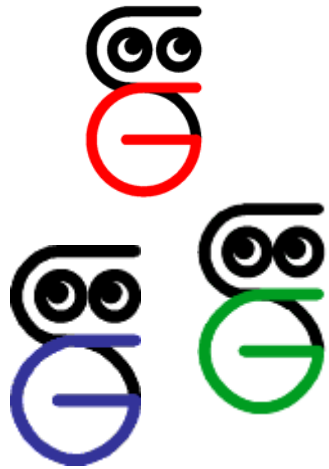
Smart Graphics: Graphics and Perception

Lecture „Smart Graphics”

Andreas Butz, Otmar Hilliges

26.10.2005

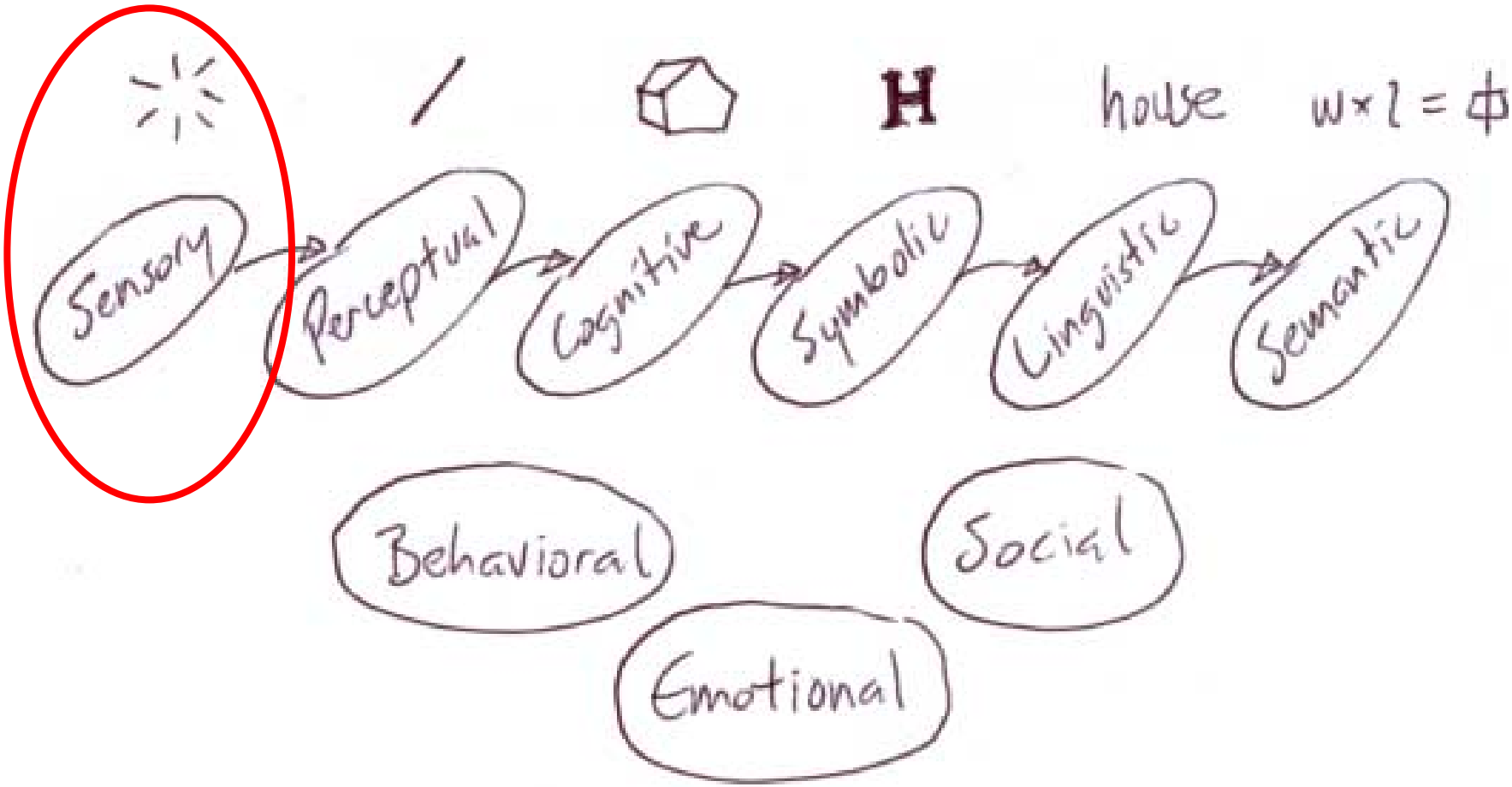


Topics Today

- Paley's knowledge acquisition pipeline
- A classical model of human perception
- Effects at different stages of perception
- Some Illusions and experiments
- An example UI using effects from different stages of perception

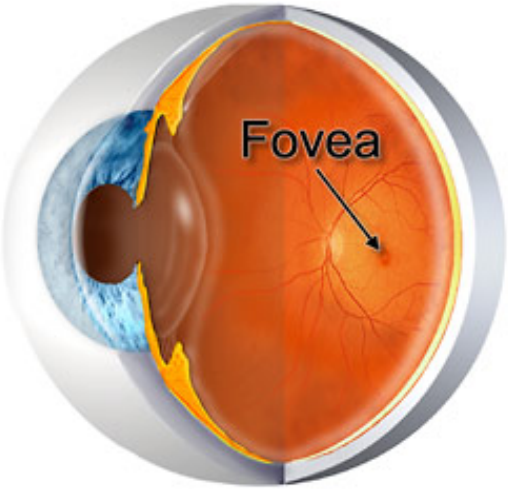
Knowledge acquisition pipeline

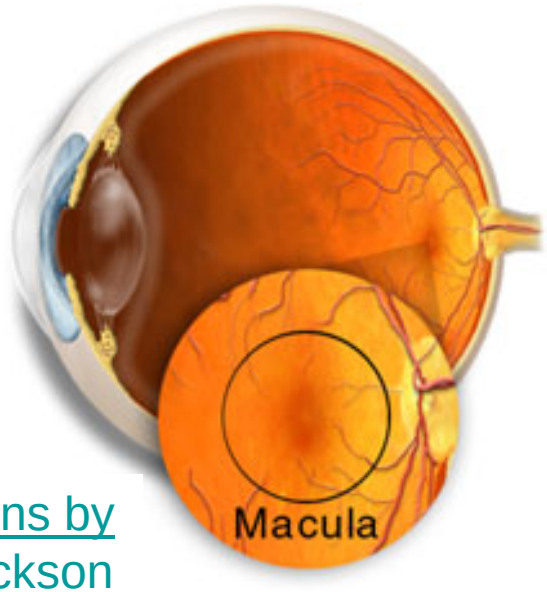
[W. Bradford Paley, SG 2003]

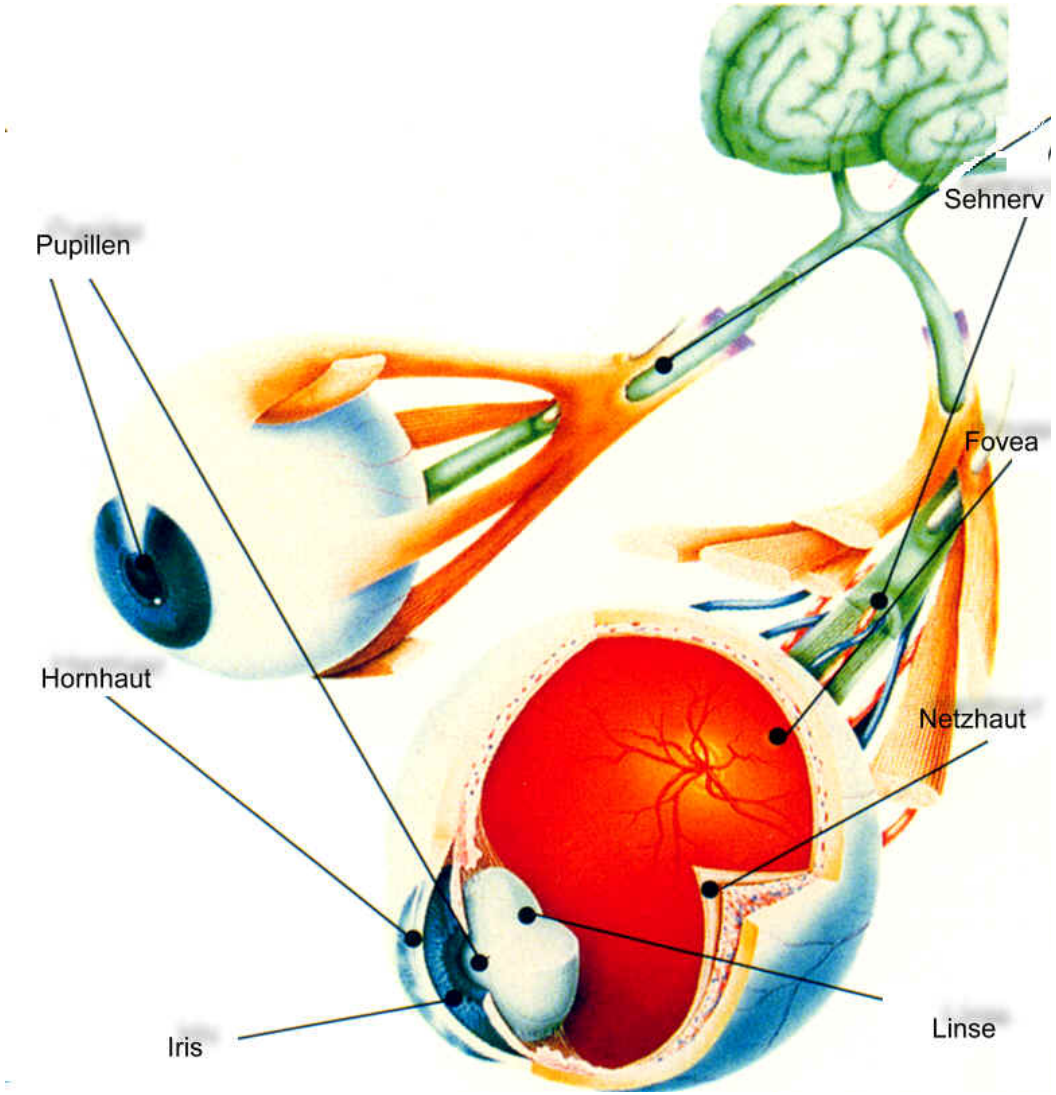


Simplified model of human sensemaking processes, useful for designing visual representations

