Human-Computer Interaction

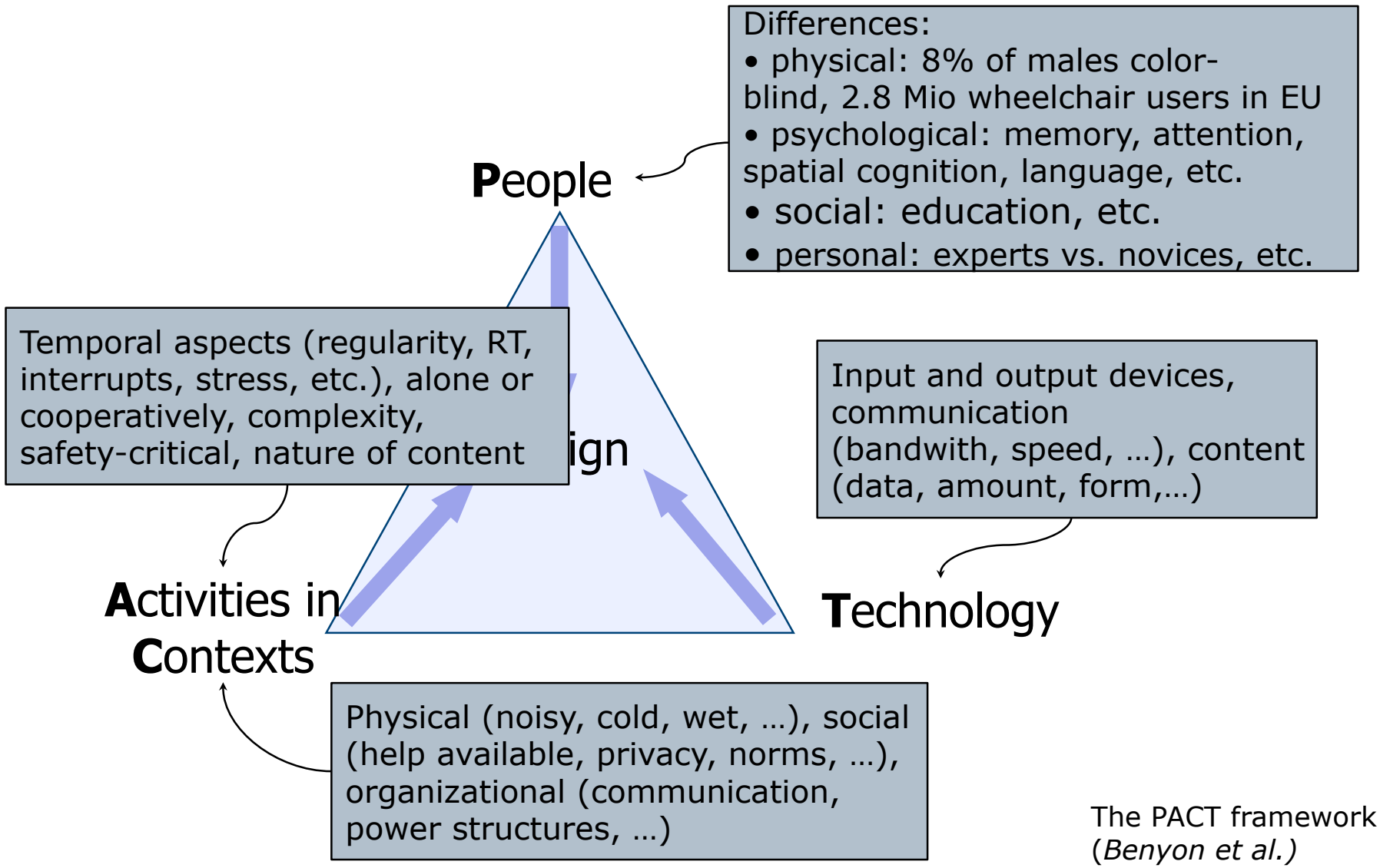
2. Termin: Design basics & the human

What is Human-Computer-Interaction?

- HCI aims at making interactions between people and machines less stressful and less error-prone, and thus 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.

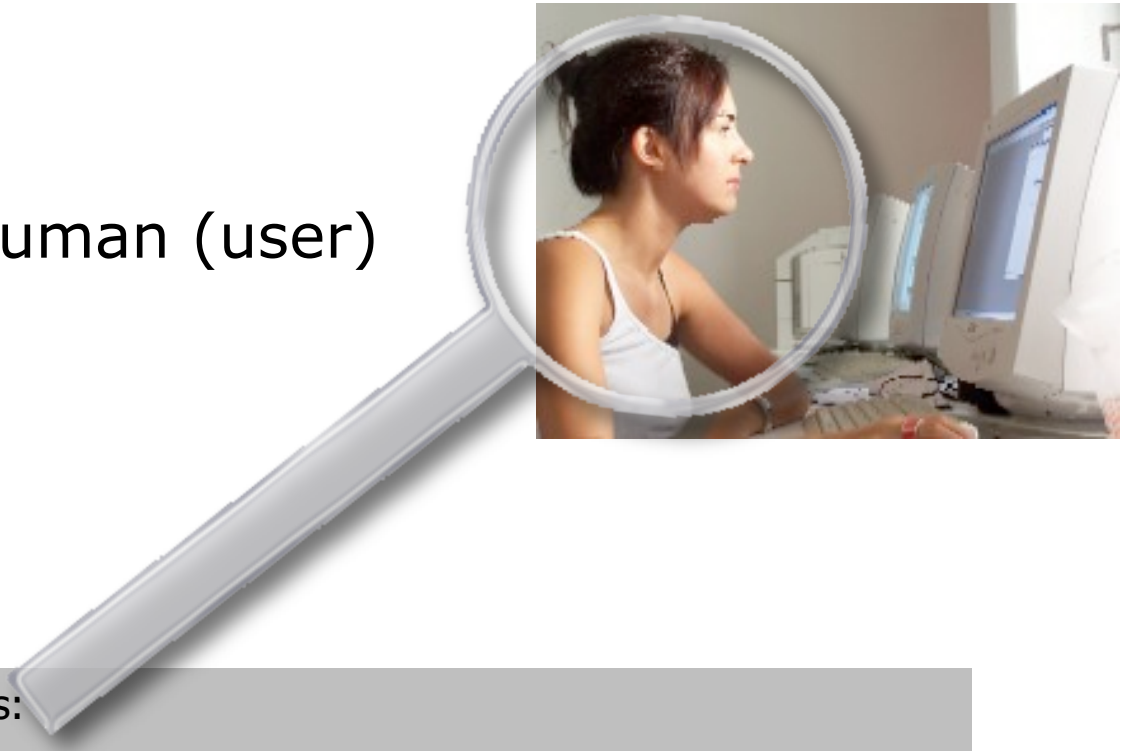
- HCI involves research on the human, the computer (technology), the interaction, the context in which everything takes place



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

- *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

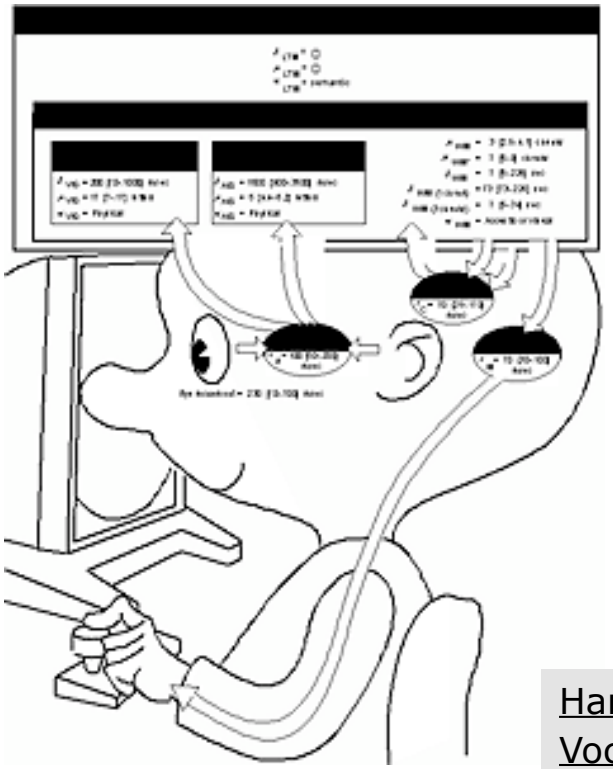
The human centred view in HCI

Almost always from Cognitve Science and Cognitive Psychology viewpoint:

Human as *information processor*

- input/output: visual, auditory, haptic, movement, force
- stored in memory: sensory, short-term, long-term
- processed and applied: reasoning, problem solving, skills and experiences, error
- influenced by emotions

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



Human

Vision, Hearing, Touch, Taste, Scent, Vestibular

Perception (senses)

Human information processing

Action (effectors)

Hands & arms, fingers, legs
Vocal tract
Face and eyes
Body posture (e.g. head)
Body position, proximity

