Objects and Scenes

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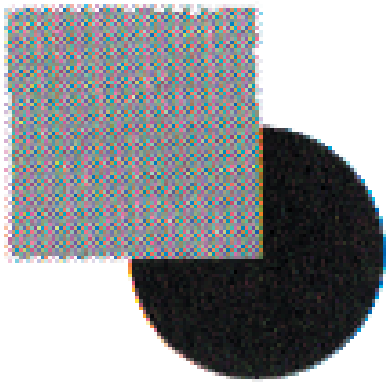
Visual Interpolation

What is it all about?

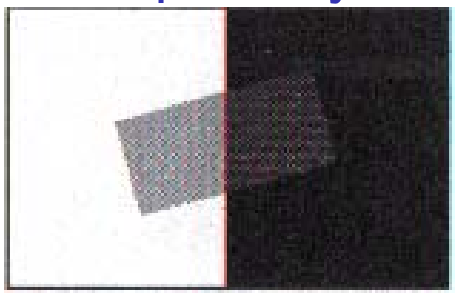
How to infer the nature of hidden part from visible ones.

Visual Completion



Illusory Contour

Perceived Transparency



Visual Completion

Automatically perceives partly occluded surface as complete

A

Visual Completion

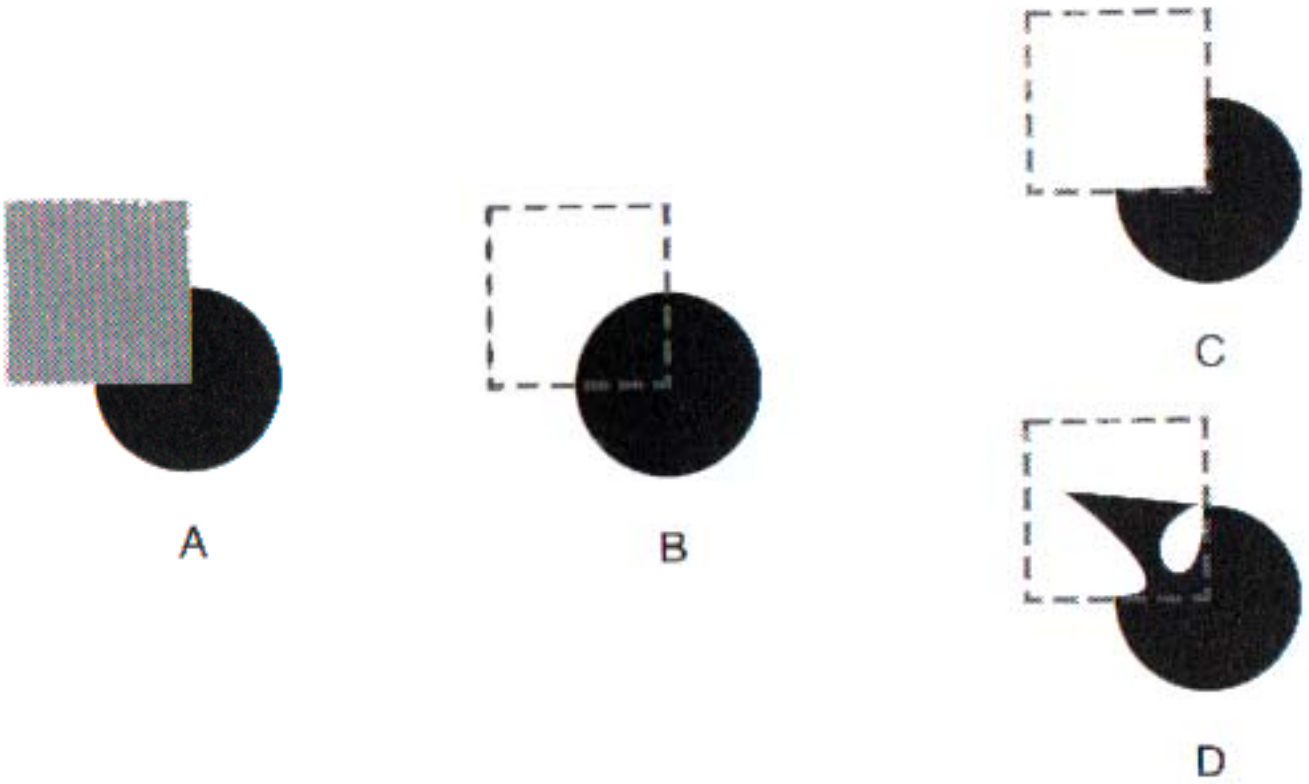
Automatically perceives partly occluded surface as complete

A

B

Visual Completion

Automatically perceives partly occluded surface as complete

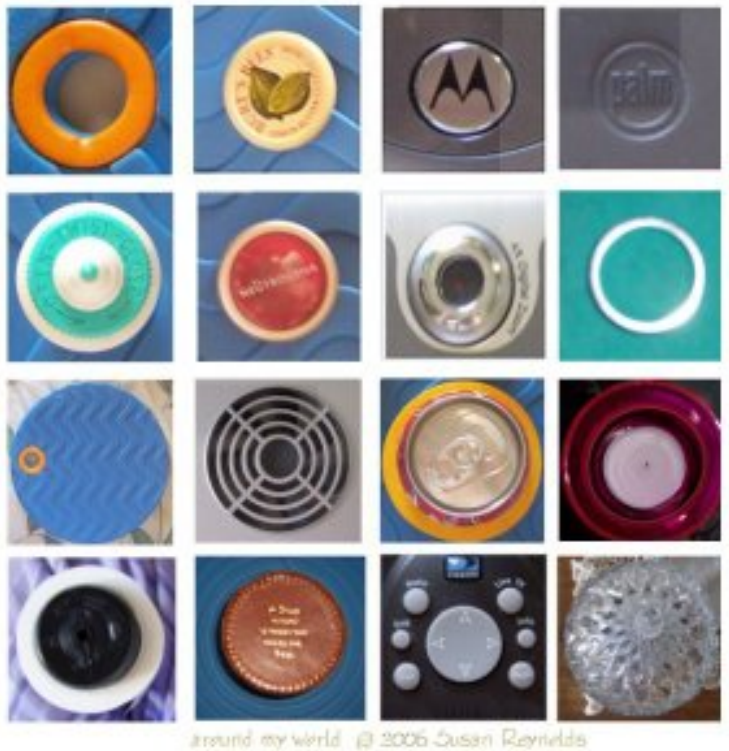


- Multiple perceptions are possible
- But there's usually single dominant one
- How might it happen?

- Multiple perceptions are possible
- But there's usually single dominant one
- How might it happen?
  - figural familiarity
  - figural simplicity
  - ecological constraint

Figural Familiarity Theory

complete occluded figures according to most frequently encountered shape that is compatible with the visible part



Pros and Cons

- Problem : we can complete novel shape
- The theory is still effective, though.

A

B

Figural Simplicity Theory

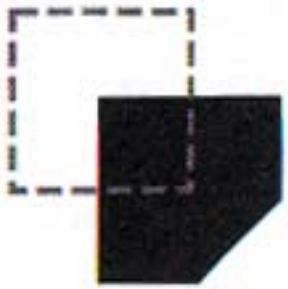
- produce the "simplest" figures

Figural Simplicity Theory

- produce the "simplest" figures
- Problem : how to measure "simplicity"

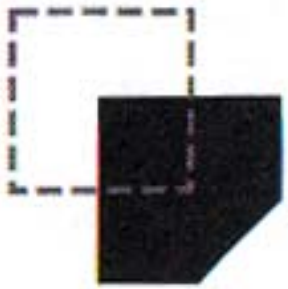
A

A



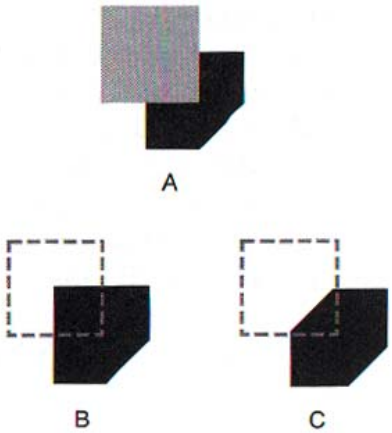
B

A



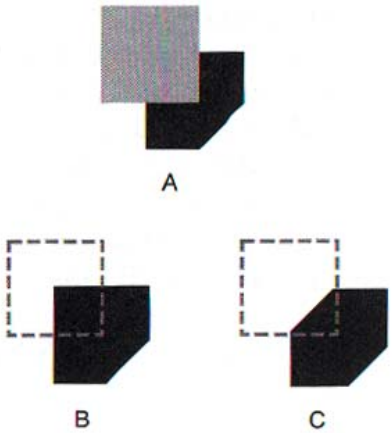
B

C



Suppose

(i) simplicity $\Rightarrow$ number of axes of symmetry



Suppose

(i) simplicity $\Rightarrow$ number of axes of symmetry

(ii) simplicity $\Rightarrow$ number of sides

Ecological Constraint Theory

- based on ecological evidence of occluded contours
- e.g. T-junction
- relatability theory

Relatability Theory

▸ Example

Relatability Theory

▸ Example

1. edge discontinuities are necessary

Relatability Theory

▸ Example

1. edge discontinuities are necessary
2. discontinuities are "relatable" ▸ relatable?
   - 2.1 intersect at an angle $\leq 90^\circ$
   - 2.2 smoothly connected

