The Art and Science of Depiction

Vision Solves Problems

Fredo Durand

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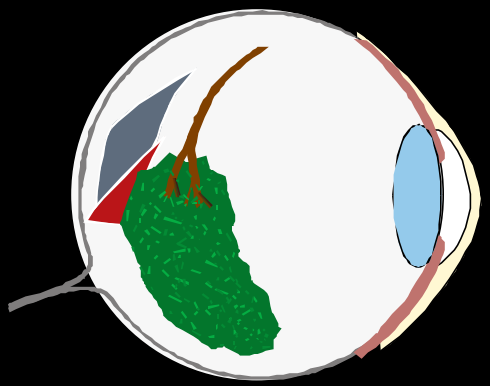
Plan

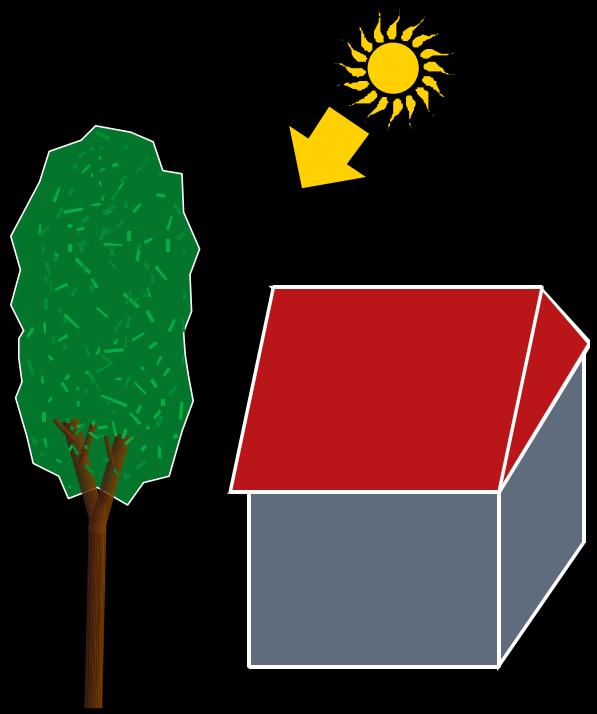
- Vision as an cognitive process
- Computational theory of vision
- Constancy, invariants

Distal vs. proximal stimulus

- Distal stimulus: reality
- Proximal stimulus: retinal image



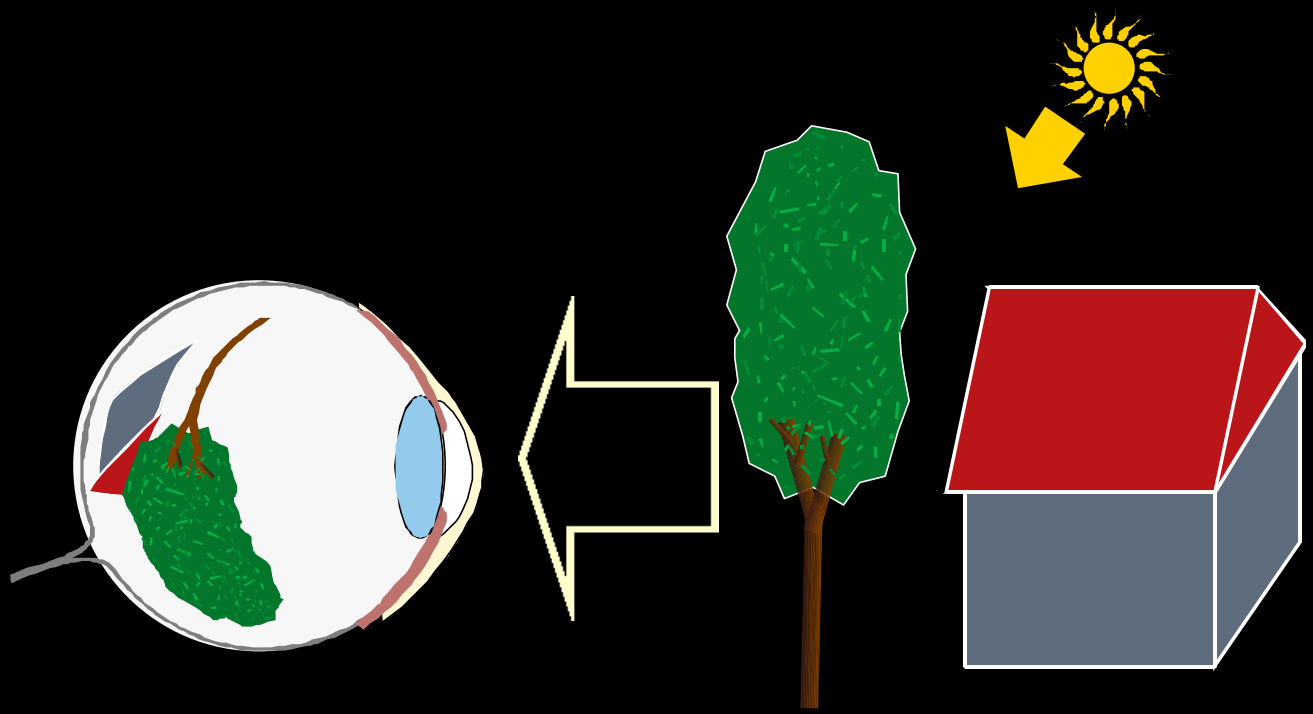
proximal stimulus (2D)



Distal stimulus (3D)

Vision as an inverse problem

- The distal stimulus is projected into a proximal stimulus

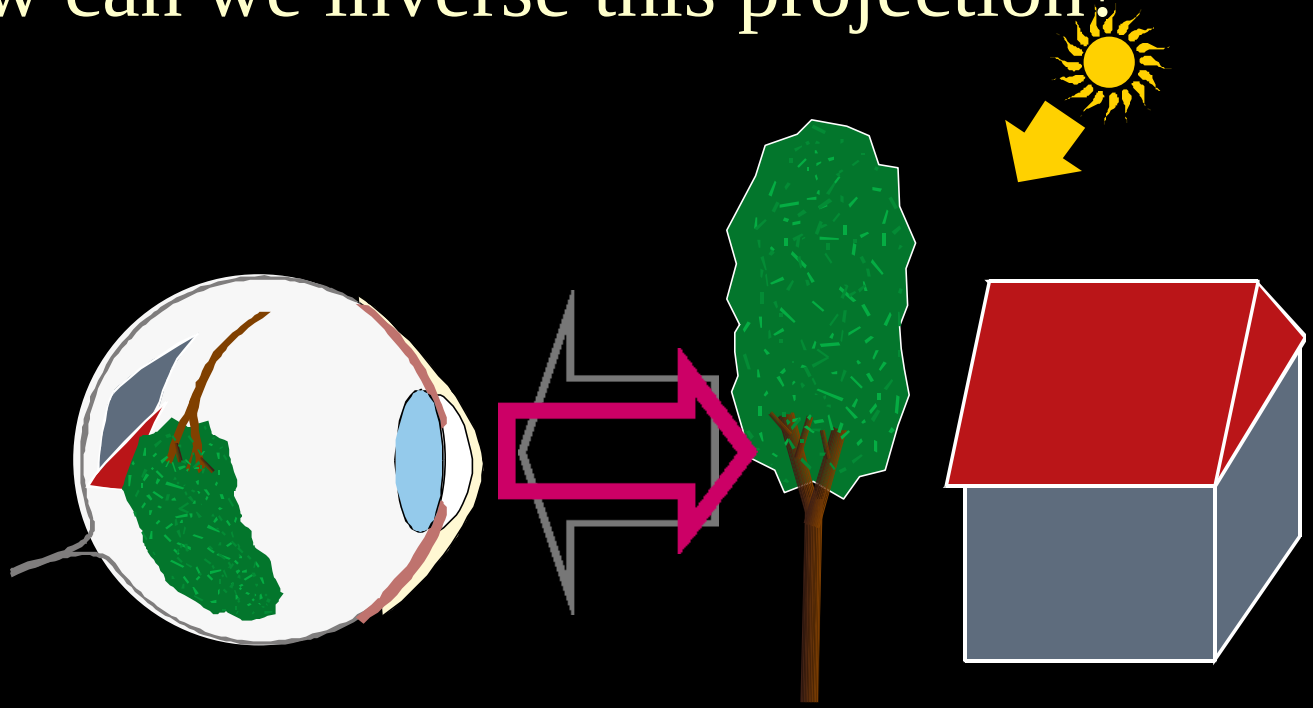


proximal stimulus (2D)

Distal stimulus (3D)

Vision as an inverse problem

- The distal stimulus is projected into a proximal stimulus
- How can we inverse this projection?

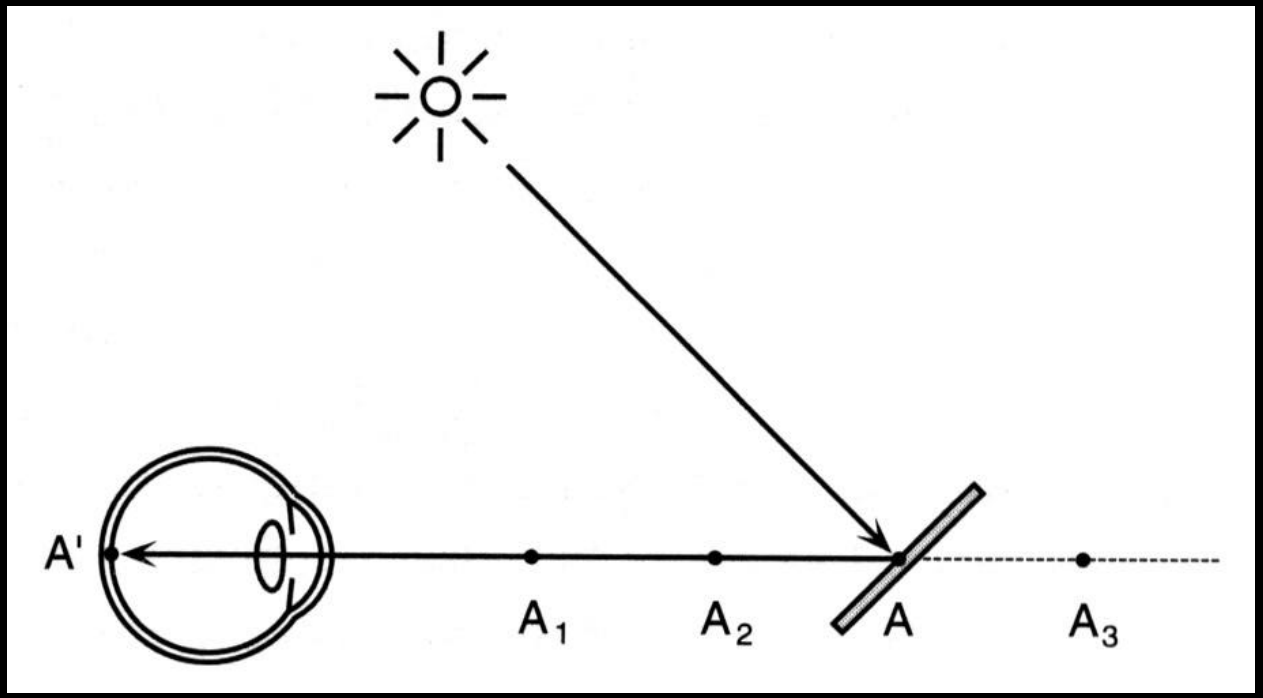


proximal stimulus (2D)

Distal stimulus (3D)

Unconscious inference (Helmholtz)

- Our vision system solves a problem
- Under-constrained problem
  - A visible point A’ can correspond to an infinity of 3D points (A1, A2, A, A3…)

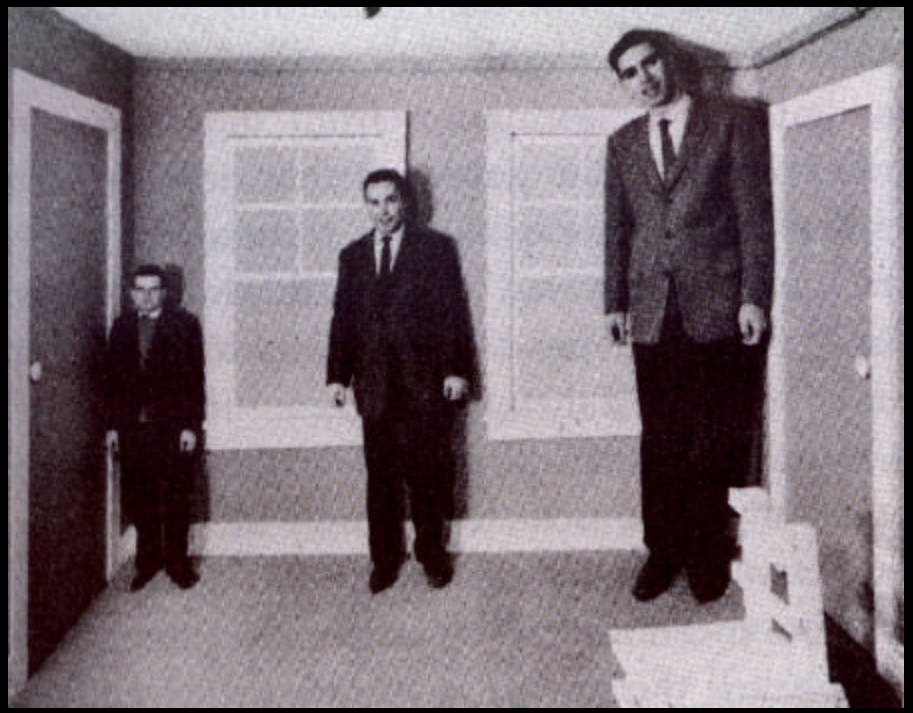


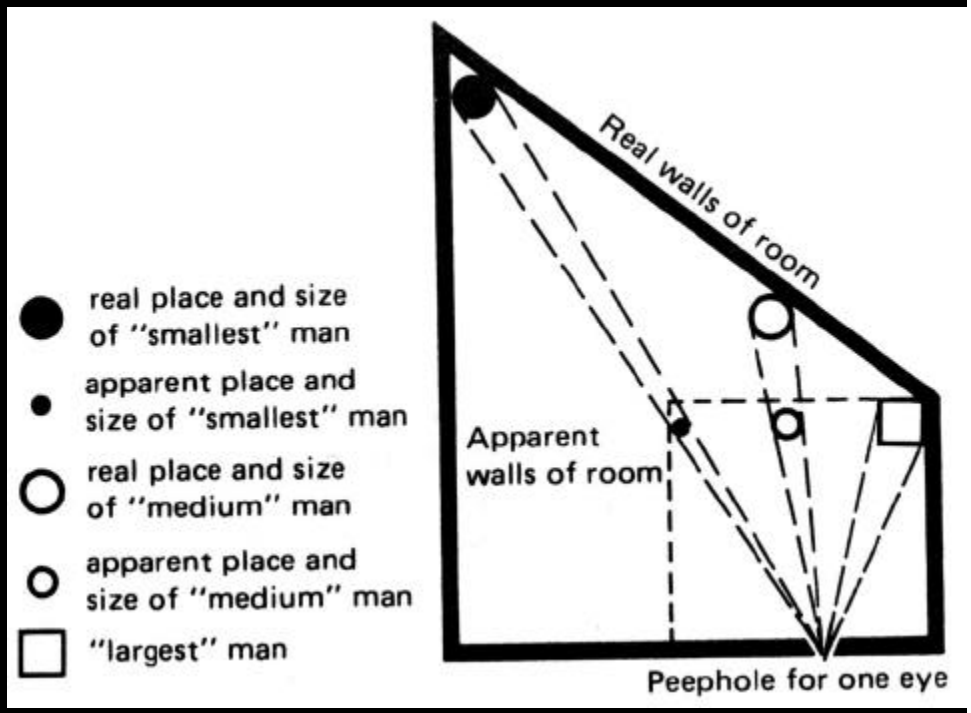
Unconscious inference (Helmholtz)

- Our vision system solves a problem
- Under-constrained problem
- Assumptions on the scene

