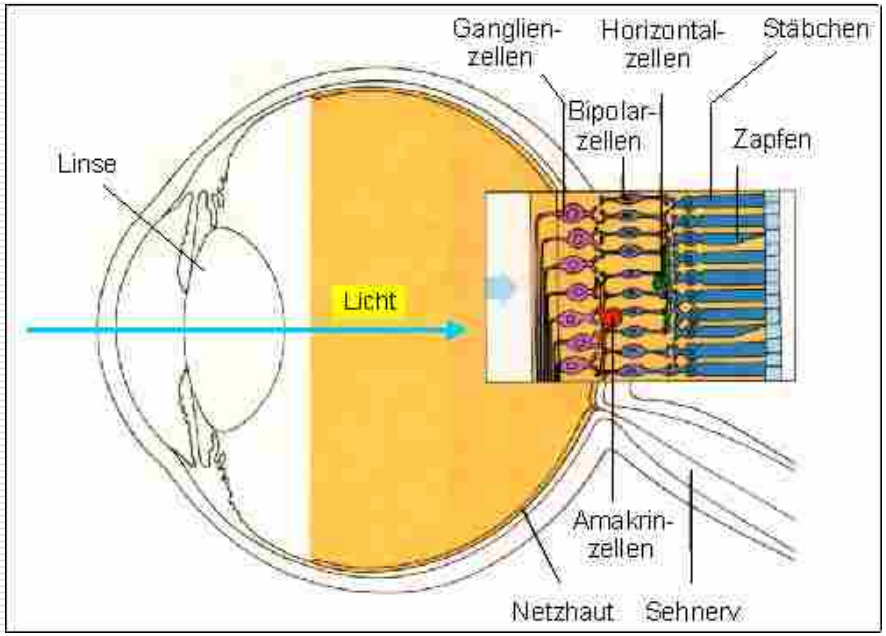


Abb.: Dix et al., 1998

Retina

- Multiple, interconnected cell layers
- “Vertical" organization
  - Two types of photoreceptors: rods (*Stäbchen)*, cones (*Zapfen)*
  - ...connected by bipolar cells
  - ...connected by ganglion cells
- "Horizontal" organization
  - Horizontal cells: connect adjacent photoreceptors and bipolars to each other and with other horizontal cells
  - Amacrine cells: connect adjacent bipolars and ganglions to each other and with other amacrine cells
- Axons of ganglion cells converge in blind spot, constituting the optical nerve, running to the brain

