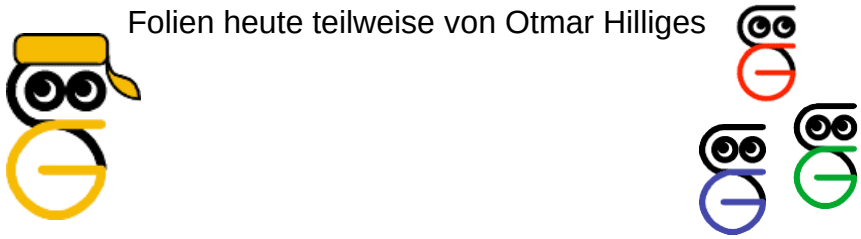
Smart Graphics: Graphics and Perception

Lecture „Smart Graphics”

Andreas Butz, Sebastian Boring

Folien heute teilweise von Otmar Hilliges

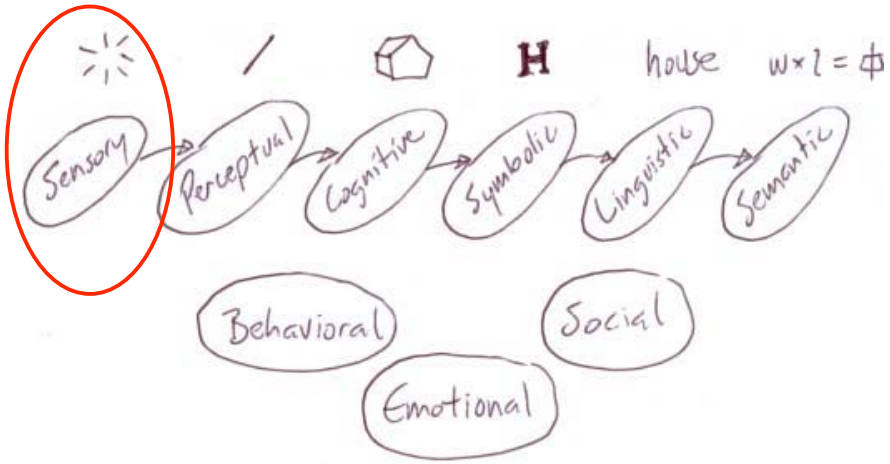


Topics Today

- 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

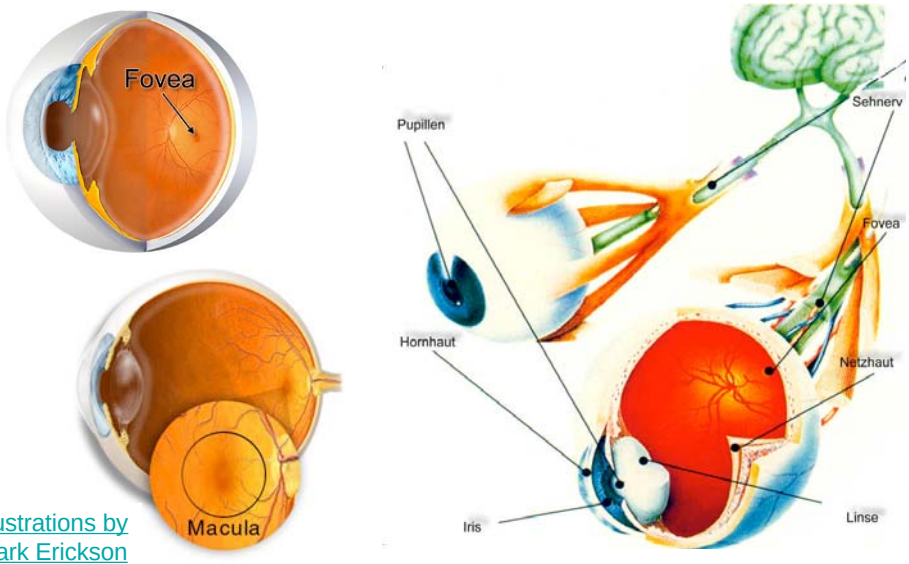
Knowledge acquisition pipeline

[W. Bradford Paley, SG 2003]



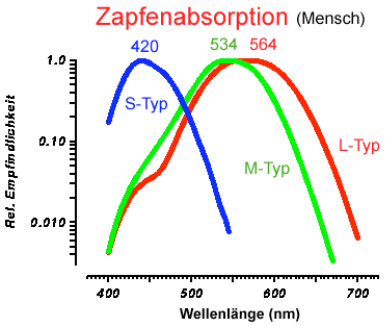
Simplified model of human sensemaking processes, useful for designing visual representations