The human eye

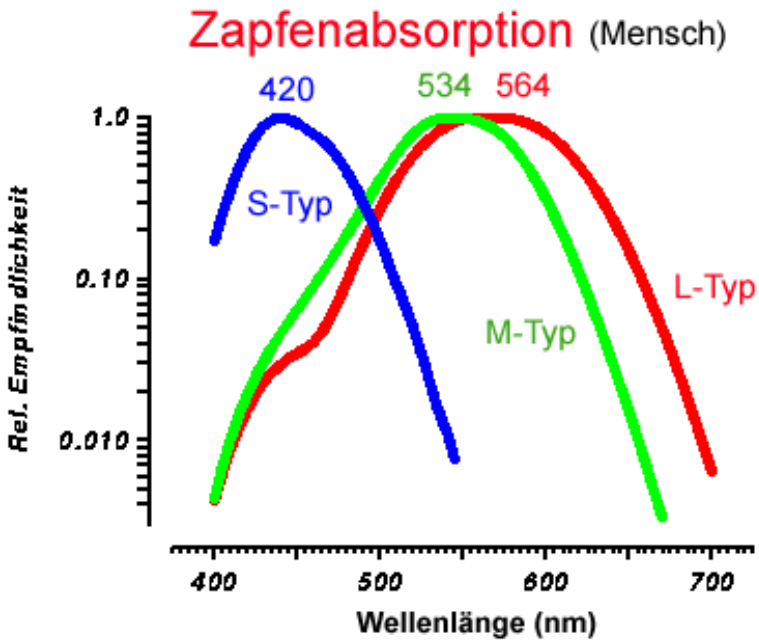


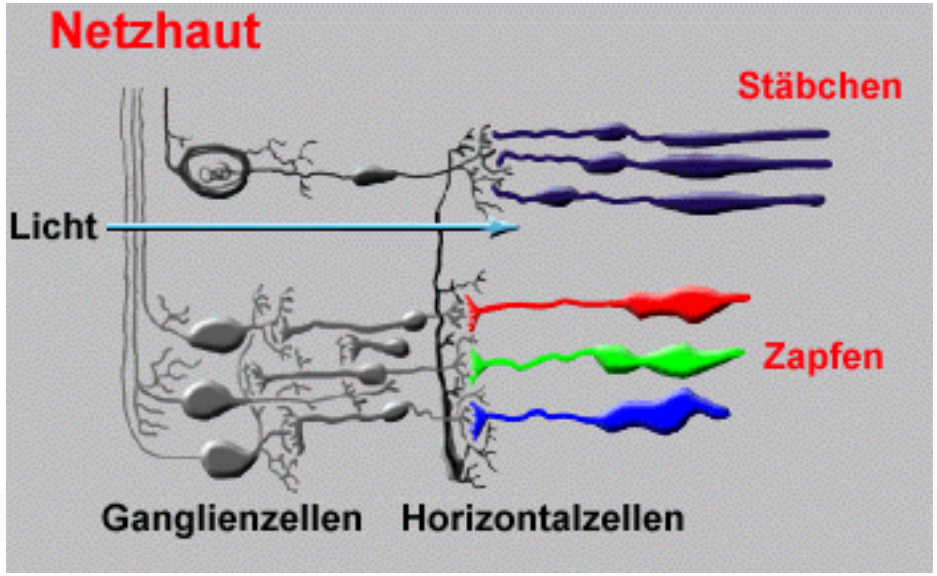


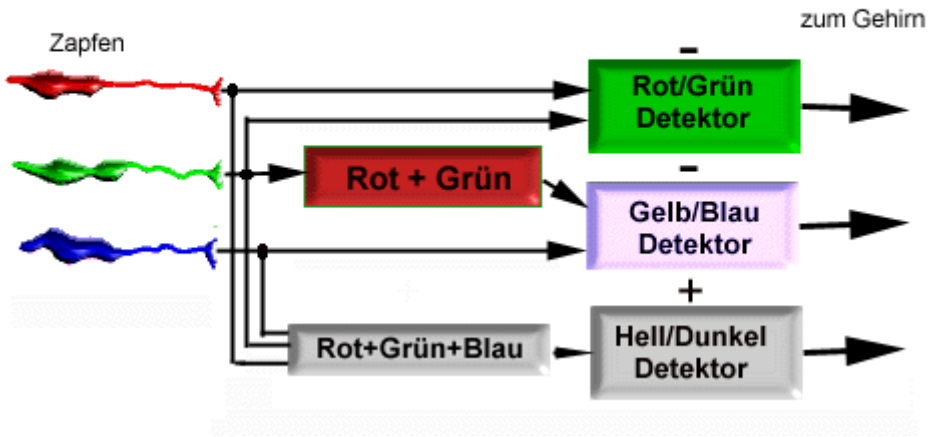


Illustrations by Mark Erickson

Die Netzhaut







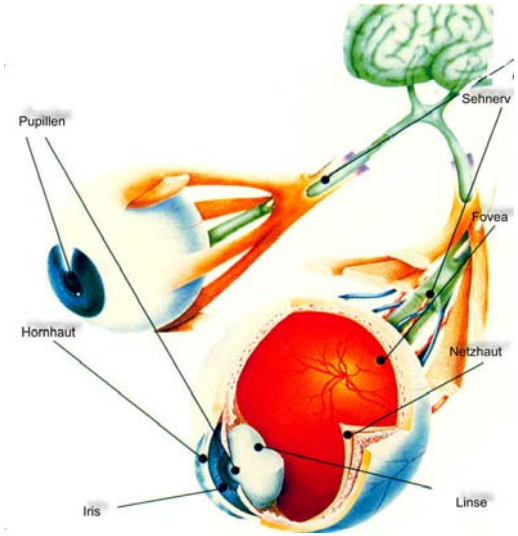
- Zapfen arbeiten bei höherer Lichtintensität
- Verteilung auf der Netzhaut im Verhältnis 1:20:40
- Stäbchen arbeiten bei niedriger Lichtintensität

Color blindness

- Most prominent kind: red/green blindness
  - ~8% of men
- Simulation with [vischeck]

Human eye: strengths and limitations

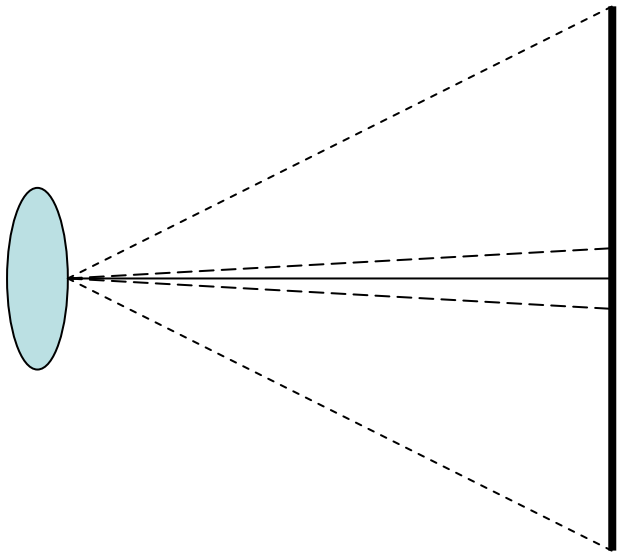
- Very high dynamic range
  - 2^{20} = 1:1.000.000 with iris adaptation
  - 2^{10} = 1:1.000 at given iris aperture
  - ➔ more than most monitors
- Bad color vision in dark conditions
- Best contrast perception in red/green



- Limited temporal resolution (reaction speed)

- Good resolution and color in central area (macula)
- Maximum resolution and color only in the very center (fovea)
- Maximum angular resolution 1 arc minute = 1/60 degree

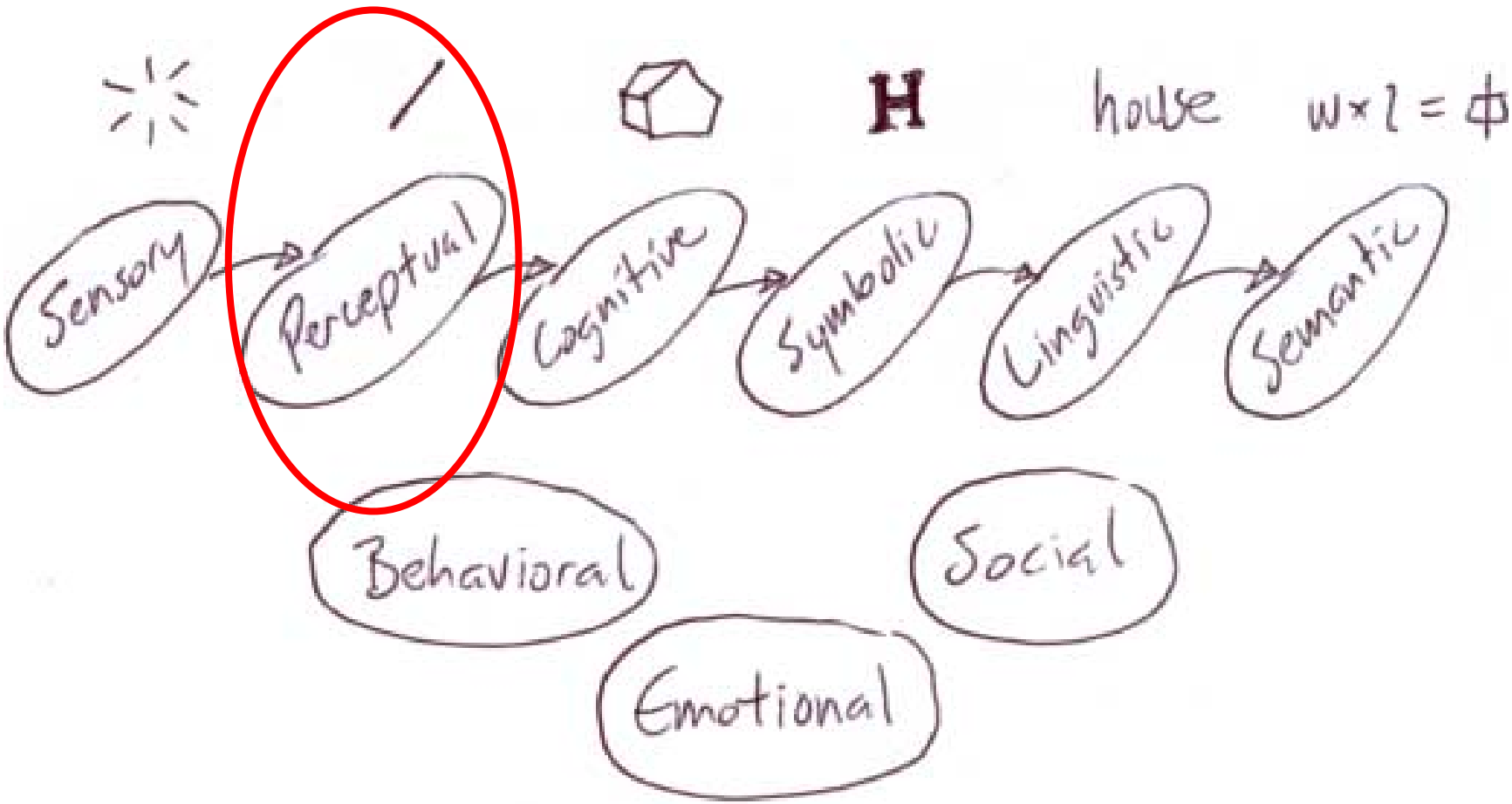
How much resolution do we need?



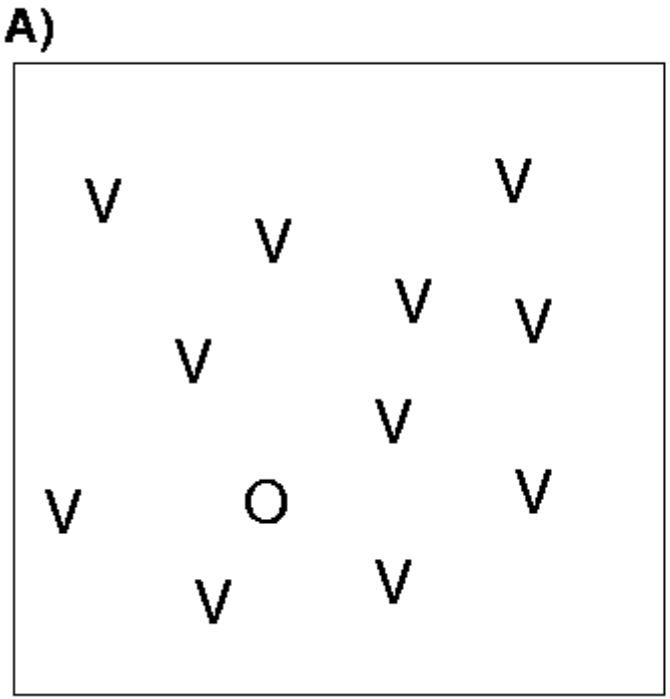
- Assumption: viewing distance = horiz. image width
- Horiz. Viewangle = 2*atan 0.5 = 53 degrees
- Max. angular resolution of the eye = 1/60 degree
- ➔ Max. horiz. resolution = 53 * 60 = 3.180 pixels
- Viewing distance of A4 paper = 10 inch ➔ 300dpi

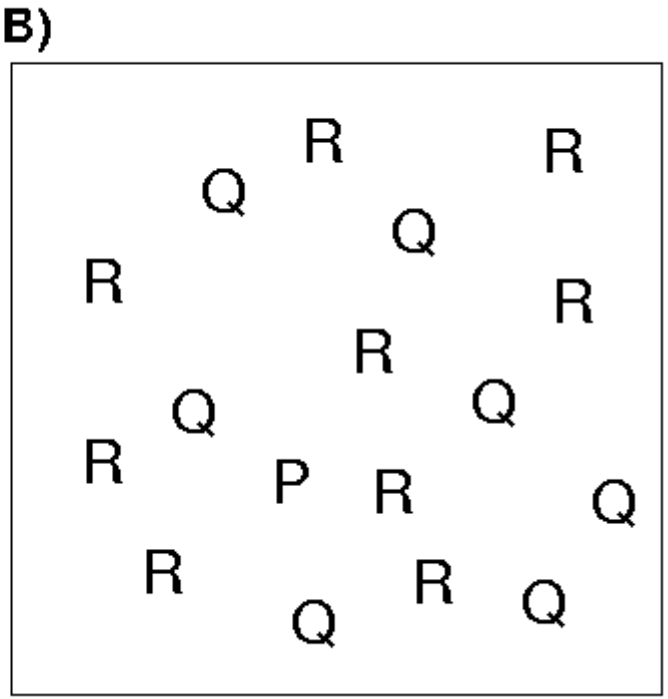
Knowledge acquisition pipeline

[W. Bradford Paley, SG 2003]