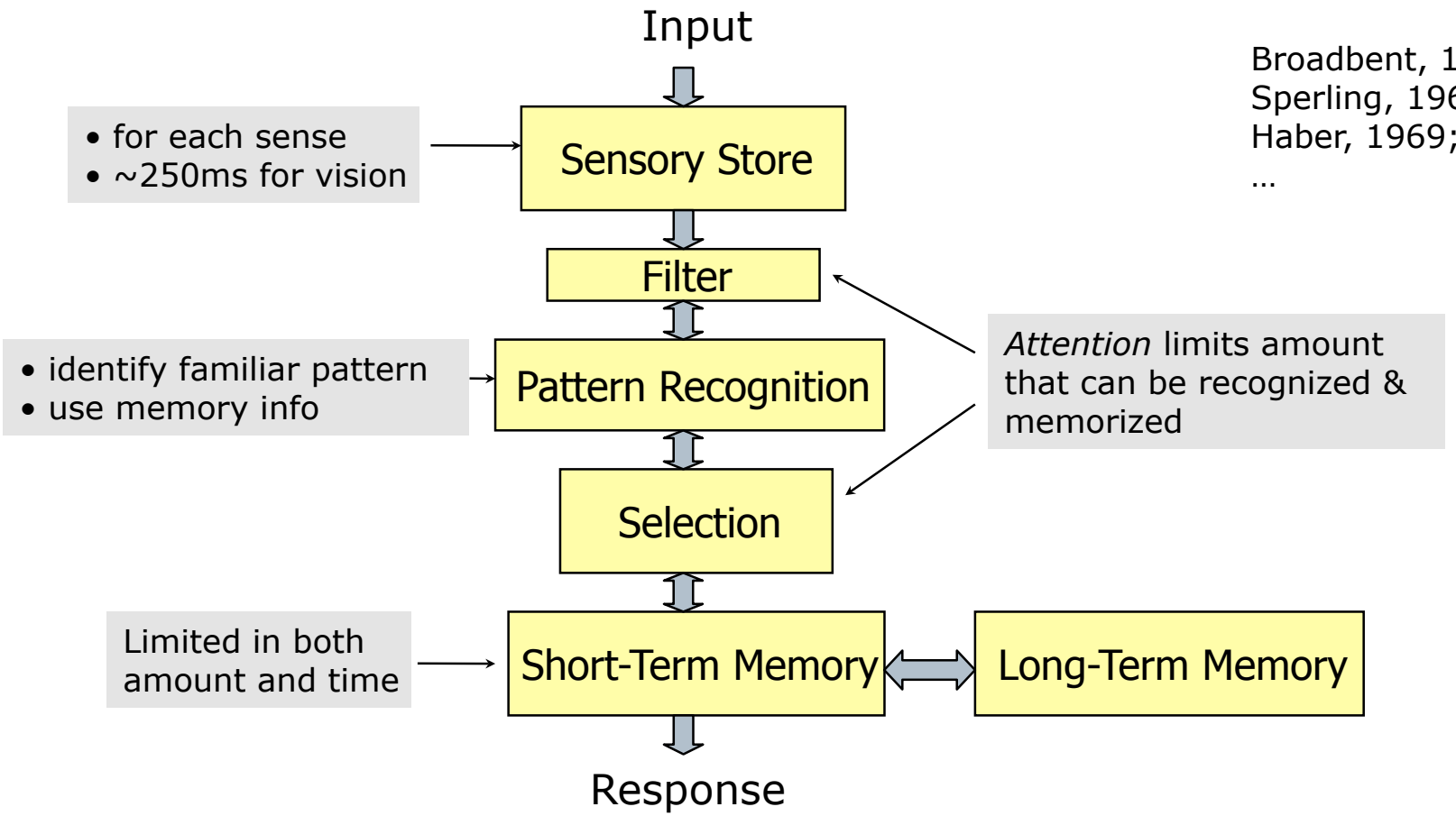
Output devices

CPU

Input devices

Computer

Human Information Processing



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

Abb. Reed, 2000

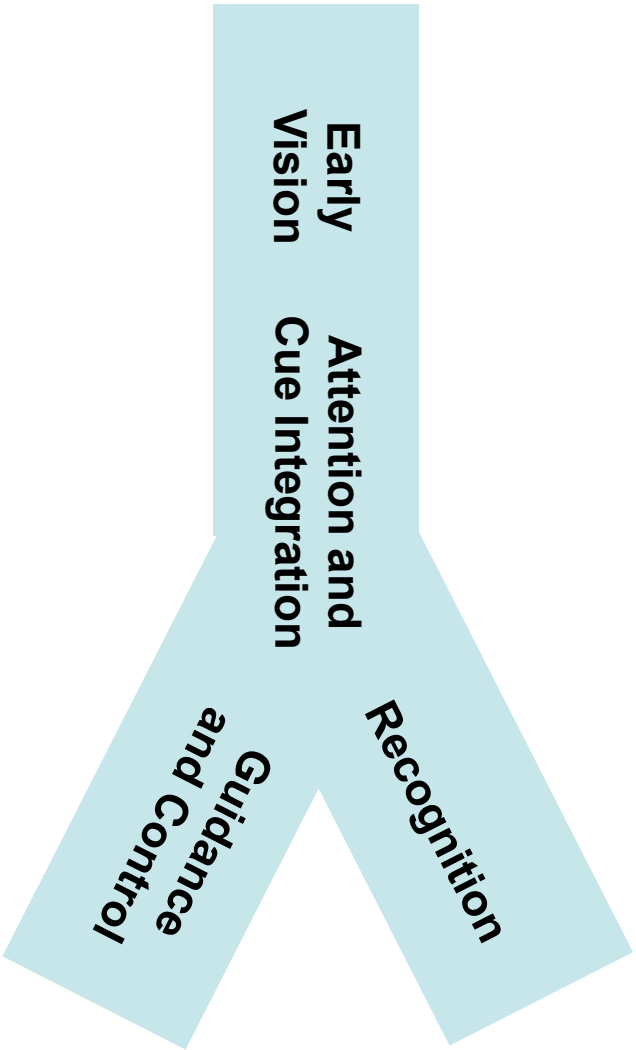
Perception

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 higher brain structures (visual cortex)

Visual Perception: Overview



- **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
  - Course control and stabilization

The human eye

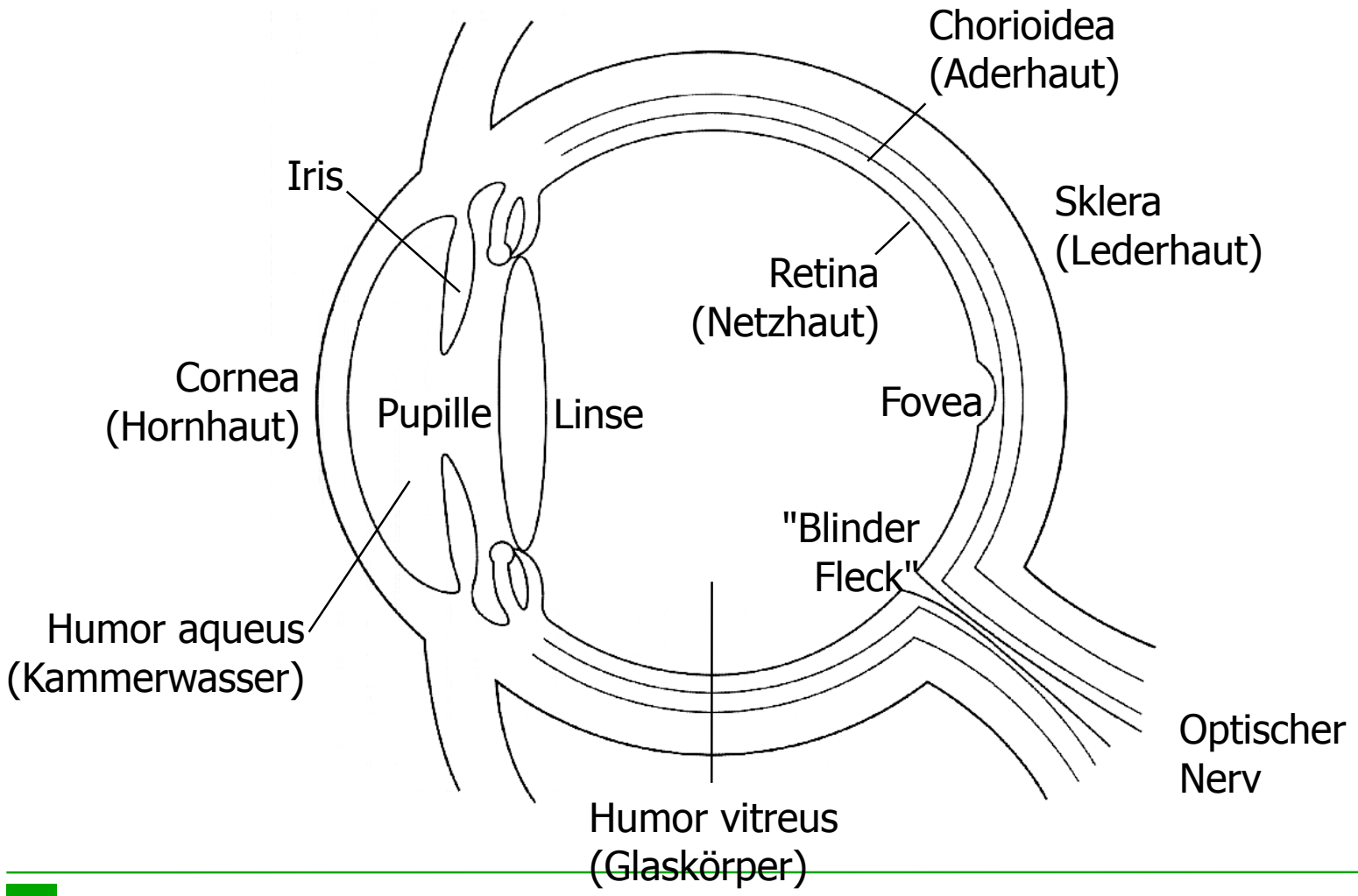
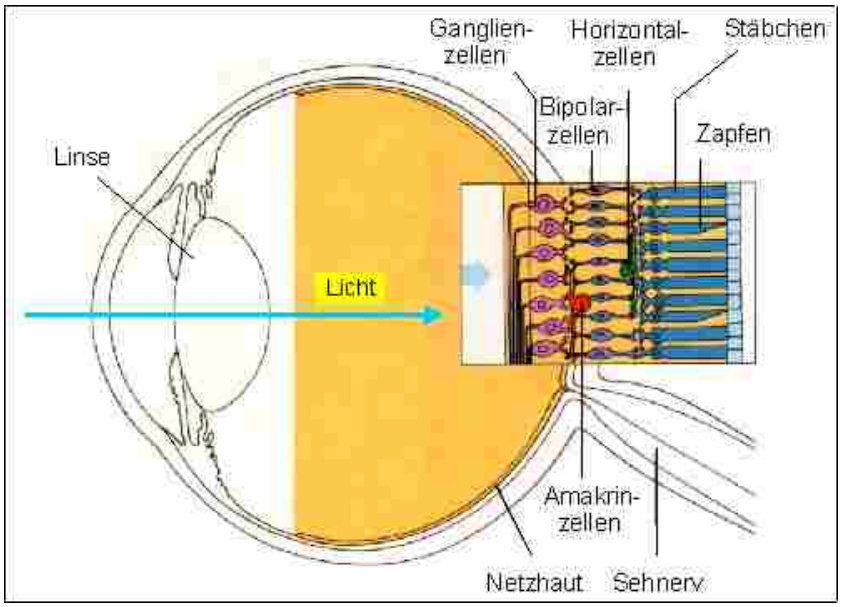