Retina



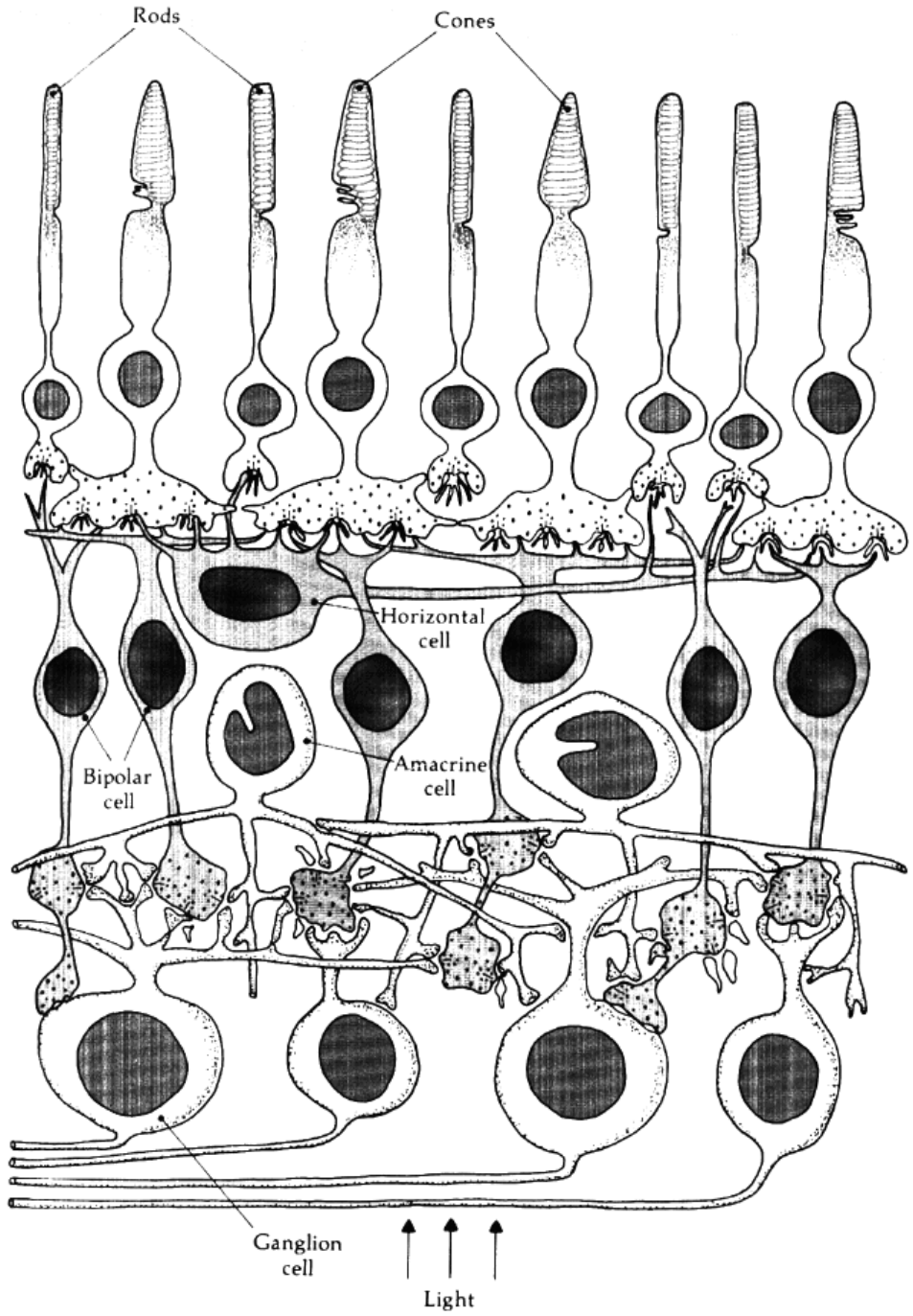


Abb.: Matlin & Foley, 1992

Photoreceptors

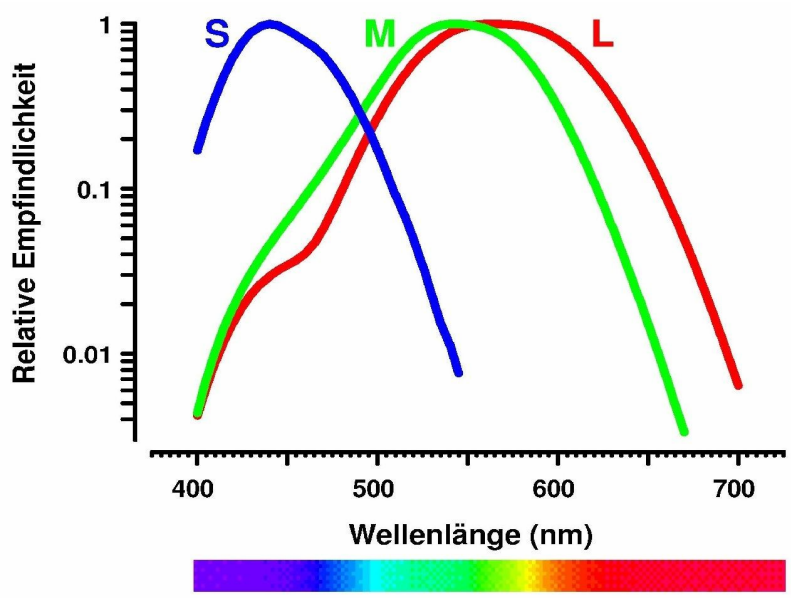
- Light with certain wave length (depends on pigments) causes receptor to “fire”

	Zapfen	*Stäbchen*
Funktion	Farbsehen	Schwarz-Weiß-Sehen
Anzahl	7 Millionen	125 Millionen
Verteilung	überall, konzentriert in Fovea	nicht in der Fovea
Arbeitsbereich	gut beleuchtet	abgedunkelt
Auflösung	sehr gut	schwach
Empfindlichkeit	schwach	sehr gut

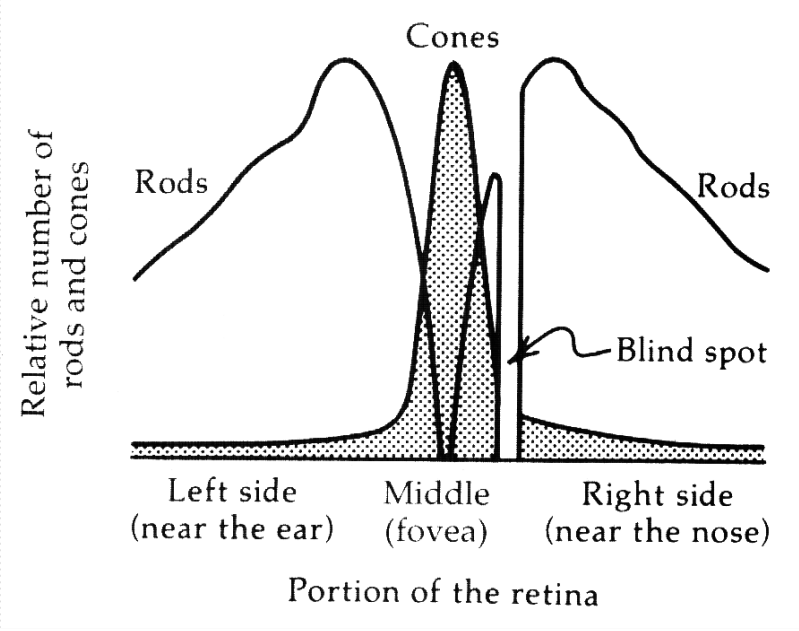
Temporary blindness when moving from dark to bright: rods activated, saturated by sudden light, suppress rods