The Ames room

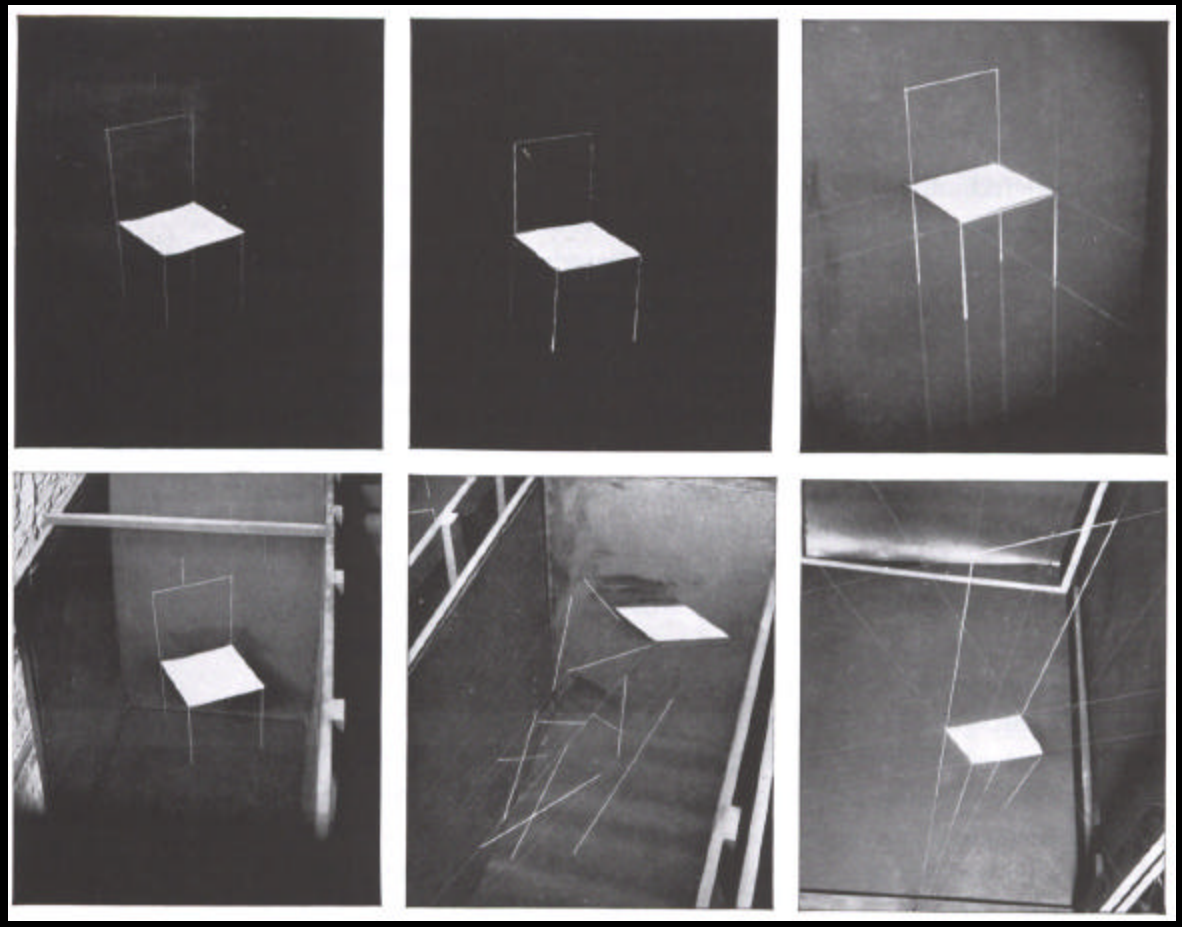
- Invalid assumption
- Wrong conclusions





Ames chair

- Different scenes
- Same projection
- We assume it is a chair

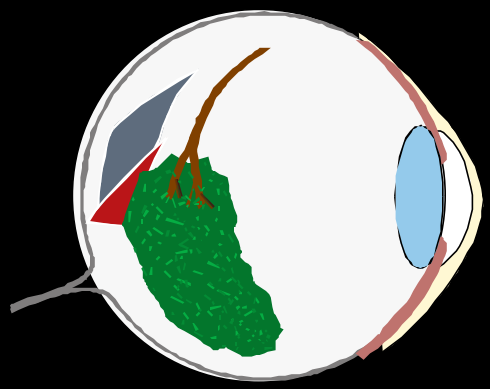


Patrick Hughes

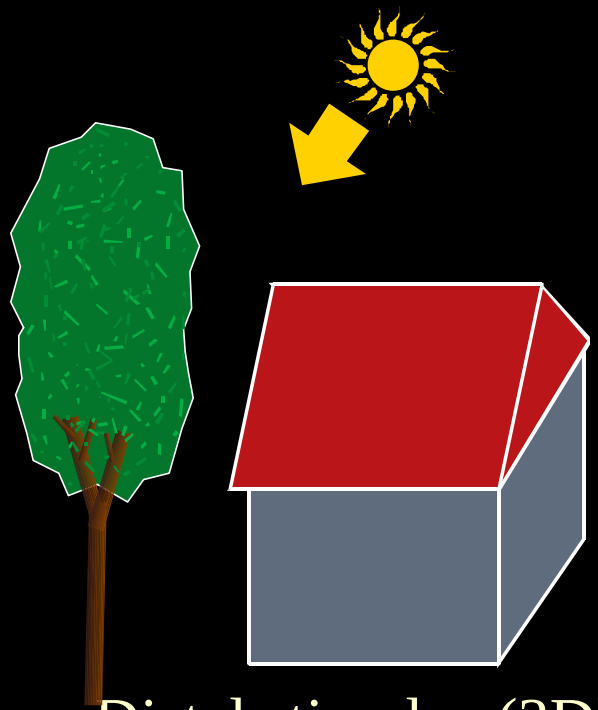
- Perspective painting on the inverse geometry

The paradox of vision

- Available information: proximal stimulus
- Conscious information: distal stimulus



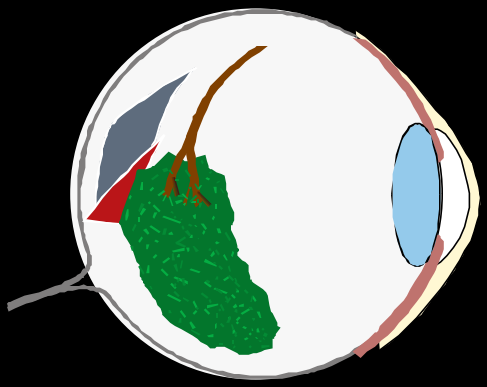
proximal stimulus (2D)



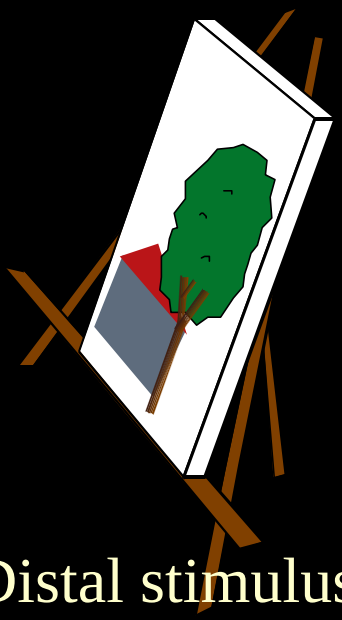
Distal stimulus (3D)

The paradox of Pictures

- Distal vs. proximal
- Available information: proximal stimulus
- Conscious information: distal stimulus



proximal stimulus (2D)



Distal stimulus (2D/3D)

Pictures and inverse problem

- Can
  - Simplify analysis
  - Be a puzzle

Plan

- Vision as an cognitive process
- Computational theory of vision
- Constancy, invariants

Vision as information processing

- Input: retinal image
- Output: 3D layout, object recognition, etc.

Computational theory of vision

- Marr's stages (extended by Palmer et al.)
- Human and Computer Vision
- Classification of different kinds of processes
- Has proved fruitful in art studies

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View-centered → Object-centered

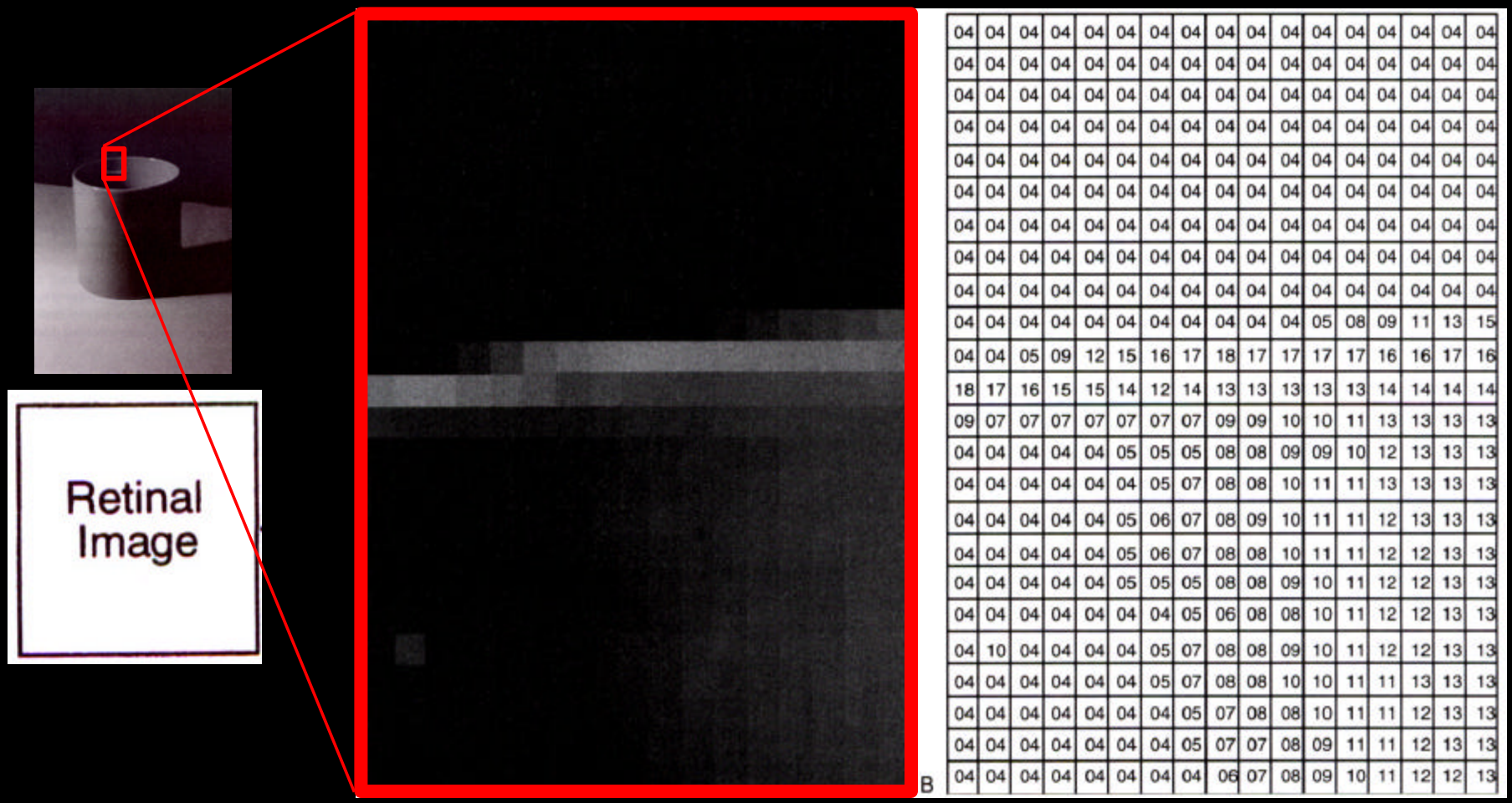
Extrinsic → Intrinsic

Retinal image

- Intensity

Retinal image

- Intensity: hard to comprehend

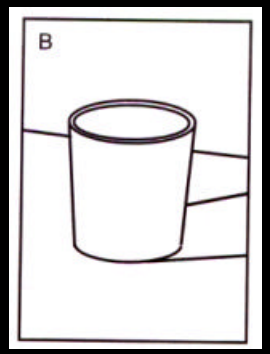


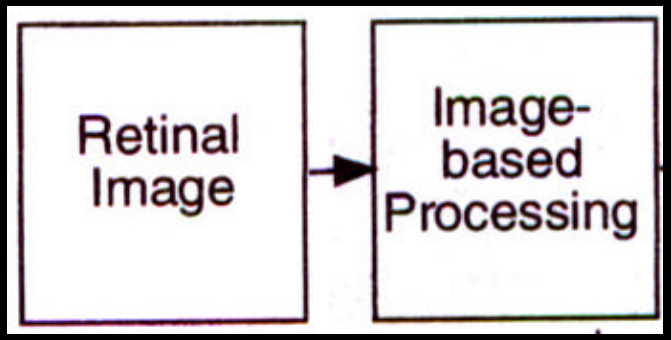
Retinal image

- Intensity

Image-based (primary sketch)

- Contrast, edge detection





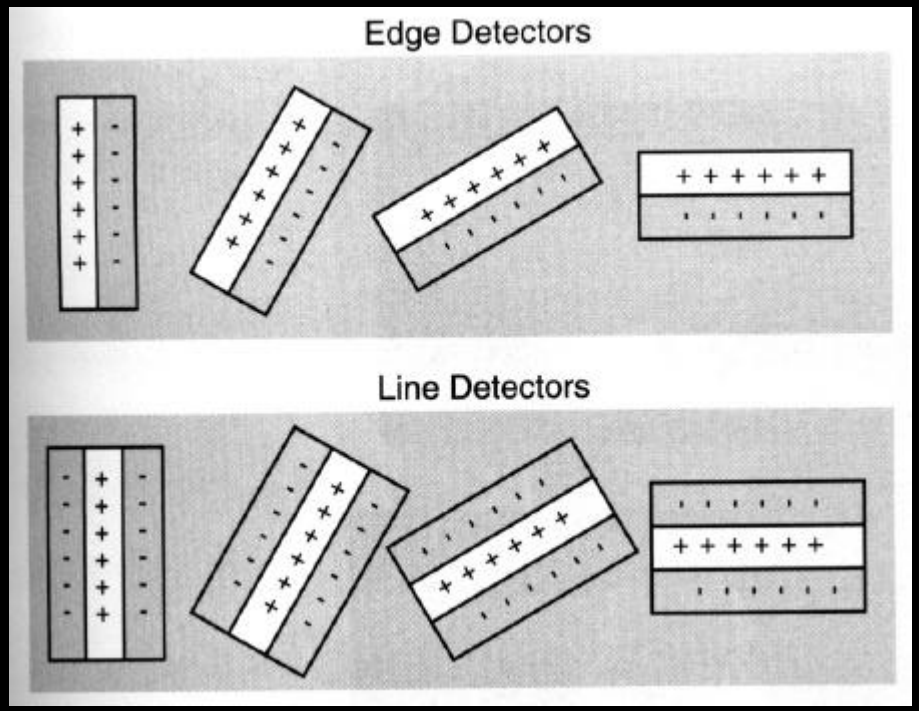
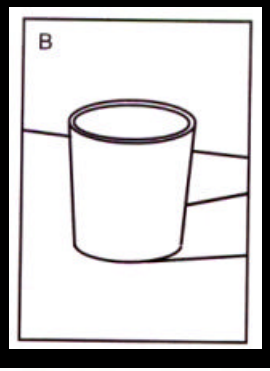
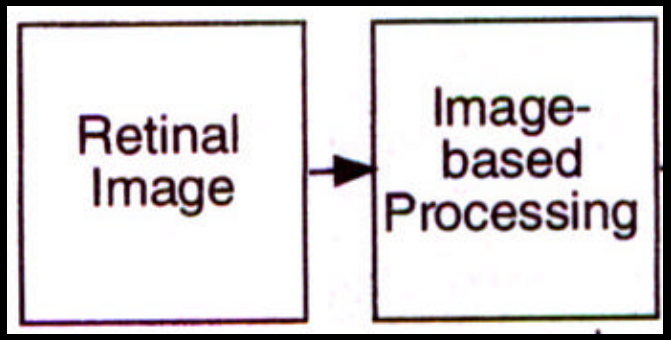
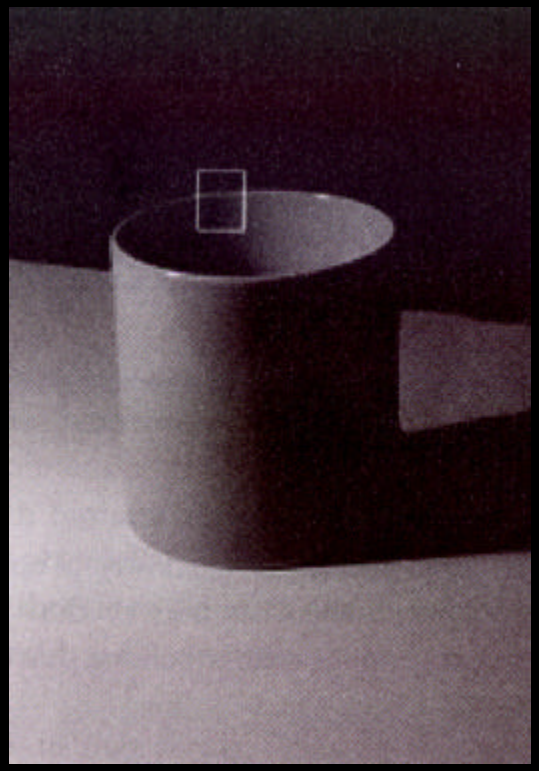