Abb.: Dix et al., 1998

Retina



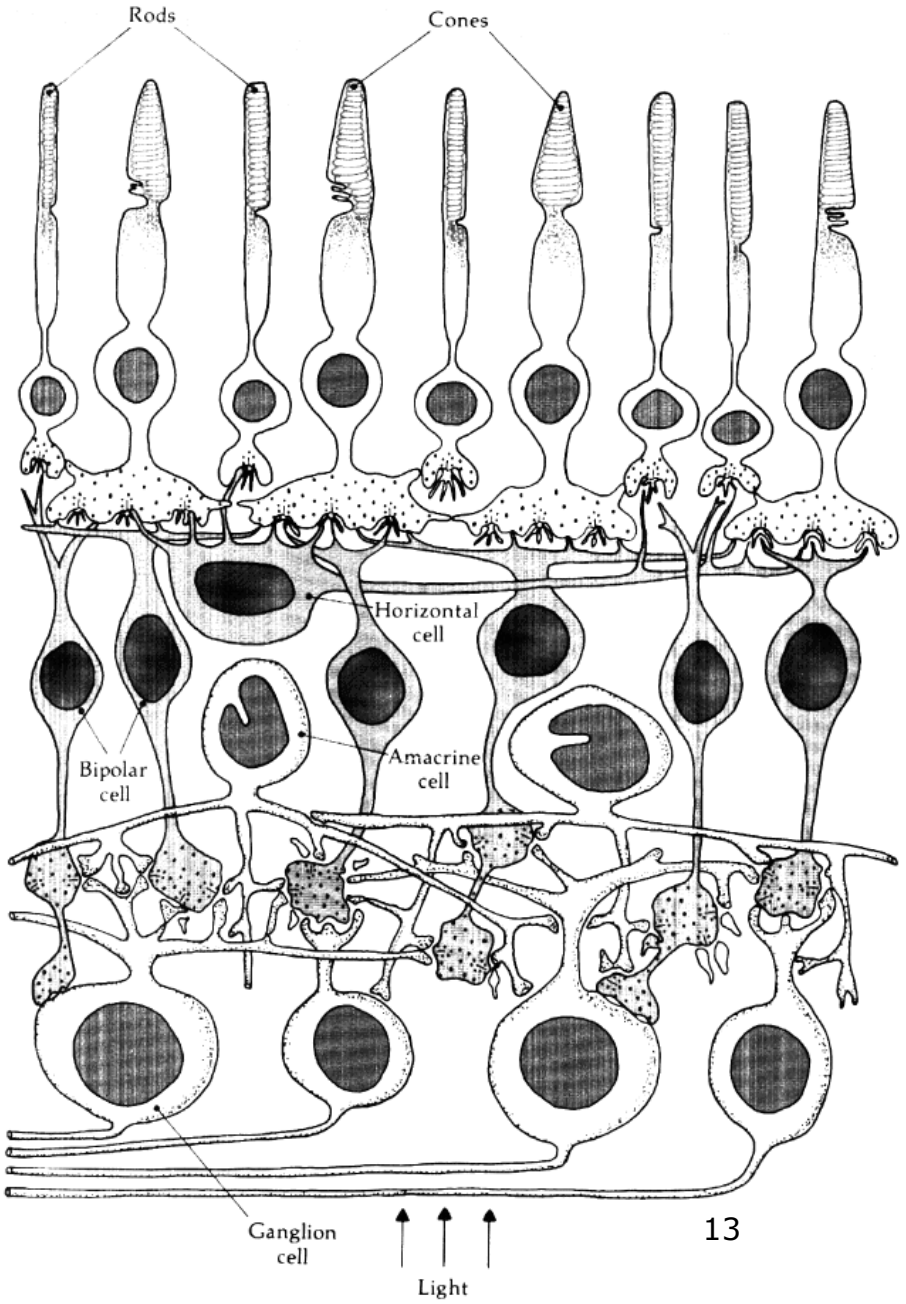


Abb.: Matlin & Foley, 1992

Photoreceptors

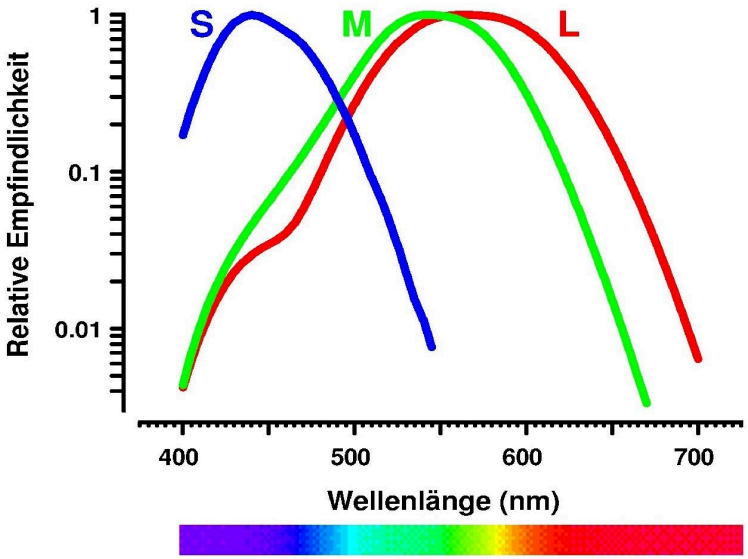
- Light with certain wave length (depends on pigments) causes photoreceptors to "fire"

	Zapfen (Cones)	Stäbchen (Rods)
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

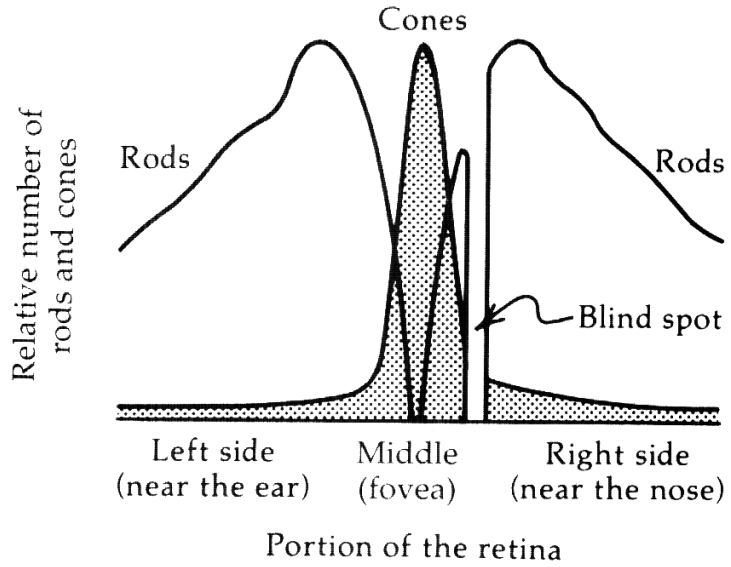
Temporary blindness when moving from dark to bright: rods activated, saturated by sudden light, suppress rods

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 → bad color perception of blue in fovea
- ca. 8% of western males and 1% of females color-blinded, most frequent: red-green-blindness