Perceiving color

- Three cone types (S, M, and L) with preferred wave lengths
- S: blue, M: green-yellow, L: yellow-red
- Humans can distinguish 150 different colors, with varying saturation and brightness ca. 7 Mio colors
- More M and L receptors in fovea than S type g bad color perception of blue in fovea
- ca. 8% of western males and 1% of females color-blinded, most frequent: red-green-blindness



Sensitivity & resolution



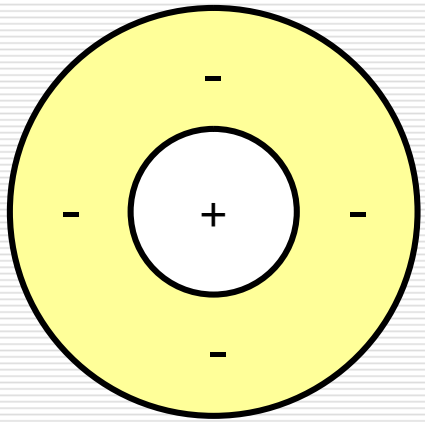
- Rods dominate peripheral vision
- visual system compensates for blind spot

- Resolution non-foveal (rods) smaller than foveal (cones), details can only be seen in foveal area
- Sensitivity non-foveal greater than foveal à night vision better in non-foveal area (e.g., a star disappears when focussed but is visible to peripheral vision)

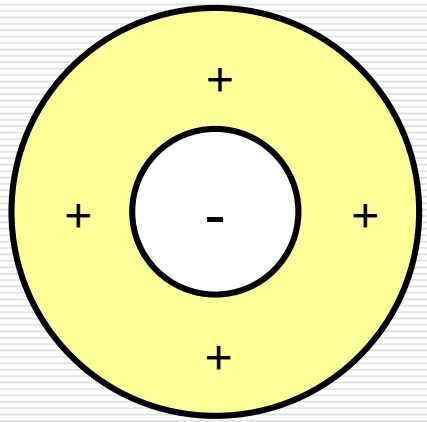
Receptive fields of ganglion cells

- area on retina that causes a ganglion cell to fire when stimulated
- either round or oval
- antagonistic: triggers only when center and surrounding stimulated in opposite ways
- two kinds:

on-center, off-surround



off-center, on-surround

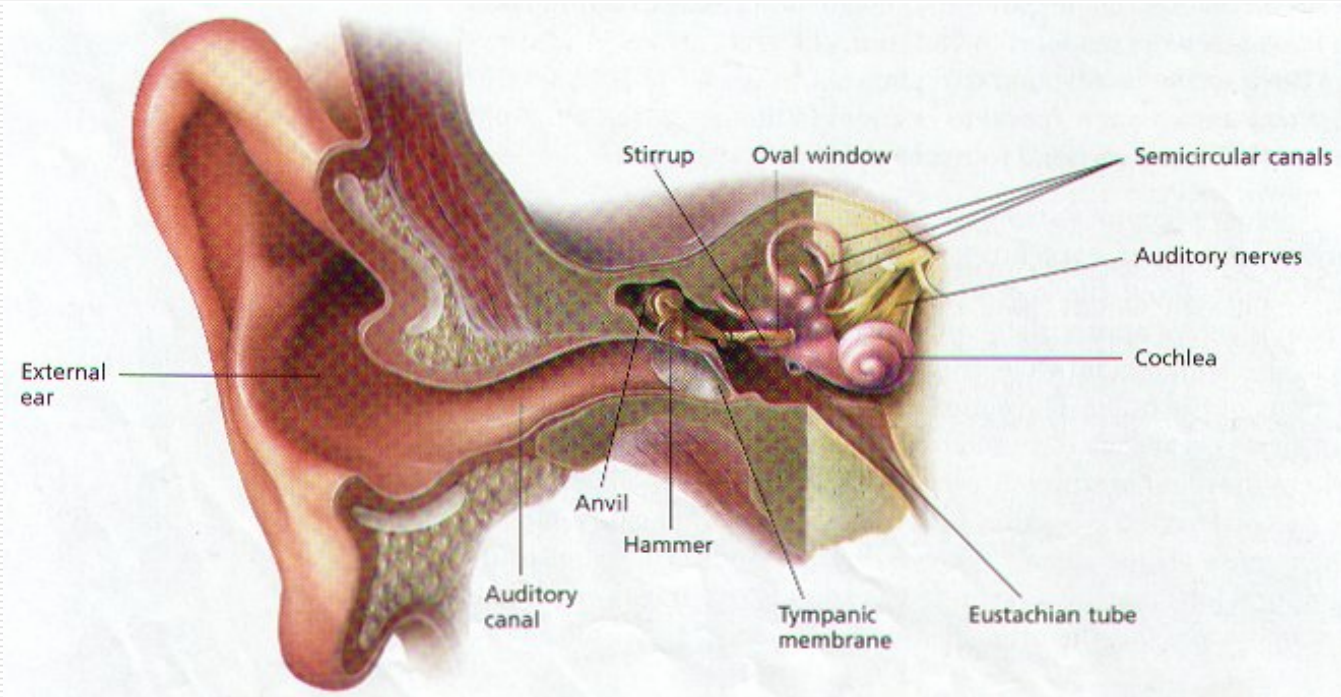


Early processing in ganglion cells

- X-cells
  - small receptive field, concentrated in fovea
  - respond to permanent stimulus
  - early detection of patterns
- Y-cells
  - respond quickly to stimulus onset, decay when stimulus lasts
  - more widely distributed in retina, relatively large receptive field
  - early detection of movement (also peripheral)
- W-Zellen
  - Homogeneous receptive field
  - Respond slowly
  - Detection of motion