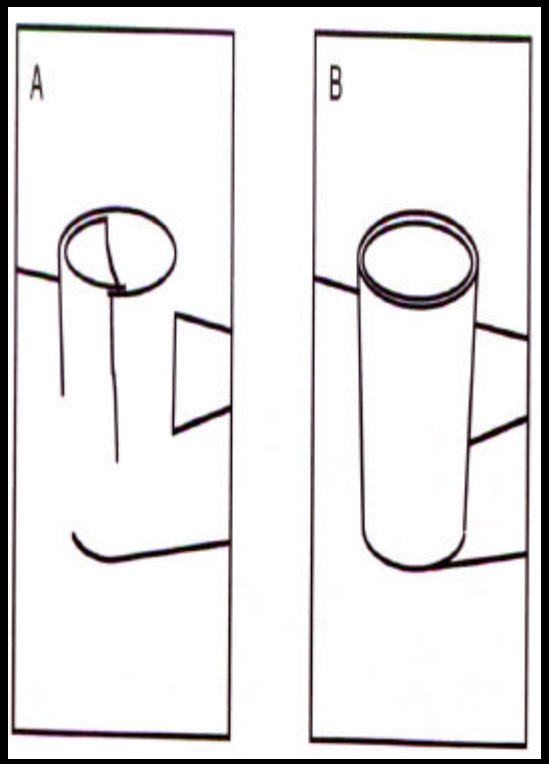
Image-based (primary sketch)

- Contrast, edge detection
- Not so easy





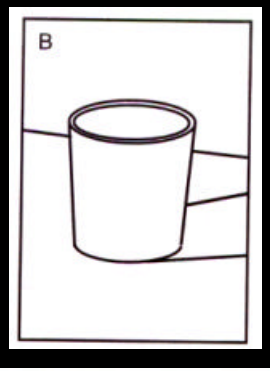


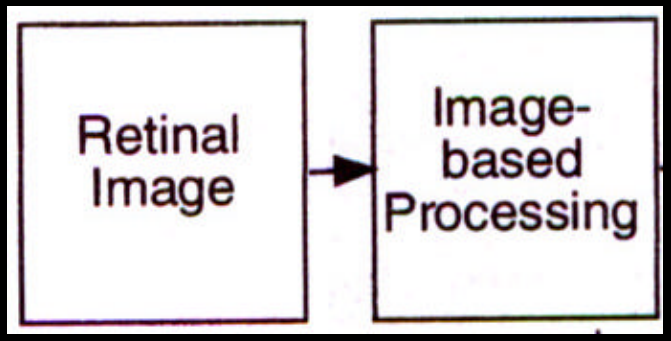


Raw edge detection

Image-based (primary sketch)

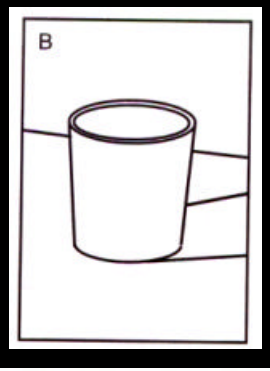
- Contrast, edge detection

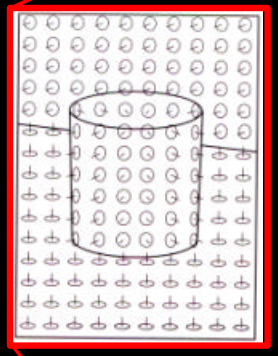


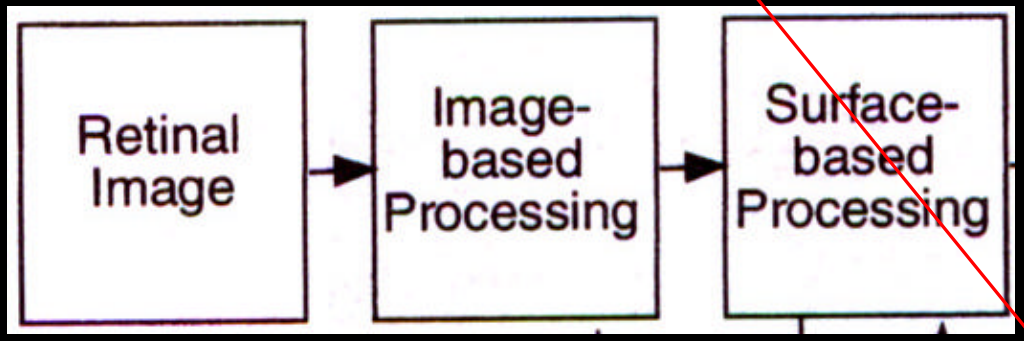


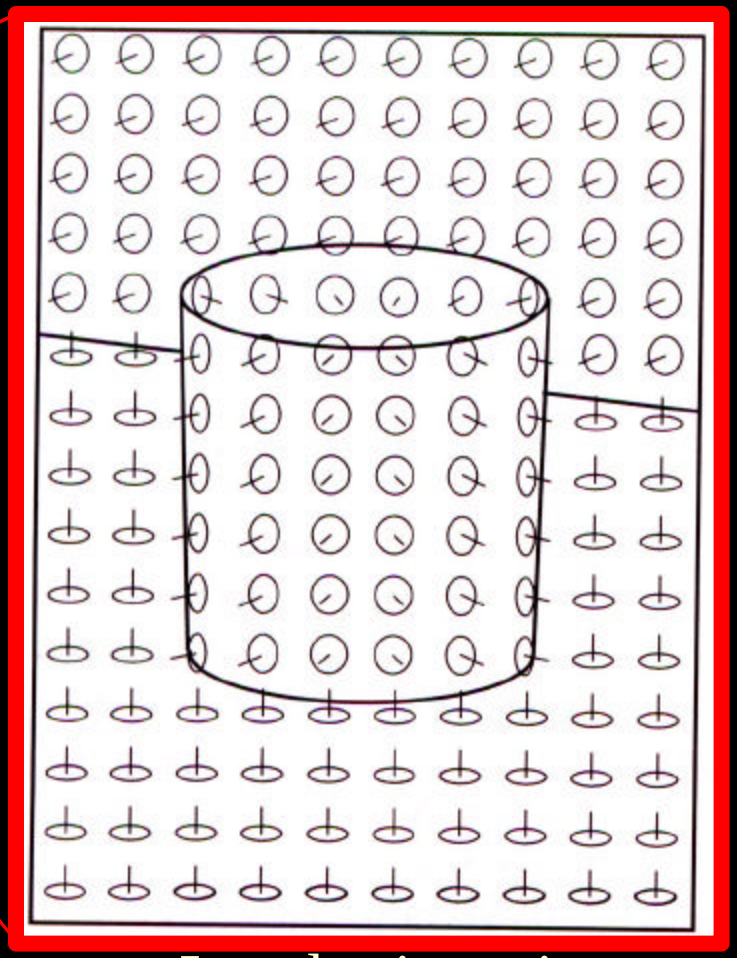
Surface-based

- Visible surfaces, organization
- Distance, orientation





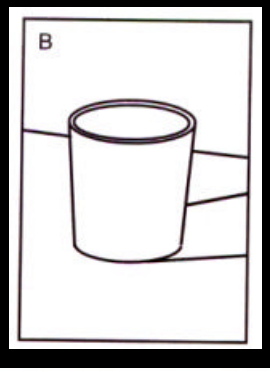


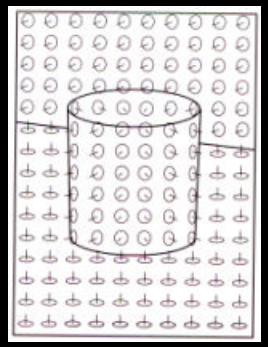


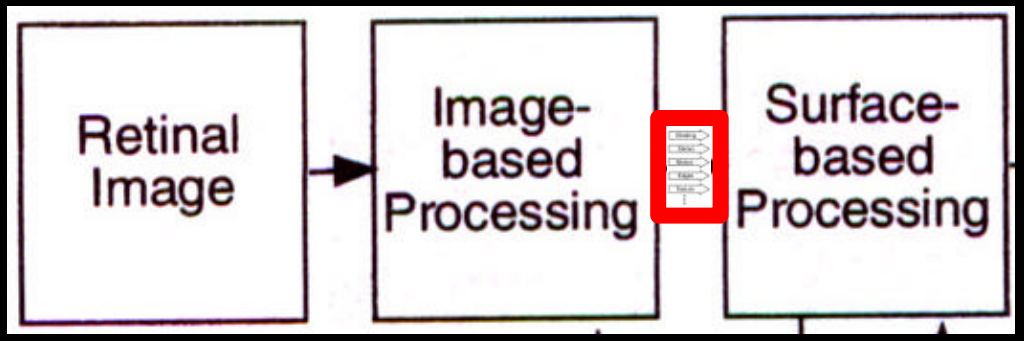
Local orientation

Surface-based

- Visible surfaces, organization
- Distance, orientation







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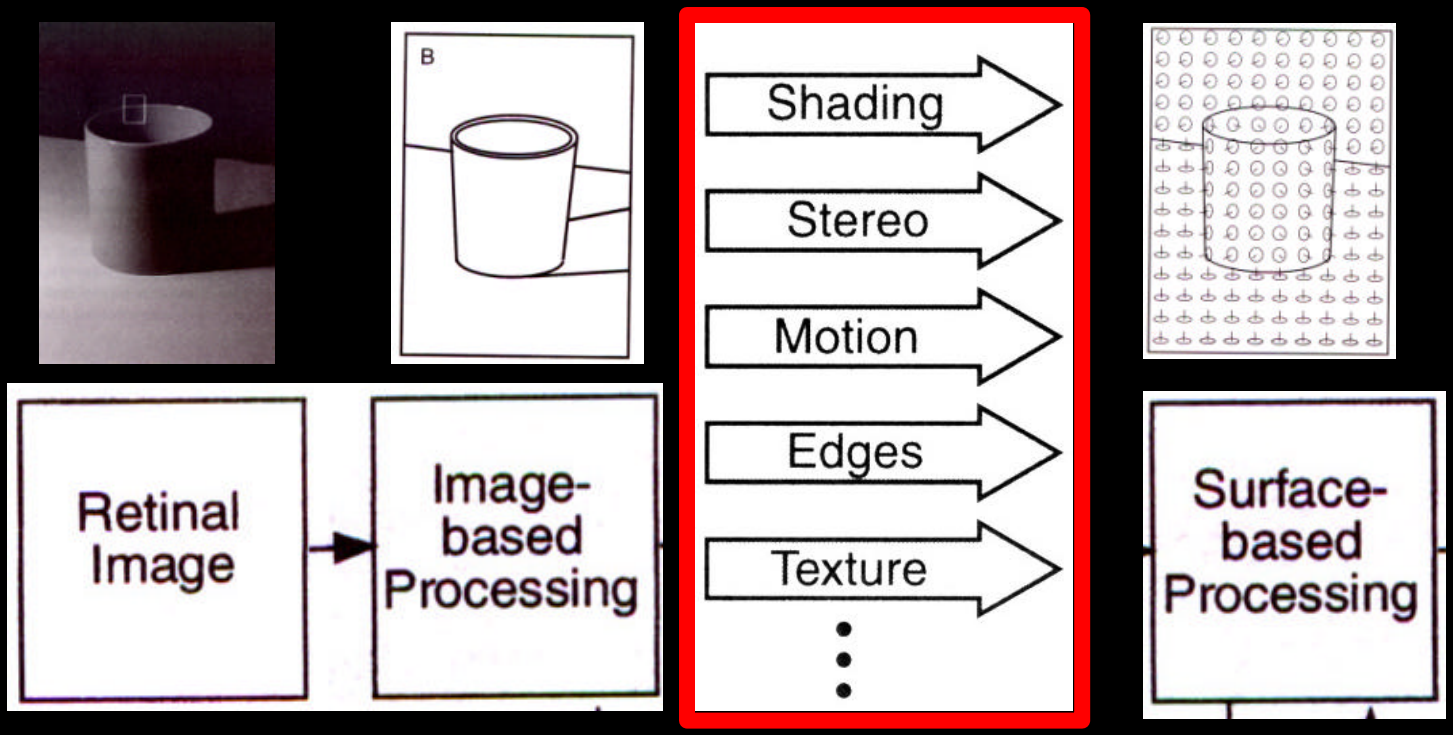

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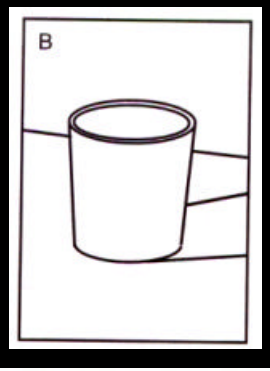
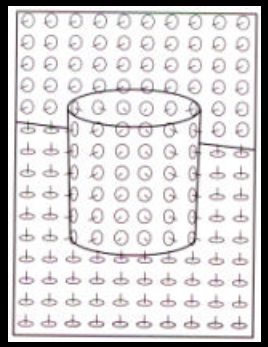
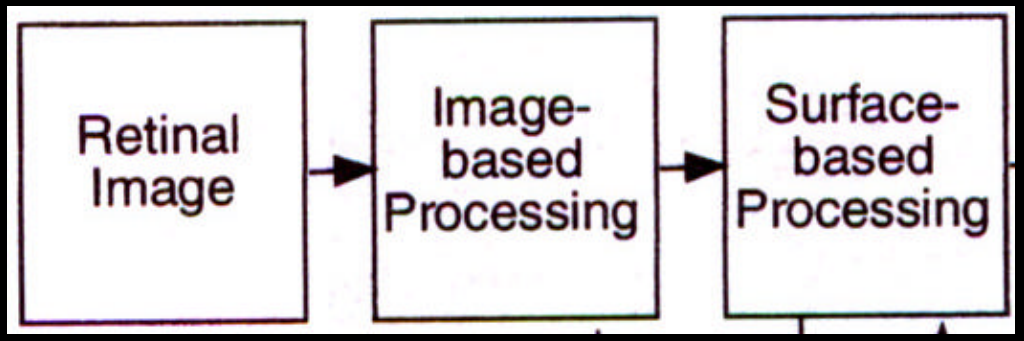