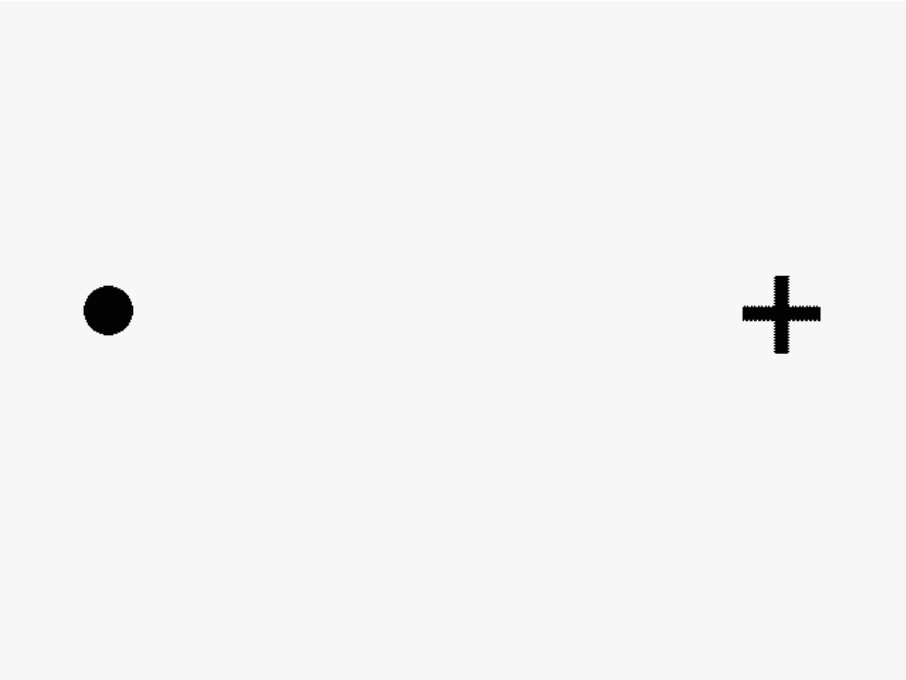
Sensitivity & resolution



- 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 → night vision better in non-foveal area (e.g., a star disappears when focussed but is visible to peripheral vision)

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: 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*")

→ brain takes depth information into account!

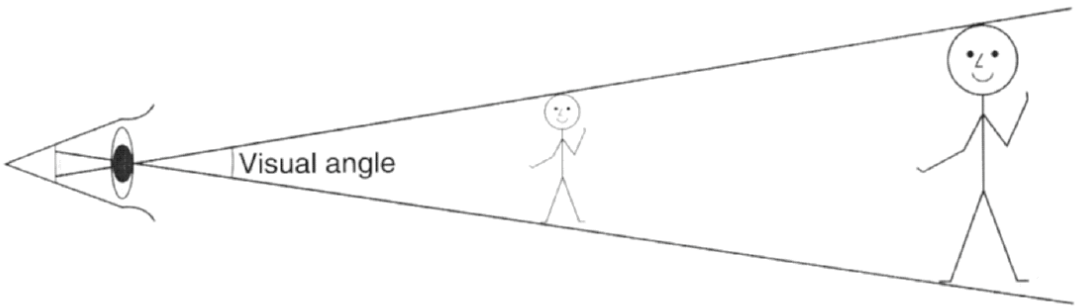


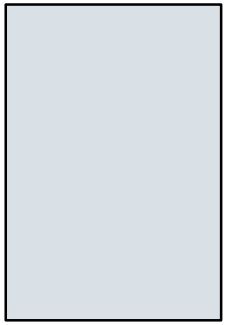
Abb.: Dix et al., 1998

Perceiving size & depth

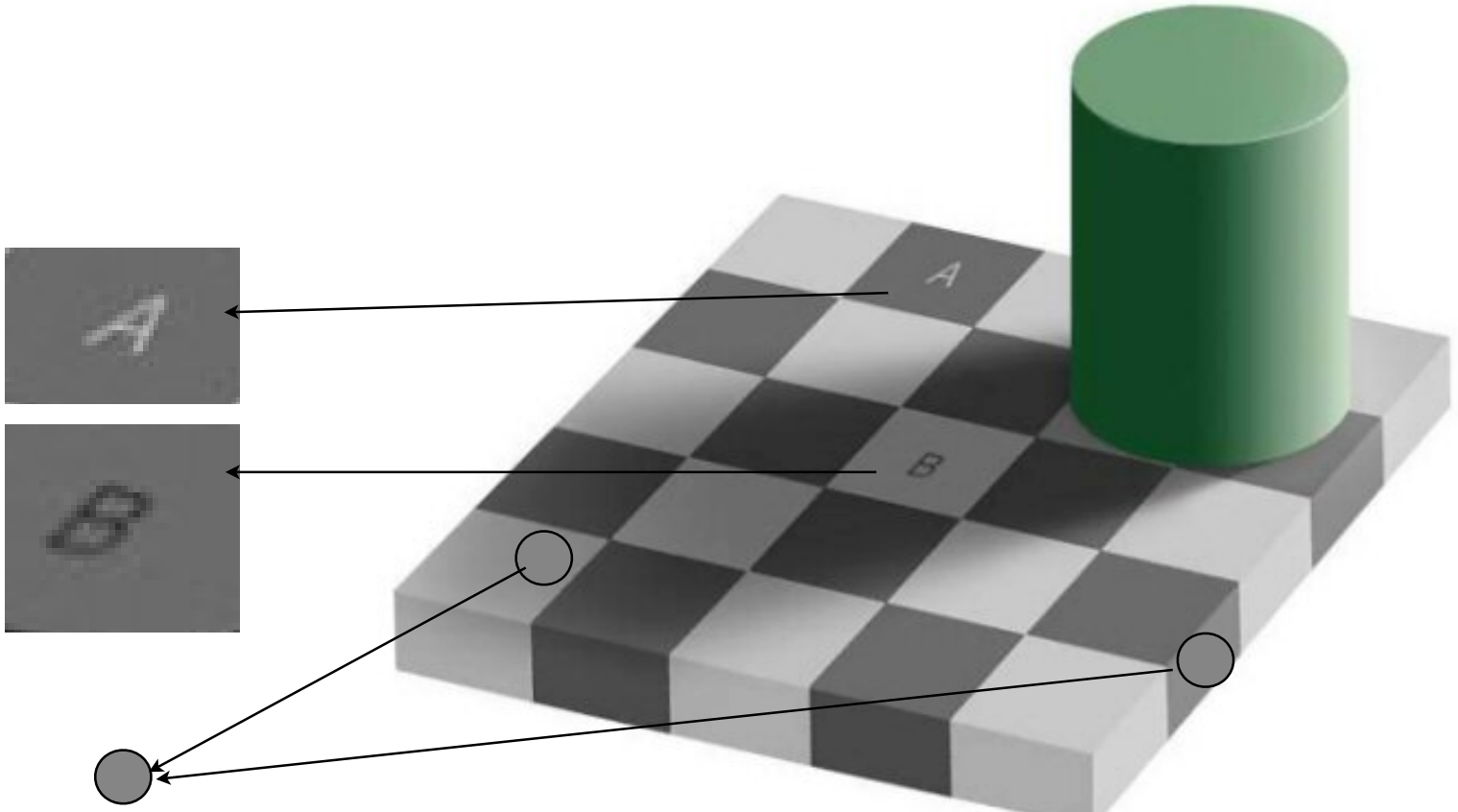
- Primary depth cues
  - difference of perceived images (close-up range)
  - process of combining these images
  - process of shaping the lens to create sharp image
  - inward movement of eyes to focus (2-7m)

- Secondary depth cues
  - Light and 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

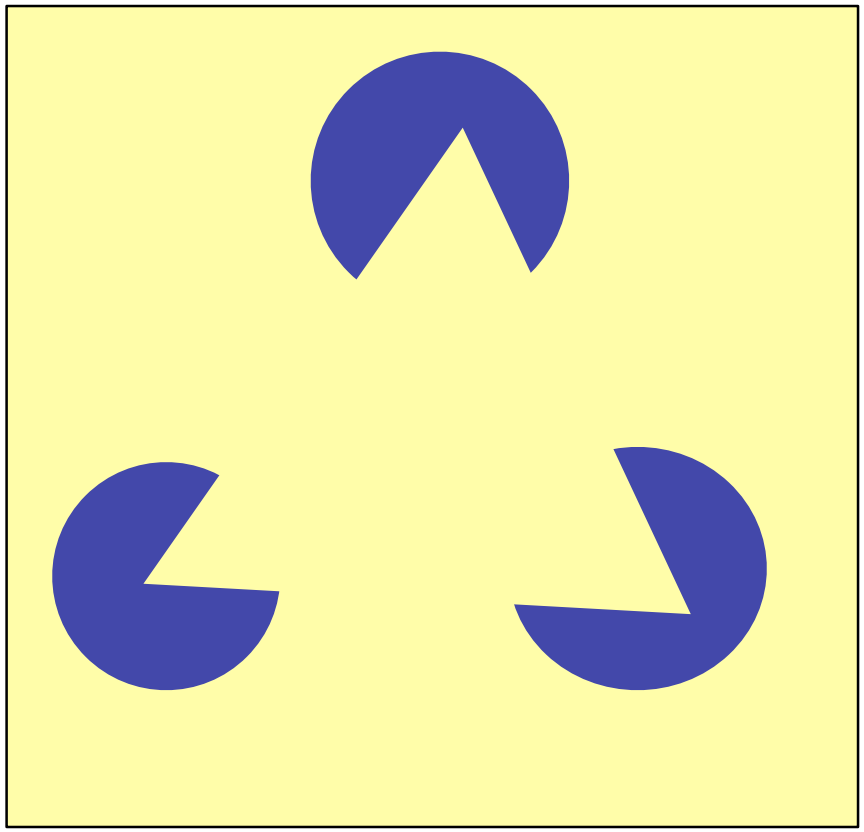
Relative size



Light & shade



Feature Integration and Perceptual Organization



Kanizsa triangle:

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

Gestalt "laws".