è Retina is already able to detect complex stimuli

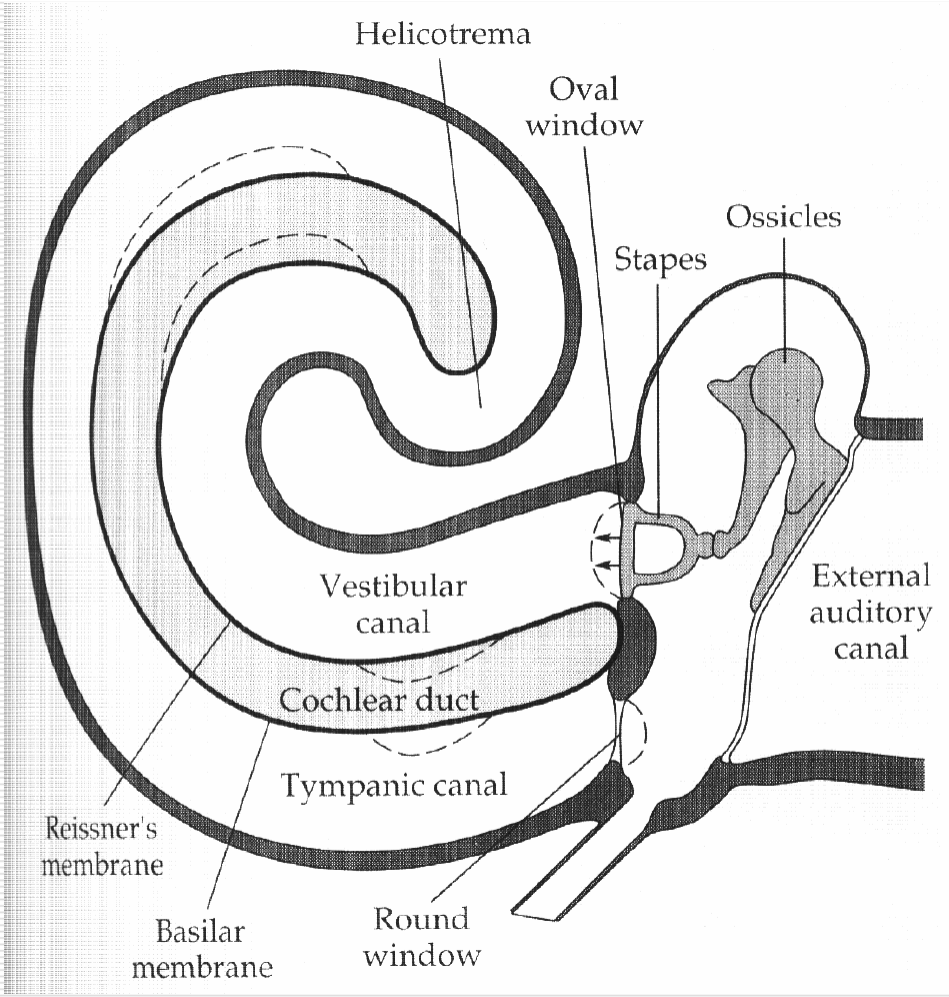
Human Ear



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

Innenohr



- vom ovalen Fenster wird die Bewegung auf die *Basilarmembran* übertragen
- Bewegung läuft wellenförmig die Basilarmembran entlang
- auf der Basilarmembran innerhalb des *Schneckengangs* befinden sich *Haarzellen*
- Haarzellen registrieren kleinste Vibrationen; sie wandeln die Schwingungen in Nervenimpulse um

Abb.: Matlin & Foley, 1992

Touch

- Sensed by receptors beneath the skin (cutaneous receptors) and in muscles and joints (kinaesthetic r.)
- Not localized, ca. 2qm receptive skin surface
- Three types of skin receptors
  - thermoreceptors: heat and cold
  - nocireceptors: intense pressure, heat, pain
  - mechanoreceptors: pressure, two subtypes
    - Respond to immediate pressure
    - Respond to continuous pressure

Sensitivity and acuity of mechanoreceptors

- more sensitive in females than in males
- differences across skin regions

Perception (higher-level processing)

Vision: Depth perception

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

g brain takes depth information into account!