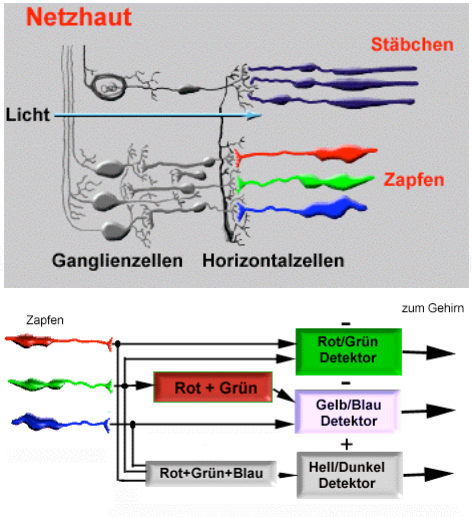
The human eye



Illustrations by Mark Erickson

Die Netzhaut



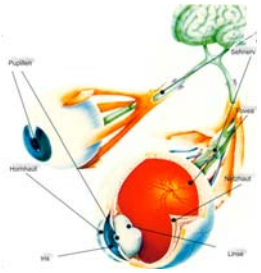


- Zapfen arbeiten bei höherer Lichtintensität
- Verteilung auf der Netzhaut im Verhältnis 1:20:40
- Stäbchen arbeiten bei niedriger Lichtintensität

Color blindness

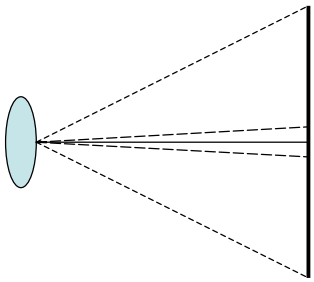
- Most prominent kind: red/green blindness
  - ~8% of men
- Simulation with vischeck

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

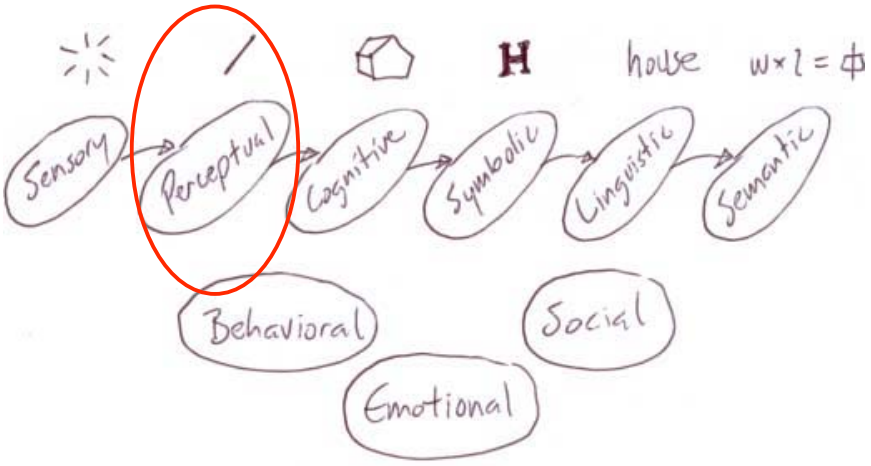
How much resolution do we need?



- 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

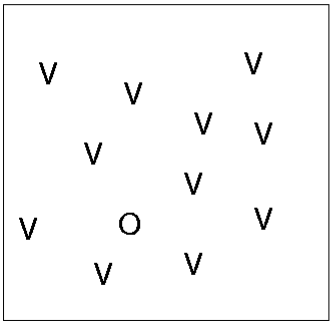
Knowledge acquisition pipeline

[W. Bradford Paley, SG 2003]



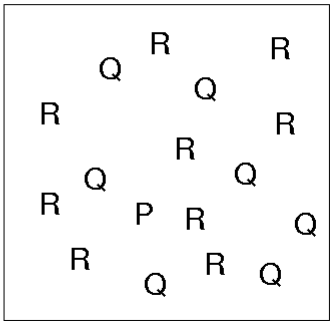
Visual Search

A)



Preattentative Search

B)