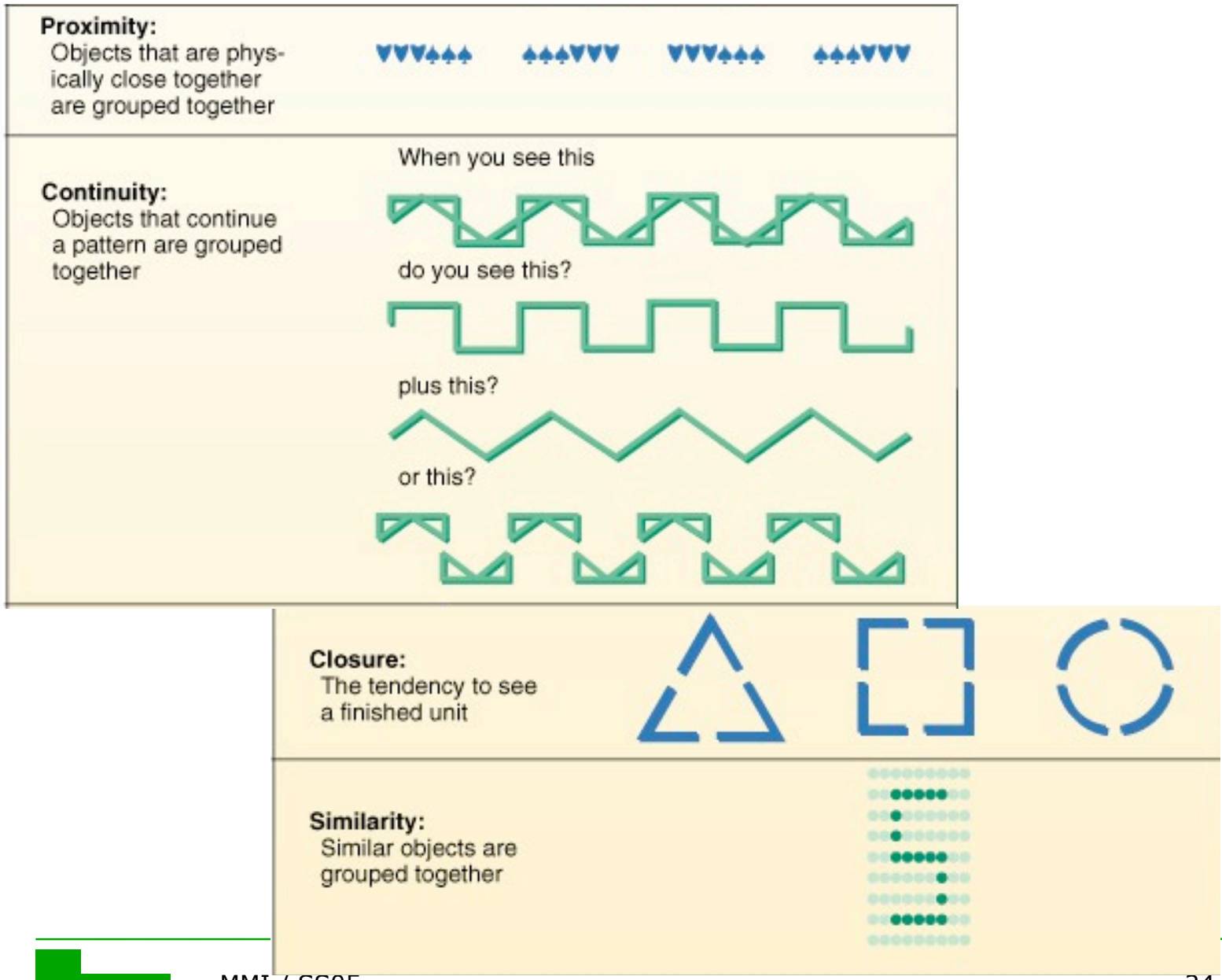
*Gestalt*prinzipien der visuellen Wahrnehmung

- Wir haben die Tendenz, Eindrücke zu "verbessern", das heißt, sie klarer, einfacher, übersichtlicher, prägnanter zu machen.

- In dem Begriff der **Prägnanz** glaubt die Gestaltpsychologie ein Grundprinzip ("Gesetz der guten Gestalt") unserer Wahrnehmung erkannt zu haben, insofern, als prägnante Formen offenbar bessere Wahrnehmungsbedingungen repräsentieren, das heißt, dass sie leichter konfiguriert, besser behalten und in der Erinnerung gespeichert werden können.

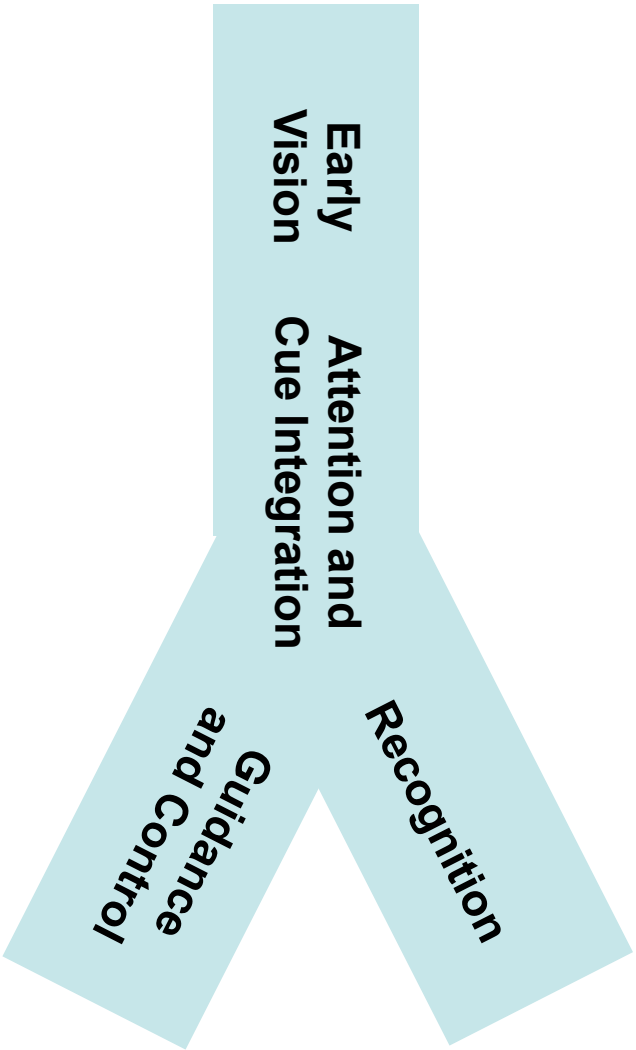
- **Gesetz der guten Gestalt**: Gestaltqualität ist dann gegeben, wenn eine Ordnung zu erkennen ist (Wahrnehmungs-erleichterung, längeres Behalten); je schwieriger die Ordnung, je mühsamer die Elemente zur Gestalt zu vereinen sind, desto geringer ist die Gestalt- und Wahrnehmungsqualität.

(Max Wertheimer)


Proximity:
Objects that are physically close together are grouped together
Continuity:
Objects that continue a pattern are grouped together
When you see this
do you see this?
plus this?
or this?
Closure:
The tendency to see a finished unit
Similarity:
Similar objects are grouped together

- How do we recognize things?

Visual Perception: Overview



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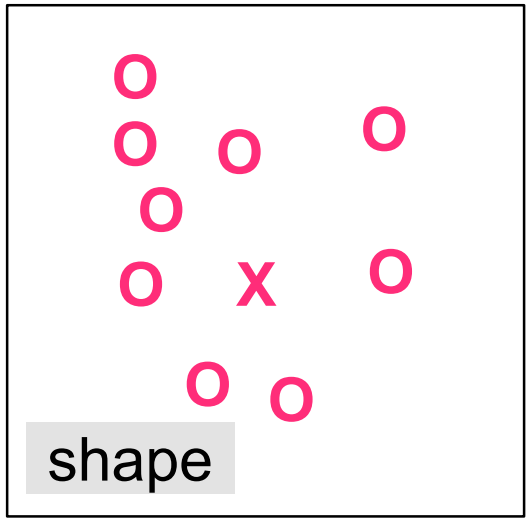
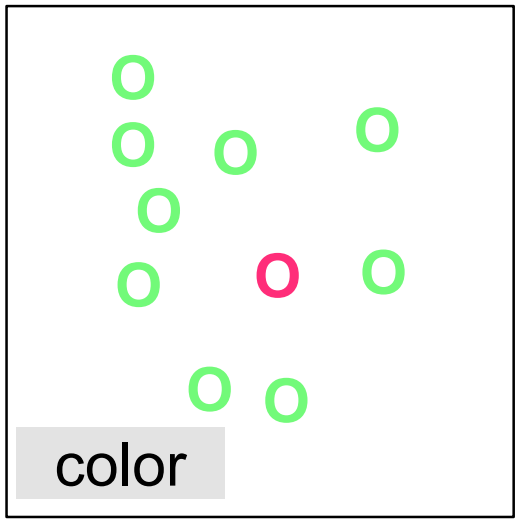
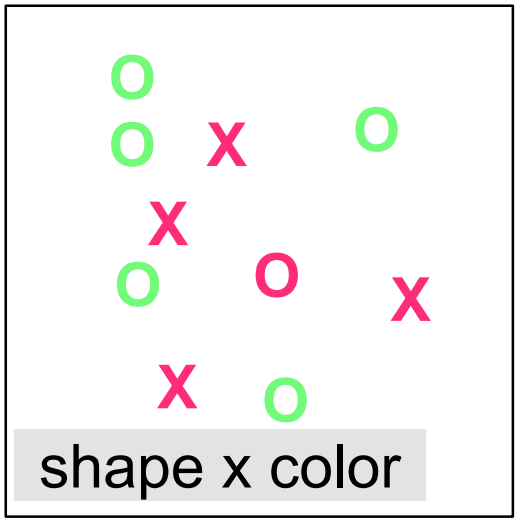
Attentive vs. Preattentive Vision: The Visual Search Paradigm