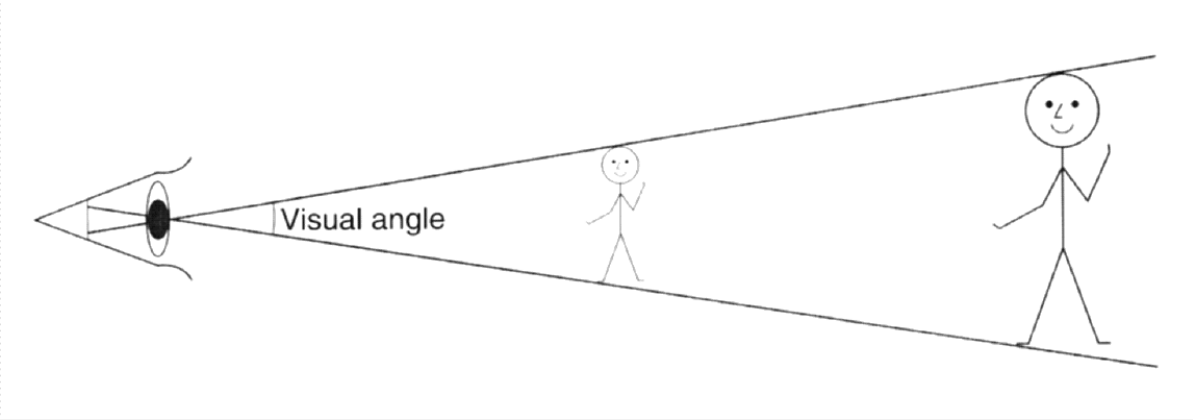


Abb.: Dix et al., 1998

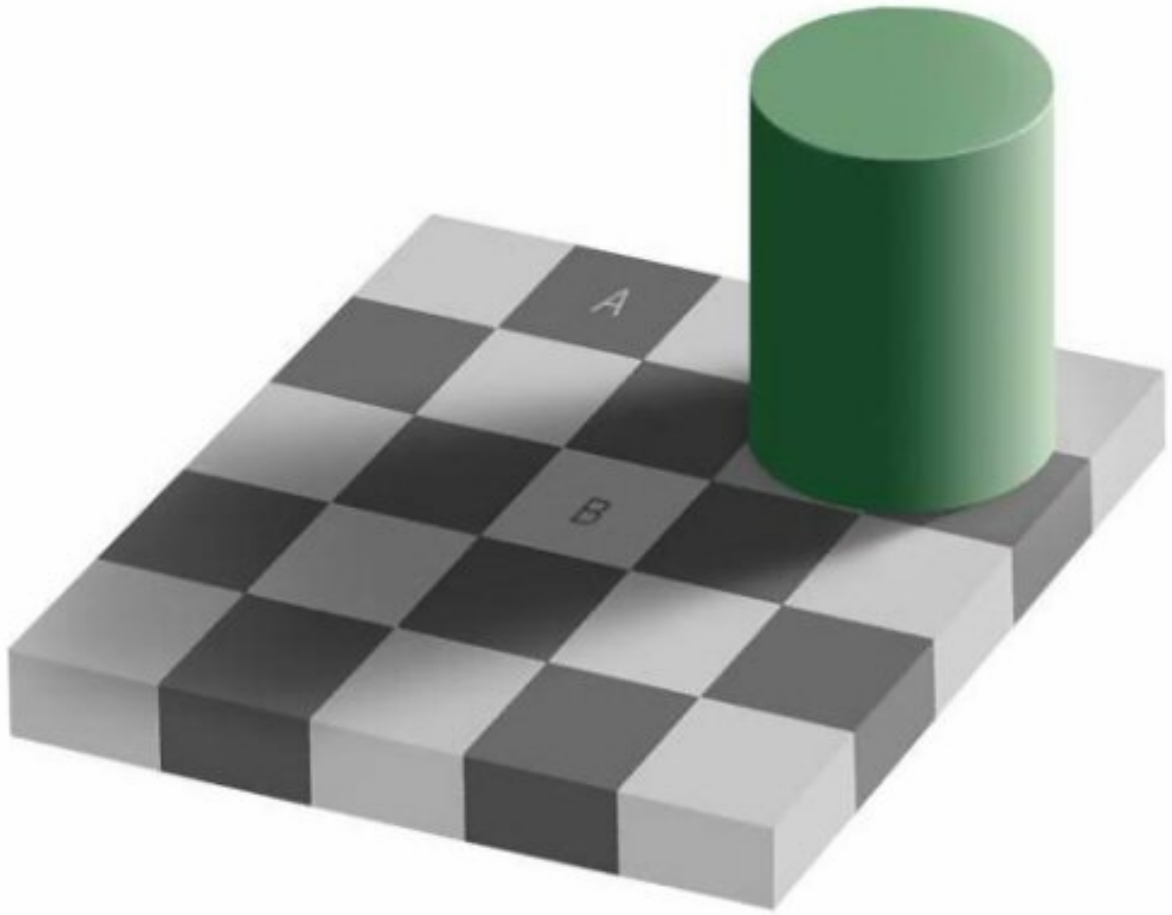
Virtual Reality–simulating depth perception

Perceiving size & depth

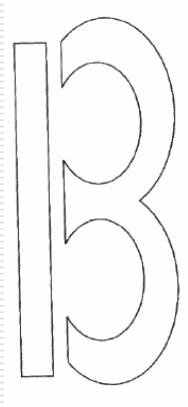
- Primary depth cues
  - Retinal disparity: difference of perceived images (close-up range)
  - Stereopsis: process of combining these images
  - Accommodation: process of shaping the lens to create sharp image
  - Convergence: inward movement of eyes to focus (2-7m)
- Secondary depth cues
  - Light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