Relatability Theory

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Relatability Theory

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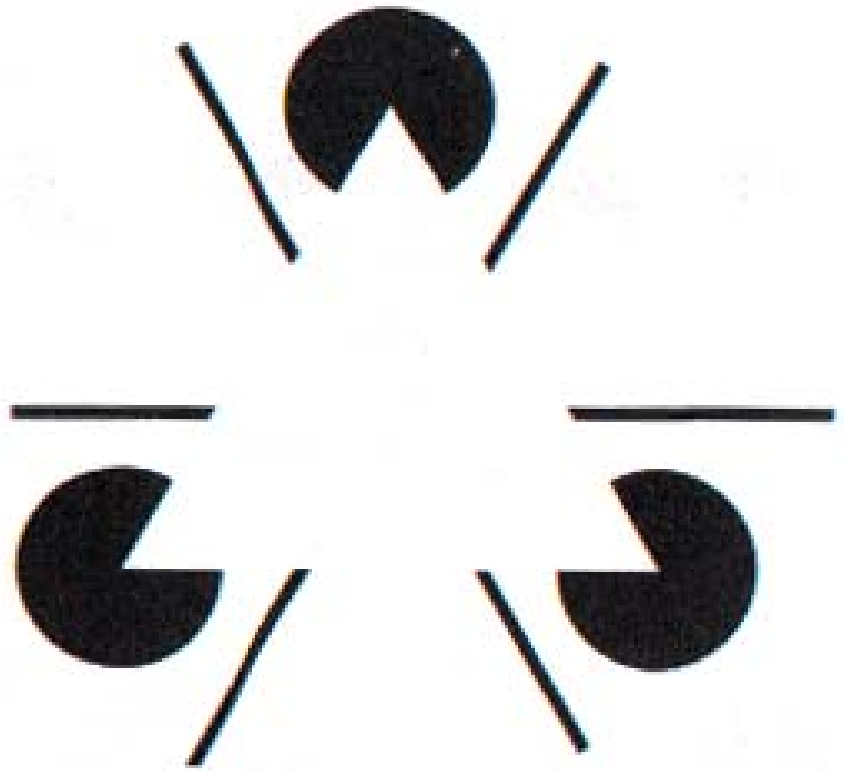
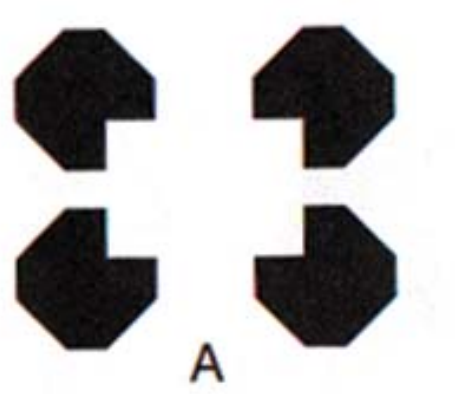
   - 2.2 smoothly connected
3. form an enclosed area
4. infer position in depth

Illusory Contours

Perceiving contours that do not exist in stimulus image





Illusory contours generally come with visual completion

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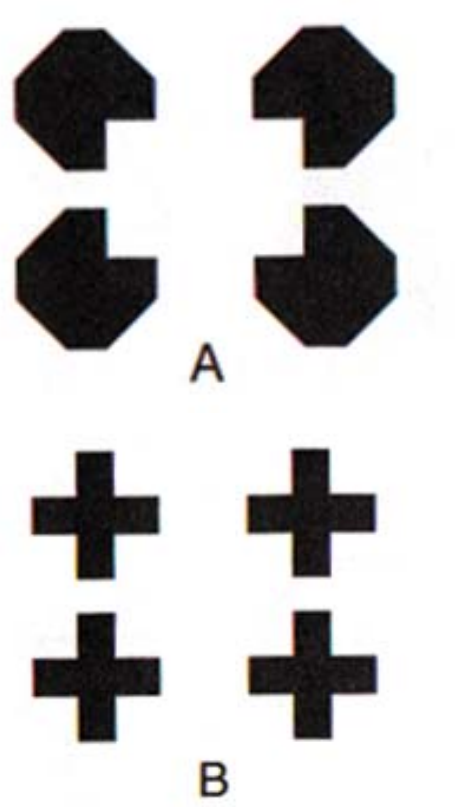

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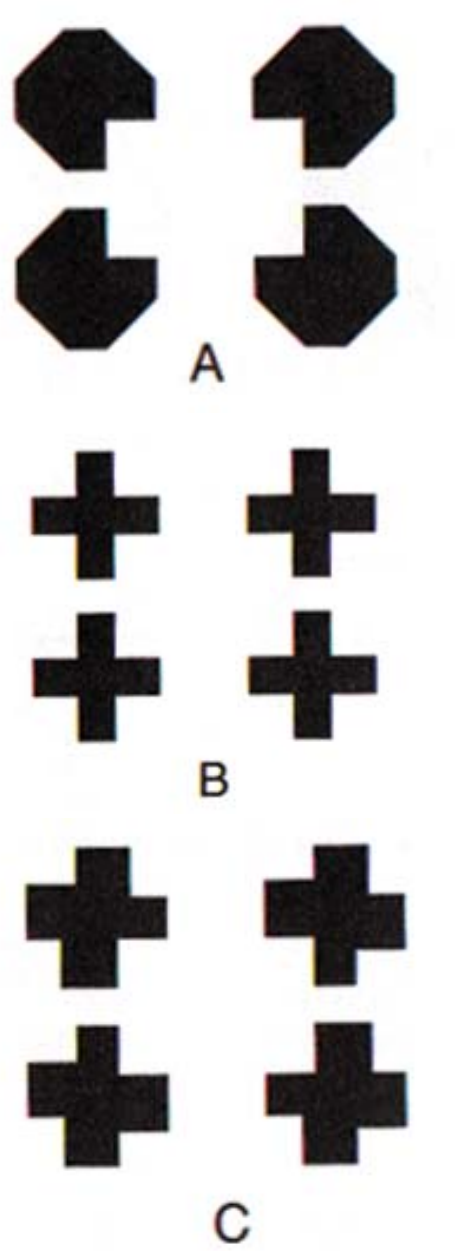
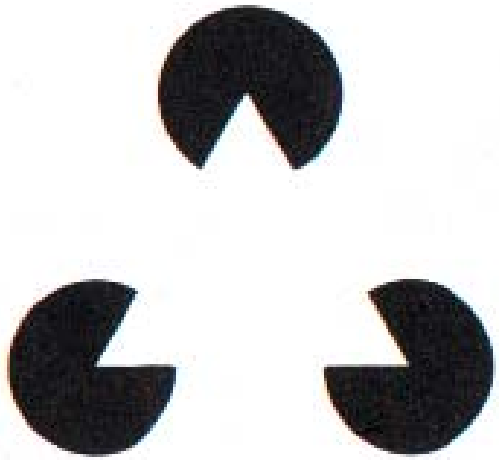


Illusory Contours and Visual Completion

Alternative perception with same underlying process of visual system



A

Illusory Contours and Visual Completion

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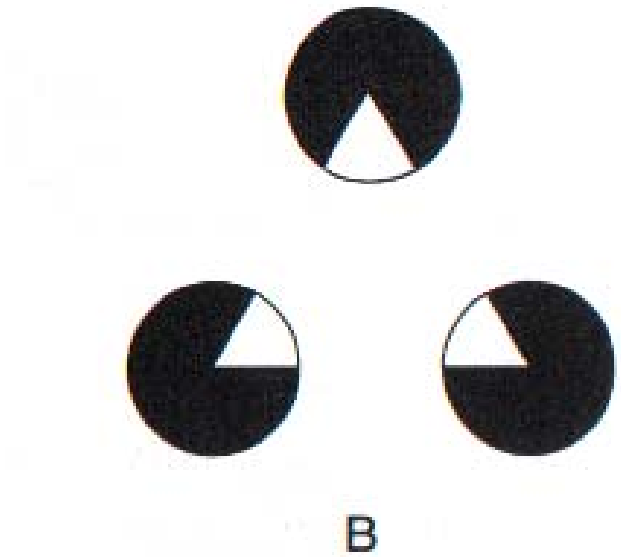

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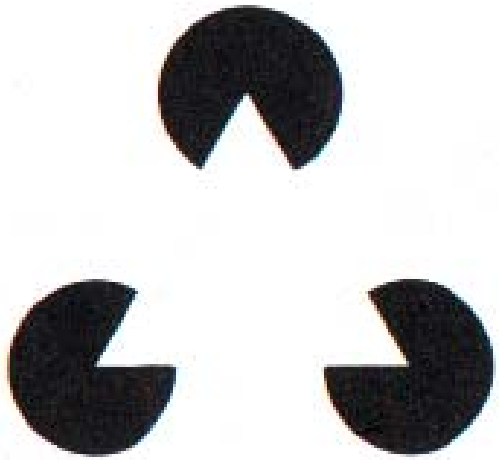
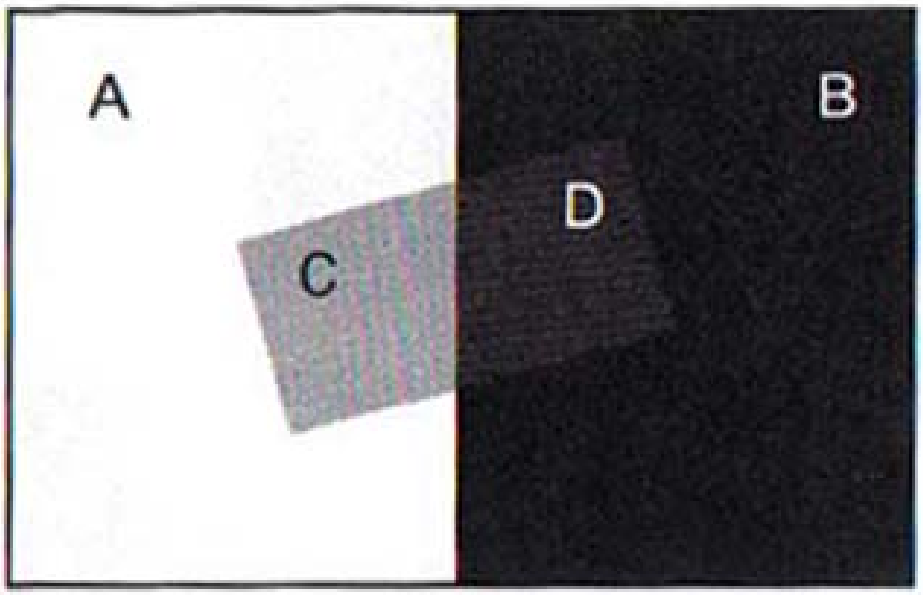