- 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

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)

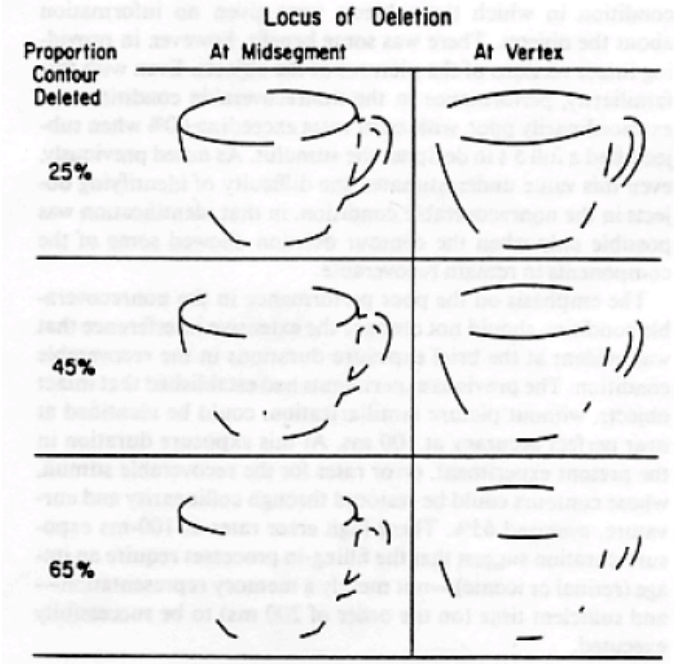


Figure 18. Illustration for a single object of 25, 45, and 65% contour removal centered at either midsegment or vertex. (Unlike the nonrecoverable objects illustrated in Figure 16, vertex deletion does not prevent identification of the object.)

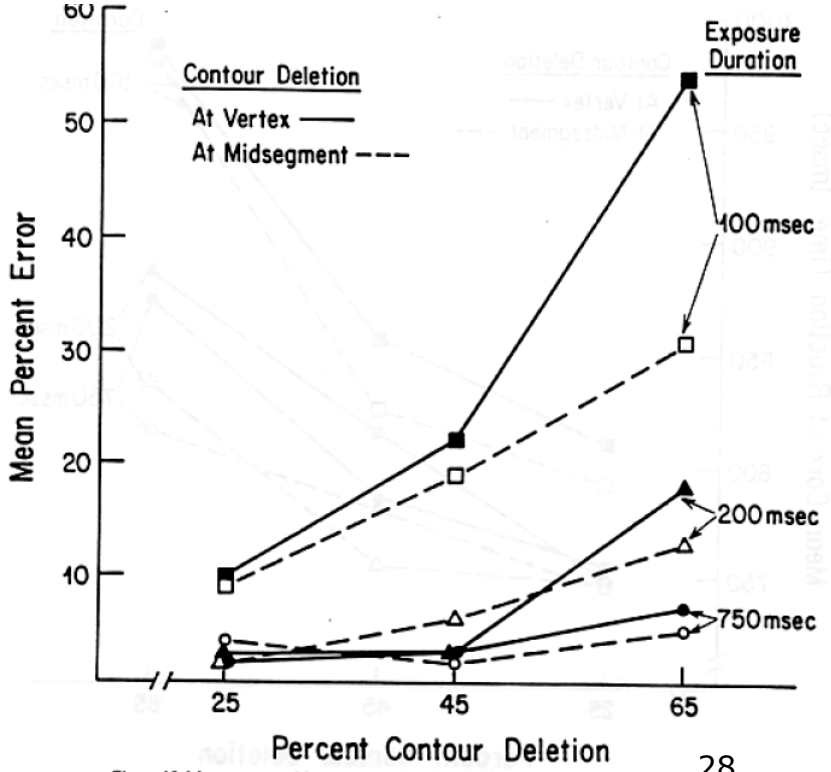
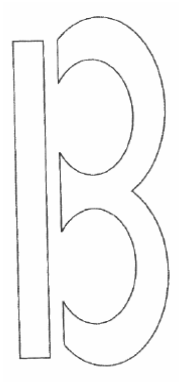


Figure 19. Mean percent object naming errors as a function of locus of contour removal (midsegment or vertex), percent removal, and exposure duration.

Recognition depends on visual context



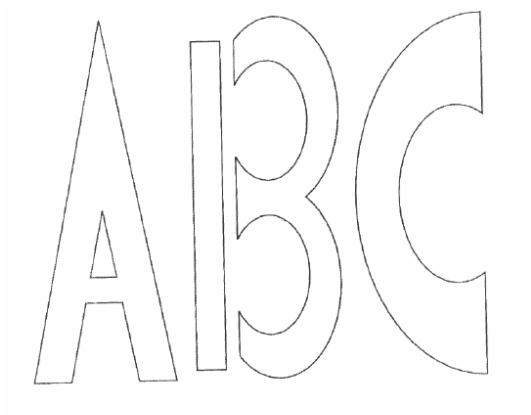
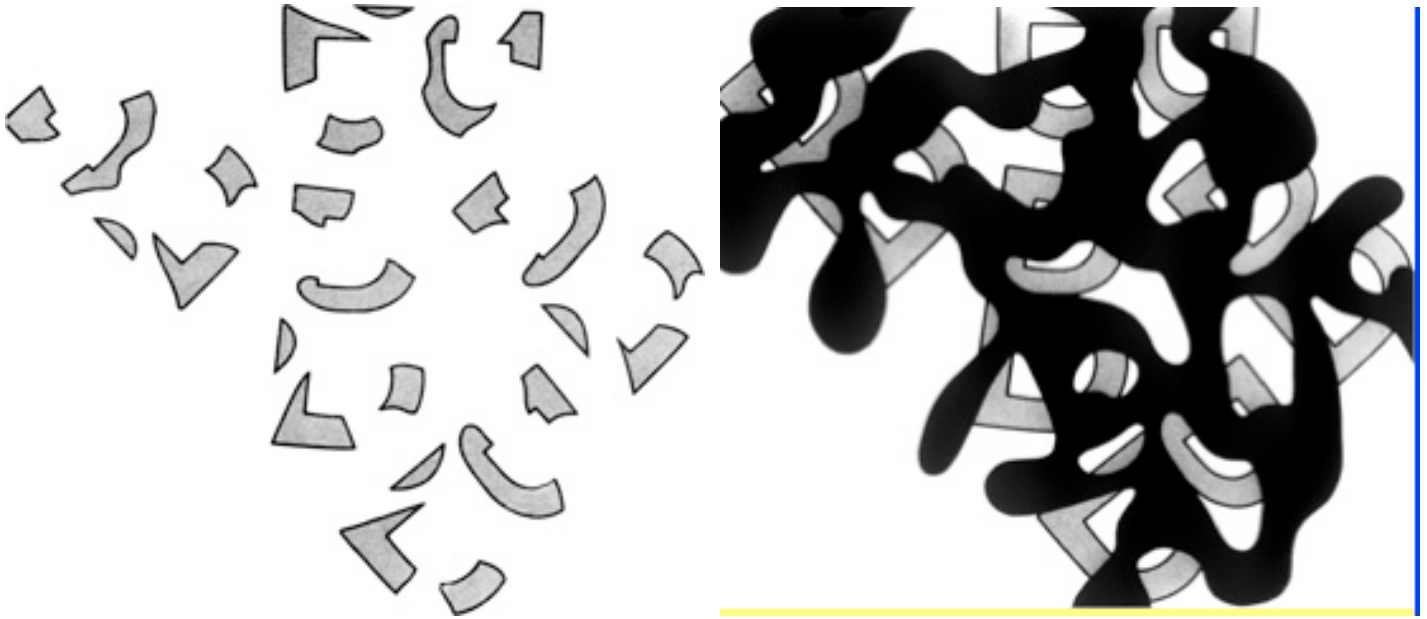
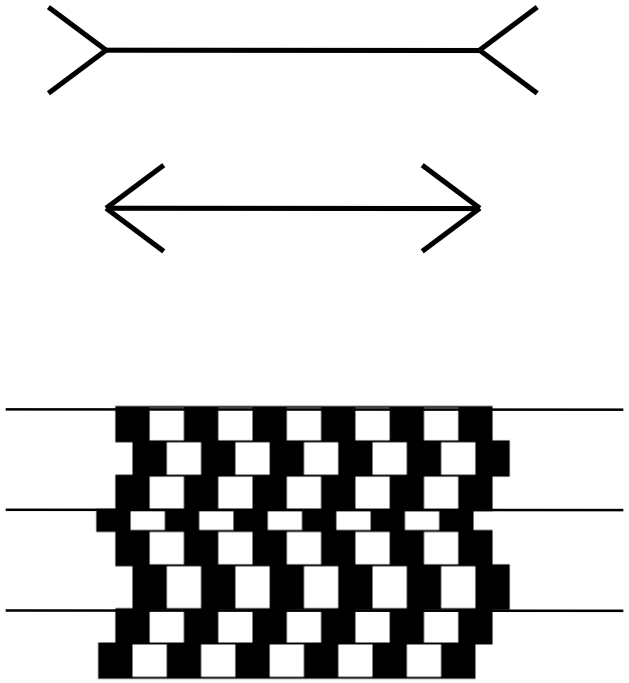