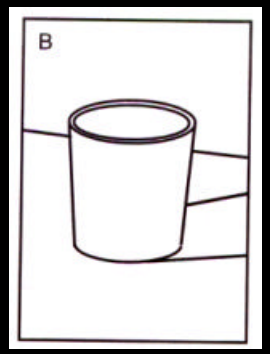


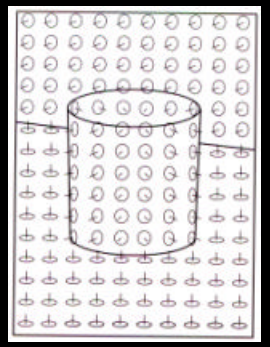


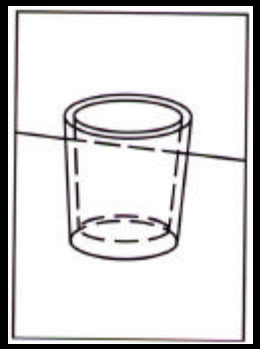
Local orientation

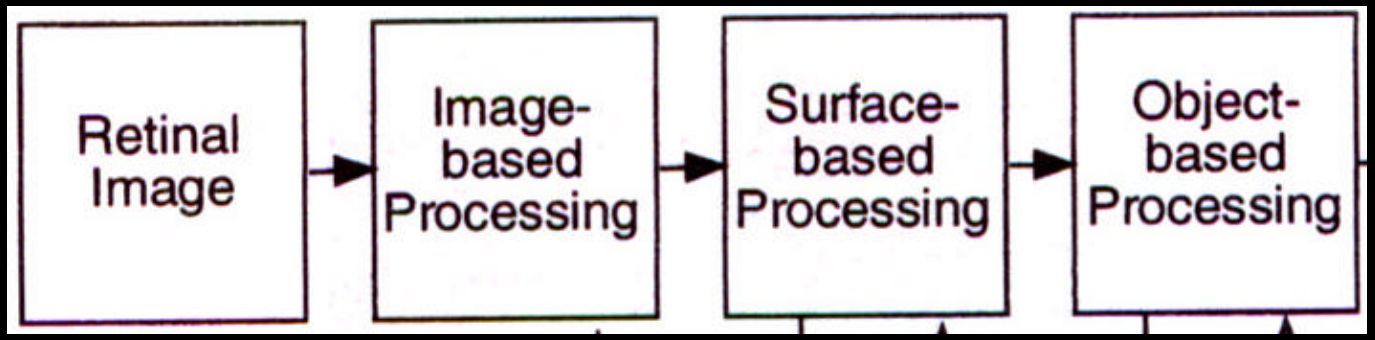
Object-based

- 3D properties, structure
- Nature of the description highly discussed



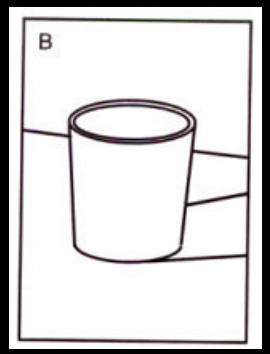


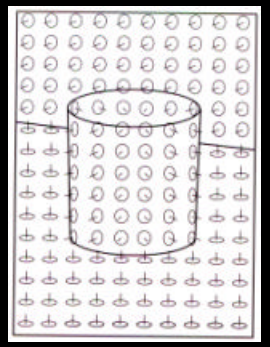


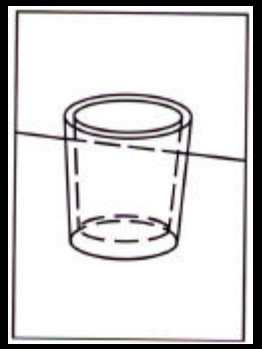


Category-based

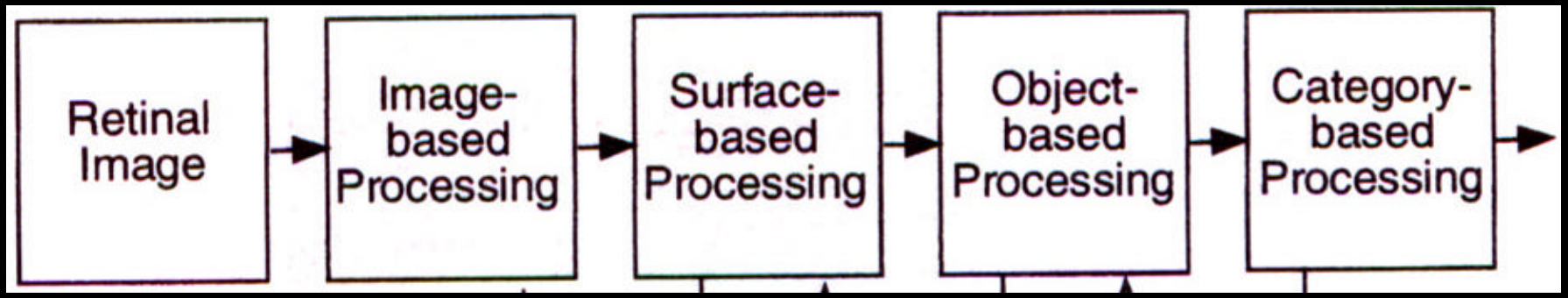
- Recognition, category, function





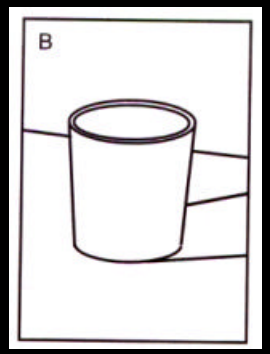


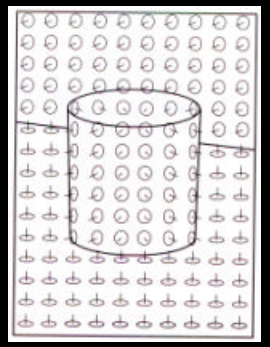
Cup

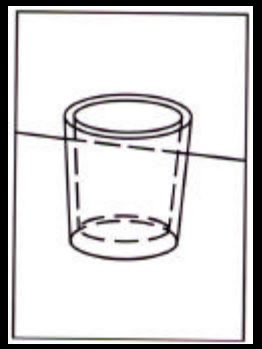


Feedback

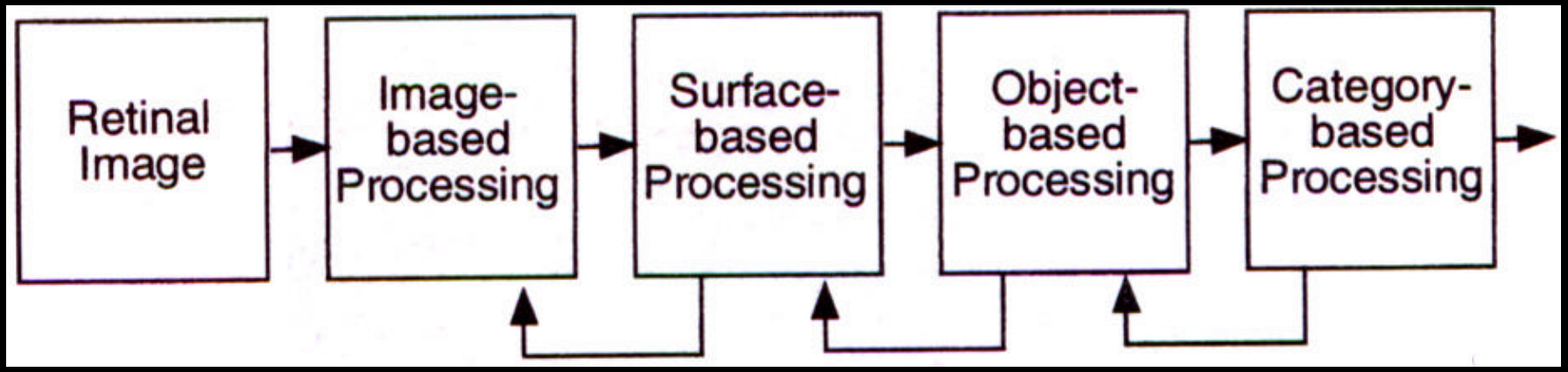
- Bottom-up and top-bottom





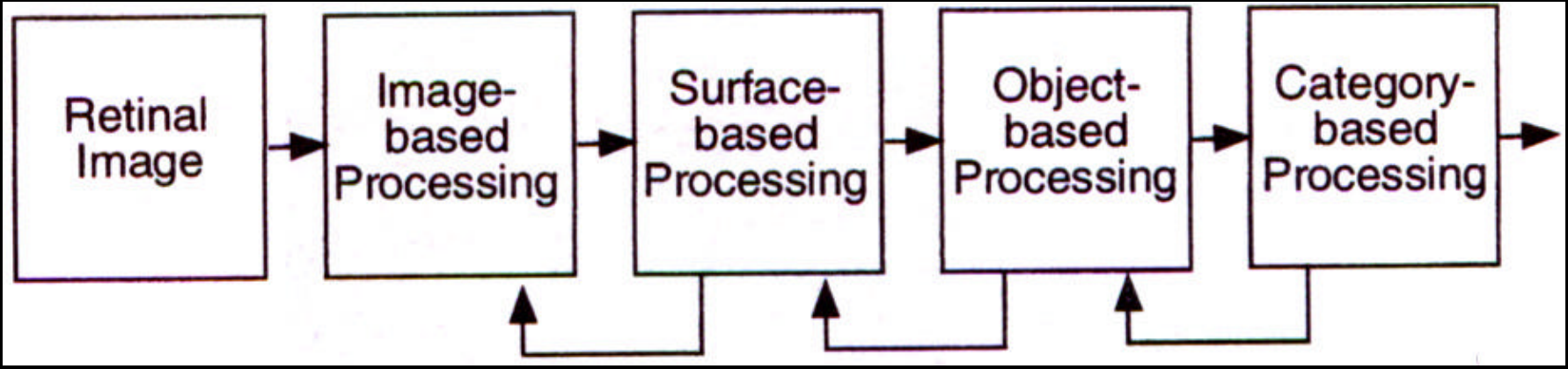


Cup



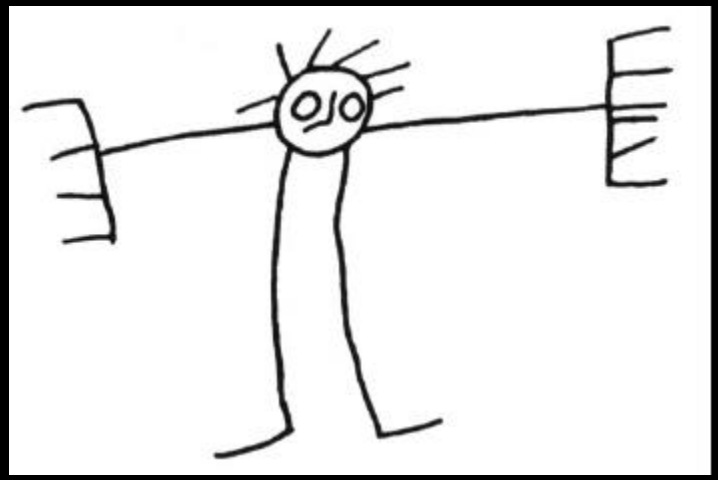
Scope of the theory

- Computer Vision
- Human Vision
- No direct correspondence in the brain
- Has proved fruitful conceptual tool



Relation to children drawing

- First children draw what they know
  - Object-centered
- Then, what they see
  - View-centered



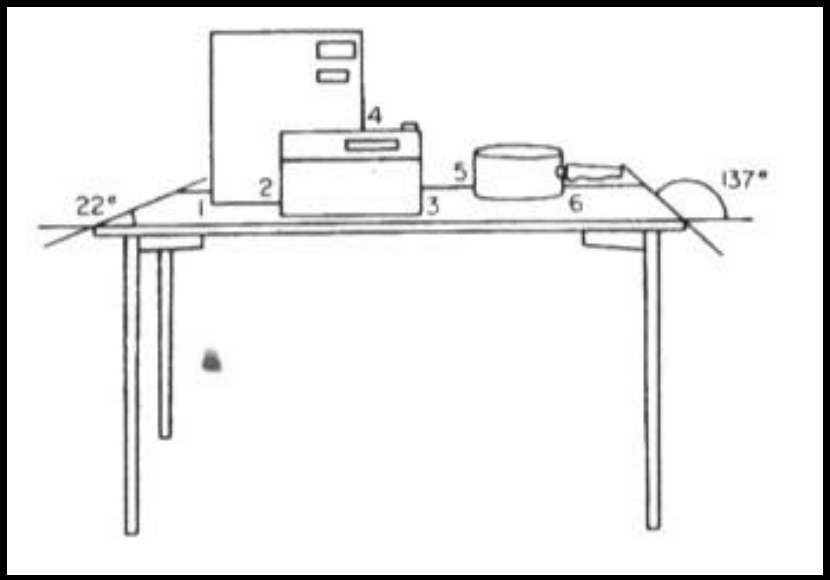
Age 5

Age 9 (gifted!)

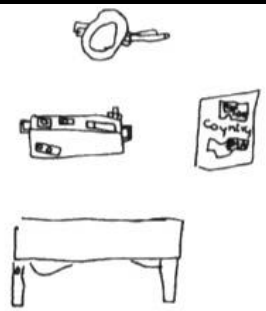
Evolution of children's drawings

- Asked to draw a table

Child's view



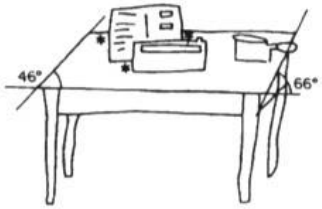
Class of drawing
& average age



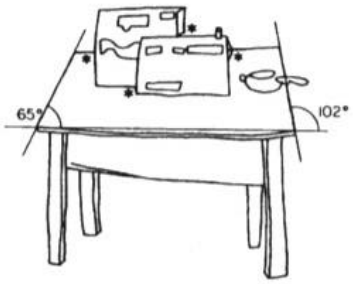
7.4

9.7

11.9



13.6

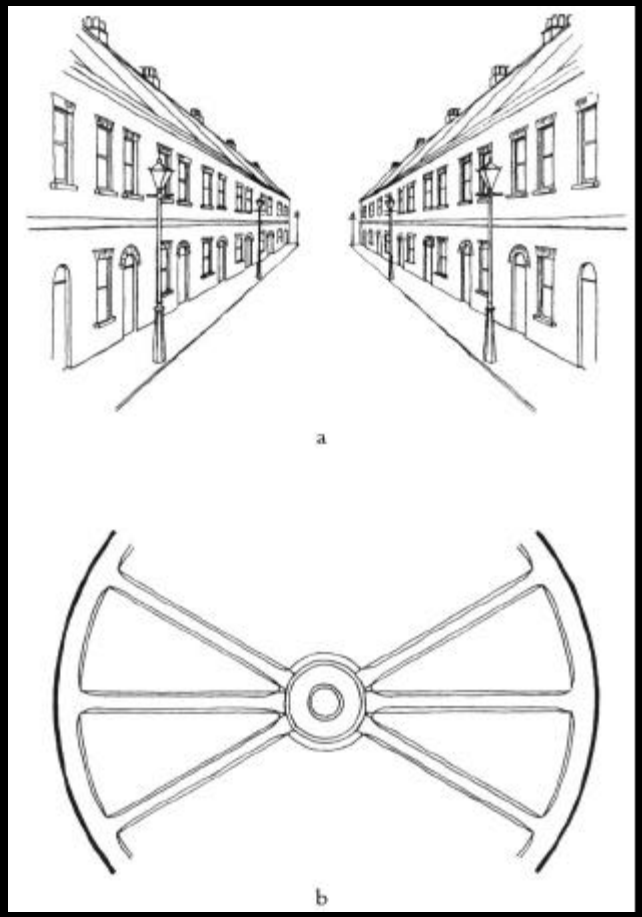


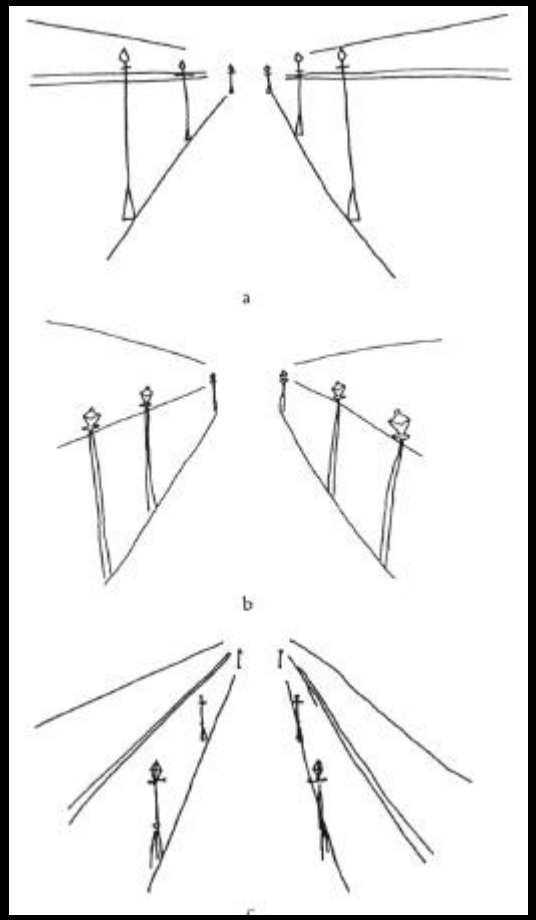
14.3

13.7

What about adults?