A

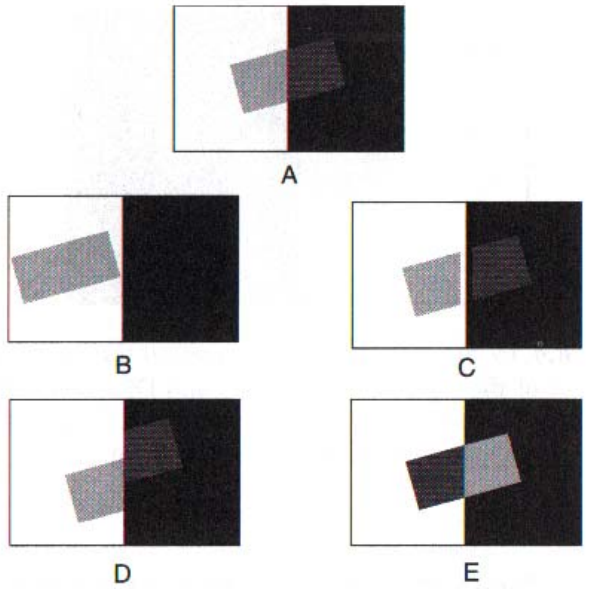
Perceived Transparency

perception as being viewed through a closer translucent object



must satisfy two conditions

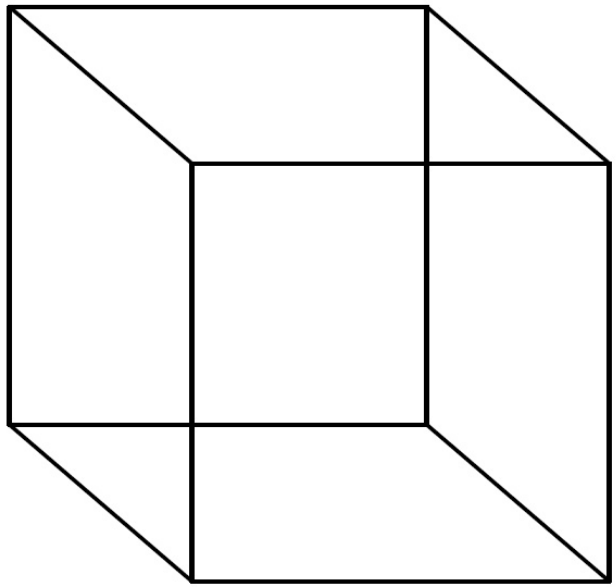
1. spatial condition
   - (i) immersed in single region (B)
   - (ii) unity destroyed (C)
   - (iii) unity weakened (D)
2. color condition (E)



Multistability

- more than one perception
- spontaneously alternate among two or more perception

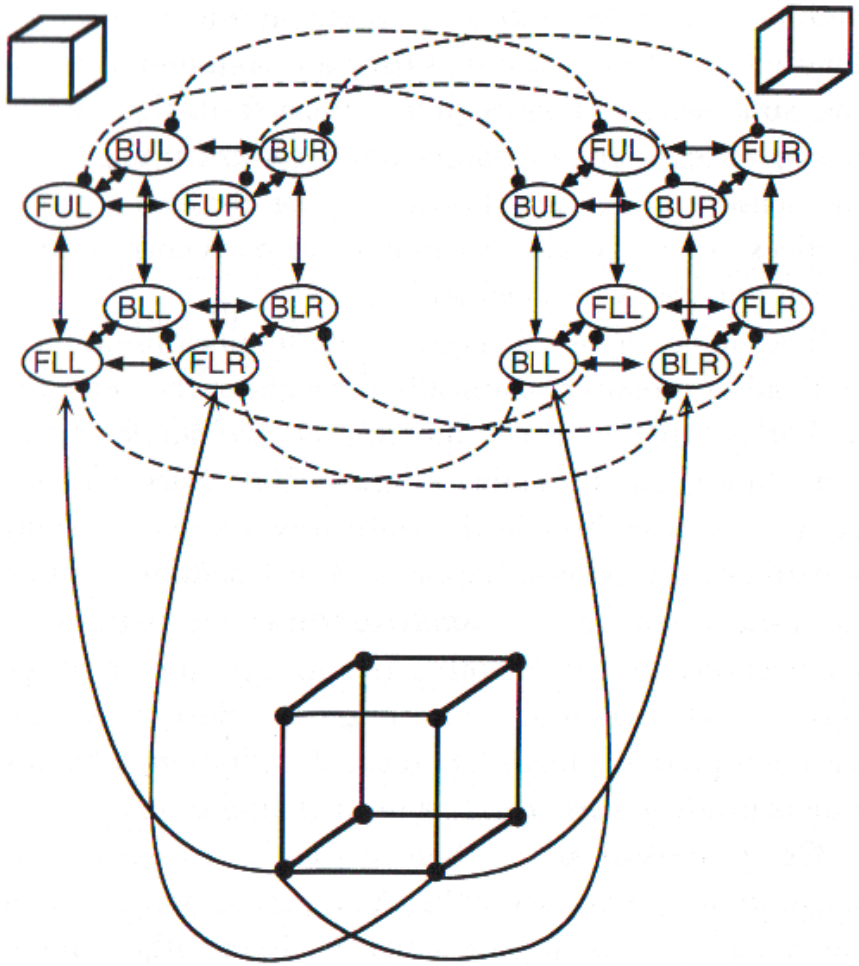
Necker cube



Q1 :

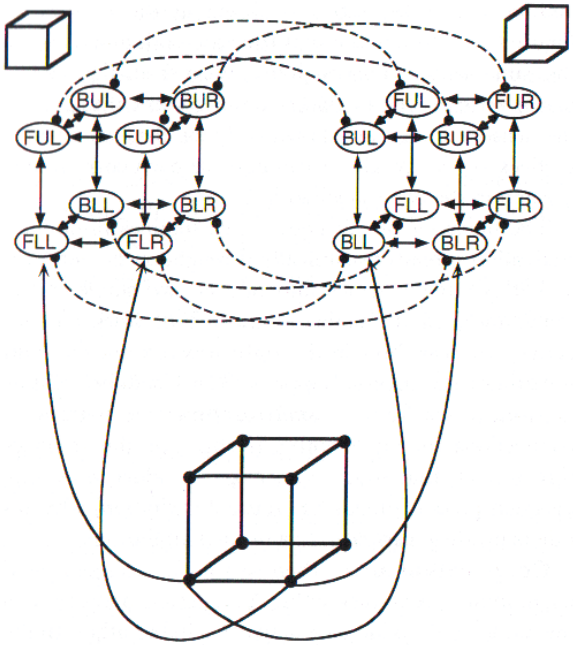
Why only one interpretation at any moment?

Network Model



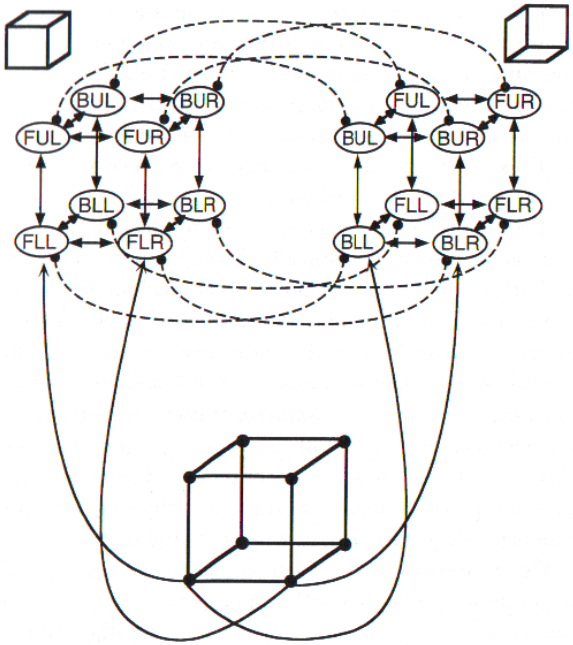
Assumption : different patterns of neural activity $\rightarrow$ different interpretations

Cooperation & Competition



Cooperation & Competition

- Cooperation
  - mutual excitatory links
  - connecting same subnetwork



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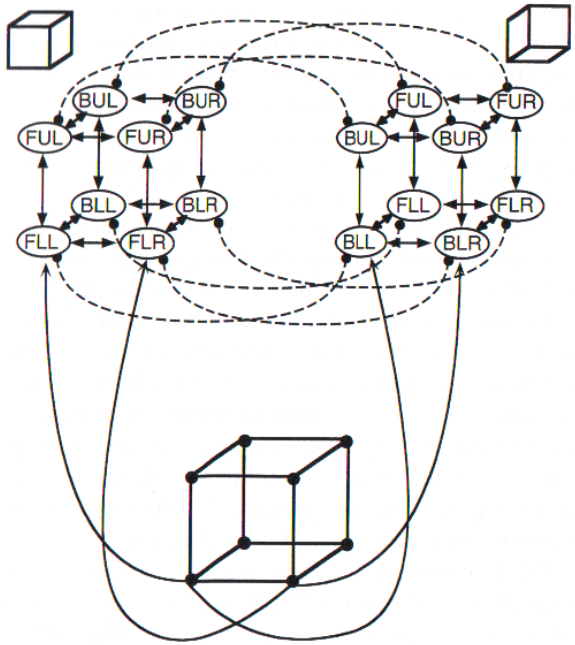