Visual Search





Preattentative Search

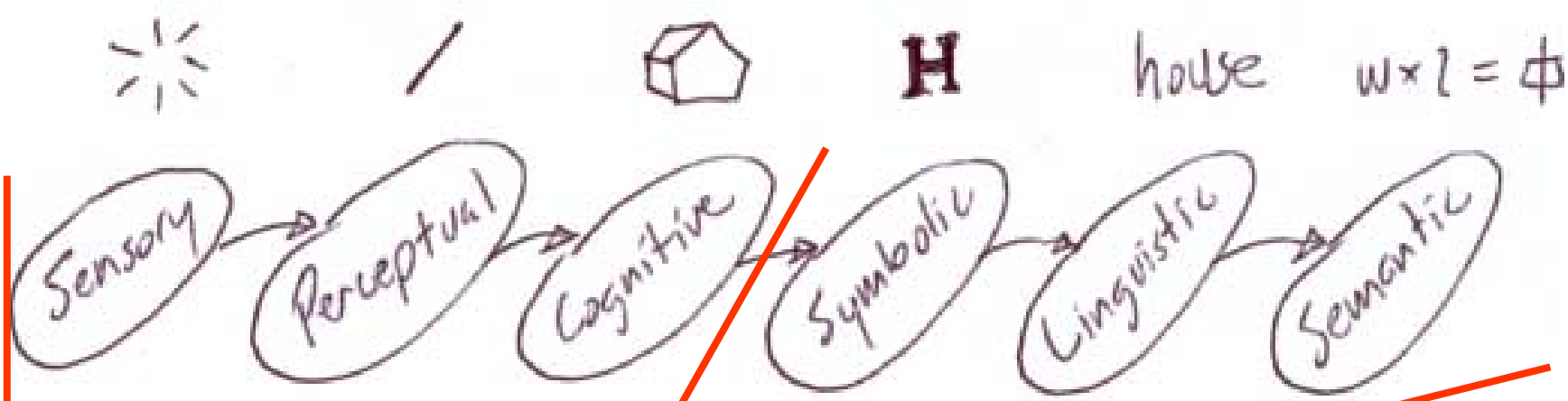
Attentative Search

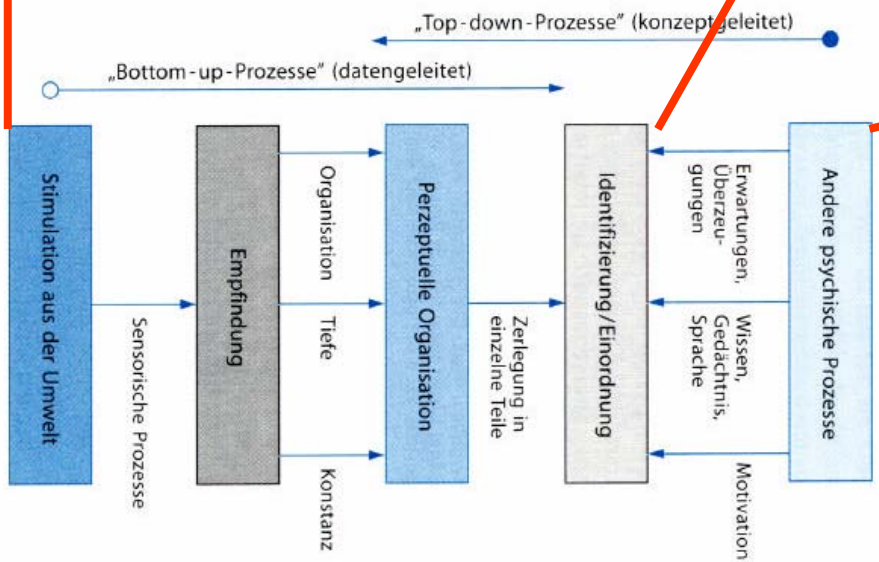
Attentative Processing

- Aggregation of several attributes
- Goal-oriented comparison of attributes
- Takes longer, but leads to better memorization of images

Knowledge acquisition pipeline

[W. Bradford Paley, SG 2003]

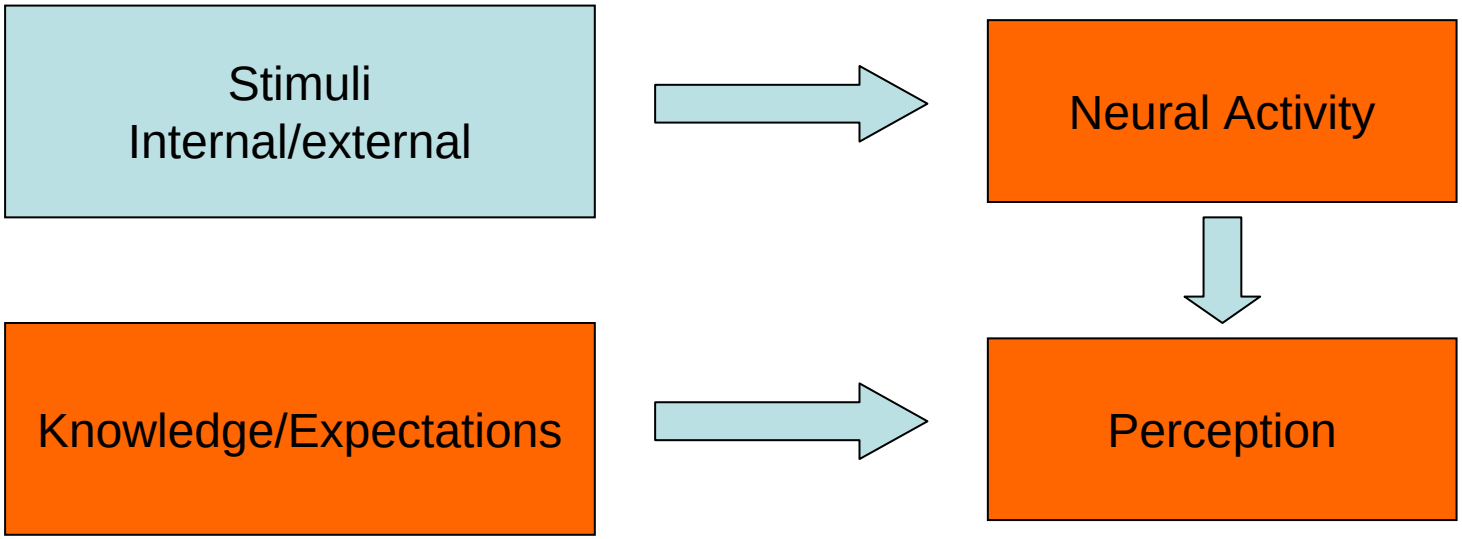




Relation to classical model of perception from cognitive psychology

Cognitive Psychology

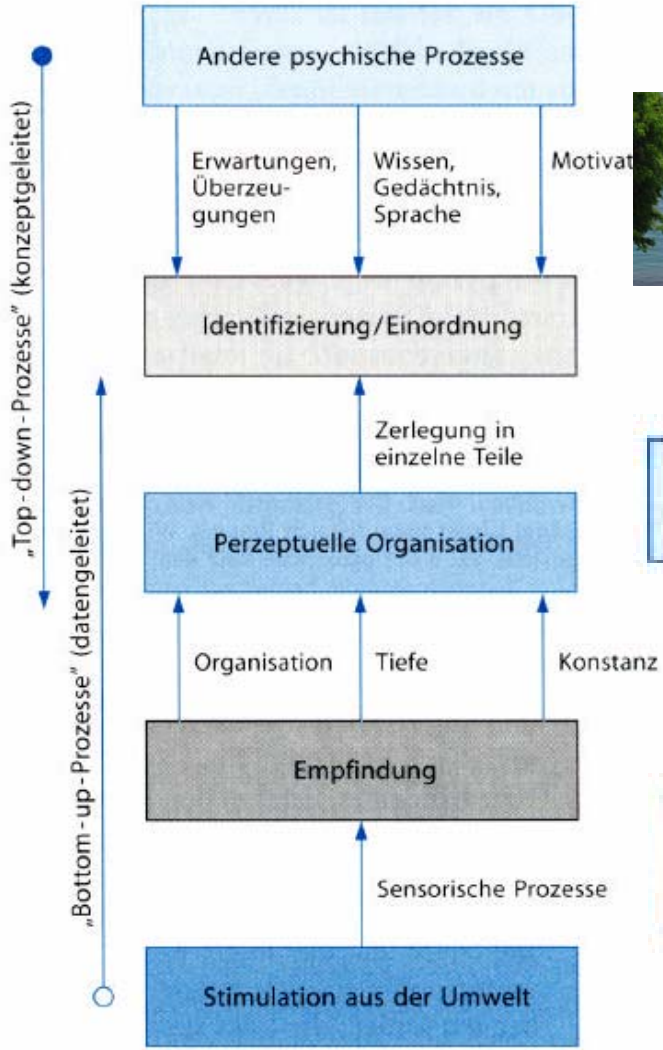
- How is perception influenced by knowledge and resulting expectations?



Cognitive Psychology II

- New discipline ca. 1940
- Comprehension that there is more than a simple Stimulus -> Reaction chain.
- Learned knowledge has an impact on perception and processing.
  - Context can substitute lost or masked information.
- Also Attention is guided by knowledge and vice versa.

Human Perception & Attention



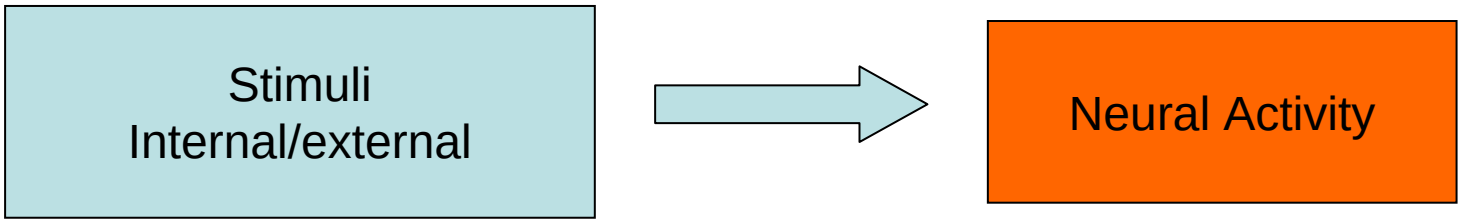
3. Implicit (learned) knowledge is used to form a conceptual representation (meaning). -> Cognitive Psychology

2. Single elements are aggregated to something whole -> Gestalt. No semantic meaning yet. -> Psychophysics

1. Stimuli from the world are being perceived. Edges, points, orientation, position, gradients and color. -> Physiology

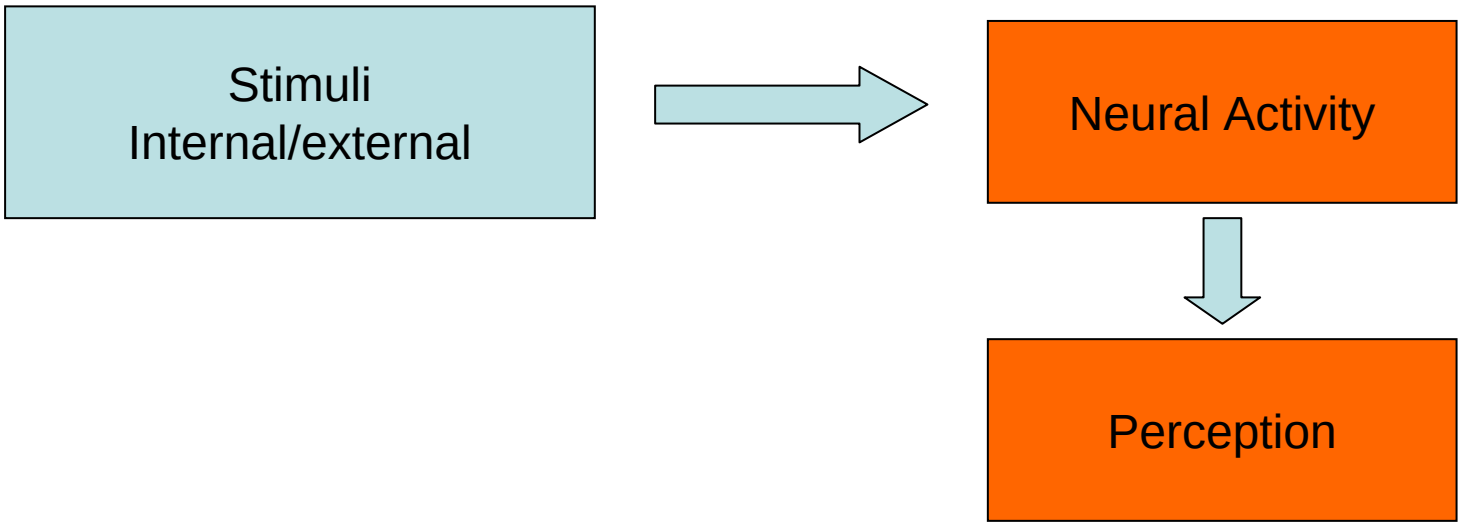
Physiology

- How are Stimuli mapped to neural activity?
  - First attempts to understand human perception (1850-1935).
  - Tightly coupled with development of sensors.