Relative size

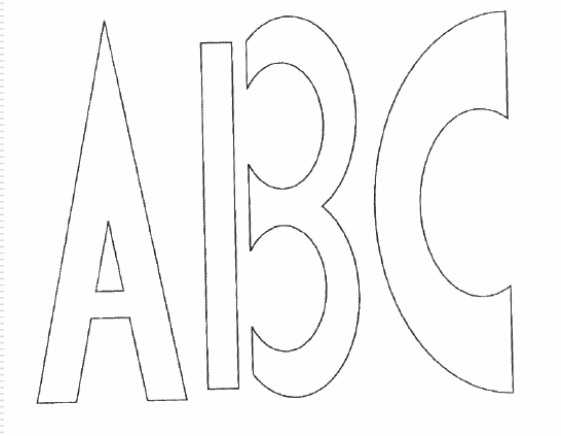
Light & shade



Interpretation depends on visual context



Letter or number?



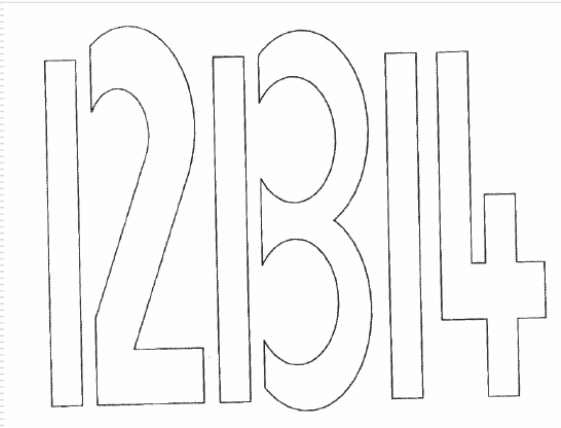
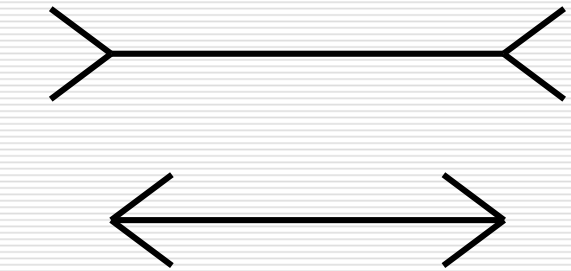
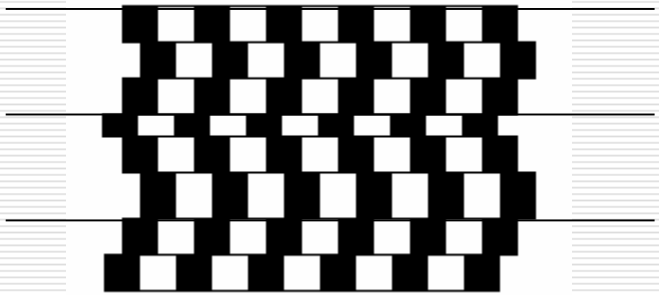


Abb.: Dix et al., 1998

Geometrical optical illusions

- Information about depth, length, orientation, etc. that are misinterpreted by higher-level processing





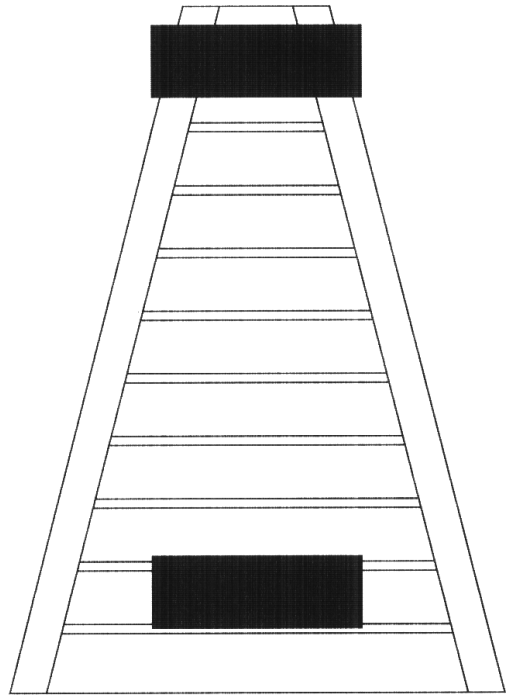
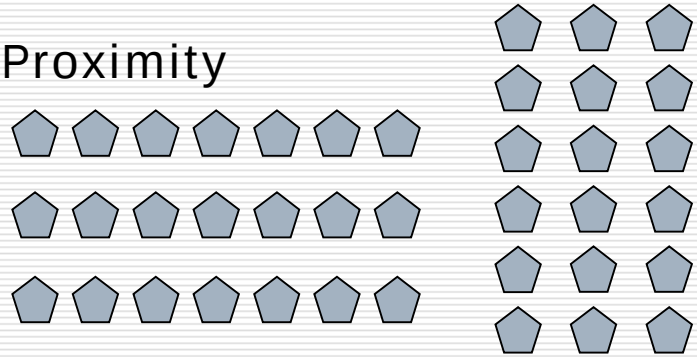