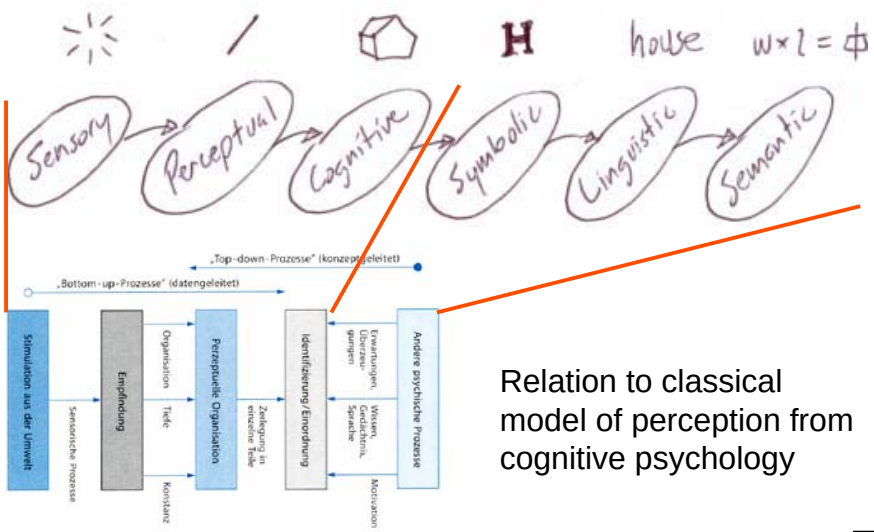
Attentative Search

Attentative Processing

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

Knowledge acquisition pipeline

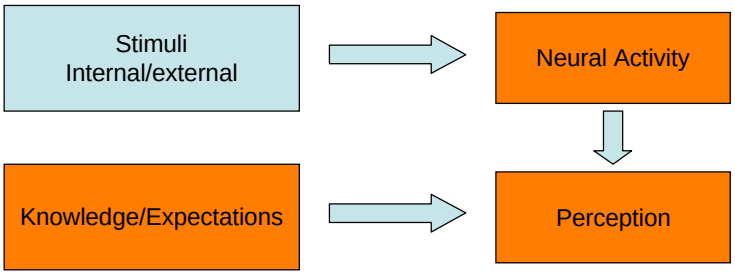
[W. Bradford Paley, SG 2003]



Relation to classical model of perception from cognitive psychology

Cognitive Psychology

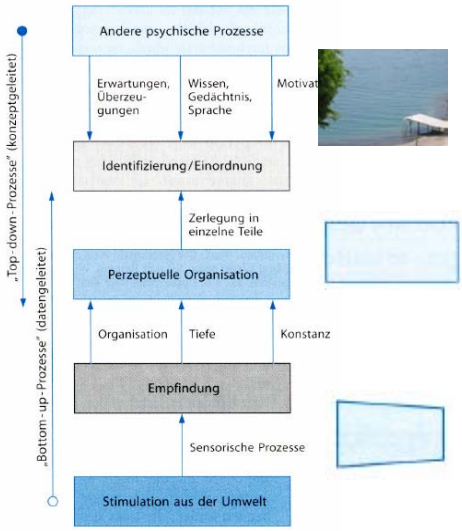
- How is perception influenced by knowledge and resulting expectations?



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



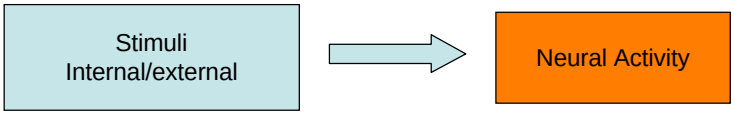
3. Implicit (learned) knowledge is used to form a conceptual representation (meaning). -> Cognitive Psychology

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

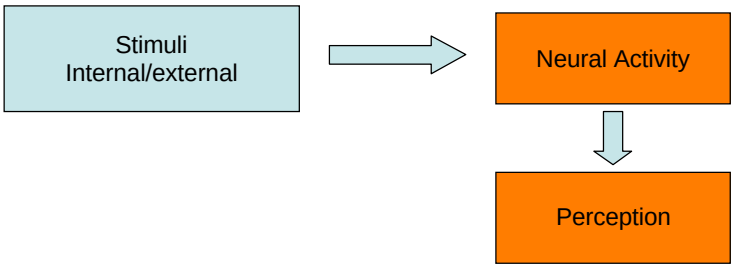
Physiology

- 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.