Psychophysics

- Relationship between Stimuli and Perception?
  - 3 main questions:
    - Perception threshold
    - Discriminating threshold
    - Influence of object properties (depth perception)



Perception Threshold

- How strong must a stimulus be so that we perceive it at all?
  - Physical units (mm, lumen, db)
  - Perceived experience (Distance, light conditions, volume)
  - Examples (average human):
    - Tone pitch: 16Hz
    - Volume: Ticking of a watch from 7m distance
    - Brightness: Candle from 30m distance in the dark.

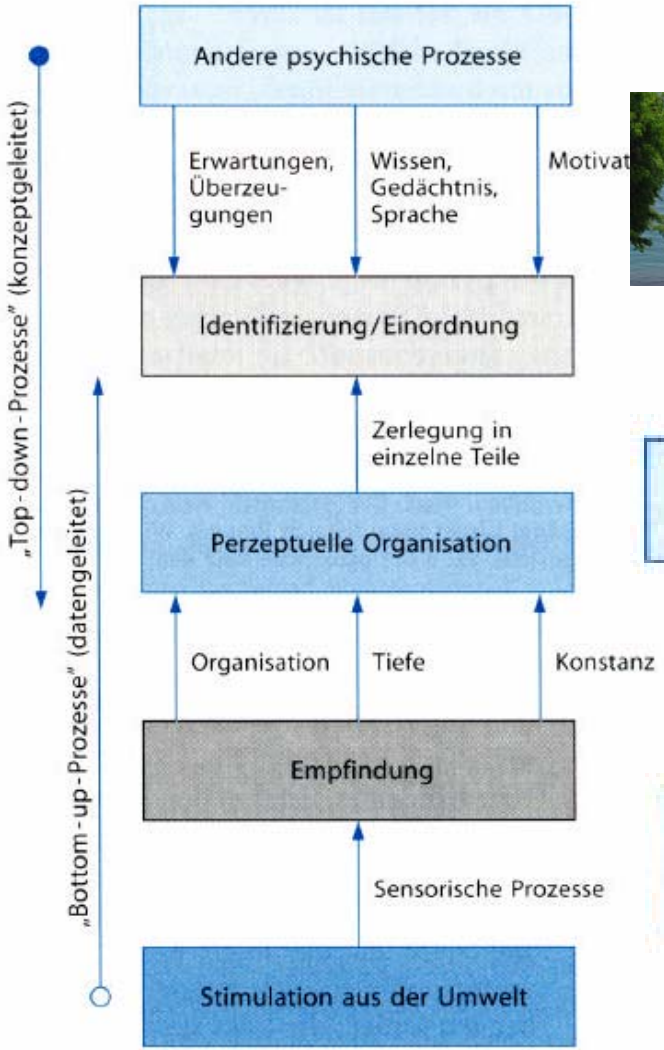
Discriminating Threshold

- How much difference in Stimulus intensity until we perceive change?
- Examples:
  - Tone pitch: Starting at 1000Hz ca. 0.3% increase
  - Distance: Starting at 1m ca. 10%
  - Tone duration: 50ms for bass frequencies
  - Brightness: nine times the stimulus to perceive double brightness

Object properties

- How do visual properties of objects change our perception?
  - Color (Foreground Background)?
  - Texture?
  - Viewing angle?
- Often reason for visual illusions.

Organization



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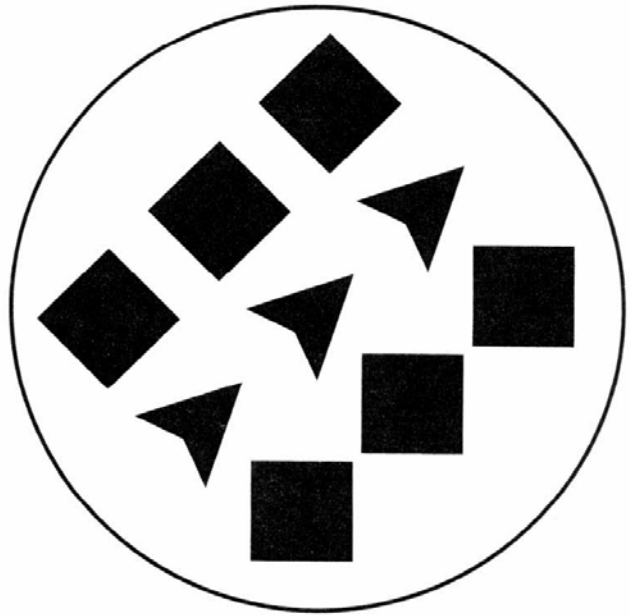
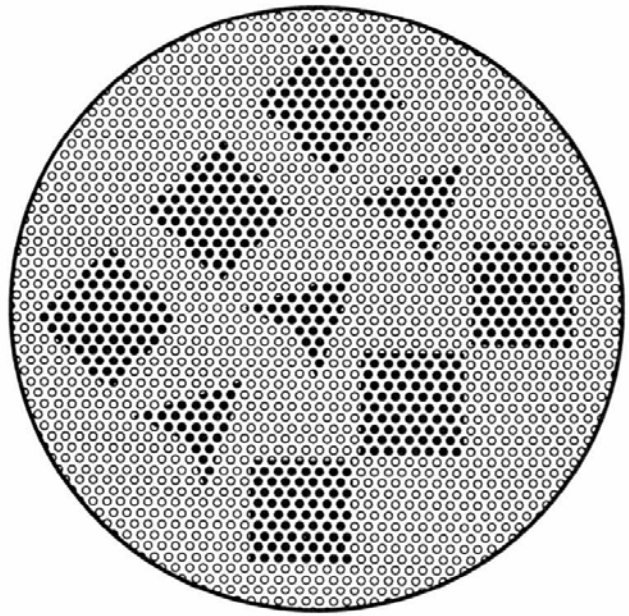
Object Discrimination

- Grouping of objects by identifying strong changes in color (edge detection)



a

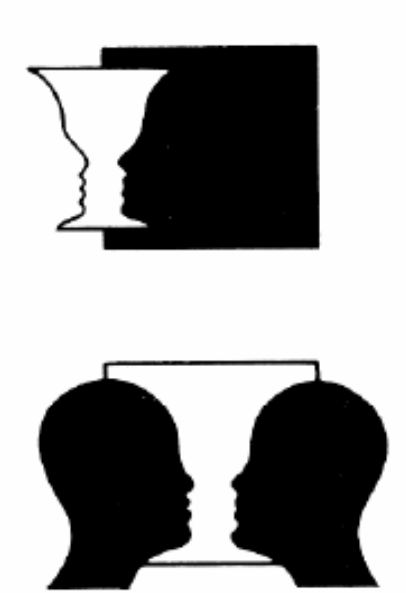
- Grouping by texture properties.