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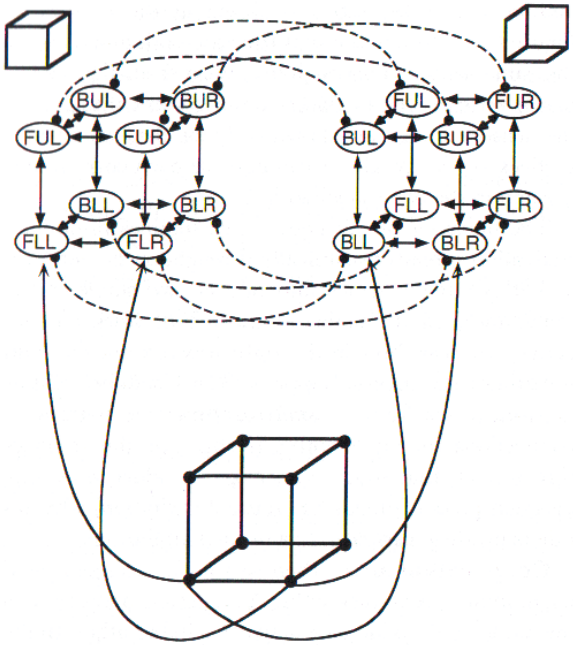


- Cooperation
  - mutual excitatory links
  - connecting same subnetwork
- Competition
  - mutual inhibitory links
  - connecting different subnetwork
- only one subnetwork is active at any moment

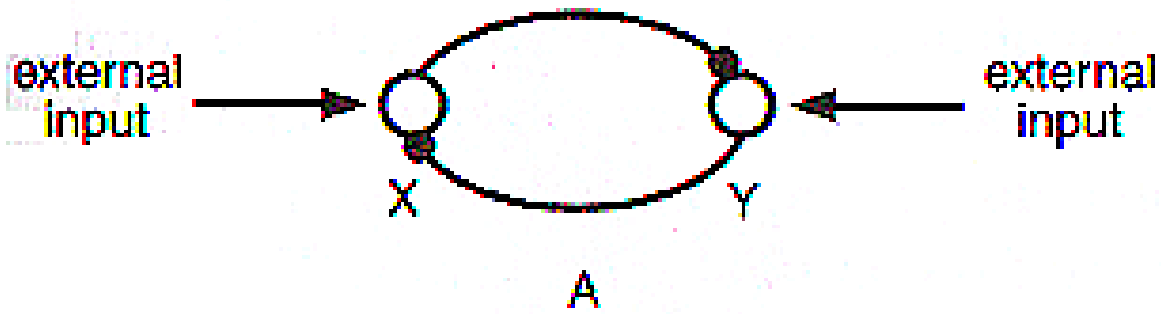
Q2 :

Why the alternation happen?

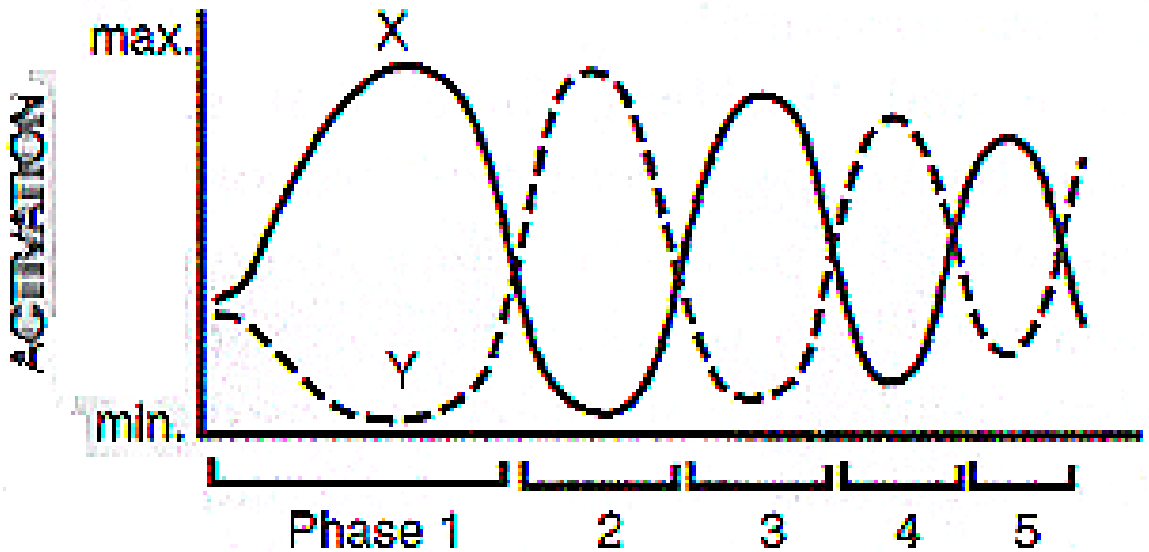
Neural Fatigue Theory

Assumption : Neurons are getting tired

- Due to depletion of biochemical resources needed to fire
- cause alternating interpretation when combined with mutual inhibition


external input
external input
X
Y

A


max.
min.
ACTIVATION
X
Y
Phase 1
2
3
4
5
TIME

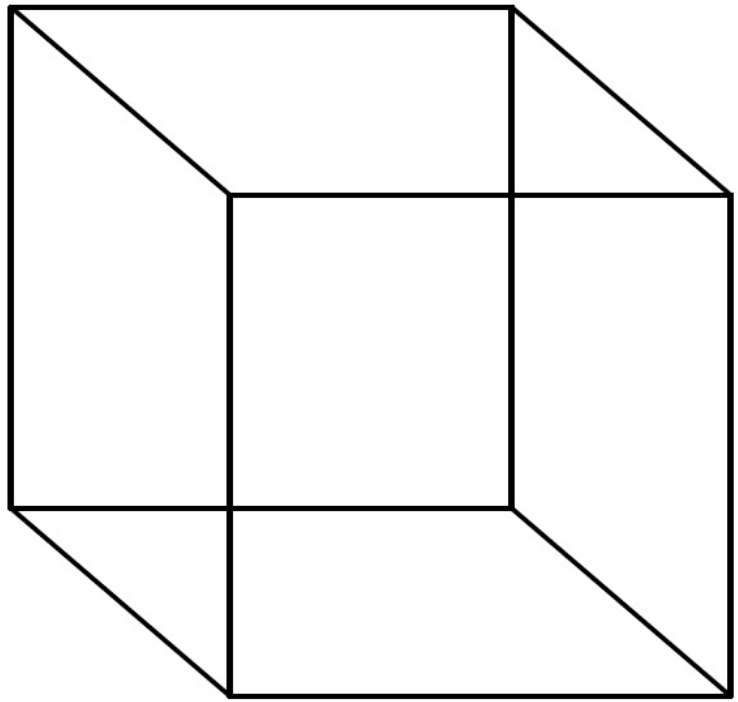
B

...

Other effects

Fatigue Theory is Not perfect

- Eye Fixation
- Role of Instructions



Perceptual Constancy and Illusions

- Shape
- Orientation
- Position

Shape Constancy

Perceive as constant despite changes in viewing perspective

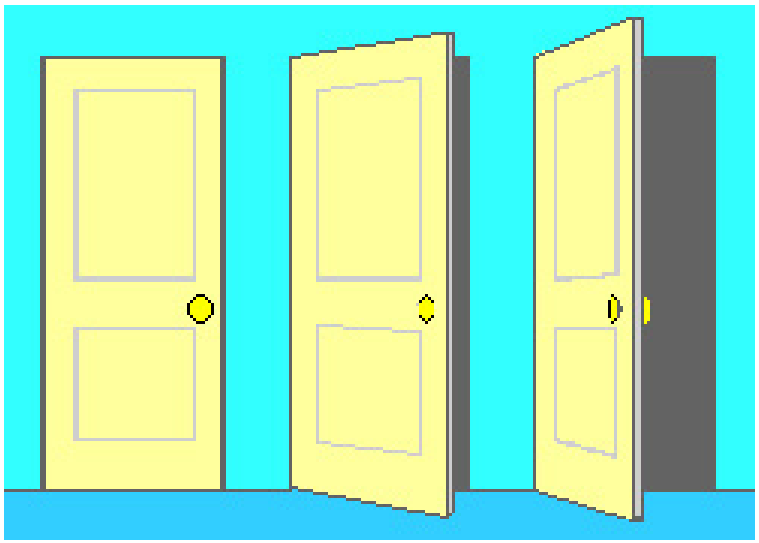


Figure: Doors at different slant look the same as door in the frontal plane.

How might we expect changes in perspective to affect shape constancy?