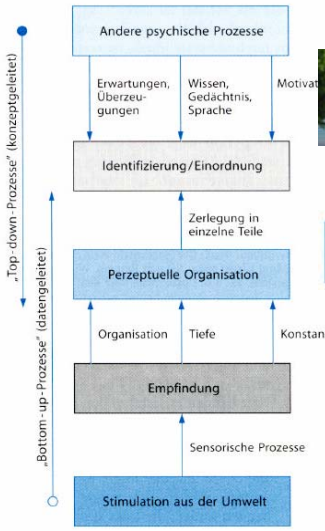
Discriminating Threshold

- 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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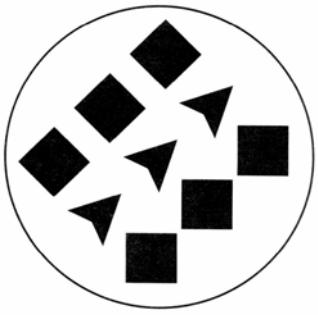
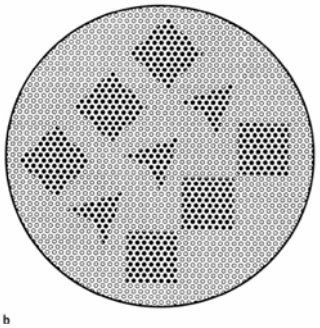
Object Discrimination

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

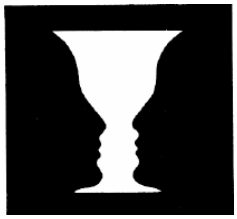


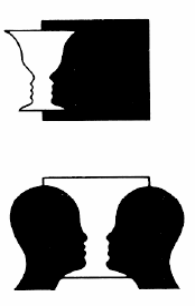
- Grouping by texture properties.

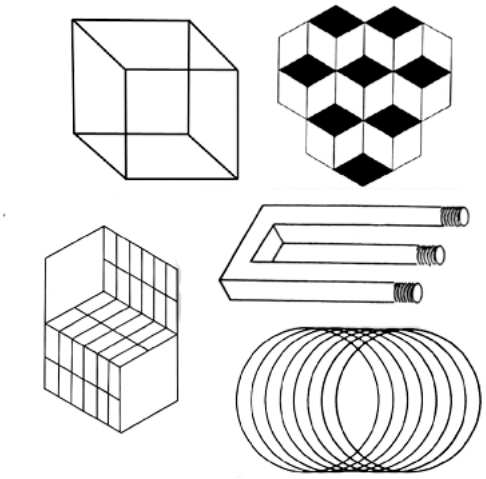


Foreground vs. Background

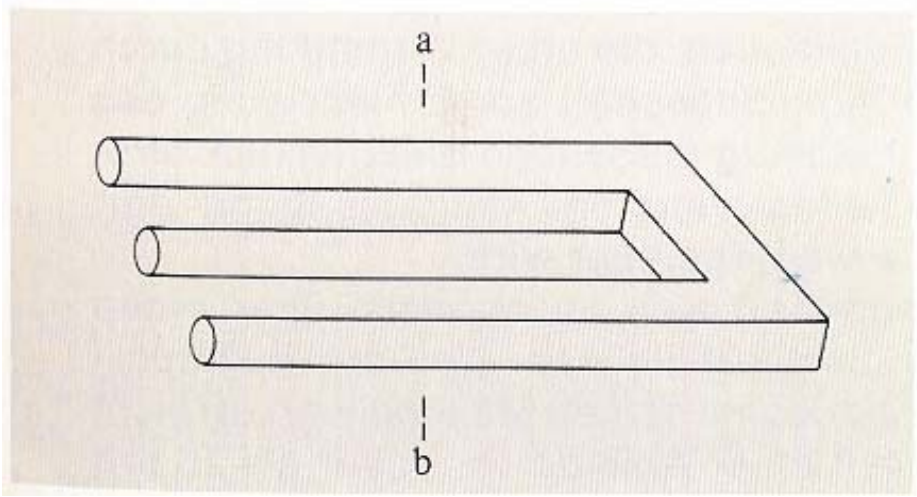
- Interpretaion of the found objects in terms of a figure (foreground) and a background