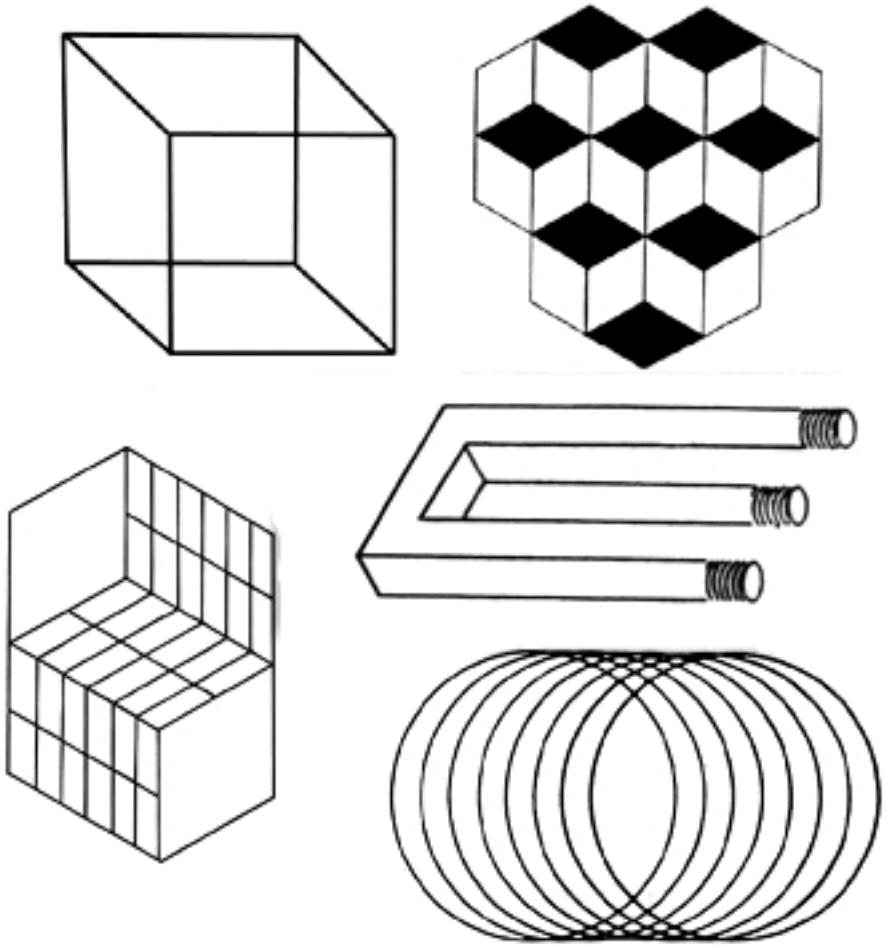


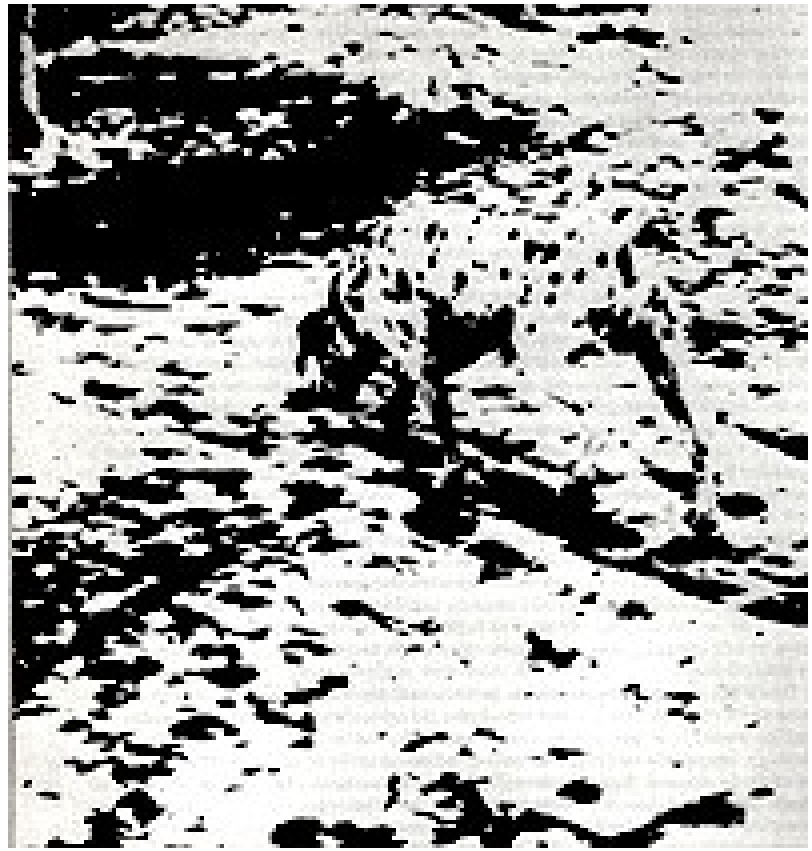
b

Foreground vs. Background

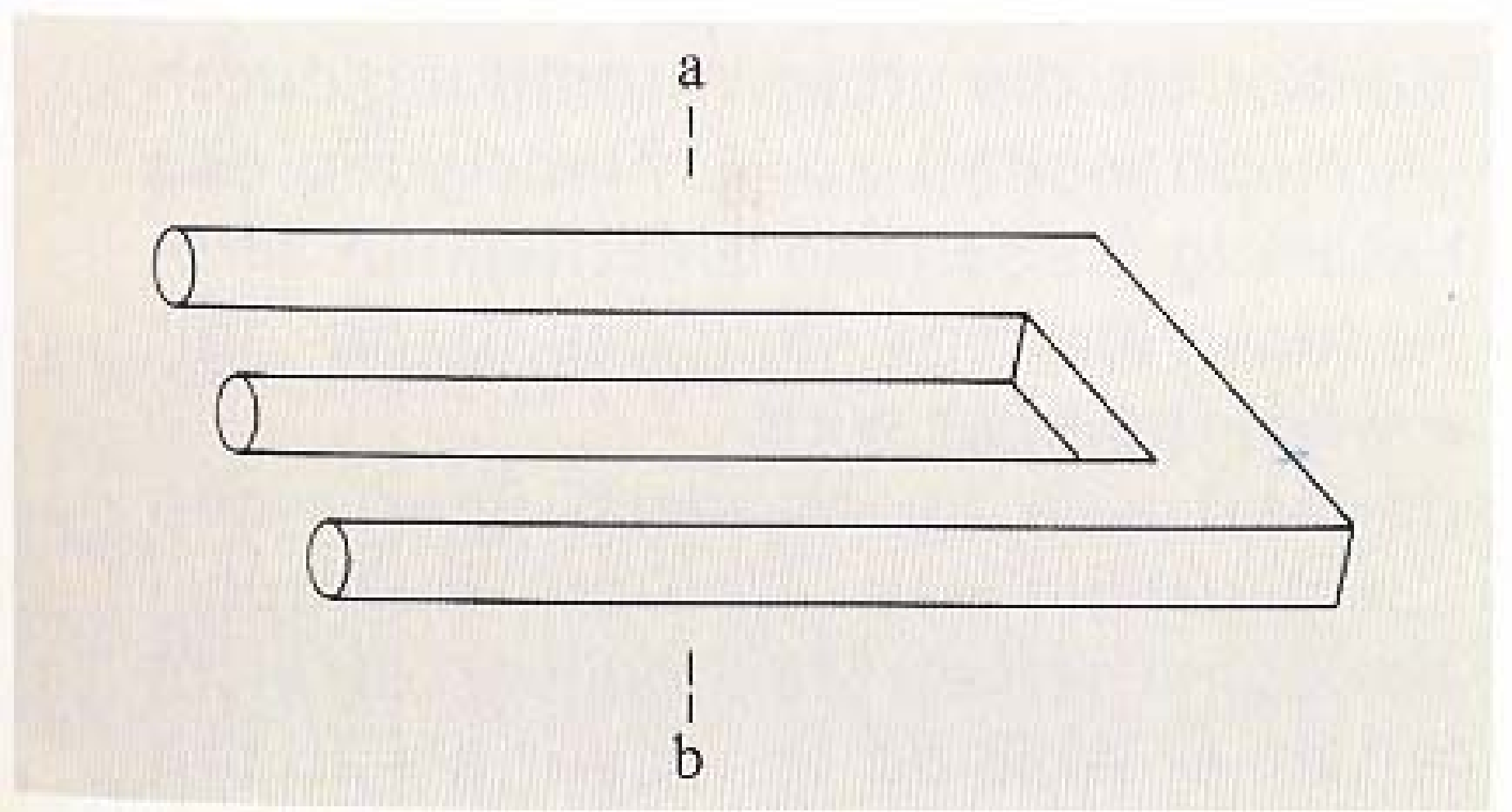
- Interpretaion of the found objects in terms of a figure (foreground) and a background







2D drawing: Make it conclusive…

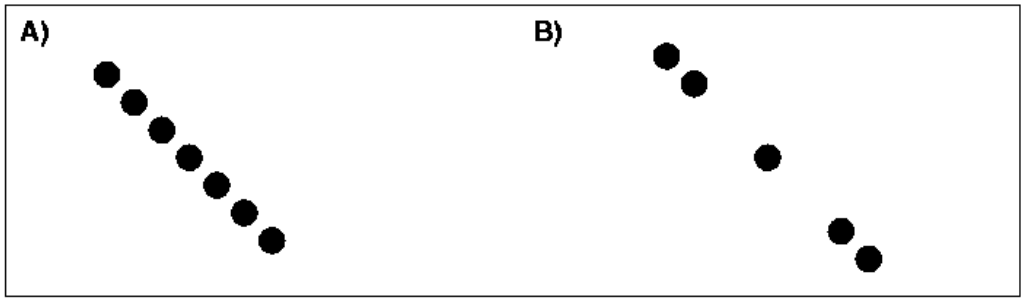


From A. Maelicke, Vom Reiz der Sinne, VCH 1990

Gestalt Laws

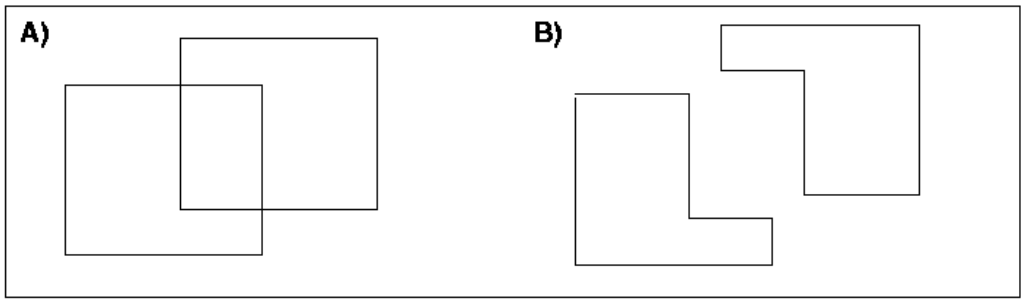
- The perception of the whole is more than the sum of its elements
- The laws are not strictly defined and describe different classes of observations
- Not just valid for visual but more general for all cognitive processes

Some Gestalt Laws



Gesetz der Nähe

Gesetz der Kontinuität



Prägnanzgesetz

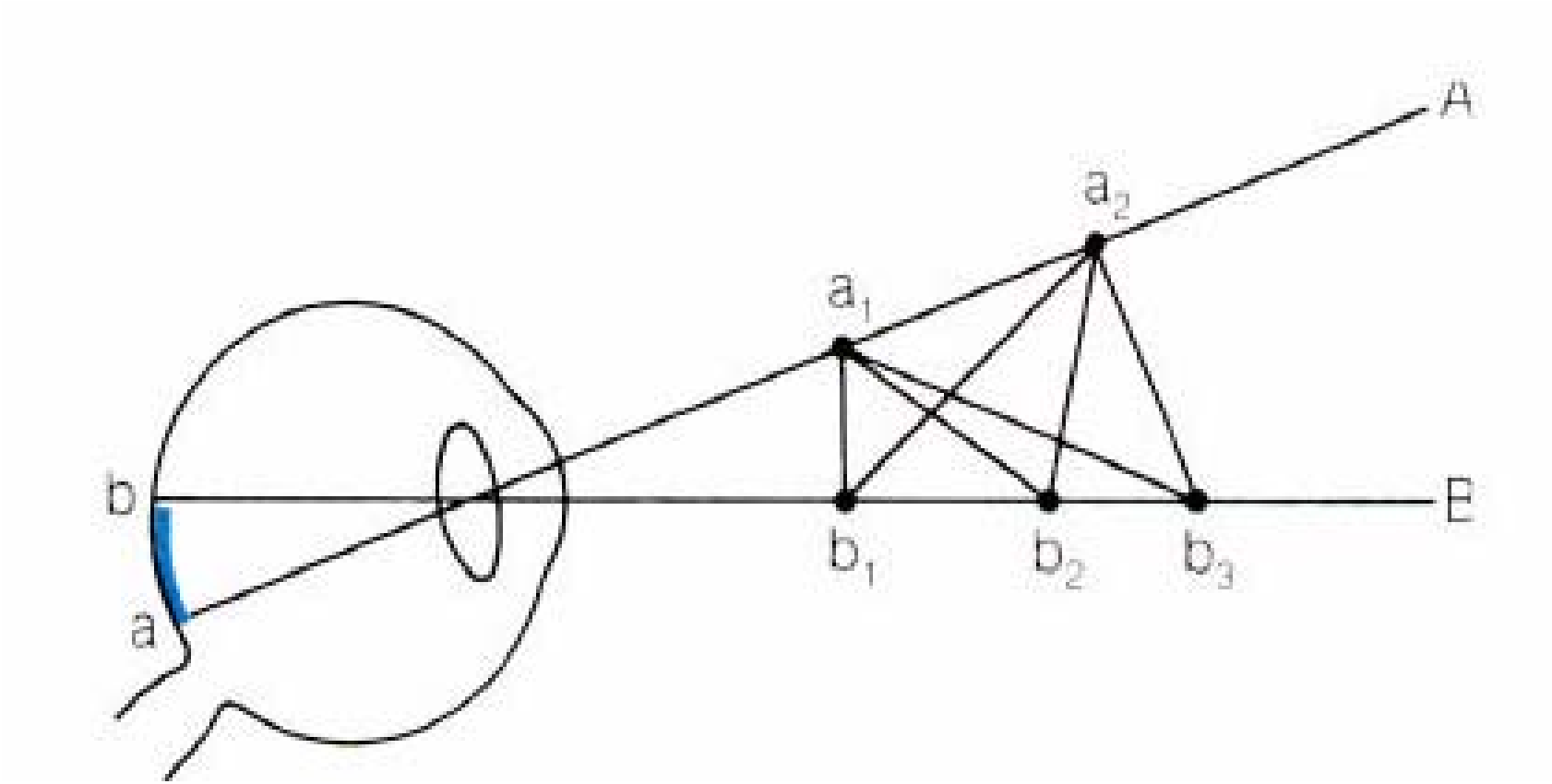
Ähnlichkeitsgesetz

Gestalt Perception Example

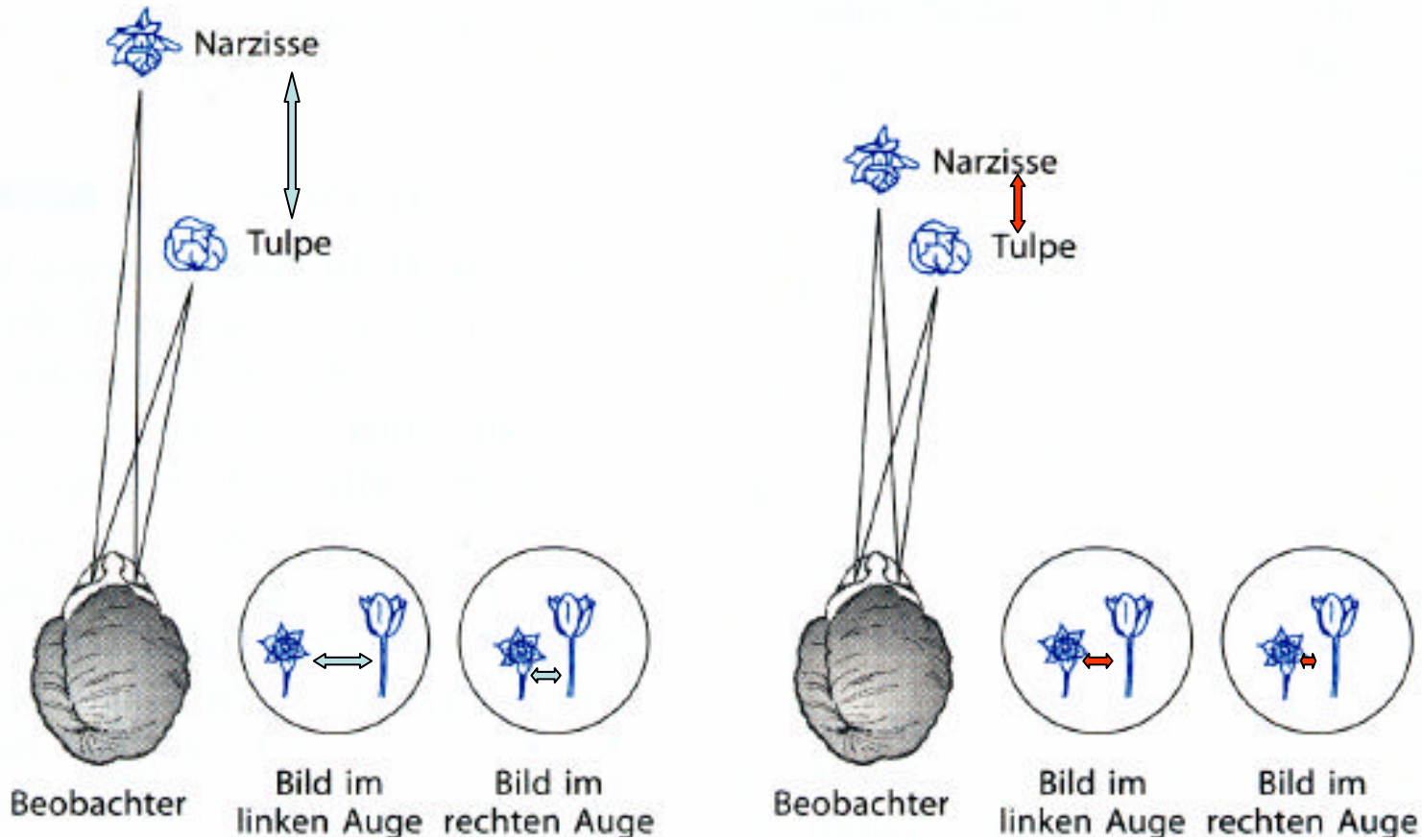

Baggage Claim
International Arrivals
Foreign Exchange
荷物受取／全てのゲート
Elevator
Sunshine Foundation
CAUTION
KEEP OFF RED LINES
KEEP RED
OFF LINE