- Reproduce two drawing with similar angles
- Wheel:
  - Accuracy ~5°
- Street:
  - Error: 32 °

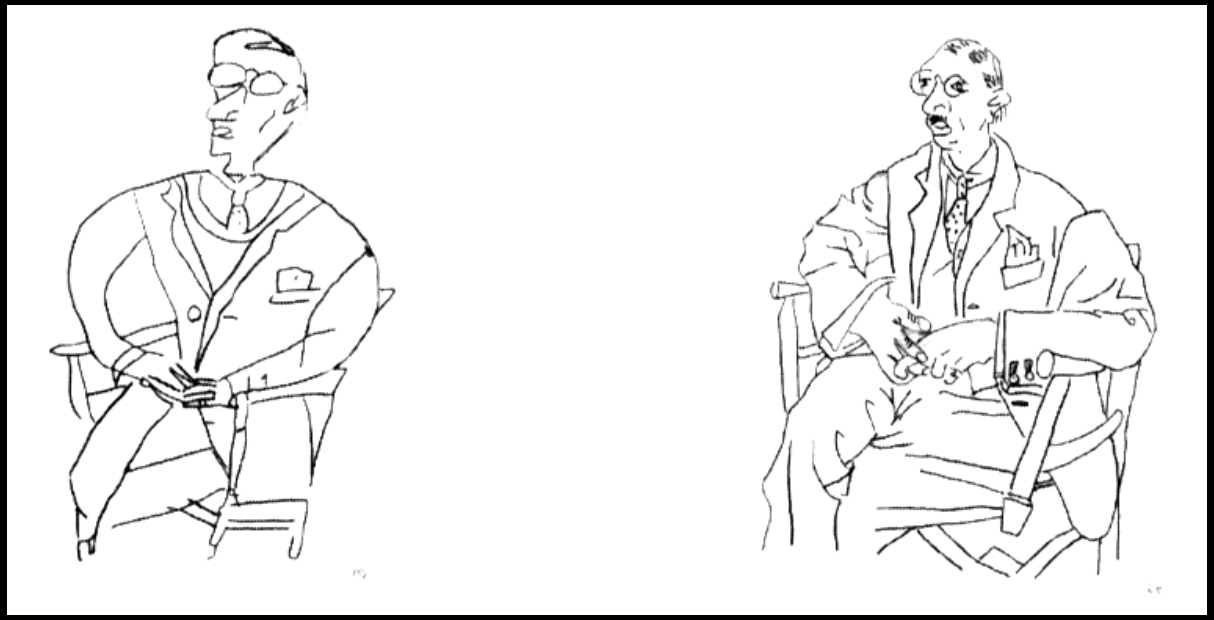




Drawing reproduction

- From *Drawing on the right side of the brain*
- Reproduction of Picasso's *portrait of Stravinsky*

Original



Regular reproduction

Performed upside-down

Relation to pictures

- How we see pictures
- Different classes of pictures for different stages

View-centered → Object-centered

Extrinsic → Intrinsic

Relation to pictures

- Different classes of pictures for different stages
- Not a strict classification

View-centered

Extrinsic

Object-centered

Intrinsic

Relation to pictures

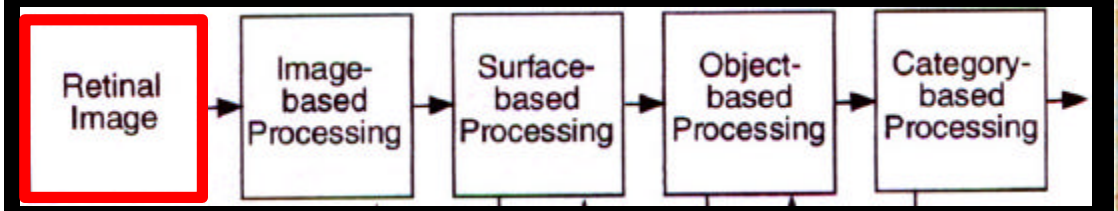
- Chinese painting refuse extrinsic, only essential
- No shadow

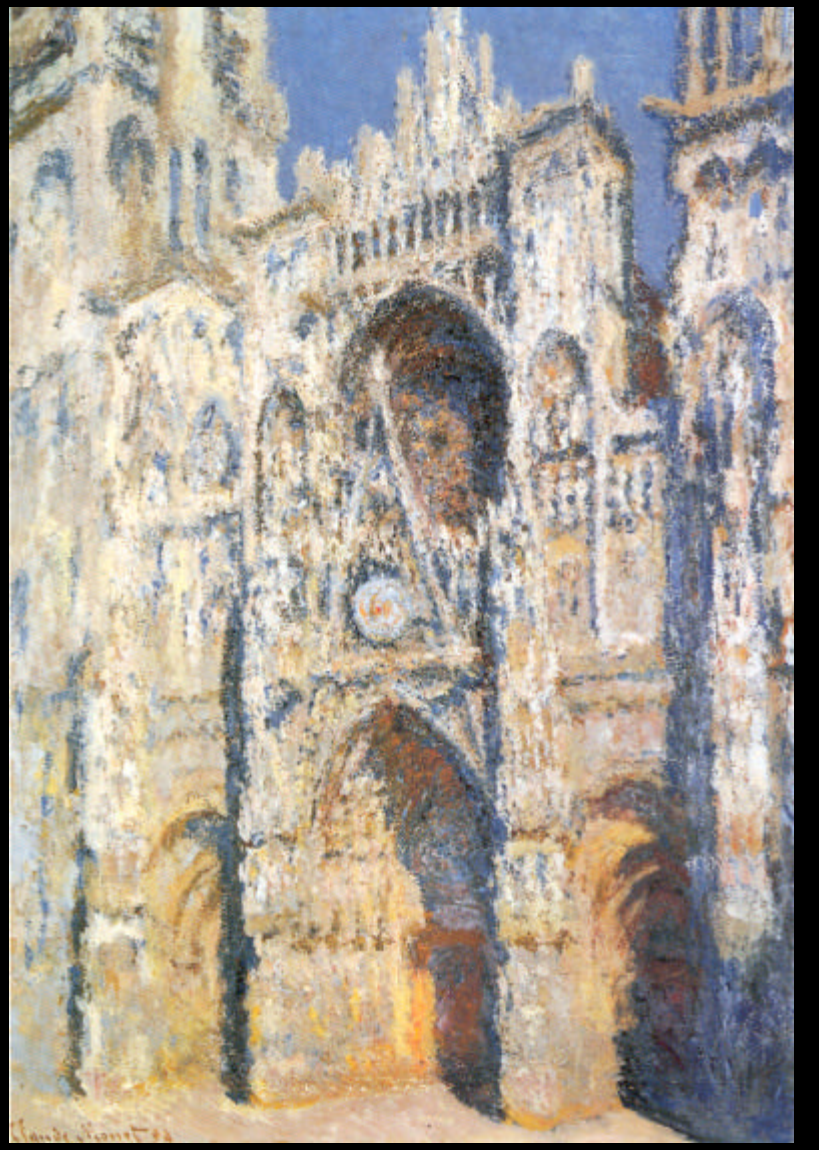
View-centered
Extrinsic

Object-centered
Intrinsic

Retinal image

- Impressionism





Retinal image

- Impressionism
- Photography

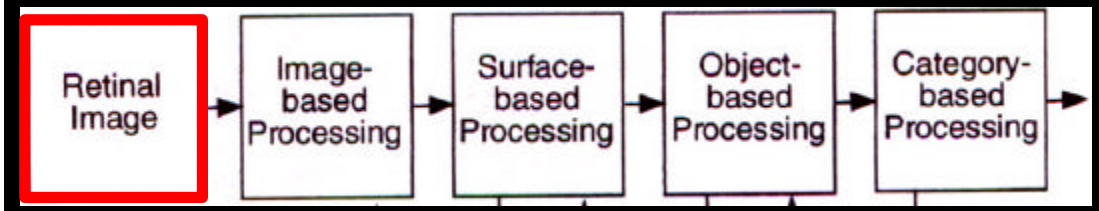
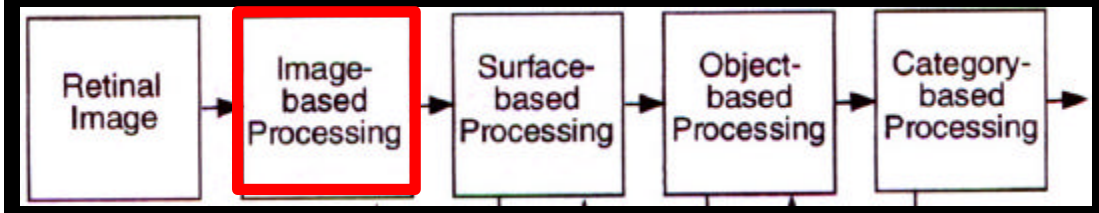


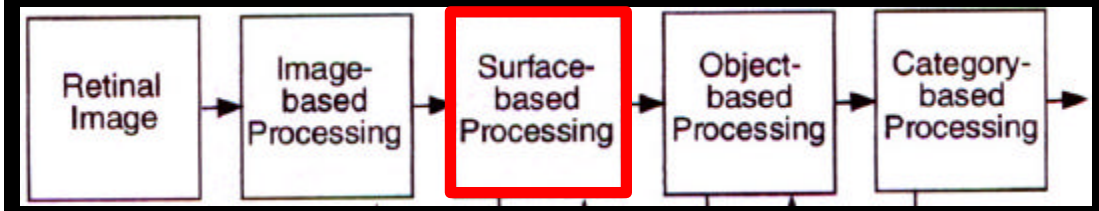
Image-based

- Line Drawing



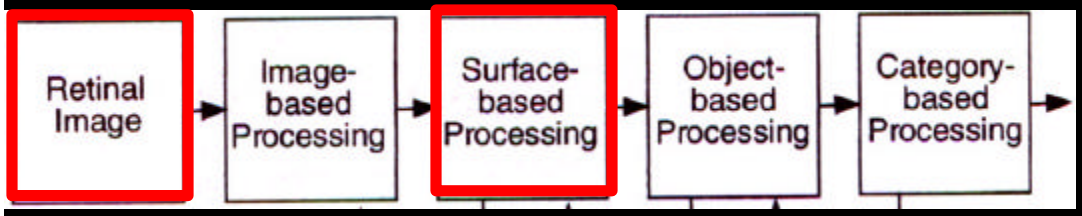
Intermediate

- View-based
- Cues for surface-based feature extraction are enhanced
  - Depth cues
  - Orientation cues
- No subjective feature (e.g. lighting)



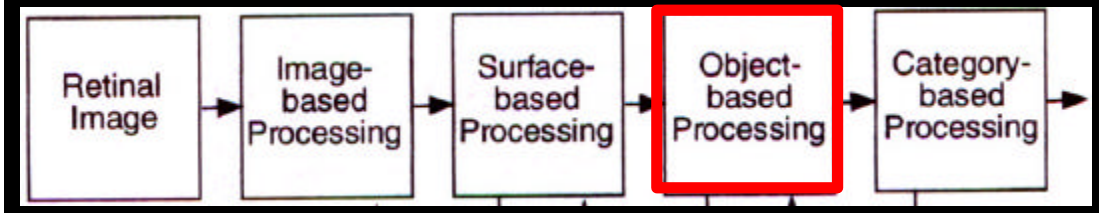
Intermediate

- View-based
- Cues for surface-based feature extraction are enhanced
  - Depth cues
  - Orientation cues
- More subjective feature (lighting)



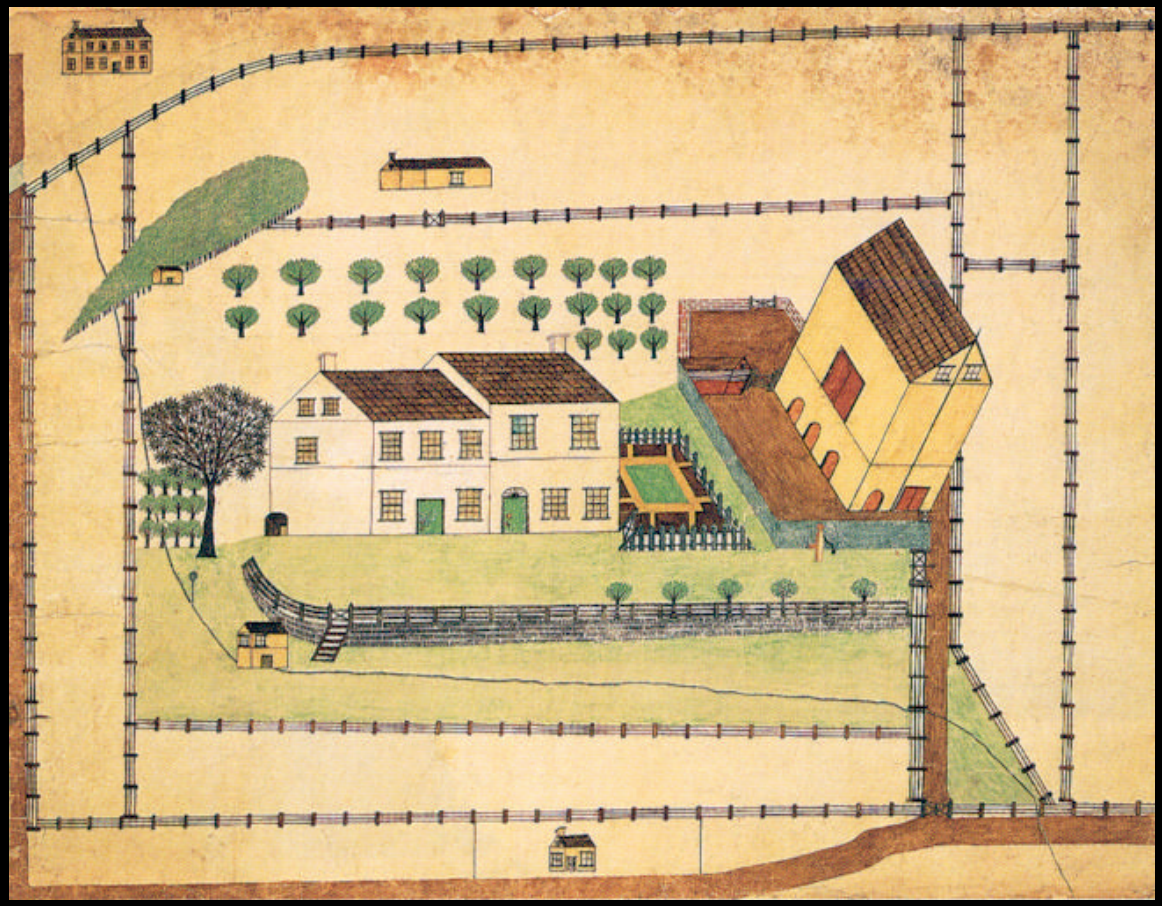
Higher level

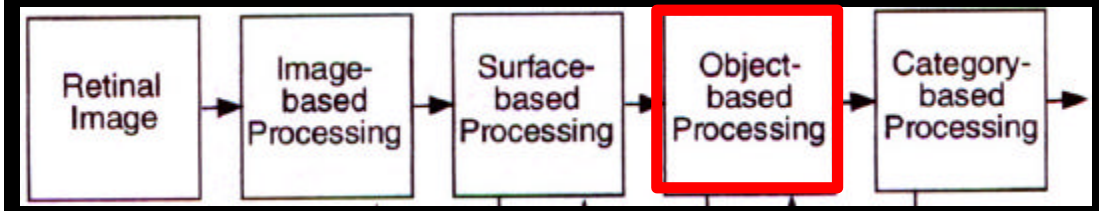
- Primitive art
- Cubism
- Schema
- “What I know”



Higher level

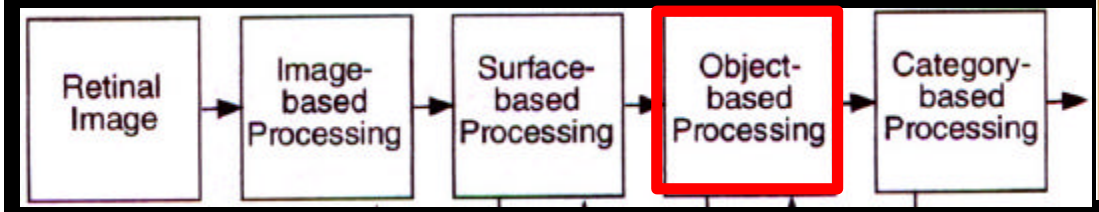
- Primitive art
- Cubism
- Schema
- “What I know”





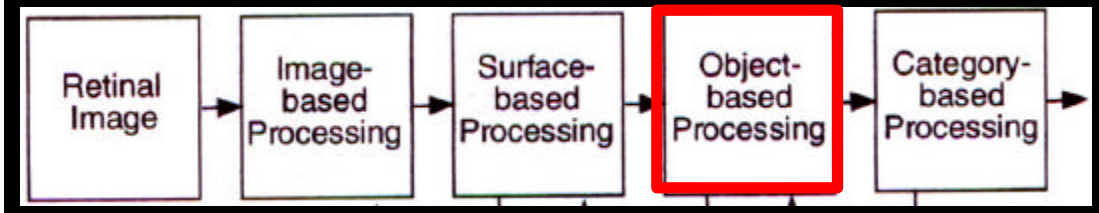
Higher level

- Primitive art
- Cubism
- Schema
- “What I know”