2D drawing: Make it conclusive…

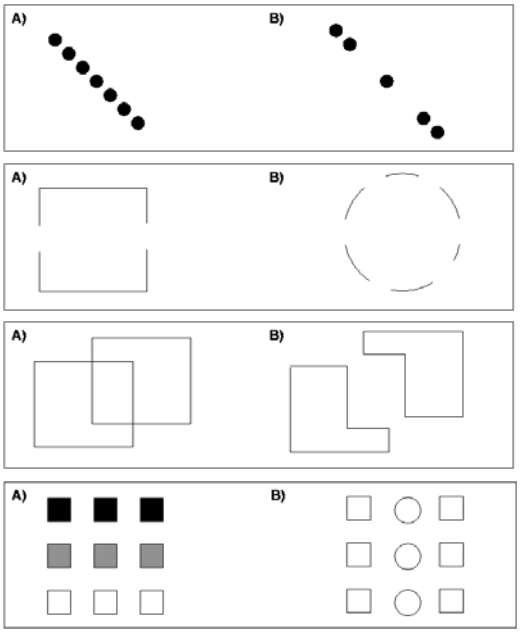


From A. Maelicke, Vom Reiz der Sinne, VCH 1990

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

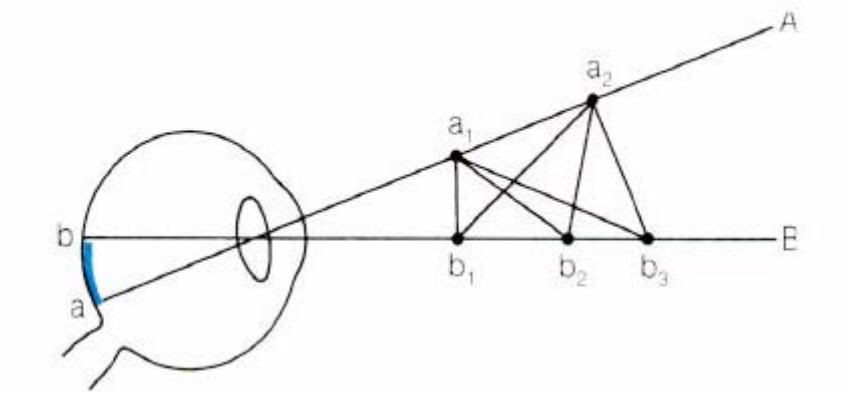
Prägnanzgesetz

Ähnlichkeitsgesetz

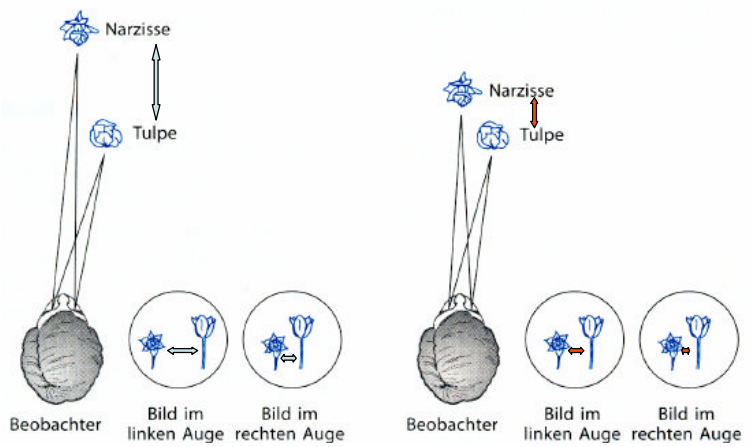
Gestalt Perception Example

Depth perception

- Ambiguities in depth perception prevent distance judgment with one eye



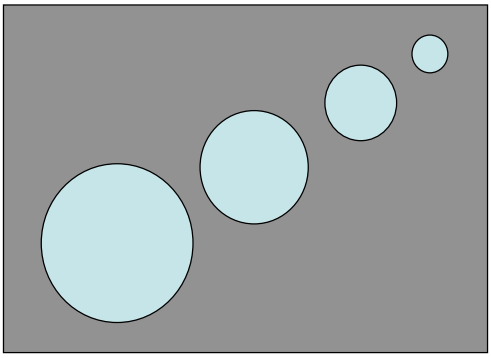
Depth perception II



- Works only for distances up to 3m

Monocular depth judgment

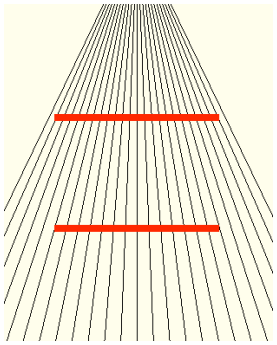
- Relative size:



The smaller, the further away

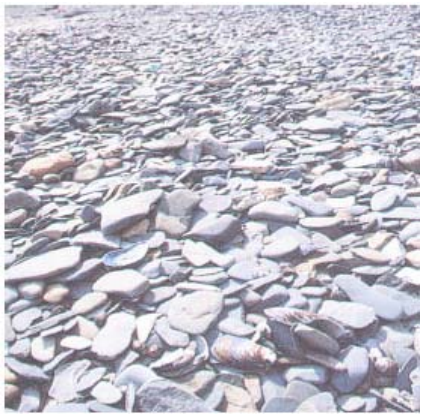
Linear perspective

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



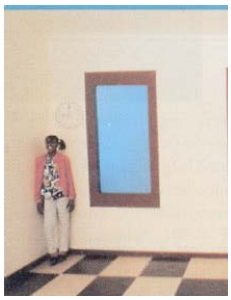
Texture Gradient

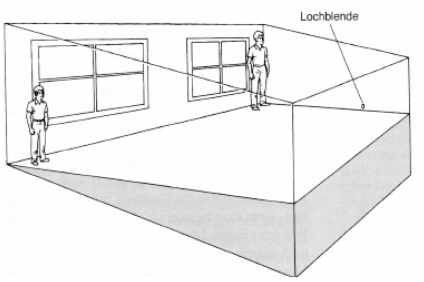
- Diminishing granularity signals depth



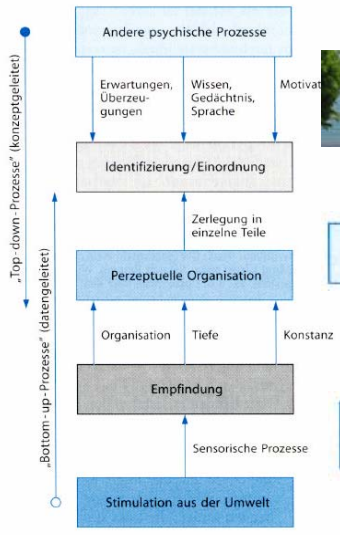
Room of Ames

- Size Illusion due to depth perception:





Processing and Identification



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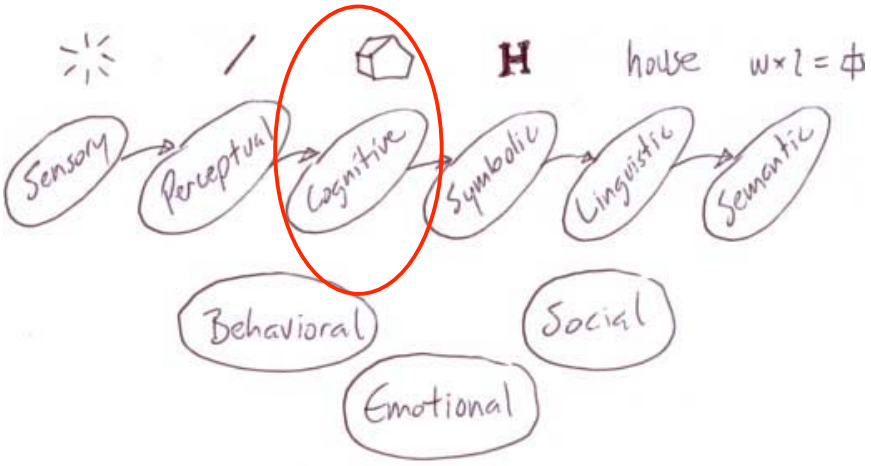
Knowledge acquisition pipeline

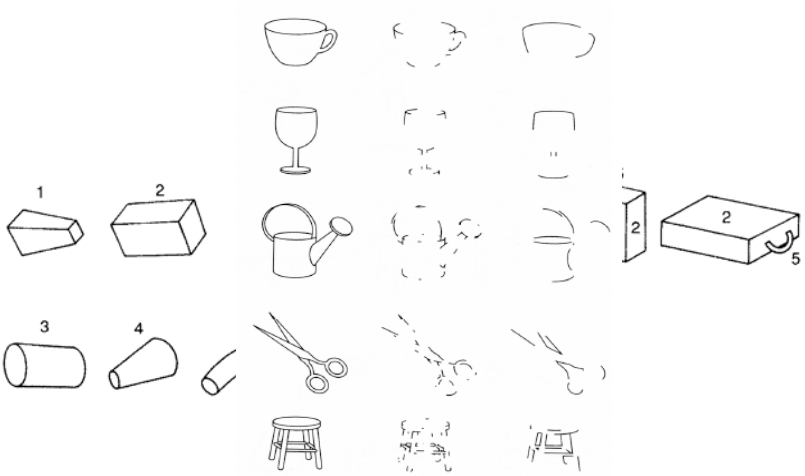
[W. Bradford Paley, SG 2003]