Abb.: Dix et al., 1998

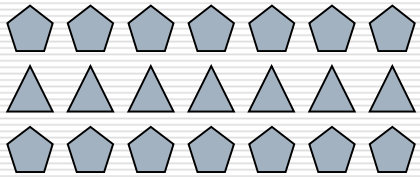
Gestalt principles of visual perception

Laws of perception, regarded as being innate.
(early 20. century, Max Wertheimer)

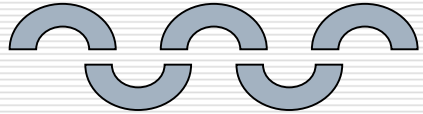
Proximity



Similarity

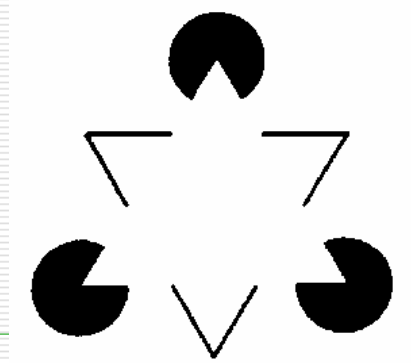


Continuity



Part-whole relations

Closure



Pattern recognition

- 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)

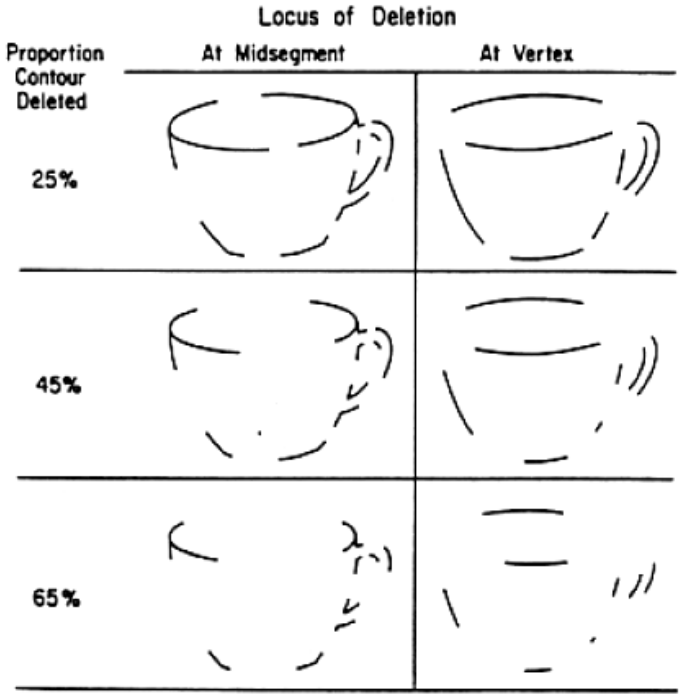


Figure 18. Illustration for a single object of 25, 45, and 65% contour removal centered at either midsegment or vertex. (Unlike the nonrecoverable objects illustrated in Figure 16, vertex deletion does not prevent identification of the object.)

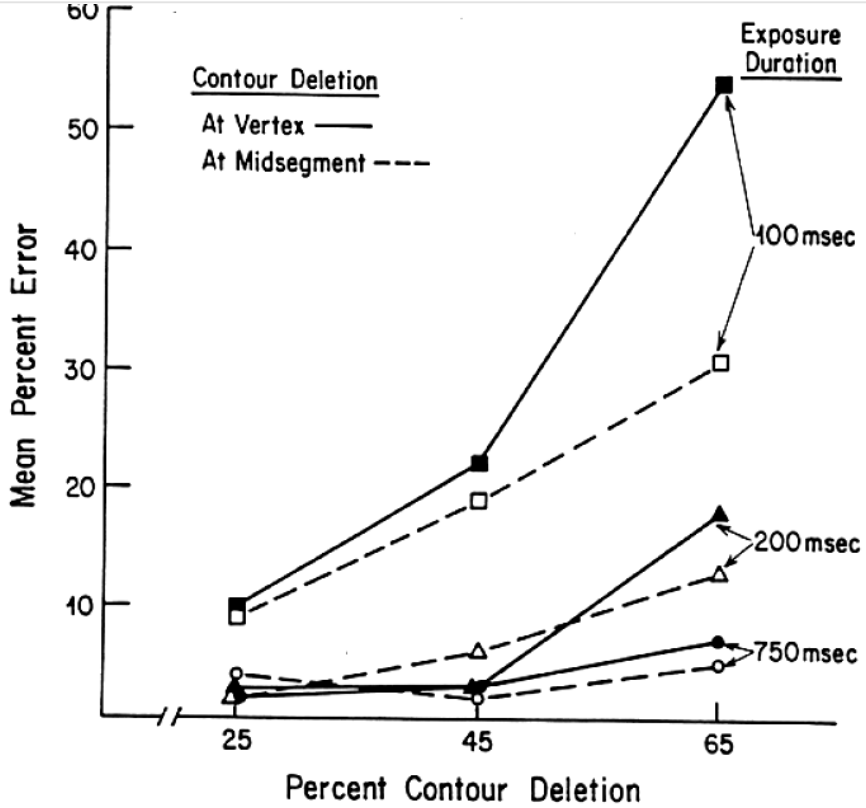


Figure 19. Mean percent object naming errors as a function of locus of contour removal (midsegment or vertex), percent removal, and exposure duration.