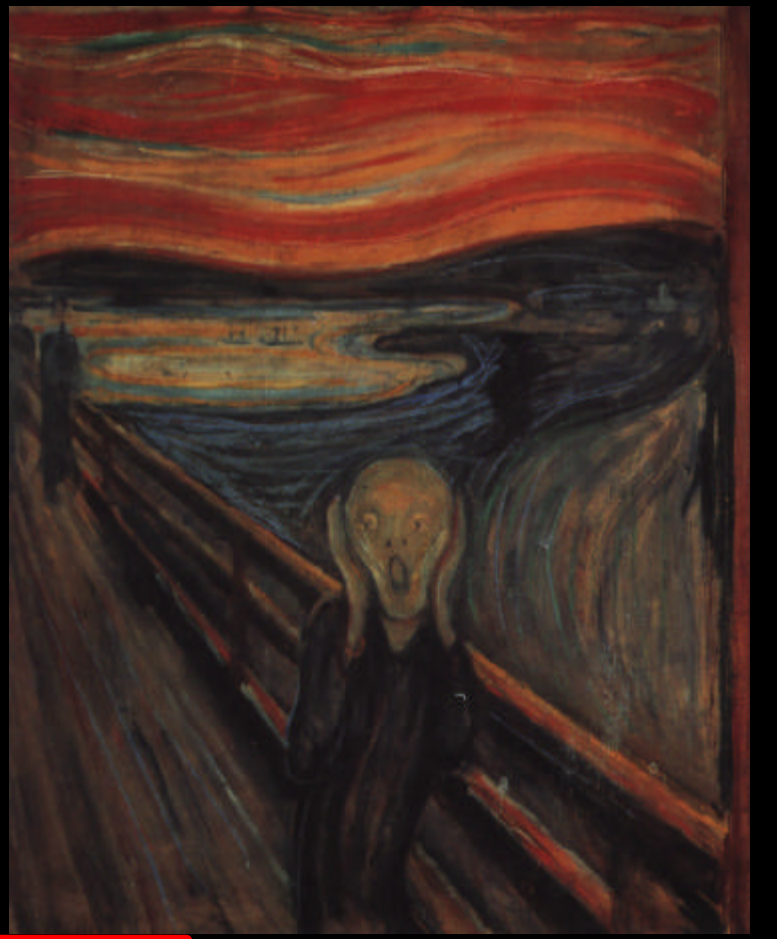
Higher level

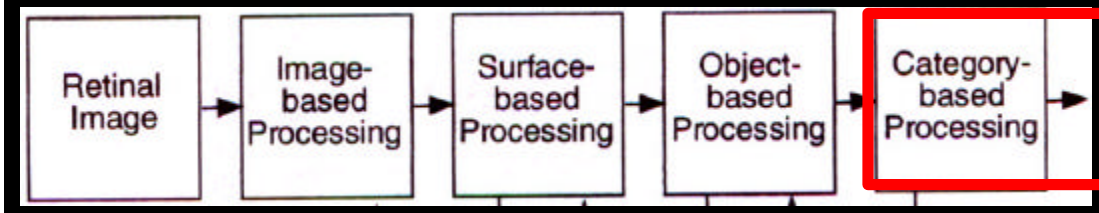
- Primitive art
- Cubism
- Schema
- “What I know”
- Not limited to picture



Expressionism

- "What I feel"





Relation with 2D/3D qualities

- Almost the opposite!
- 3D quality correspond to retinal image
- 2D quality arises from higher-level pictures
- Because of vision paradox
  - Distal is seen when proximal is shown

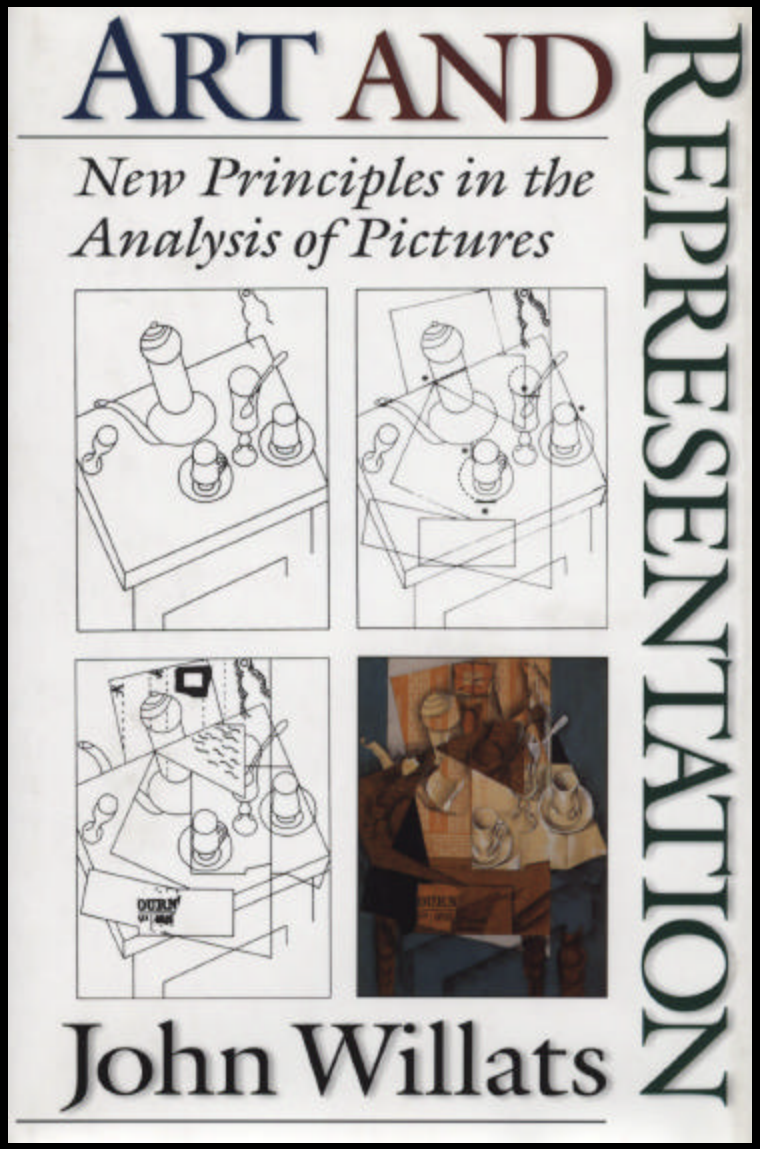
Relation with 2D/3D qualities

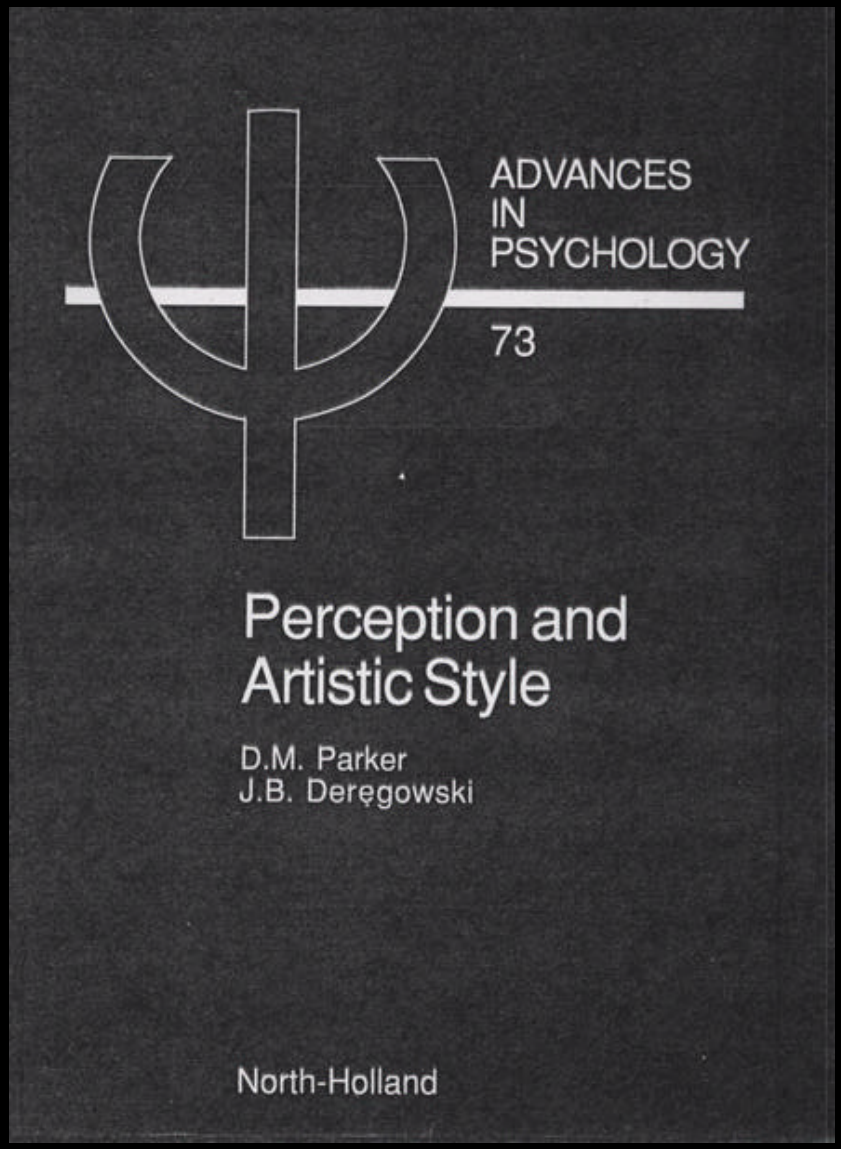
- 3D quality but Retinal image

Relation with 2D/3D qualities

- 2D quality but Higher level

Further reading





Plan

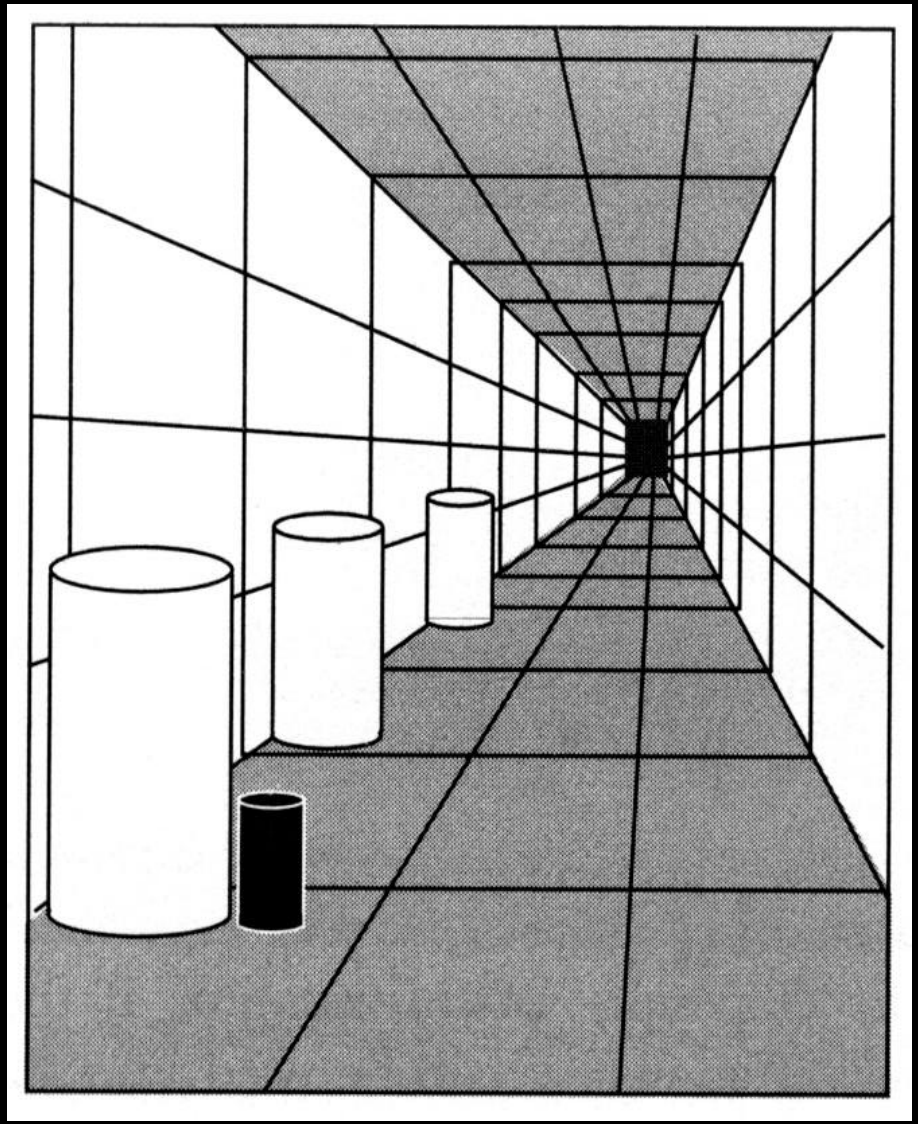
- Vision as an cognitive process
- Computational theory of vision
- Constancy, invariants

Constancy & Invariants

- We see intrinsic properties of objects
- They are “invariant” or “constant”
- Ecological advantage

Visual angle vs. size

- We see cylinders with same size
- Valid most of the time

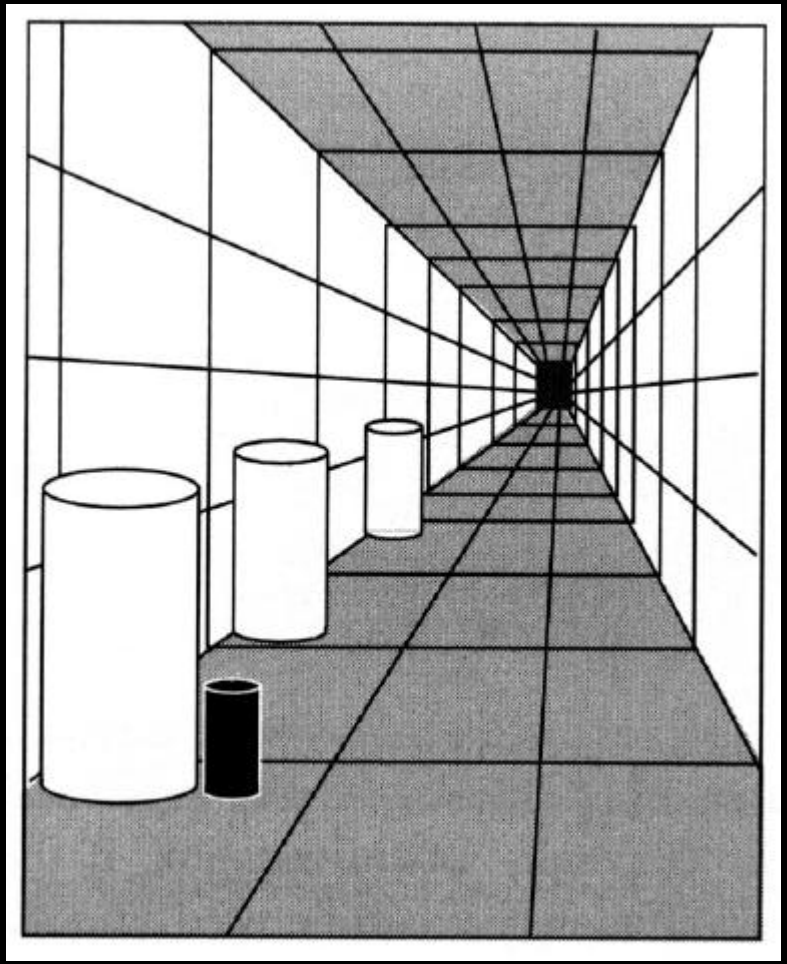


Visual angle vs. size

- Mirror experiment:
  - Draw your face on a mirror
  - Measure: the drawing is ½ your face
  - However, you see “full size”

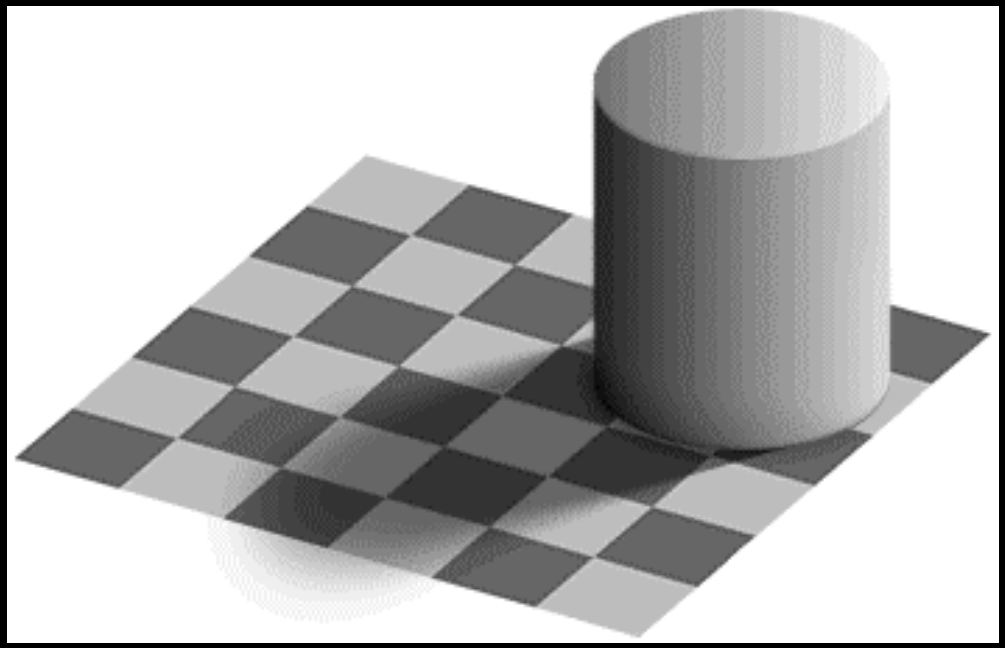
Visual angle vs. size

- How do we do that?
  - Distance
  - Familiarity
  - Assumptions
- Here
  - Perspective
  - Position on ground plane
  - Similarity