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Depth information

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Depth information

- Accurate depth information from absolute sources
  - accommodation and/or convergence
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  - shape and size can be completely recovered
- Accurate relative depth from quantitative sources
  - binocular disparity, motion parallax, or many of the metric sources of perspective information
  - shape will be recoverable but not size
- Only qualitative depth information
  - edge interpretation
  - neither precise shape nor size can be unambiguously recovered

Two-Dimensional Figures

- When objects are close enough to provide accurate depth information, shape constancy is quite good
- Shape constancy declines as the degree of slant increases
- Strong bias toward perceiving symmetrical shapes and familiar shapes

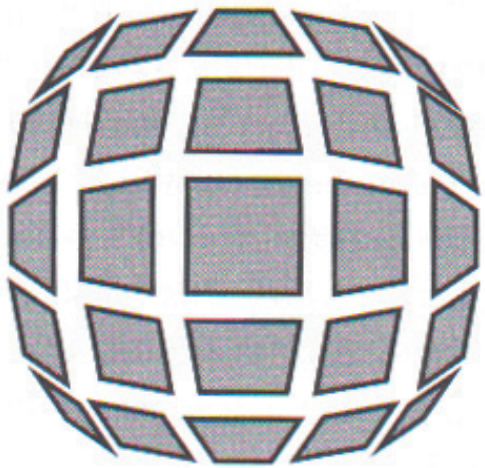

Figure: Perspective views of a square on a wide variety of different perspectives

Three-Dimensional Objects

Irvin Rock and his colleagues

- Observers have surprisingly poor shape constancy
- Perception of shape is strongly influenced by the qualitative changes in the retinally projected shape
- Under distant viewing conditions, shape constancy should be worse than in near viewing conditions

Three-Dimensional Objects

Everyday experience

- We see objects from many different perspectives and manage to recognize them reasonably well despite the variations in appearance

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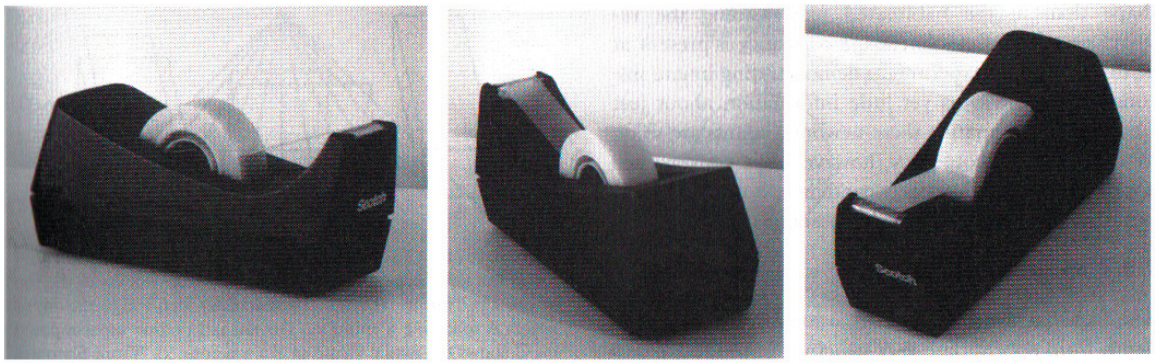
Possibilities

- Continuously moving from one view to another
- Correlated with object's identity
- Axes of symmetry or elongation



Shape Illusions

The ellipse/circle illusion

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Orientation Constancy

Objects in the environment appear to retain their original orientations

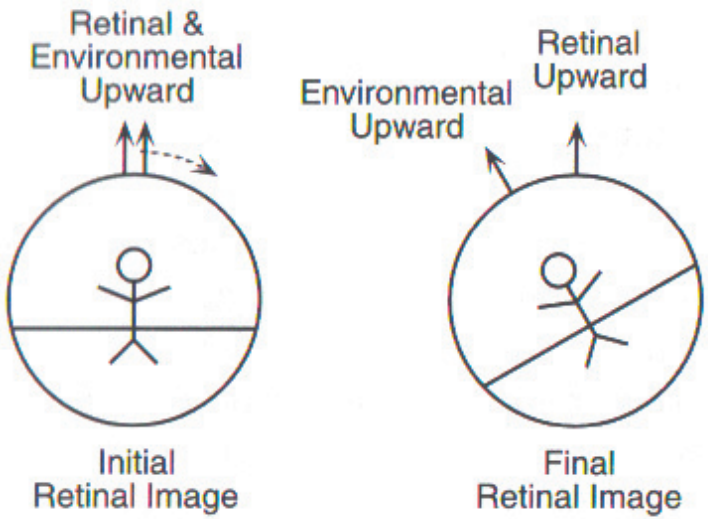


Figure: The perceived orientation of objects in the environment does not appear to change when we tilt our heads, even though their retinal images rotate in the opposite direction.

Orientation Constancy

- O_{object} - object's environmental orientation
- O_{image} - object's image orientation with respect to the long axis of the head
- O_{head} - observer's head orientation with respect to gravity

$$O_{object} = O_{image} + O_{head}$$

Proprioceptive System

The primary source of information about gravitational orientation of the head

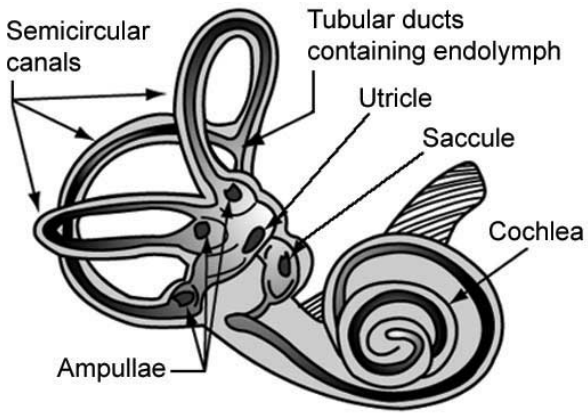
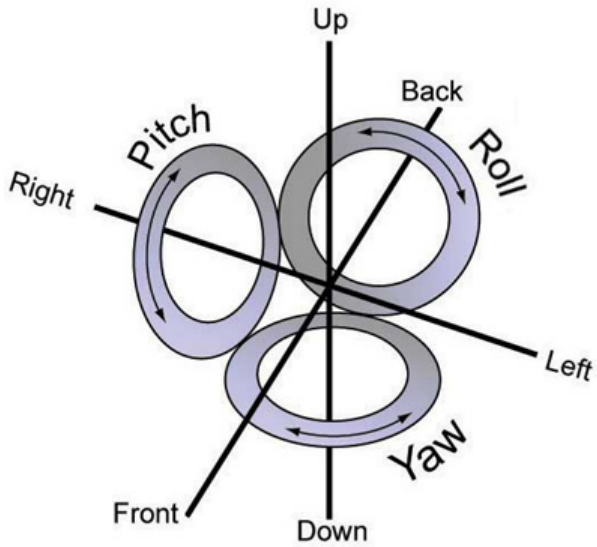
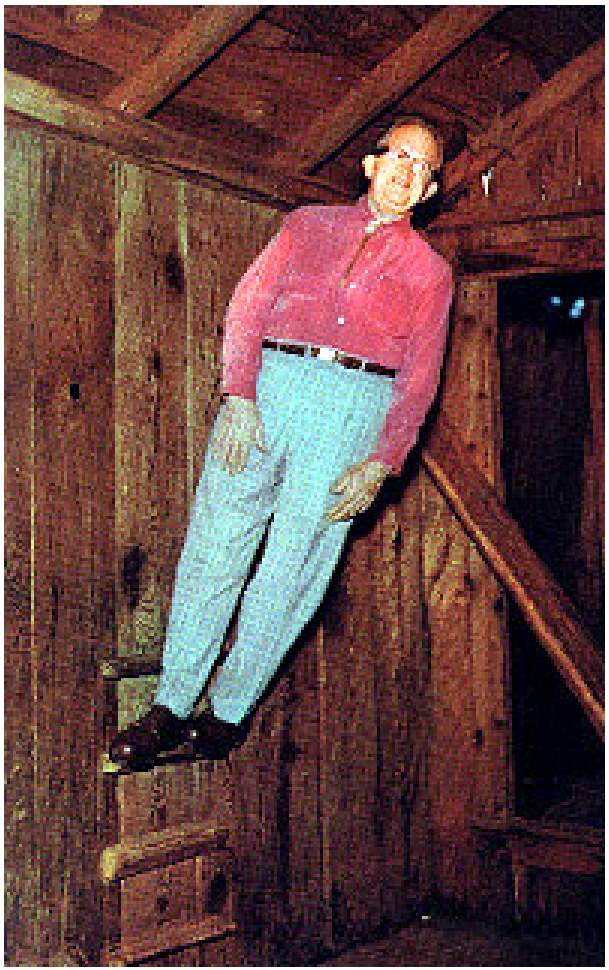


Figure 2: The Vestibular System - semicircular canals and otolith organs



Orientation Illusions

Frames of Reference - The Tilted Room Illusion



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http://www.youtube.com/watch?v=FngLFzS-Sa0