Abb.: Dix et al., 1998



Optical illusions

- Information about depth, length, orientation, etc. can be misinterpreted by higher-level processing



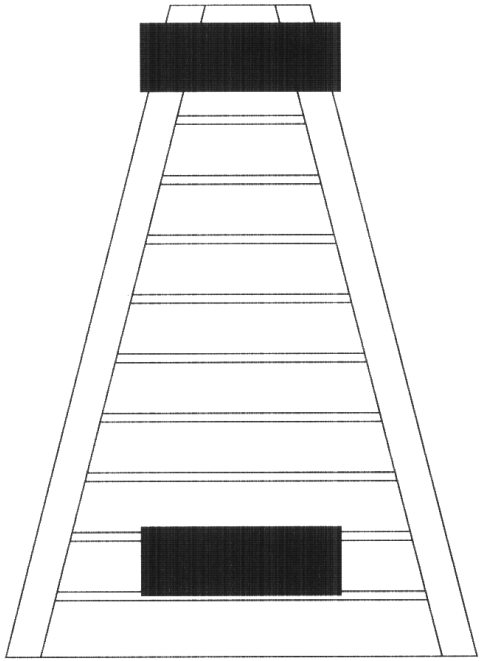


Abb.: Dix et al., 1998

Reading - applied pattern recognition

- *Not* a sequential process of perceiving letters one by one
  - *Saccades & fixations* (depend on text complexity), perception occurs during fixations
  - 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, but negative contrast improves reading from screen

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.

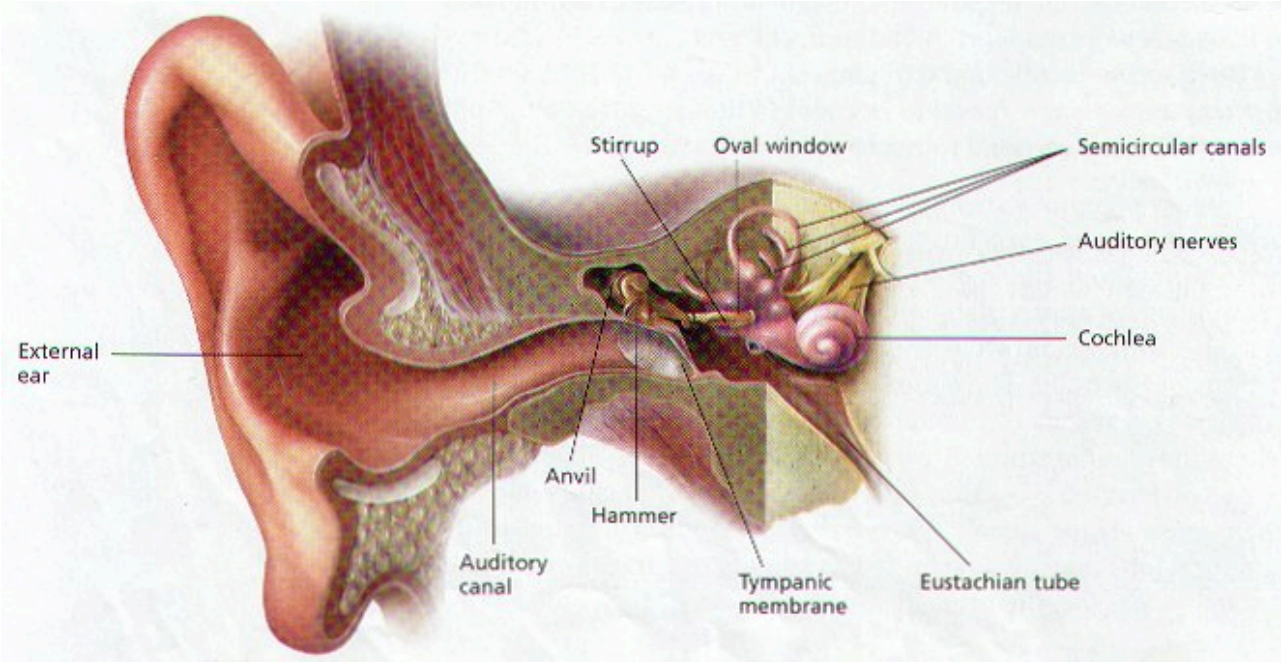
Hearing & auditory perception

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

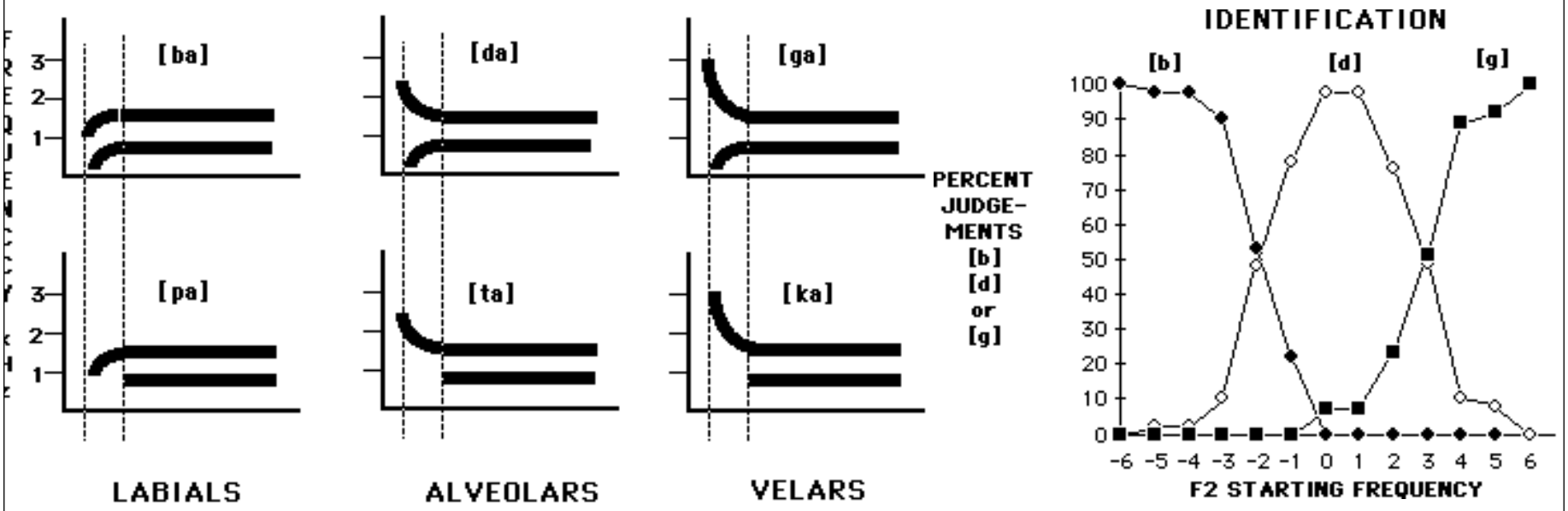
Auditory perception

- Features processed:
  - Loudness (= amplitude)
    - Whisper (15 dB), conversation (60 dB), car horn (110 dB), rock concert (120+ dB)
  - Frequency (= pitch)
    - Human hearing range: 20 Hz - 15.000 Hz
    - Sampling rate <1.5 Hz, less accurate for high frequencies
  - 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*)

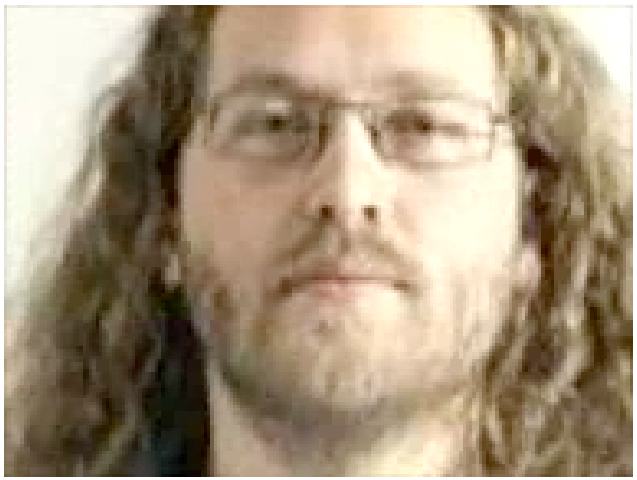
Categorical speech perception

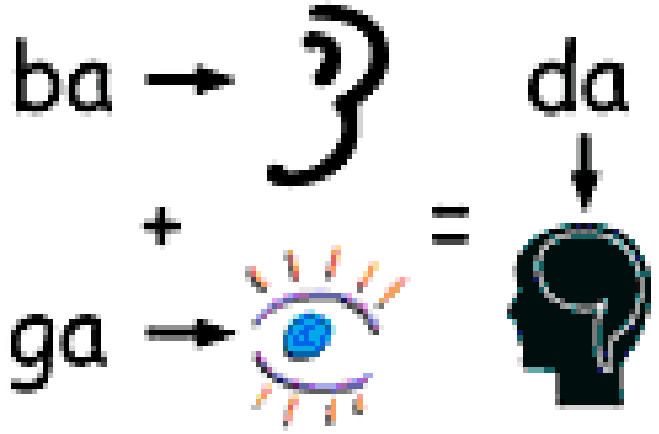
When hearing similar sounds (ba, da, ga), that differ slightly in starting frequency of an harmonic (2nd formant F2), speakers seem to discriminate between learned categories



Vision & listening in speech understanding

„McGurk-Effekt“: What does he say?