Depth perception

- Ambiguities in depth perception prevent distance judgment with one eye



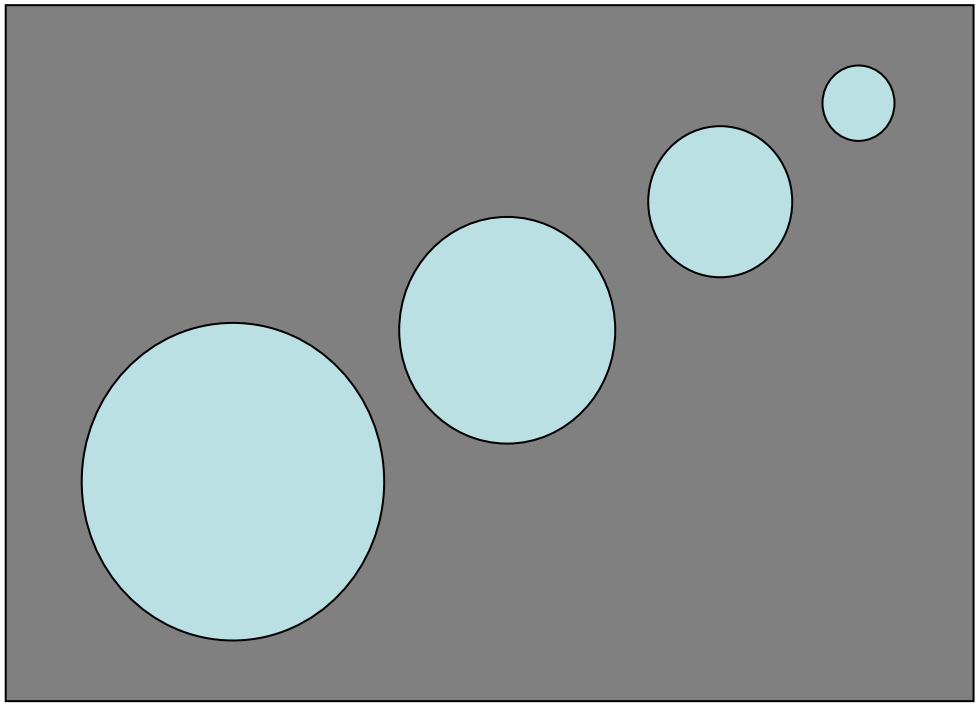
Depth perception II



- Works only for distances up to 3m

Monocular depth judgment

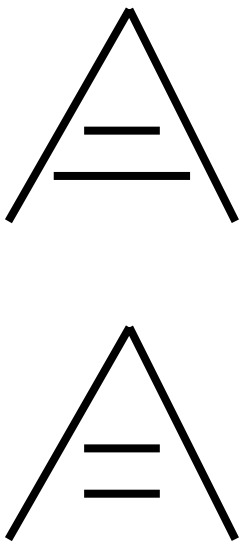
- Relative size:



The smaller, the further away

Linear perspective

- Converging lines signal depth (see also Ponzo Illusion).

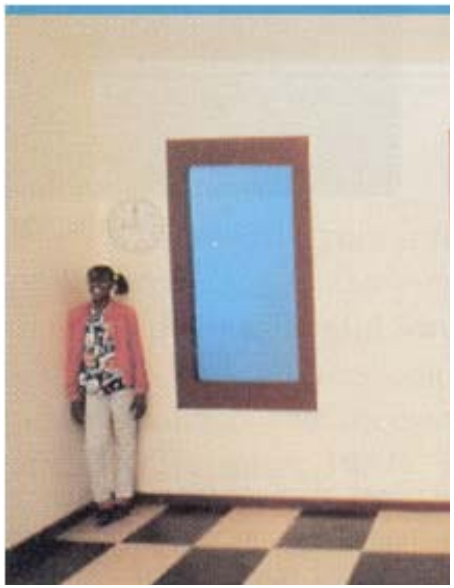


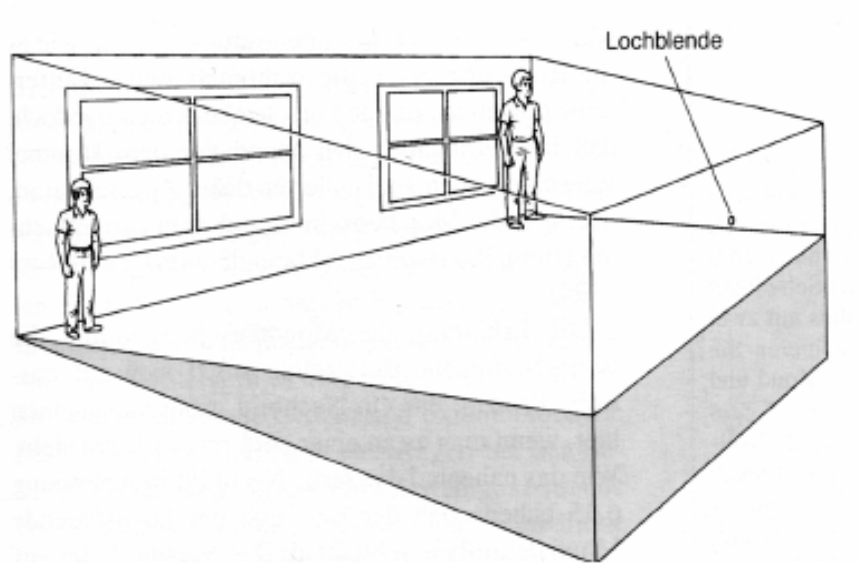
Texture Gradient

- Diminishing granularity signals depth

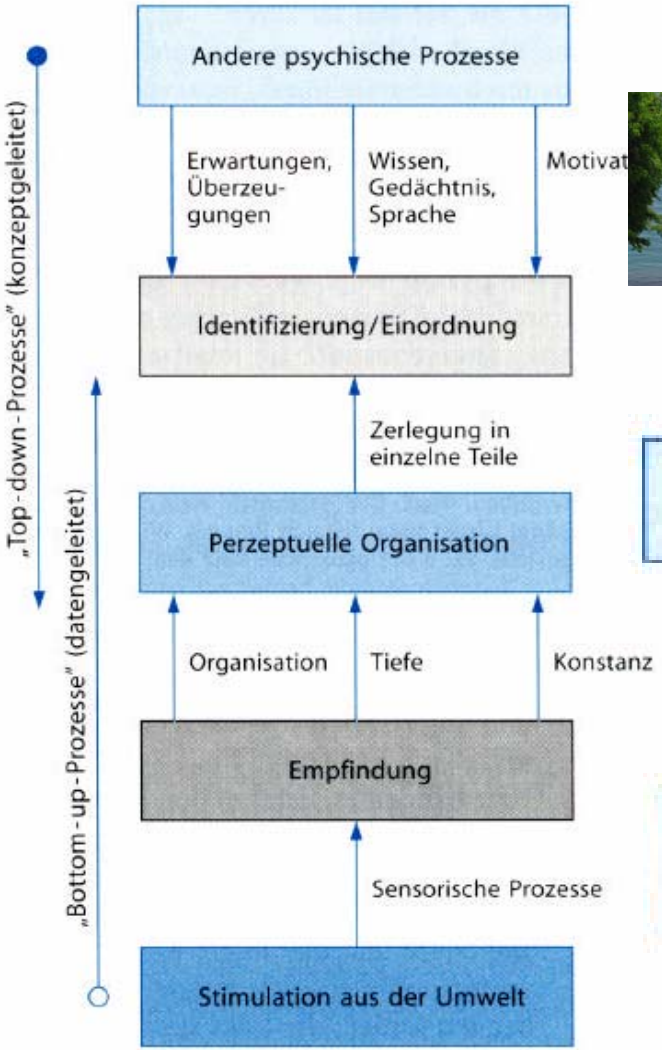
Room of Ames

- Size Illusion due to depth perception:





Processing and Identification



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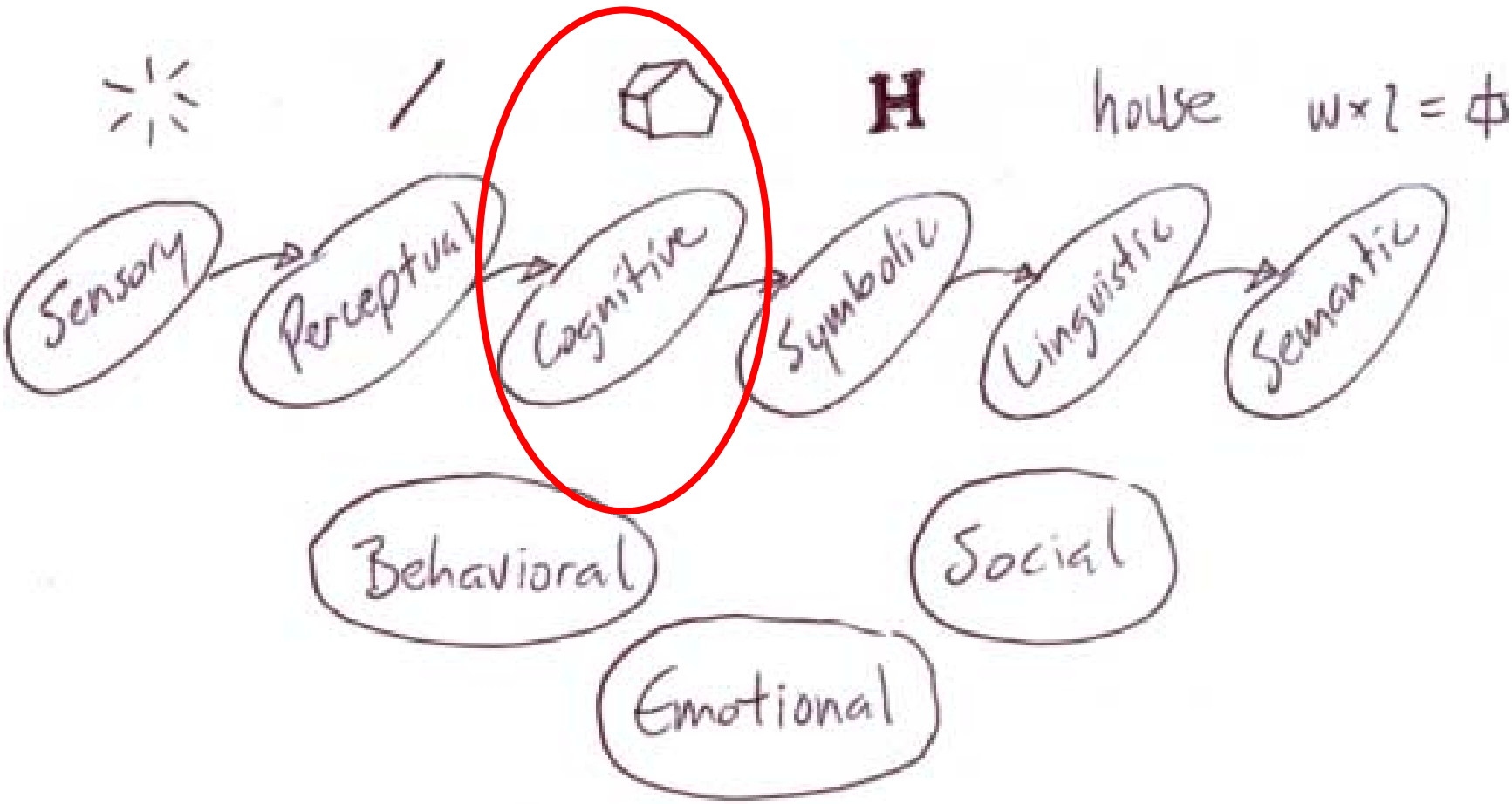
Knowledge acquisition pipeline