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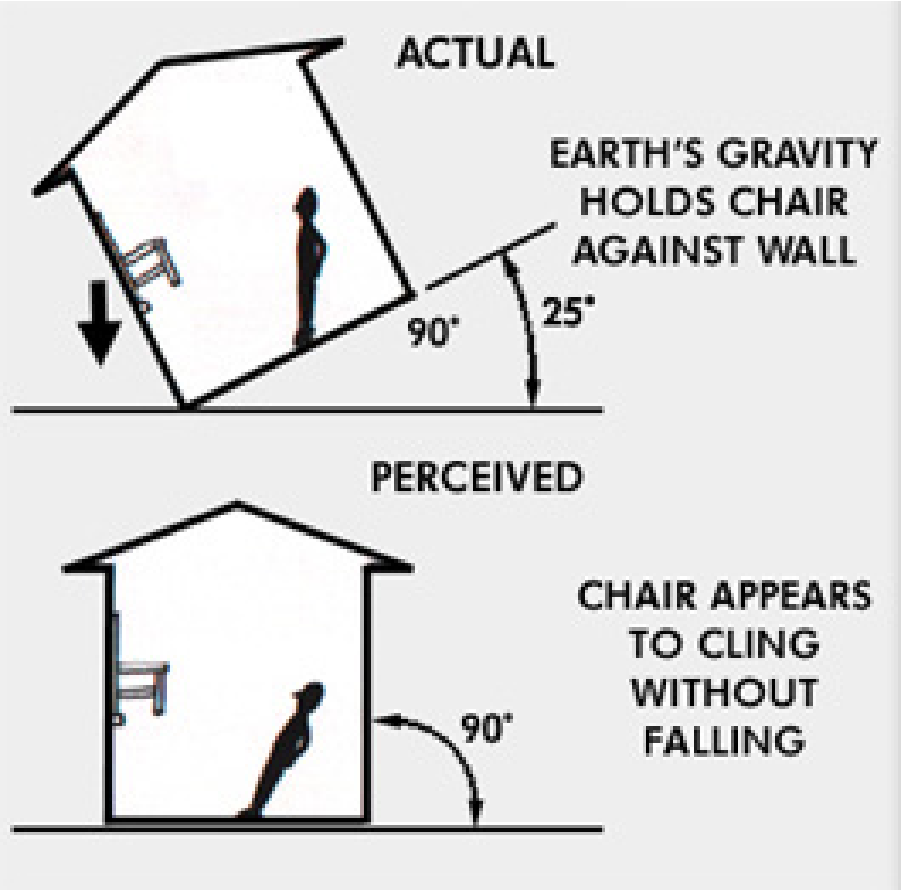
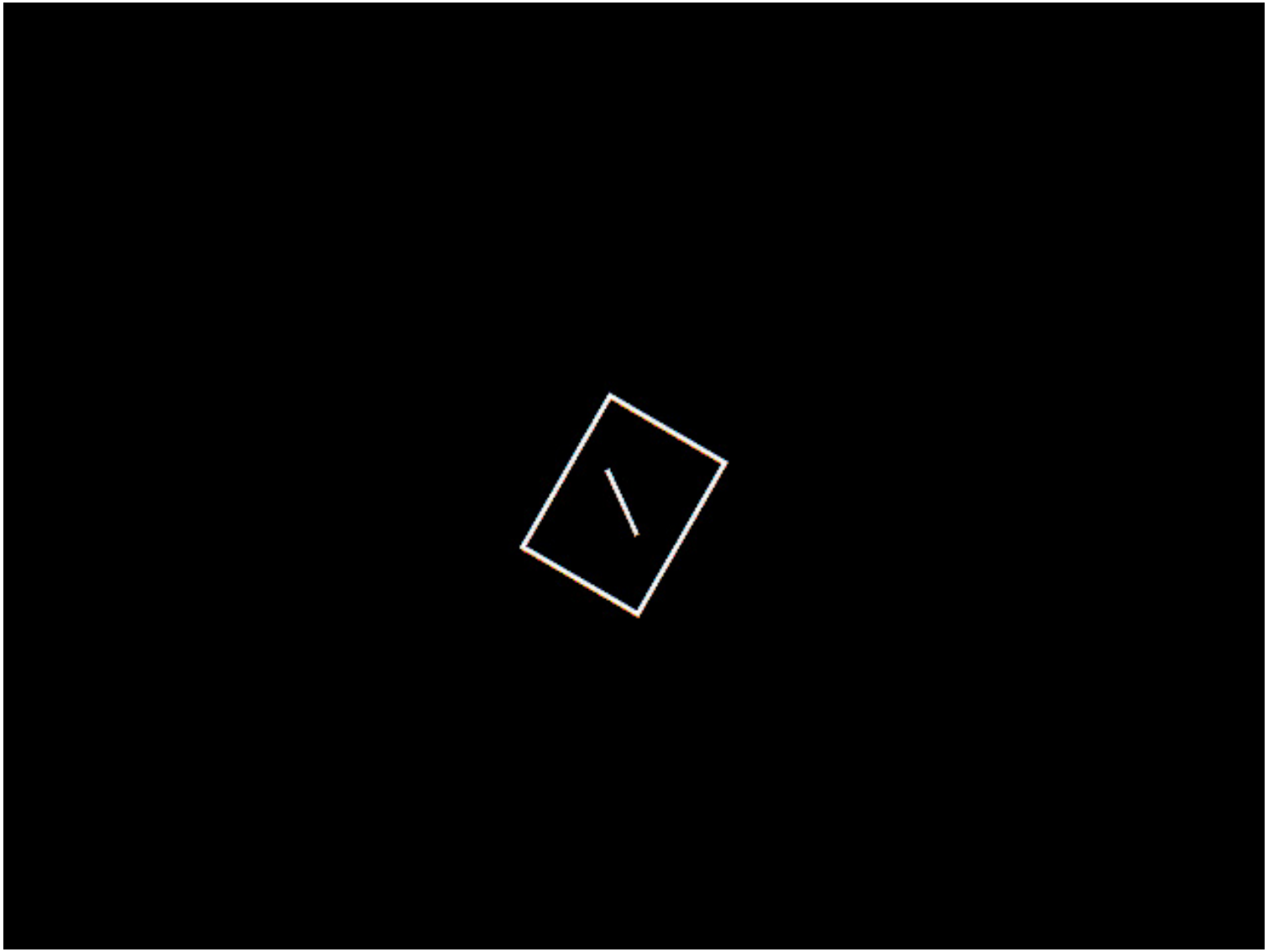


Orientation Illusions

The rod-and-frame effect



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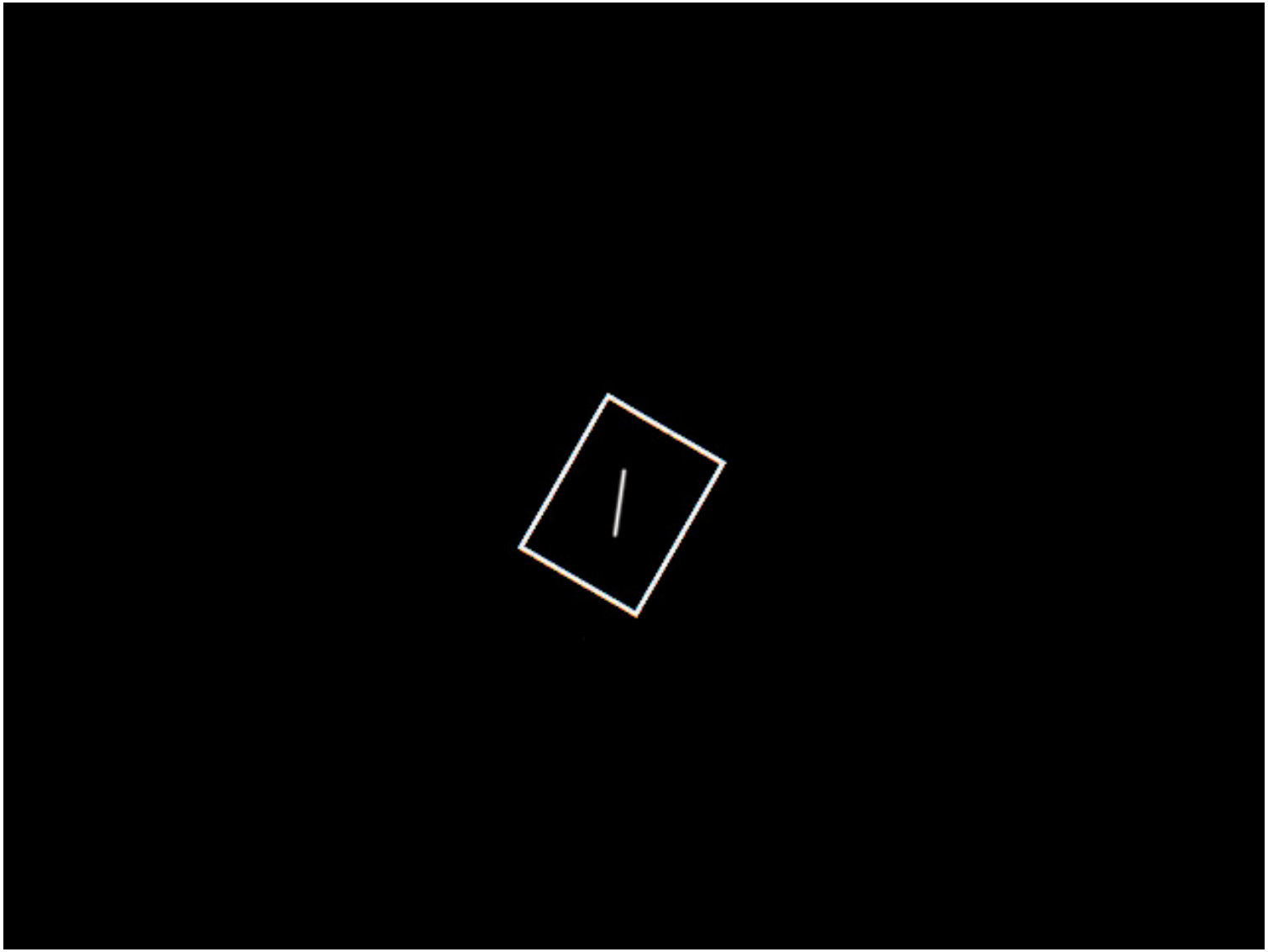