Geons (Biederman et al, 1991)

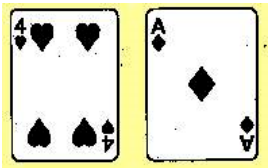
- All geometric objects can be decomposed into 36 „Geons“
- Every Geon leaves a unique pattern on the retina -> Bottom-Up part.
- Knowledge about Objects in the world helps constituting these from single geons -> Top-Down part.

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]

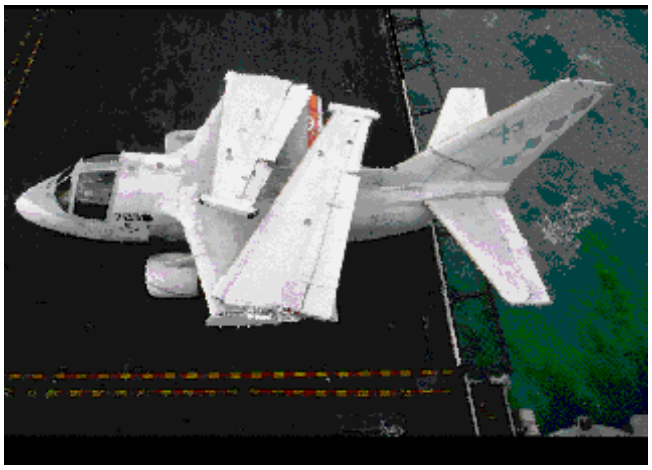
- Large changes in a scene are not noticed
- …when there is a short distraction, e.g.
  - "mud splashes"
  - "brief flicker"
  - "cover box"

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

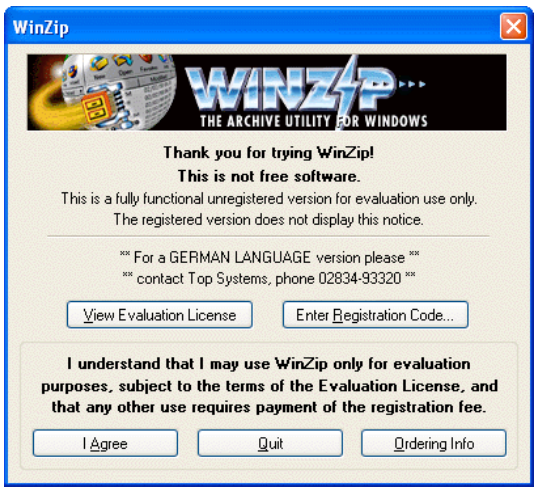
- One possible conclusion: no complete visual buffer
  - Instead: directed attention to smaller area