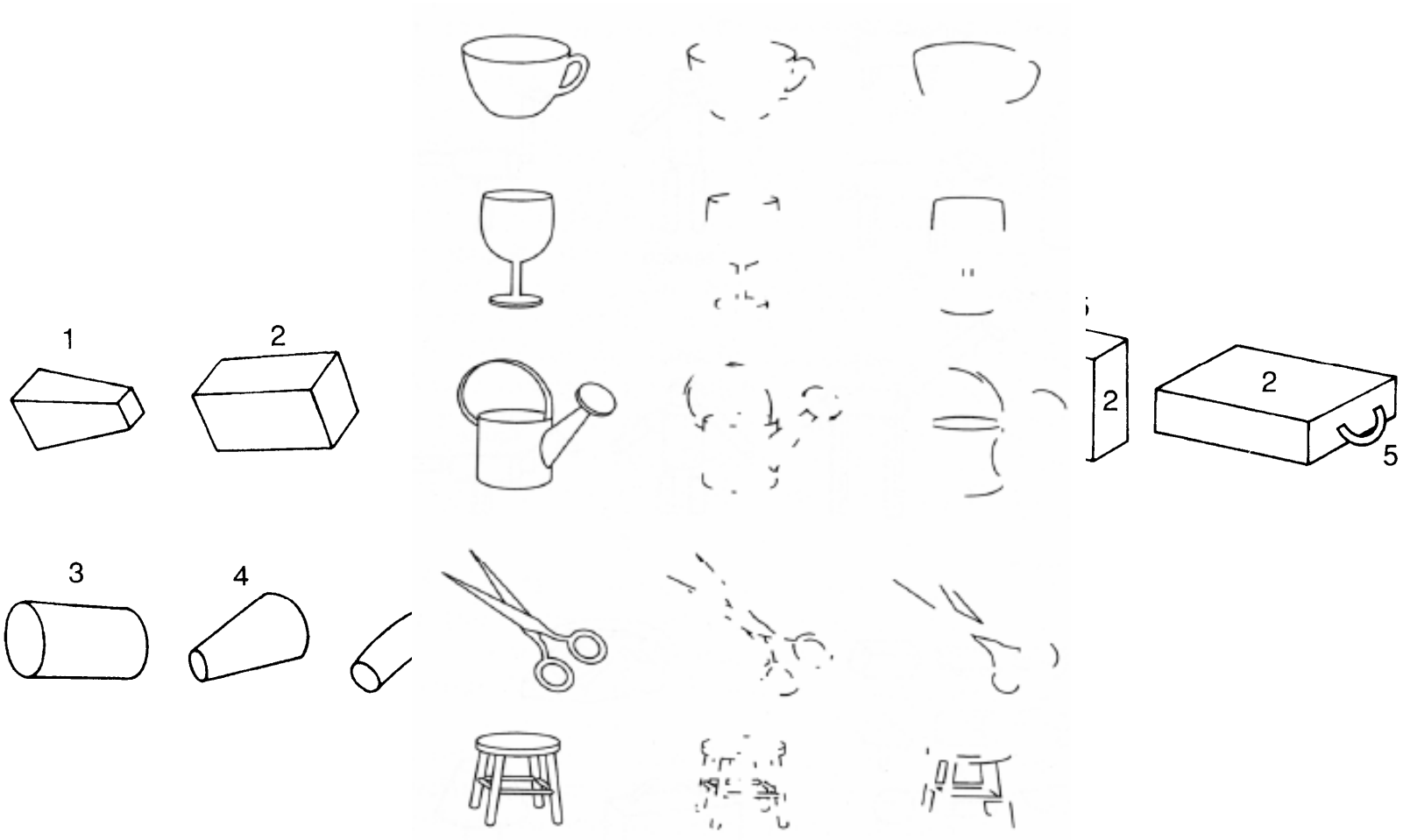
[W. Bradford Paley, SG 2003]



Geons (Biederman et al, 1991)

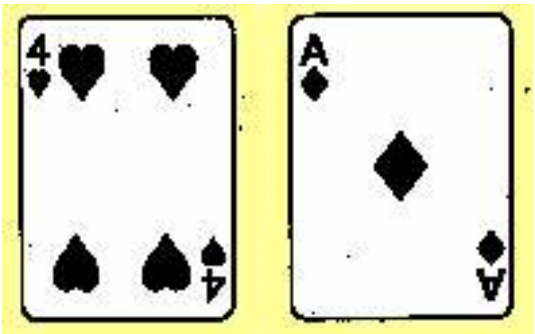
- All geometric objects can be decomposed into 36 „Geons“
- Every Geon leaves a unique pattern on the retina -> Bottom-Up part.
- Knowledge about Objects in the world helps constituting these from single geons -> Top-Down part.

Geons (Biederman et al, 1991)



Knowledge and Perception

- Influence of Knowledge
  - unusual colors slow down identification.



Attention – Cocktail Party Phenomenon

- Cocktail party – Part 1:
  - Lots of people
  - Noisy chatting everywhere
  - You‘re engaged in conversation
- How can we follow our own conversation – but not get distracted by others?

➡ Attention is selective

Attention – Cocktail Party Phenomenon

- Cocktailparty – Part 2:
  - Suddenly you hear your name from the surrounding noise. Even if everything else was blocked out before.
- How can we perceive blocked Information?
- Perception buffers.

➡ Different theories for selective Attention.

Change Blindness [Ronald A. Rensink, 1998]

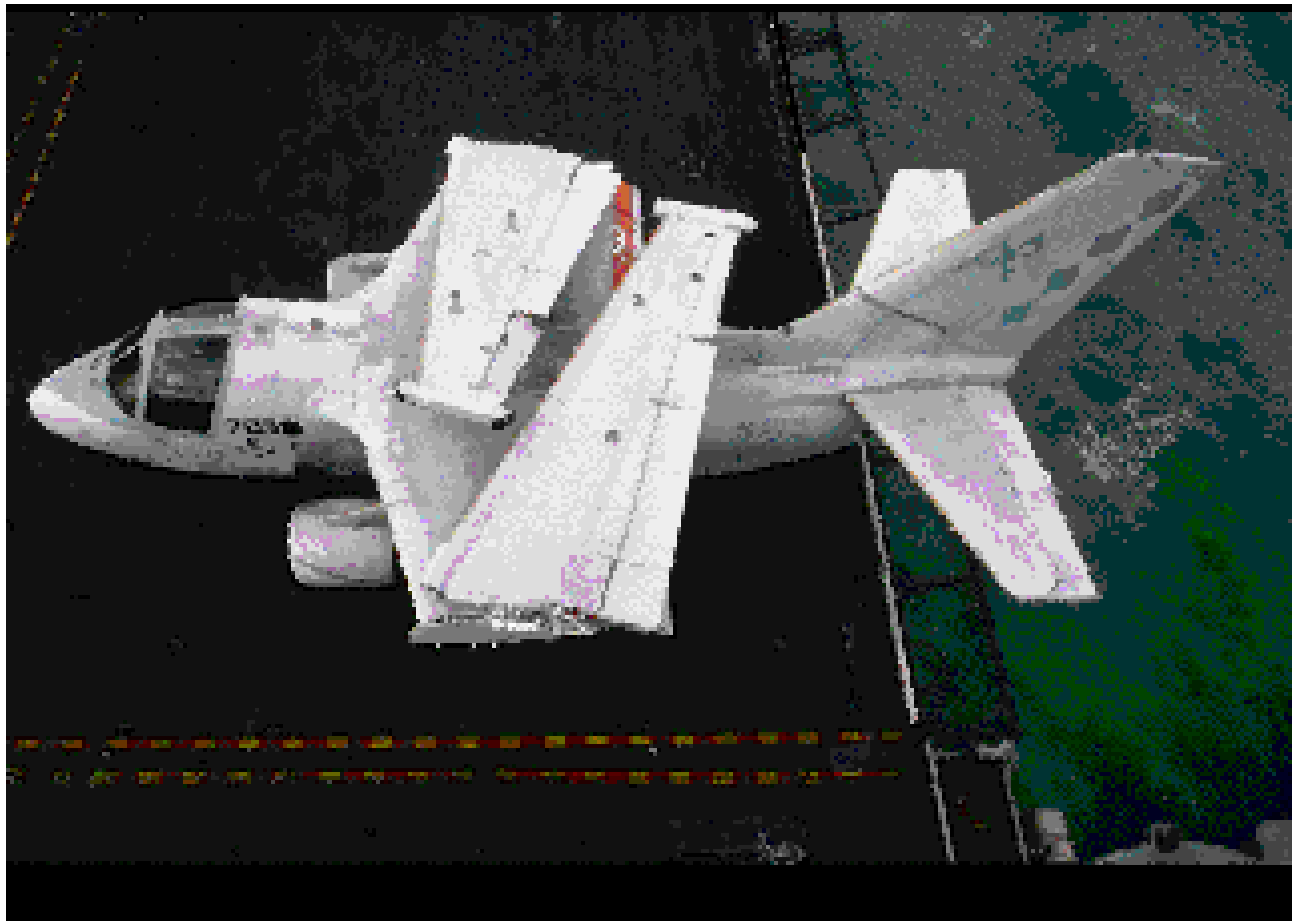
- Large changes in a scene are not noticed
- …when there is a short distraction, e.g.
  - "mud splashes"
  - "brief flicker"
  - "cover box"

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

- One possible conclusion: no complete visual buffer
  - Instead: directed attention to smaller area

Change blindness
example: mud splashes

Change blindness example: flicker



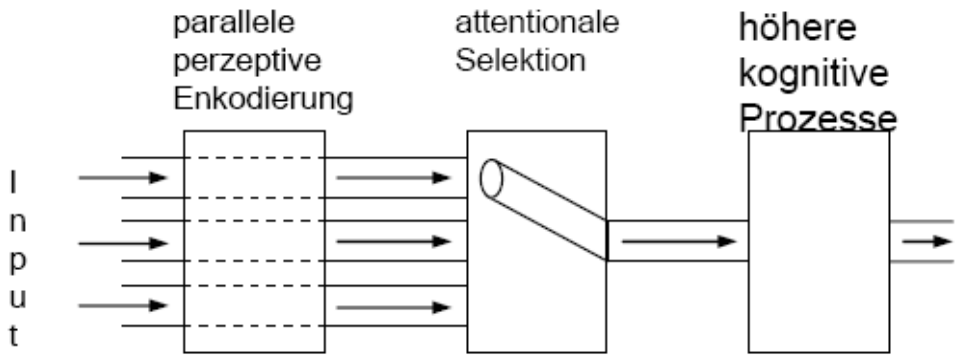
Change blindness example: dialog box

References

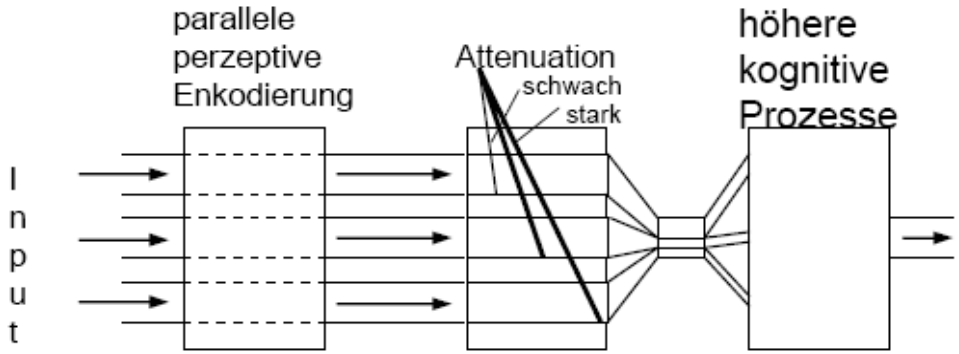
- Change blindness demo applet http://www.usd.edu/psyc301/Rensink.htm
- Encyclopedia of Cognitive Science: Change blindness http://nivea.psycho.univ-paris5.fr/ECS/ECS-CB.html