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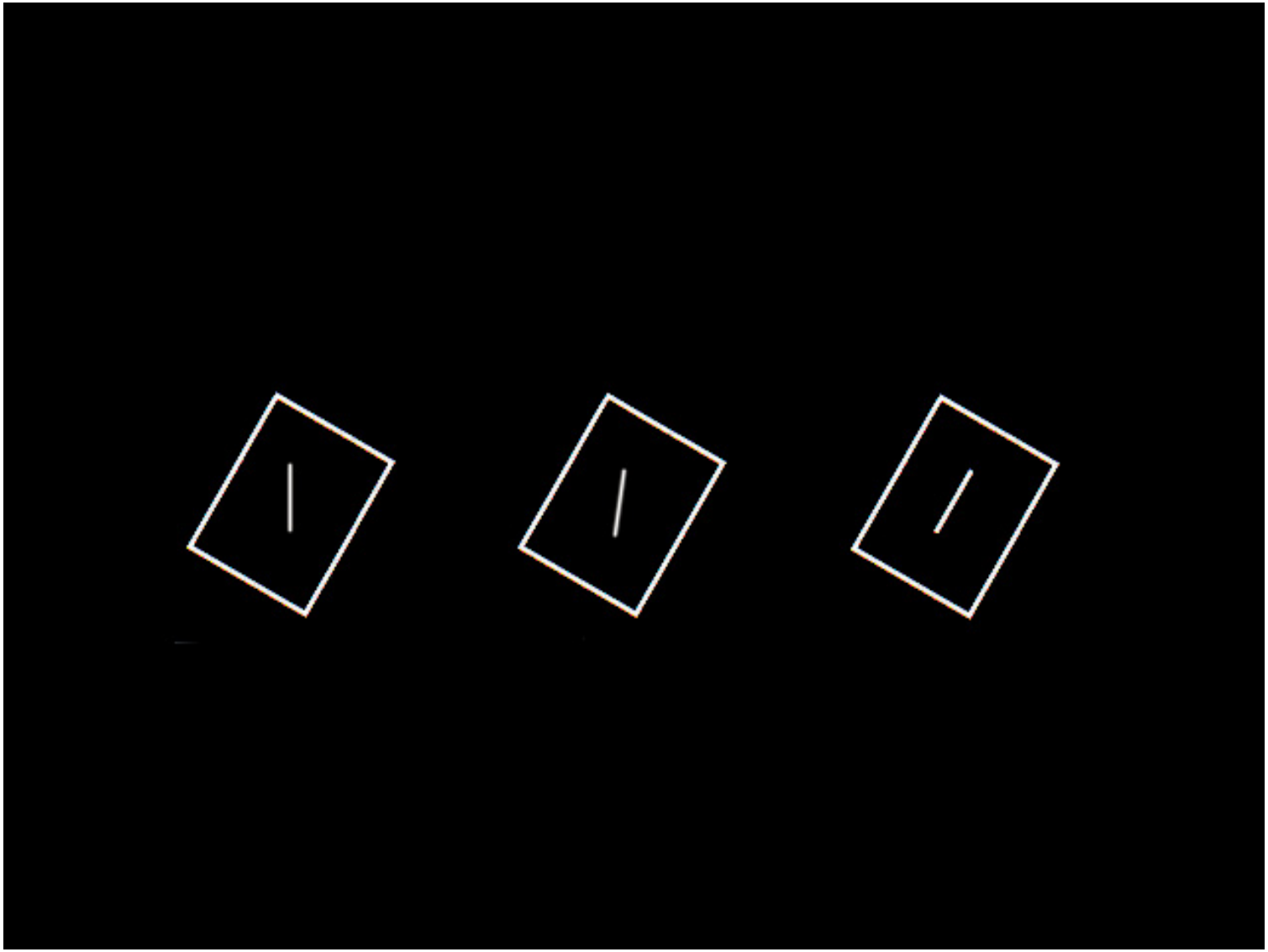
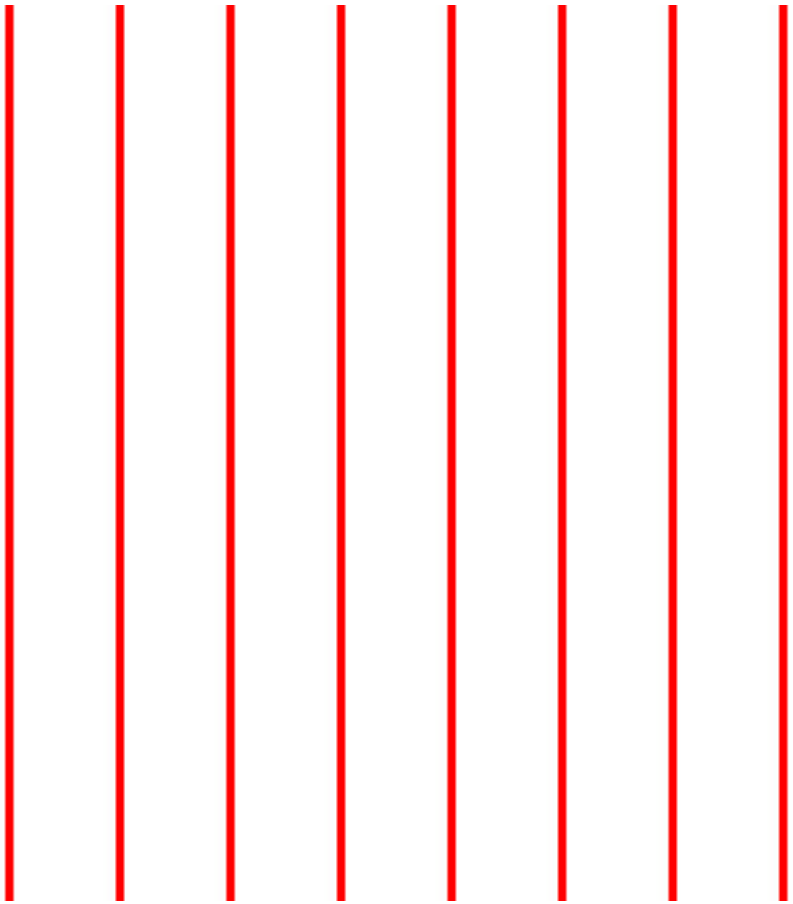


Orientation Illusions

Geometric Illusions - The Zollner Illusion



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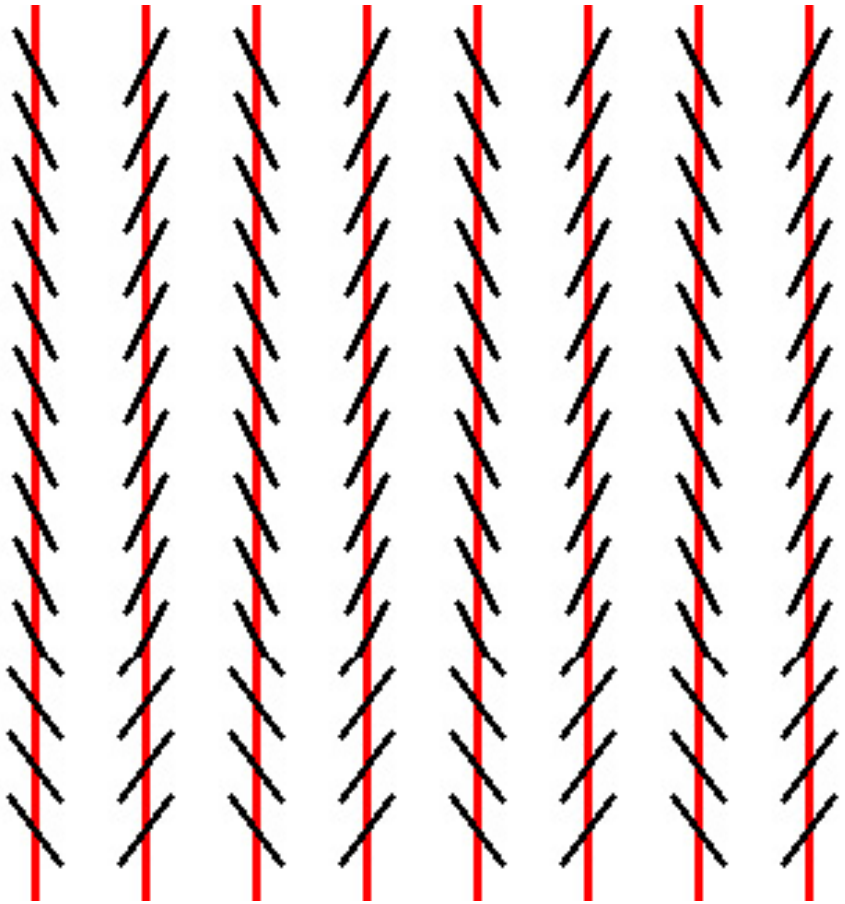
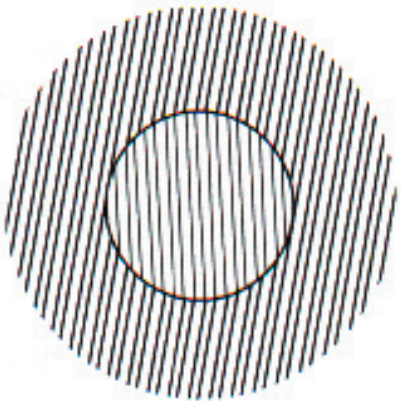
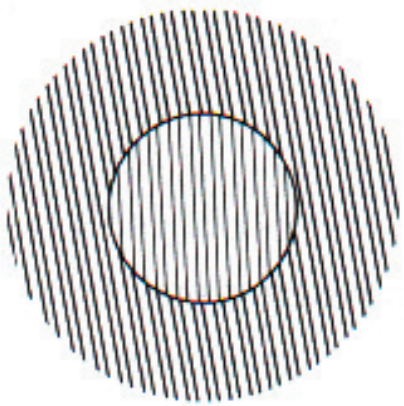