Reading - applied pattern recognition

- *Not* a sequential process of perceiving letters one by one
  - *Saccades & regression* (depend on text complexity)
  - Words 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
- Adults read ca. 250 words per minute
- Dark characters on light backround easier to read

Reading

- Context and expectations have great influence
- Just read this:

"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."

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

Read quickly:

The quick brown

fox jumps over the

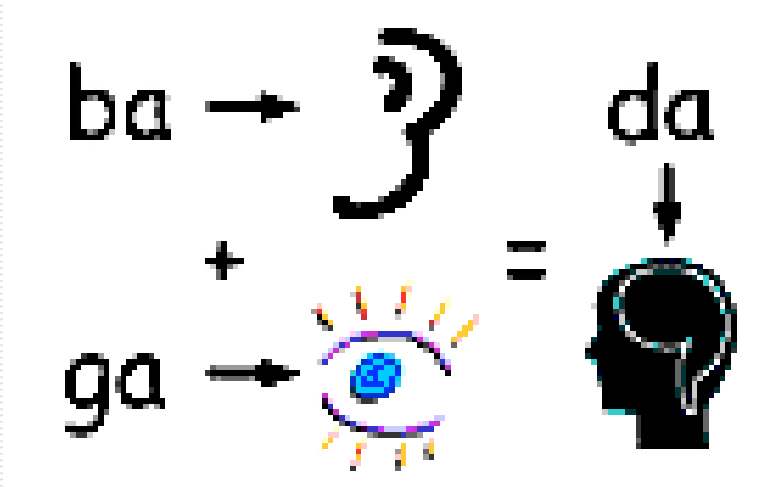
the lazy dog.

Auditory perception

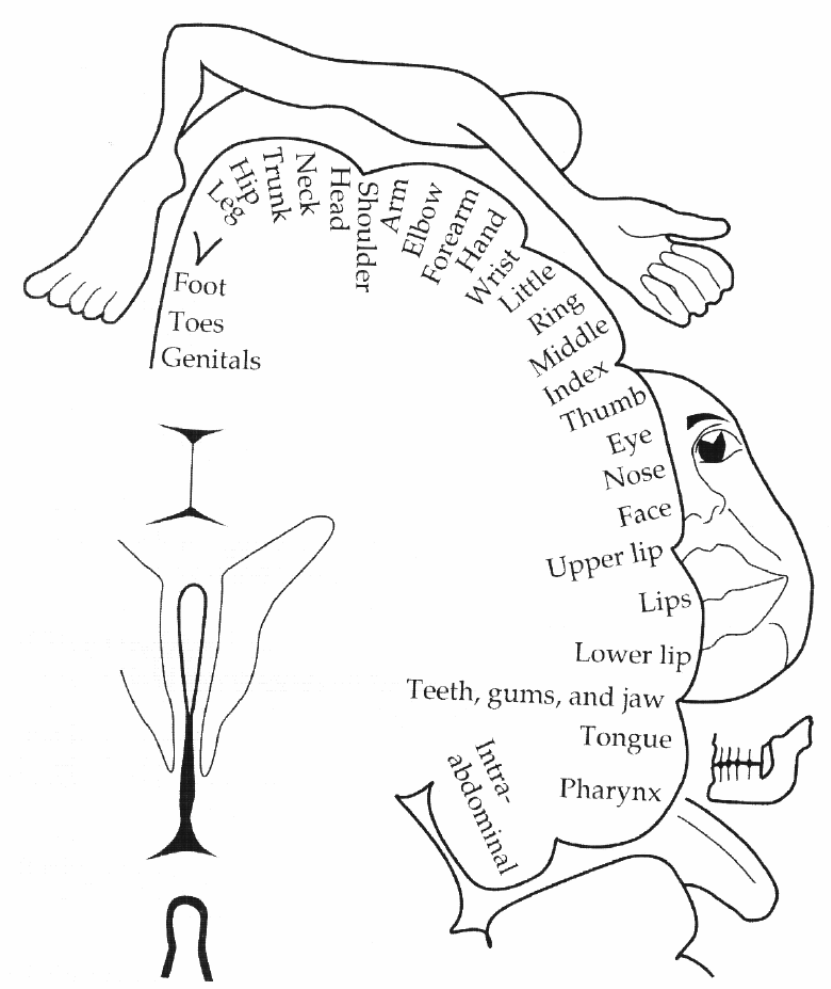
- Features processed:
  - Loudness
    - Whisper (15 dB), conversation (60 dB), car horn (110 dB), rock concert (120+ dB)
  - Frequency = pitch
    - Human hearing range: 20 Hz - 20.000 Hz
    - Sampling rate <1.5 Hz, less accurate for high frequencies
  - Timbre (quality of sound)
- Directed hearing: temporal and intensity differences at the two ears
- Filtering of background noise *(cocktail party effect)*
- Impression of non-existent sounds (*tinitus*)

Vision & listening in speech understanding

„McGurk-Effekt“: What does he say?



Processing of skin receptions



Somatosensory cortex processes representations of skin receptors proportional to the sensitivity of the respective skin area.