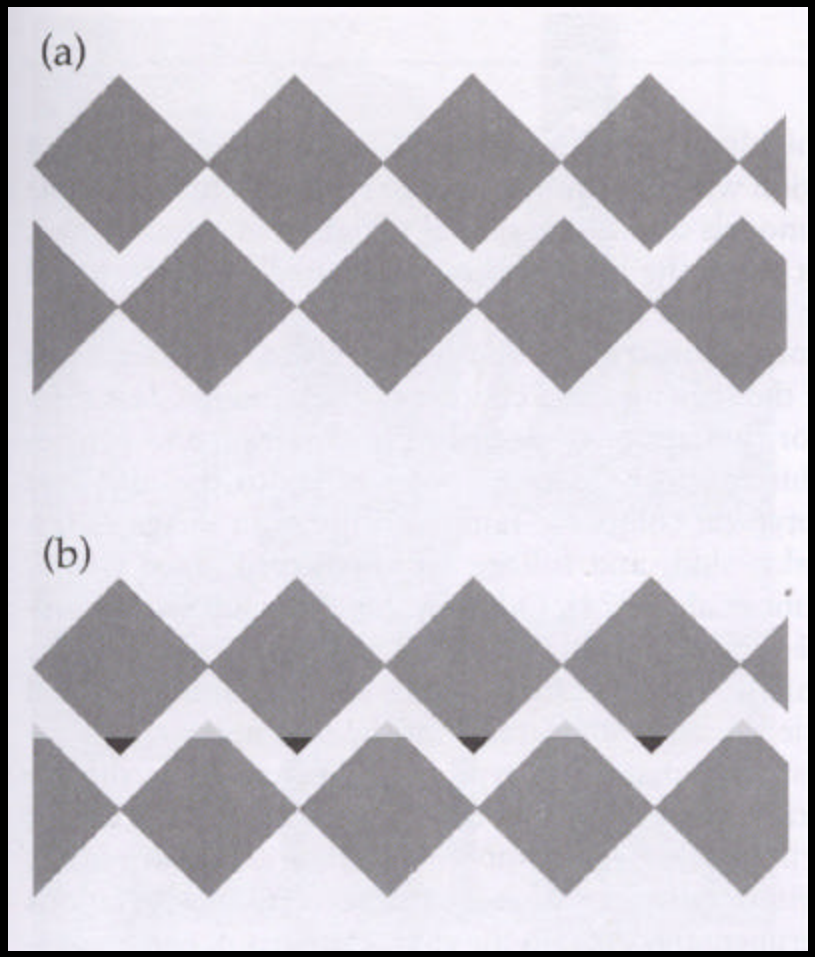
Brightness vs. lightness

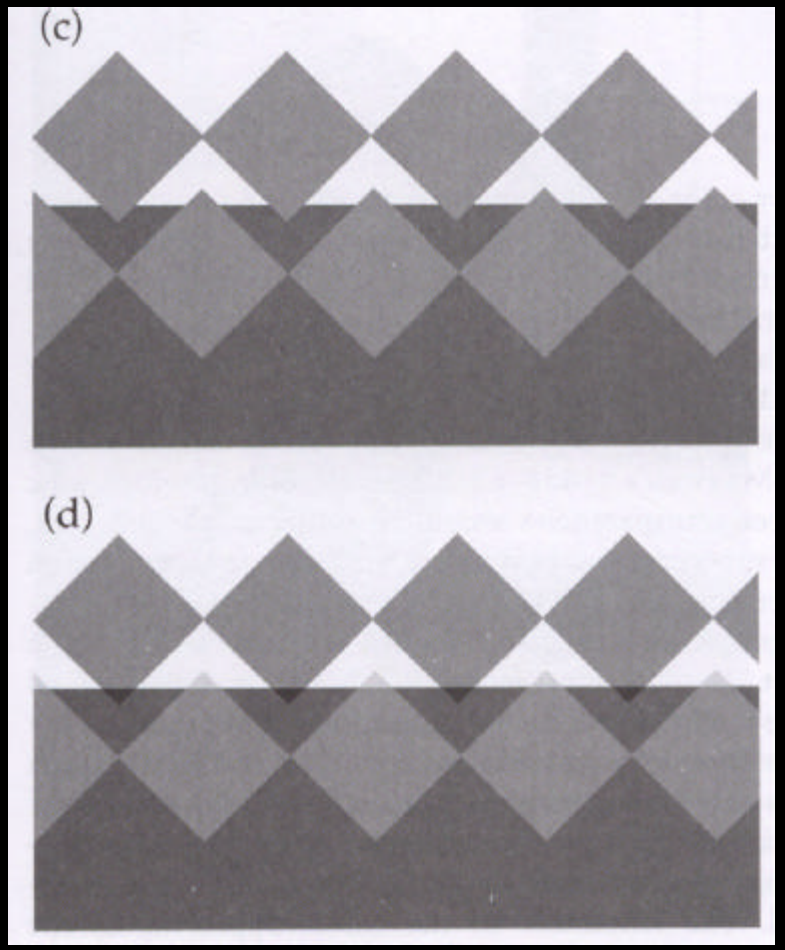
- Brightness: subjective amount of light
- Lightness: how “white”



The white cells in shadow are as dark as the black illuminated cells

Lightness constancy





Lightness constancy

- Sargent
- White in light and in shadow

Color constancy

- Chromaticity of light sources vary
- Chromatic adaptation
  - Similar to white balance on camcoder
  - Different films, filters

Objective colors under neon lighting

With chromatic adaptation

Constancy

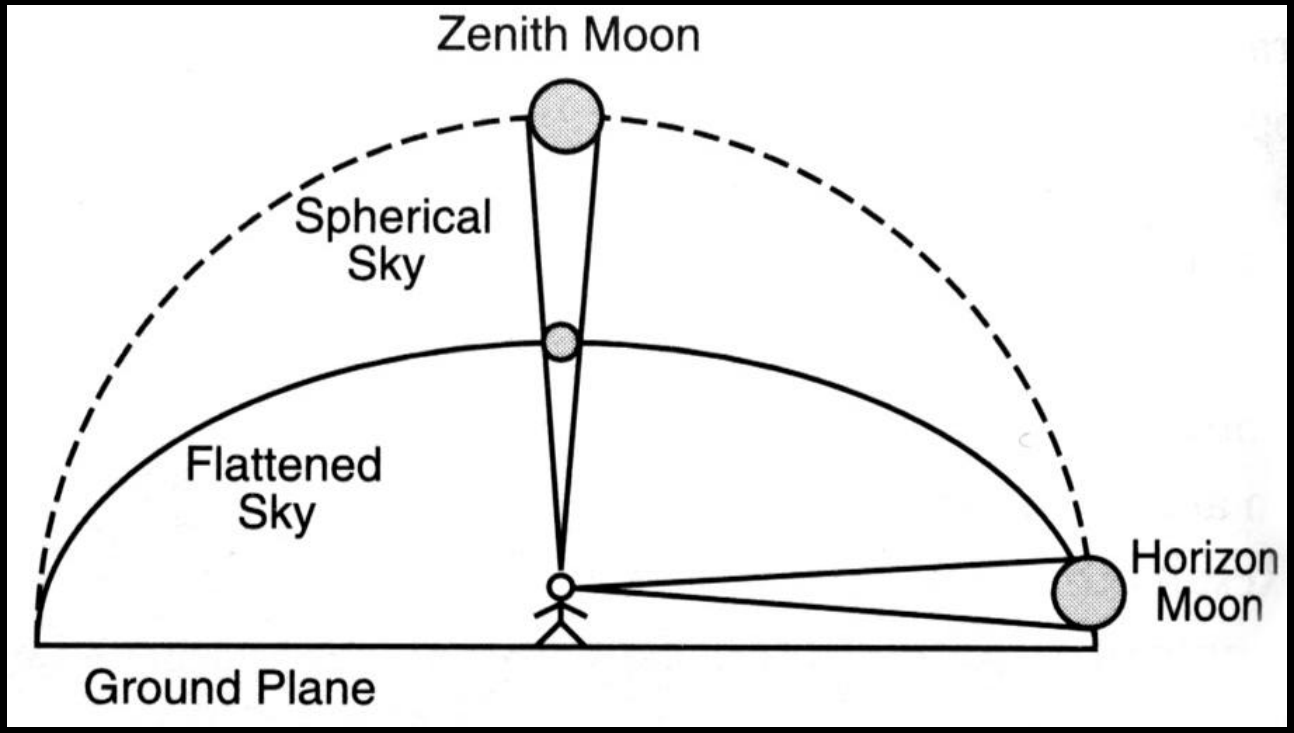
- Size
- Lightness
- Color
- Position
- Orientation
- Shape

Degree of constancy

- Not always perfect
- Sometimes too much

Degree of size constancy

- The Moon illusion
  - The Moon appears bigger on the horizon
  - Because it looks farther (Emmert's law)
  - Because references



Degree of color constancy

- Incandescent light looks warmer
- Sodium lighting looks yellowish
- Depends on intensity

Constancy & Pictures

- Estimate size of depicted objects
- Different virtual viewpoints

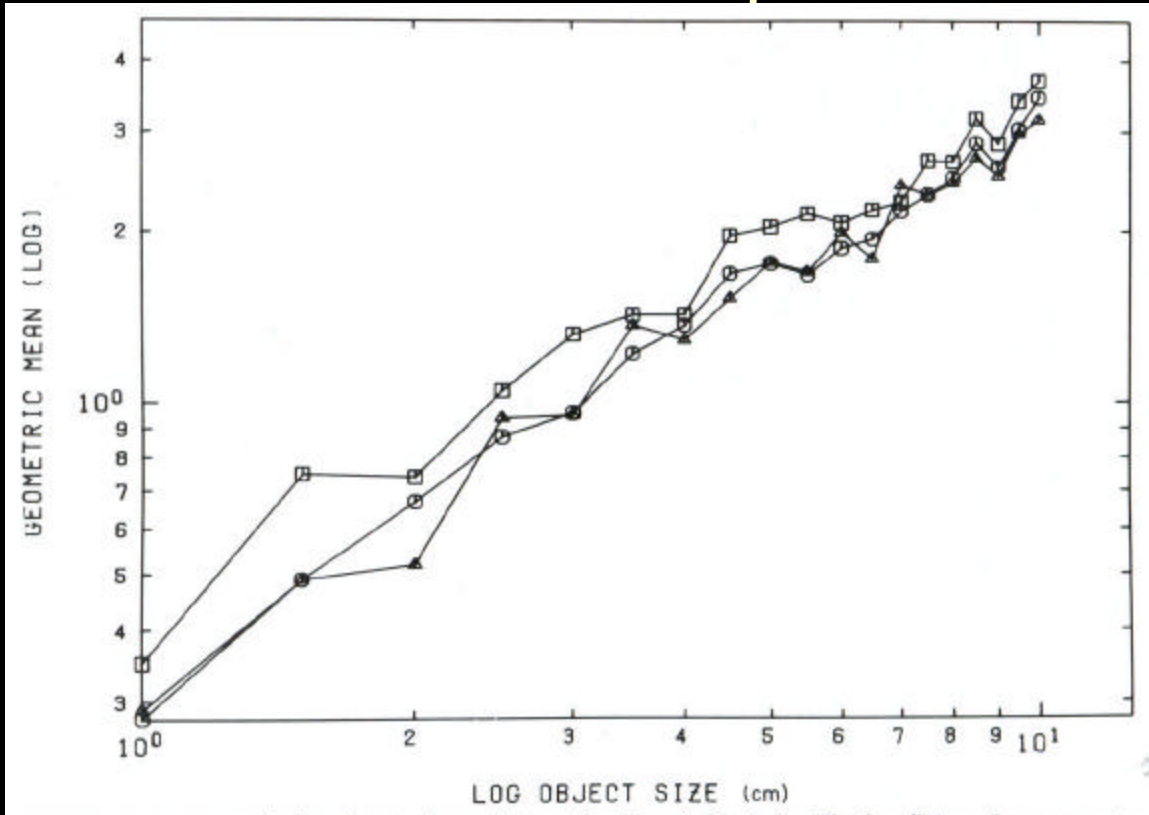


FIGURE 4.8. Mean magnitude estimates (log scale) as a function of object size. Viewing distance is a parameter. Data collected for photographs. (○, 75 cm; △, 50 cm; □, 25 cm.)

Constancy & Pictures

- Estimate slant of depicted objects
- Different real viewing angles

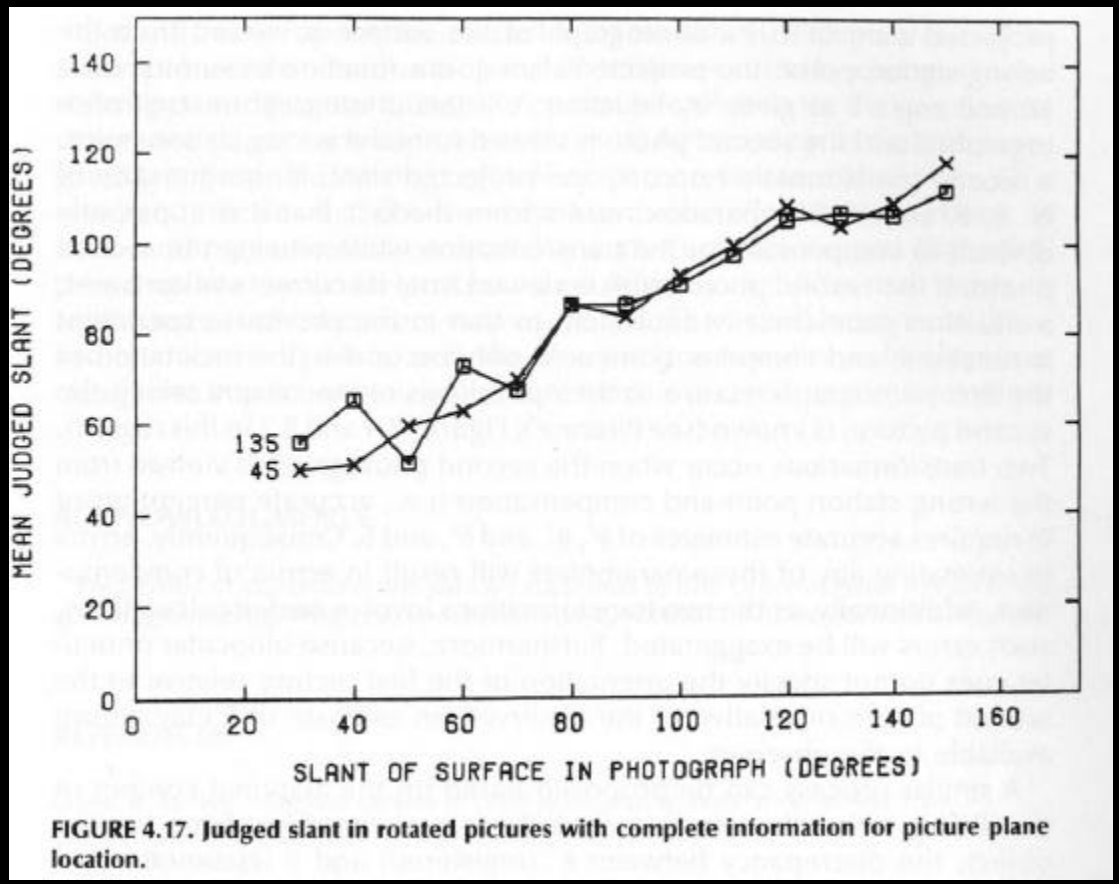


FIGURE 4.17. Judged slant in rotated pictures with complete information for picture plane location.