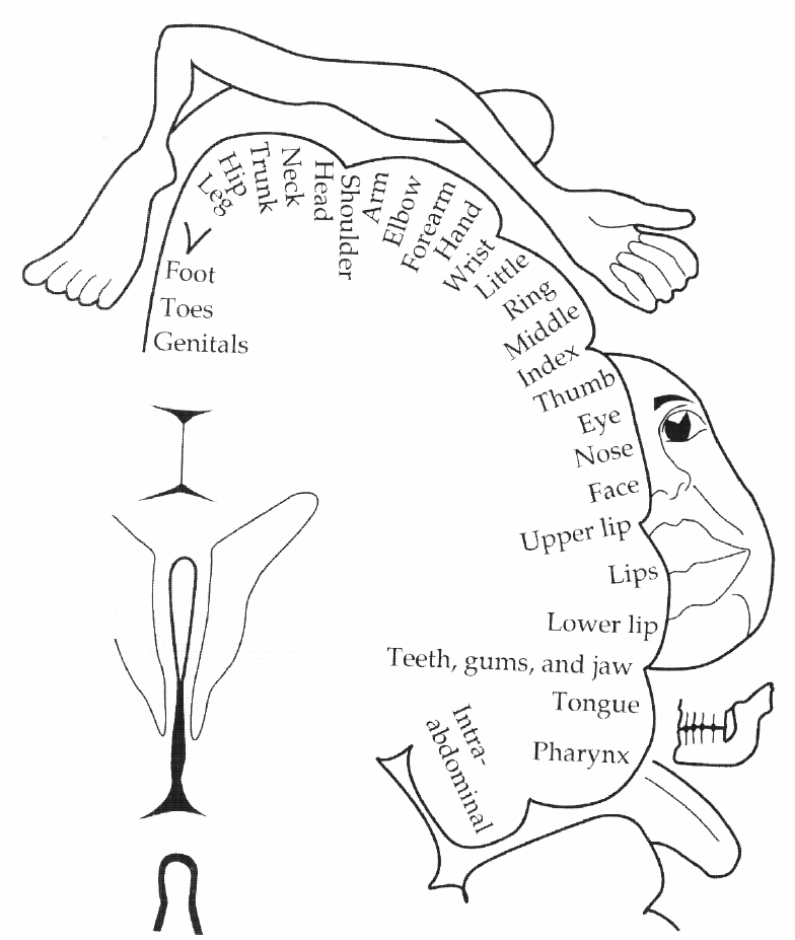




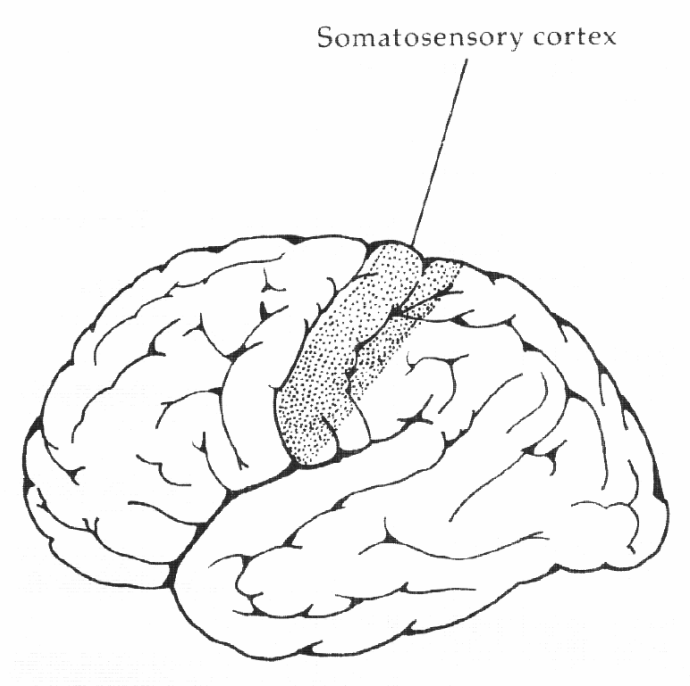
Touch perception

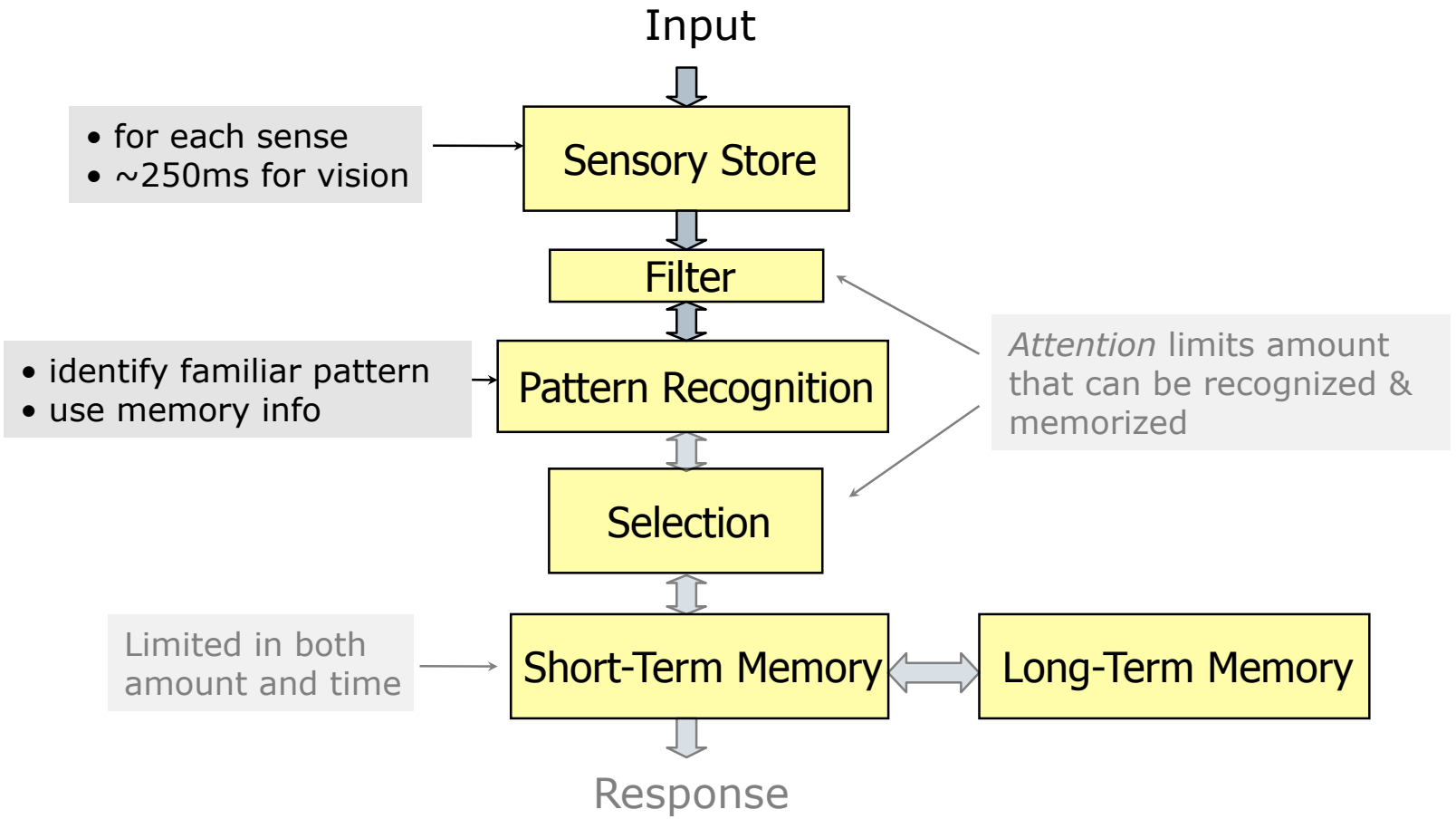
- Receptors underneath the skin and in muscles and joints
- Almost everywhere, ca. 2qm receptive skin surface, but not equally distributed
- Three types of skin receptors
  - thermoreceptors: heat and cold
  - nocireceptors: intense pressure, heat, pain
  - mechanoreceptors:
    - respond to immediate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

Processing of skin receptions



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





Next week:

Memory and Attention