Change blindness example: mud splashes

Change blindness example: flicker



Change blindness example: dialog box

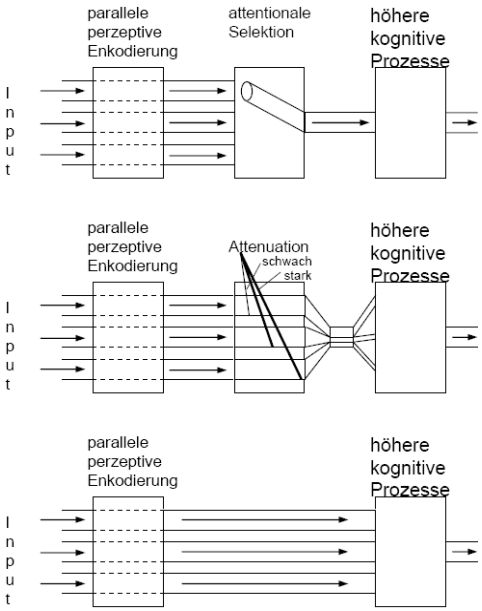


References

- 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

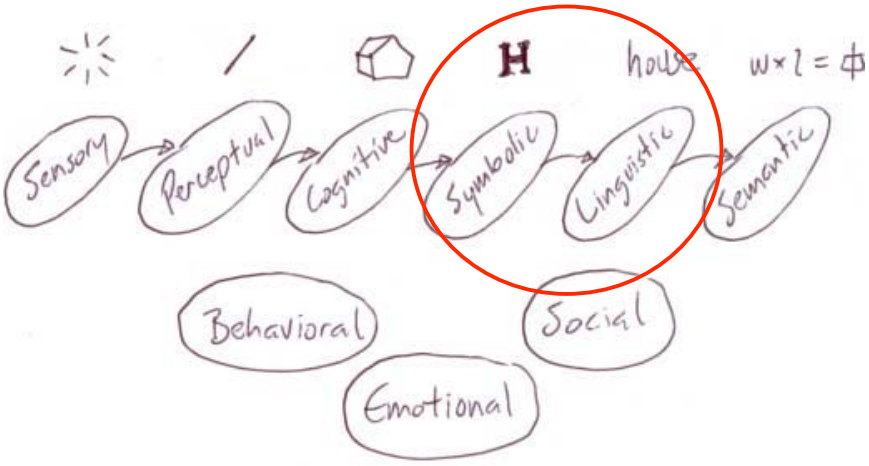
Filter Theories

- Broadbent (1958)
  - Early selection
- Treismann (1964)
  - attenuation
- Deutsch&Deutsch (1963)
  - Late selection



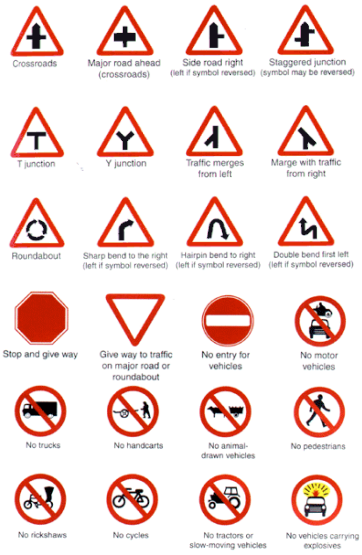
Knowledge acquisition pipeline

[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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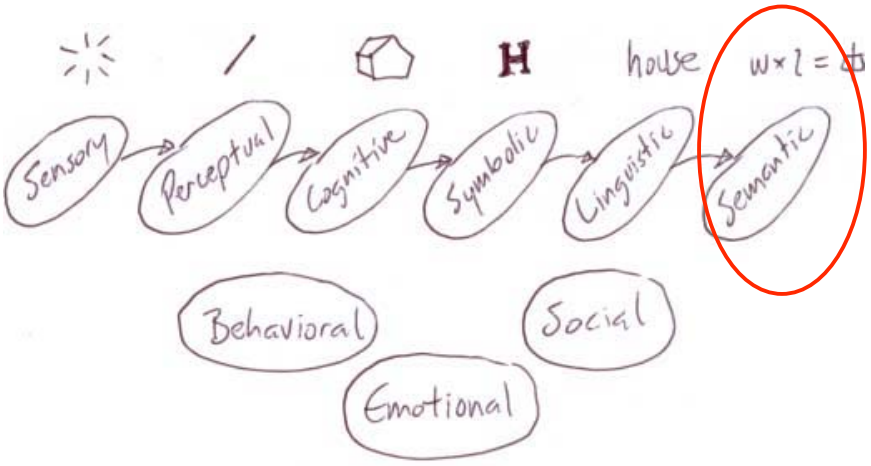
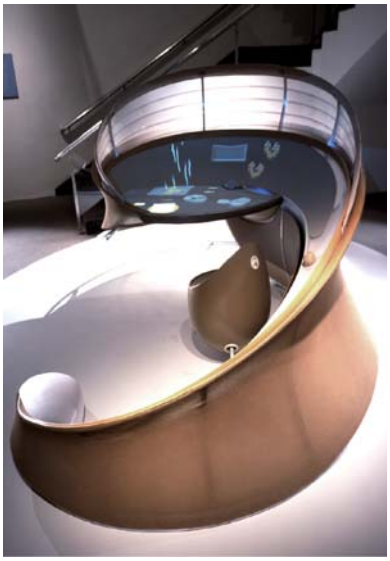


MindSpace (Brad Paley, http://www.didi.com/brad/)



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

Live demo