Importance of frame

- Estimate slant of depicted objects
- Different real viewing angles, invisible frame

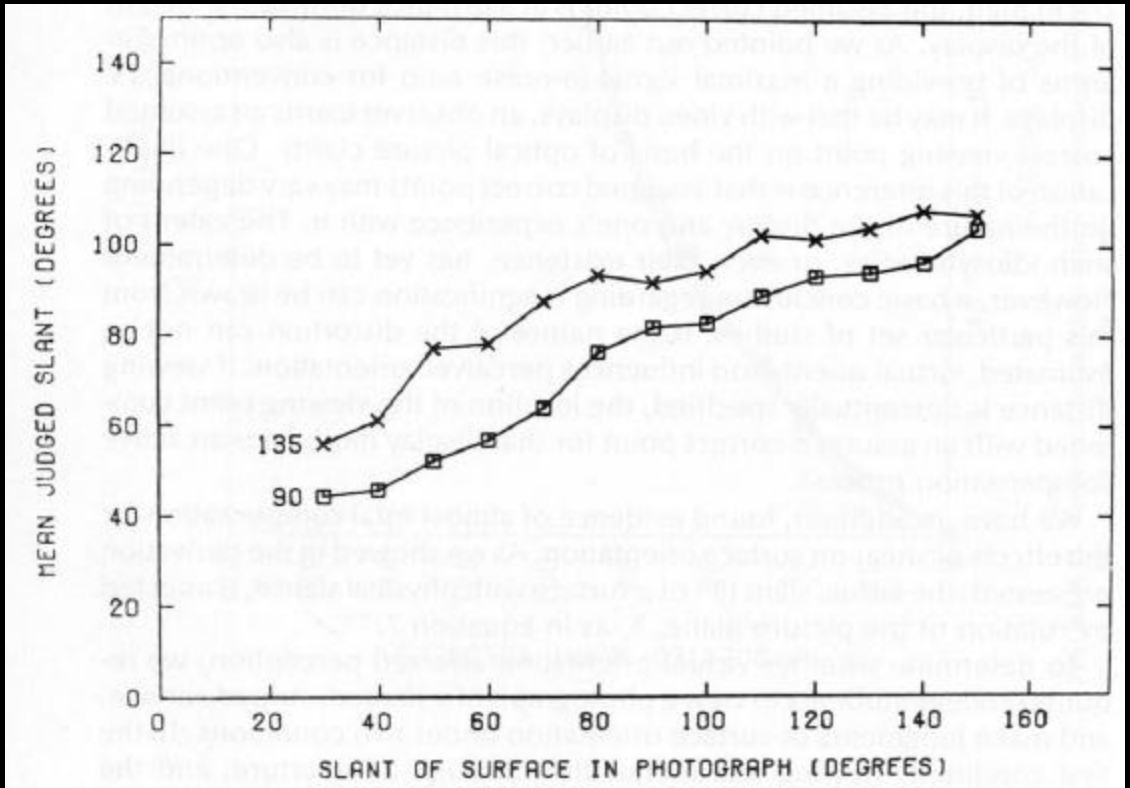
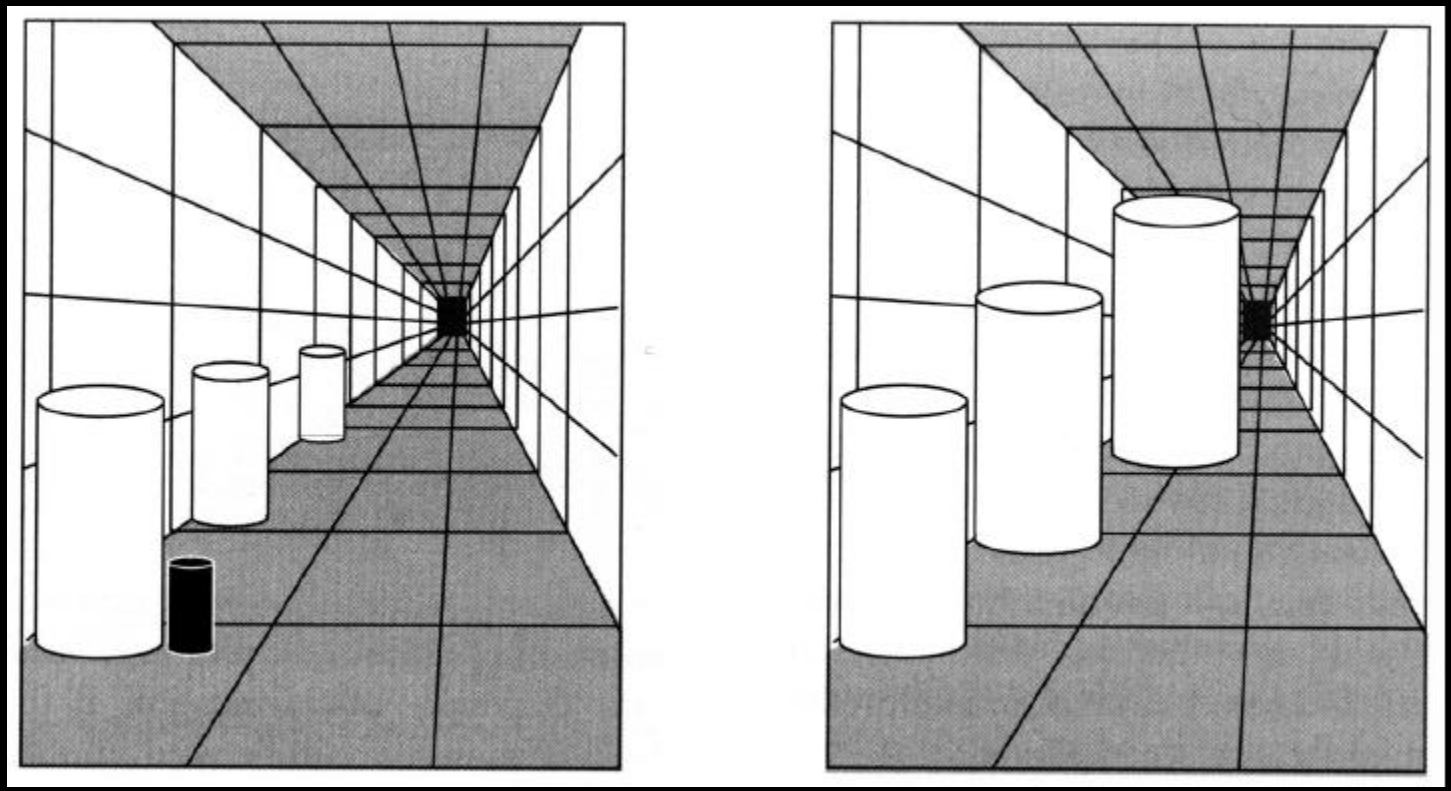


FIGURE 4.16. Judged slant in rotated pictures with reduced information for location of picture plane.

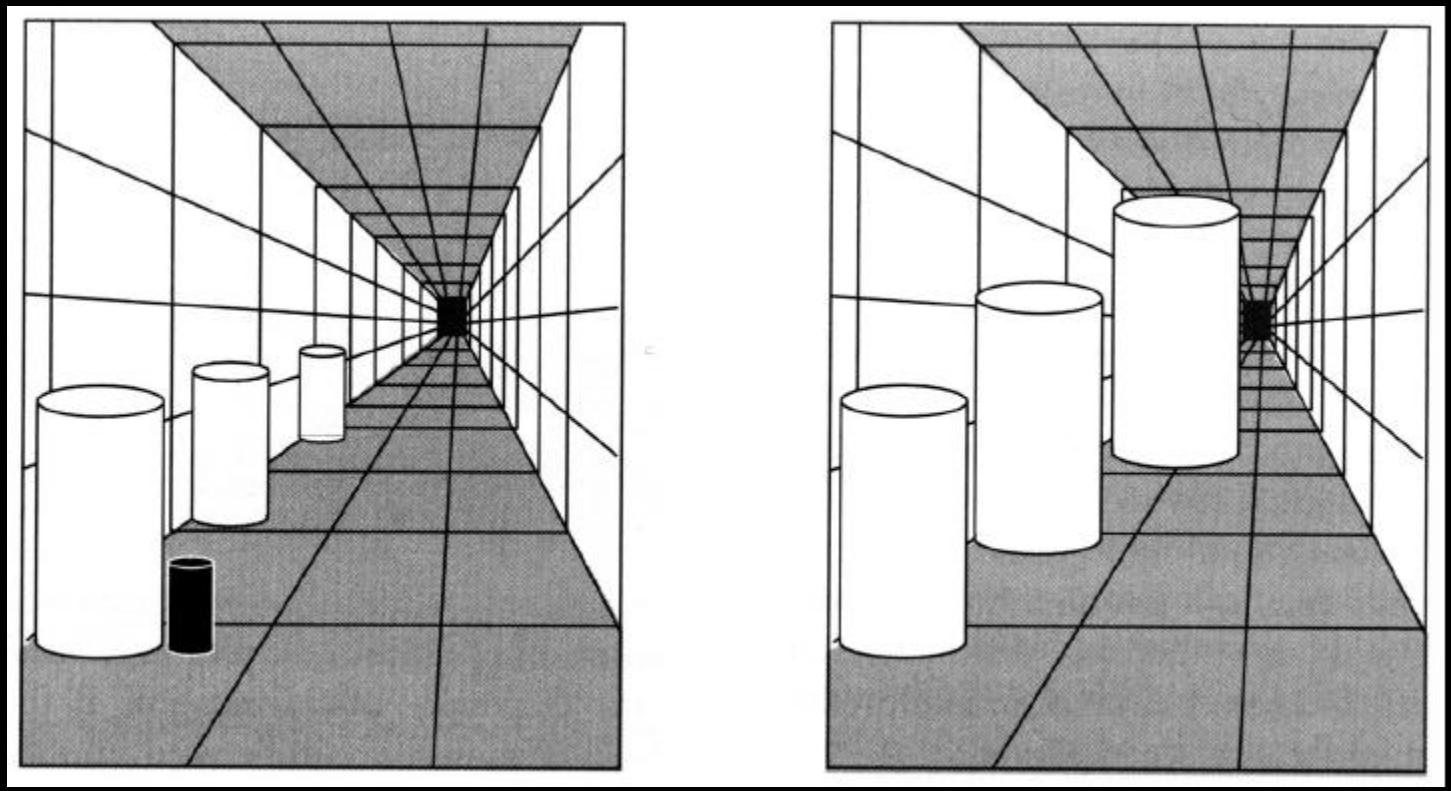
Constancy & Pictures

- Hybrid constancy with respect to
  - Picture object
  - Depicted scene



Constancy & Pictures

- Hybrid constancy
- Problem
- Richness



Degree of constancy

- Vermeer *Soldier and a Laughing Girl*
- Too good to be true: use of camera obscura

Size constancy failure

Size constancy failure

Size constancy failure

Breaking size constancy for symbol

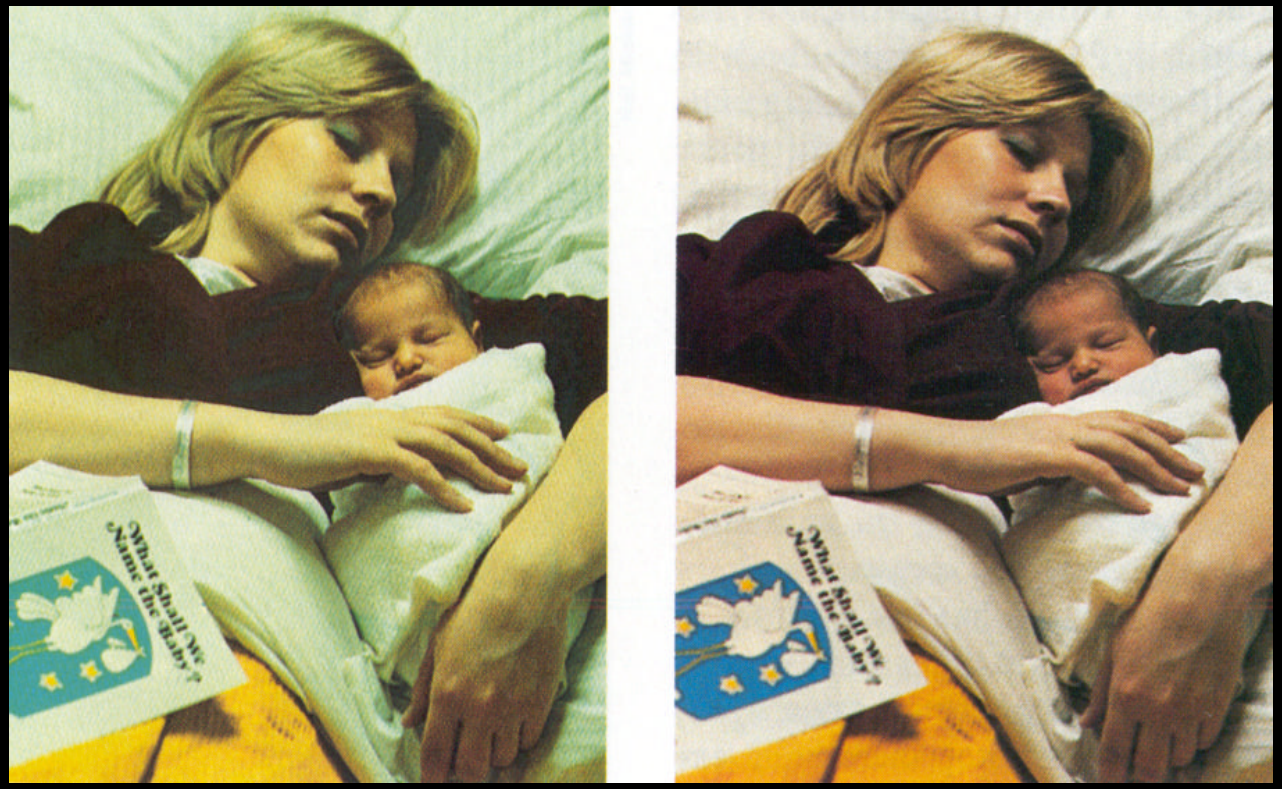
- Middle-age
- Size = social importance

Size constancy dissonance

- Surrealism (Magritte)

Color constancy and pictures

- Chromatic adaptation with respect to picture object, not with respect to dicted scene

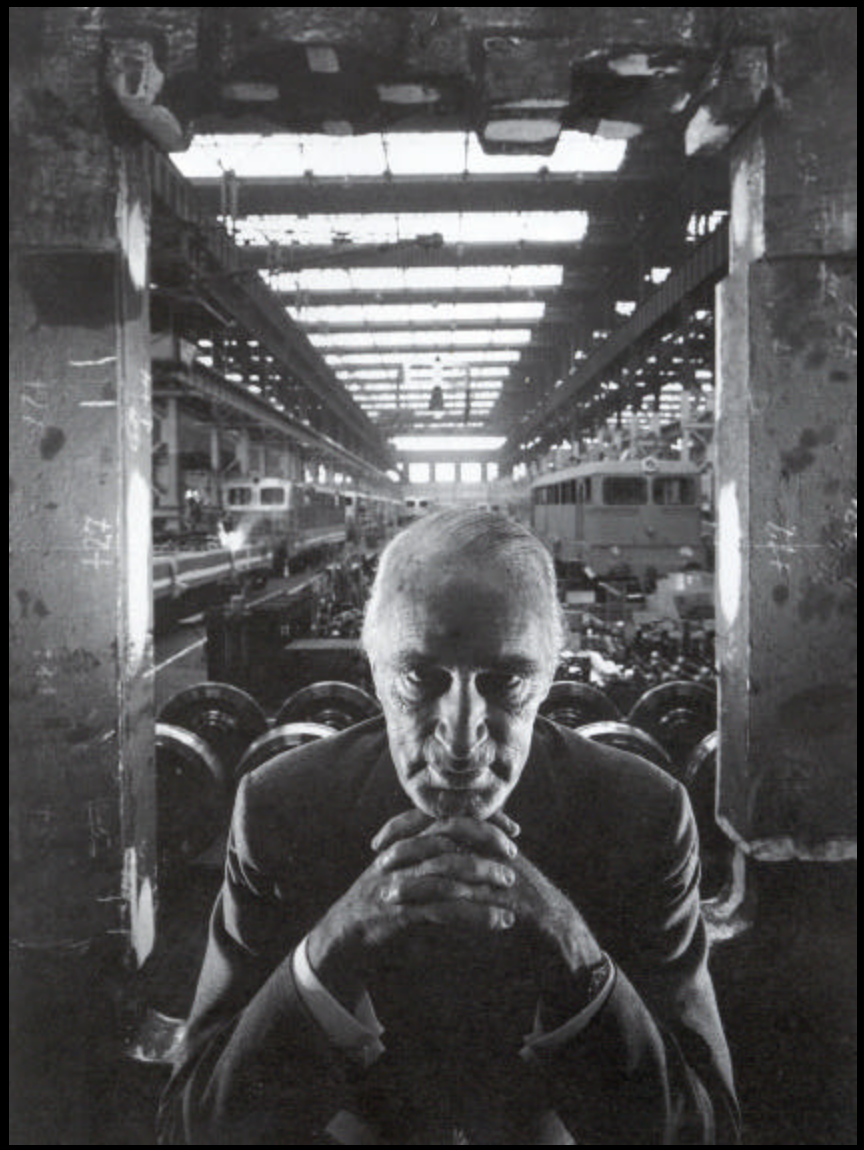


Constancy & architecture

- Palazzo Spada in Rome (by Boromini)
- Short corridor
- Column size decreases
- Appears longer

Constancy & Make Up

Constancy & Lighting



Next session

- Gestalt and picture organization
- Gaze movement and focal point

Assignments

- Piranesi
  - Tutorial 1 to 4
- Reading
  - Art and Illusion, Gombrich
  - Summary 1 to 2 pages
  - 2 Discussion issues
- Feedback, 1 picture

Discussion

- *The Man Who Mistook his Wife for a Hat*
- *The Colorblind Painter*
- Oliver Sacks