Filter Theories

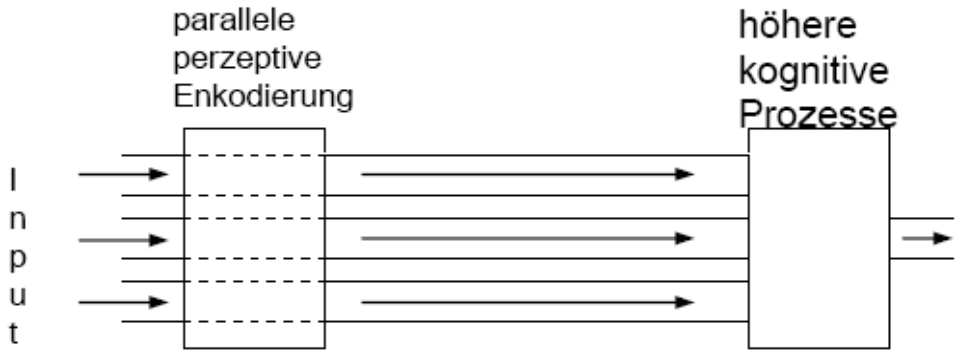
- Broadbent (1958)
  - Early selection



- Treismann (1964)
  - attenuation

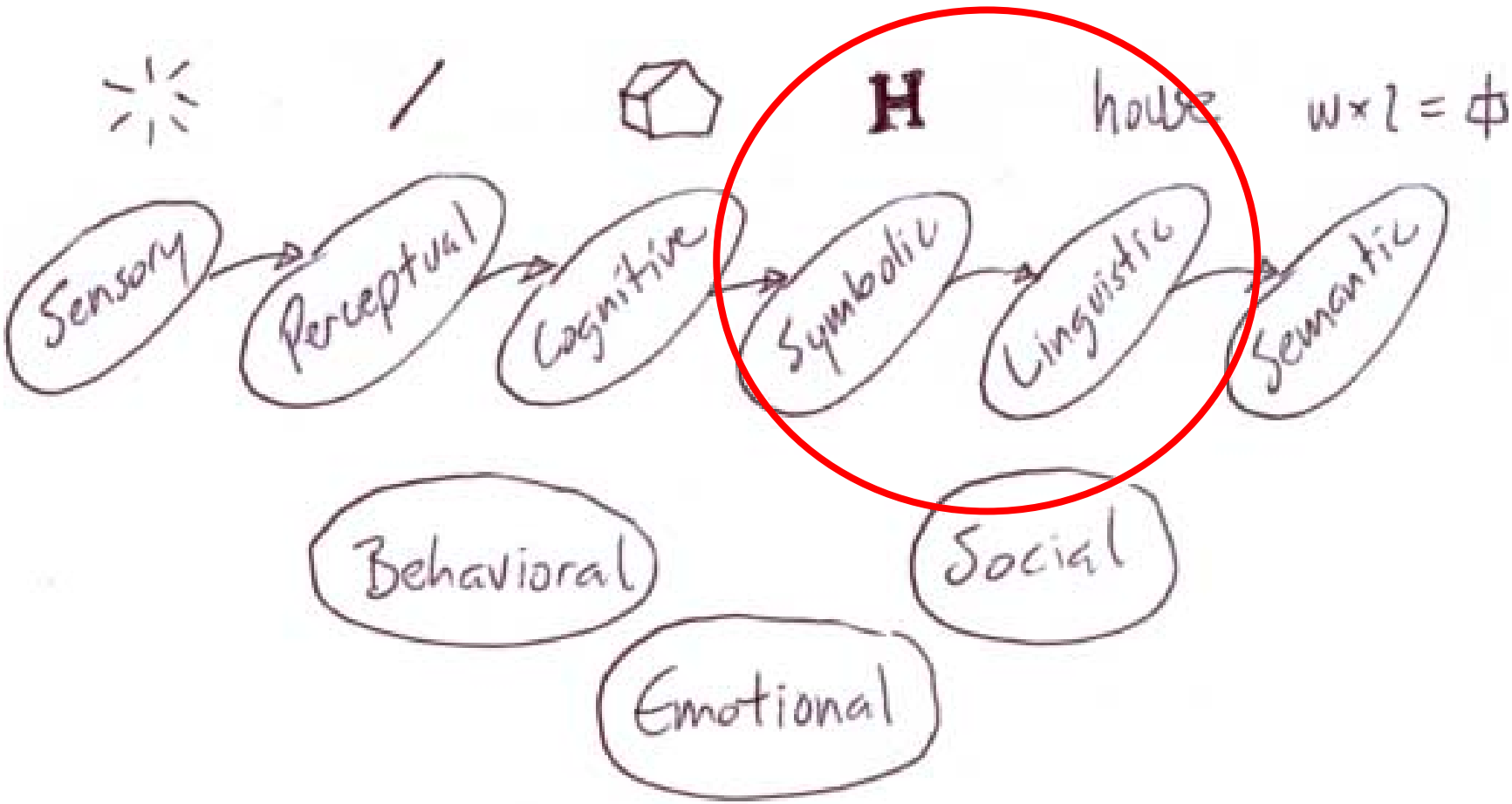


- Deutsch&Deutsch (1963)
  - Late selection



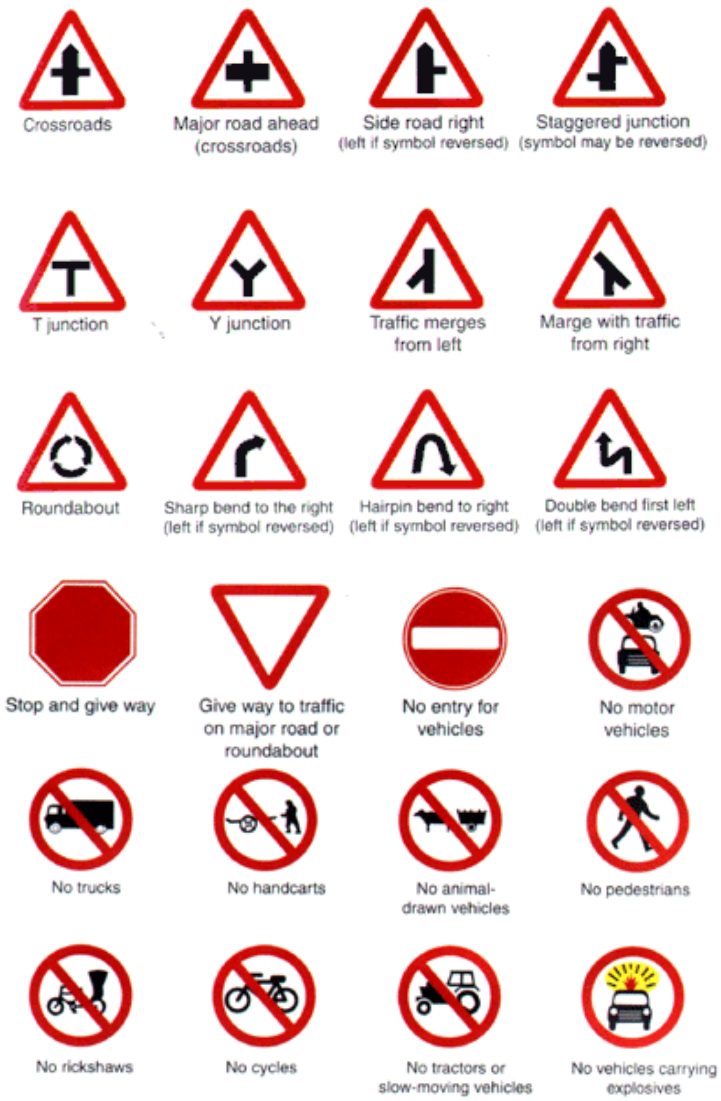
Knowledge acquisition pipeline

[W. Bradford Paley, SG 2003]



Interpretation of symbols

- Associate the recognized object or shape with a meaning (symbolic)
  - Characters
  - Symbols
- Can also be combined to a language (linguistic)
  - Words from characters
  - Different traffic signs from same base elements



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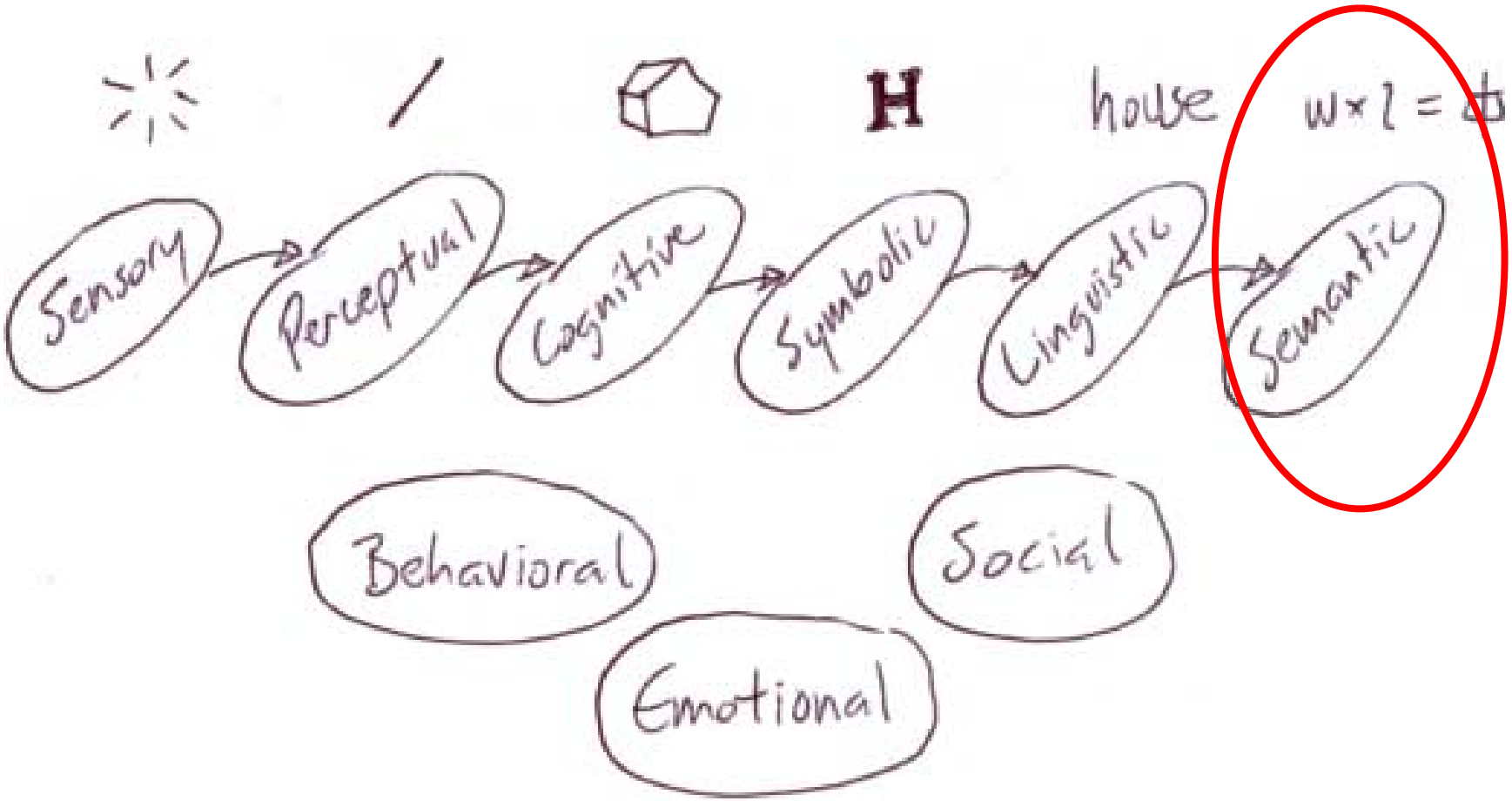
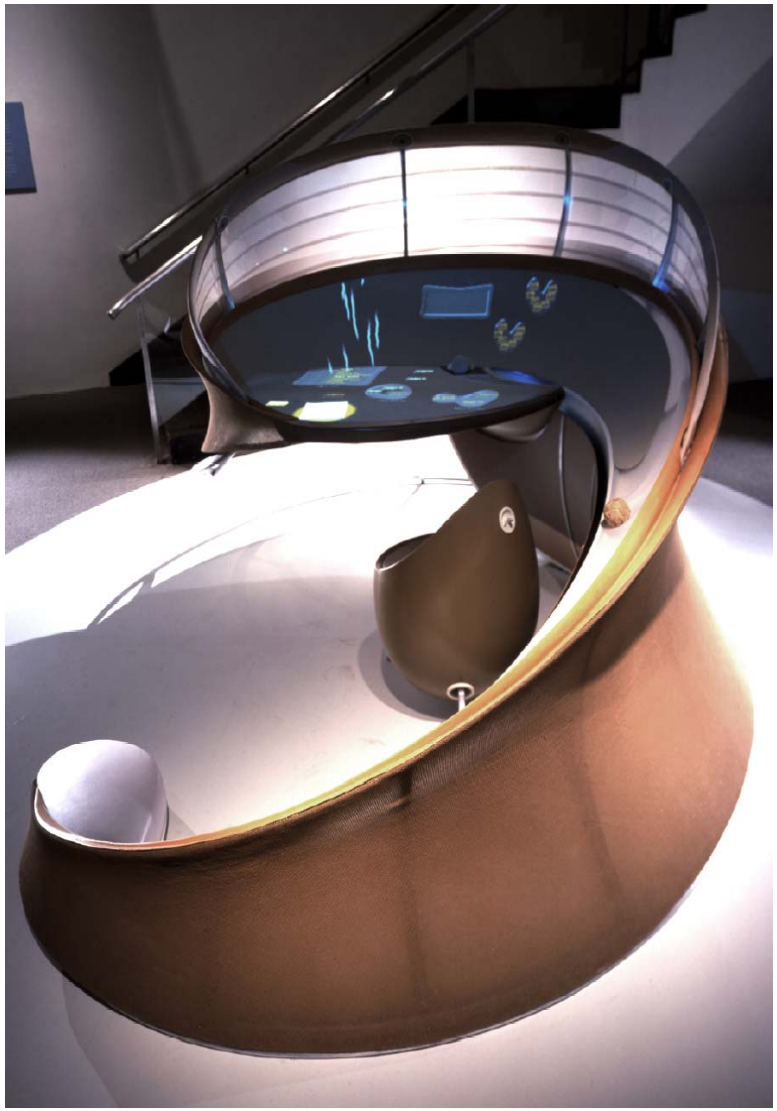


MindSpace (Brad Paley, http://www.didi.com/brad/)



- Interaktive Visualisierung einer Hierarchie
- Verschiedene synchonisierte Darstellungen
- Gruppenbildung durch aneinanderrücken von Objekten
- Spielerisches Ordnen und Klassifizieren

Live demo