Orientation Illusions

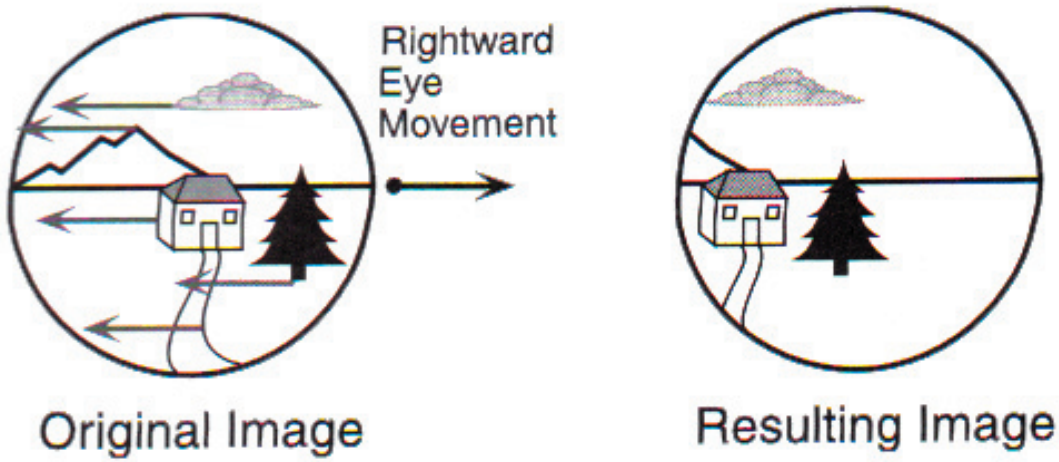
Geometric Illusions - Contrast Illusion





Position Constancy

The visual systems ability to perceive unmoving objects as stationary



Egocentric position

- Objects' positions relative to the observer's body
- Polar coordinates
  - Radial direction from observer to object
  - Distance from observer to object

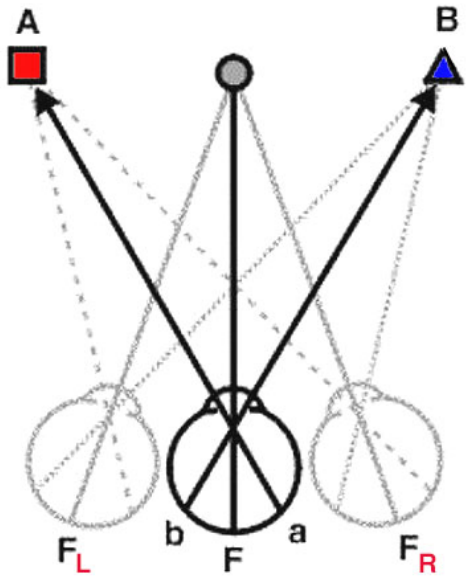
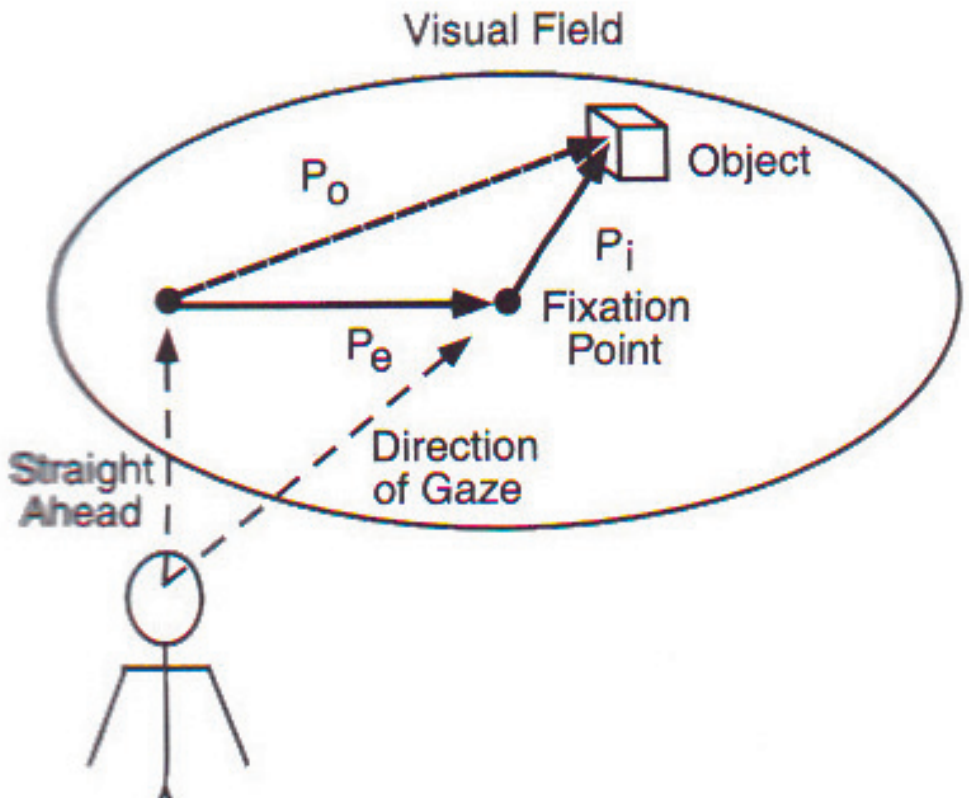


Figure 4. The cyclopean eye is used to determine the direction of point A and point B. Point A stimulating the temporal retina of right eye and the nasal retina of the left eye, that is, stimulates a retinal point to the right of the fovea.

Perception of Direction

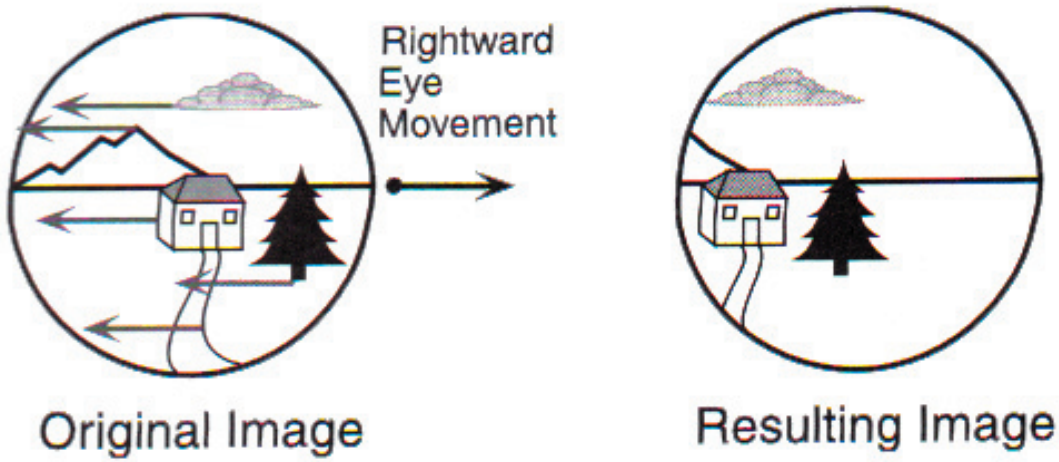
- P_{object} - the environmental position of the object with respect to egocentric straight ahead
- P_{image} - the image position of the object projection with respect to the center of the retina
- P_{eye} - the position of the eye with respect to the egocentric straight ahead

$$P_{object} = P_{image} + P_{eye}$$



Position Constancy

The visual systems ability to perceive unmoving objects as stationary



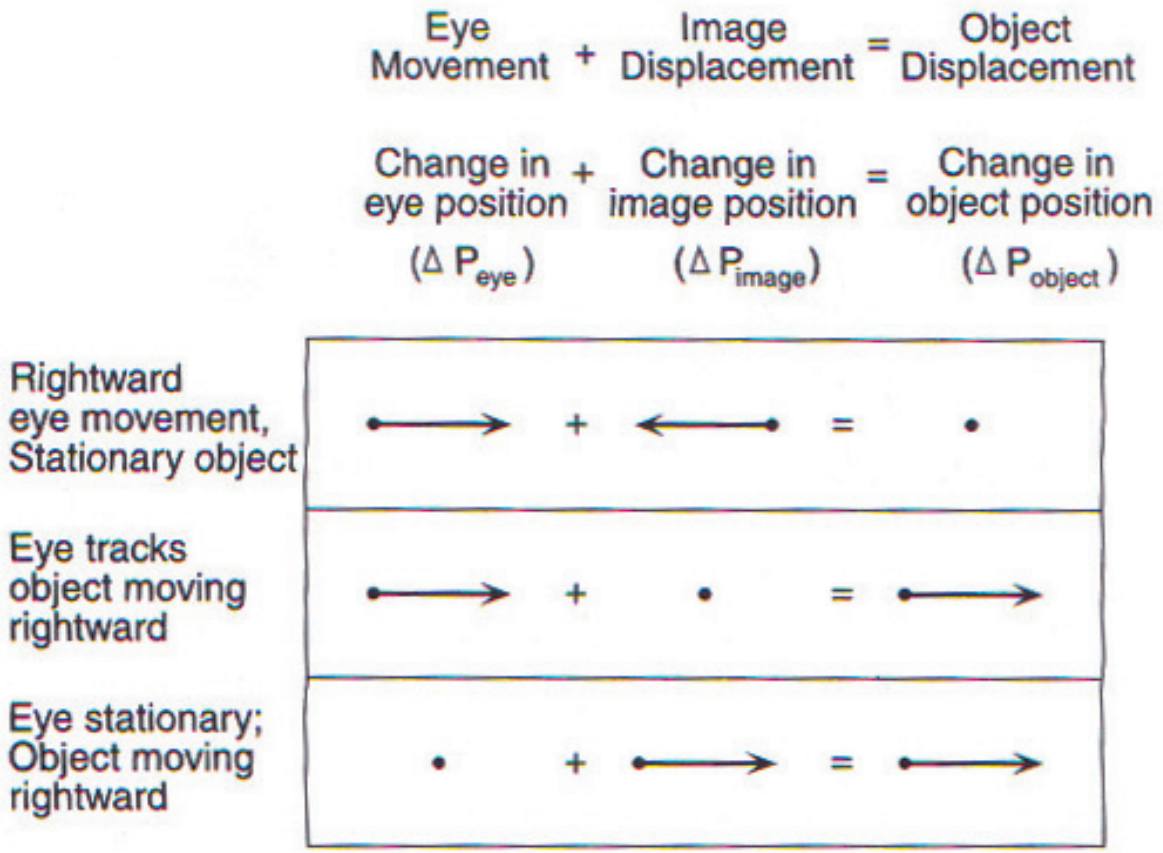
Position Constancy

A change in the position relative to its previous position

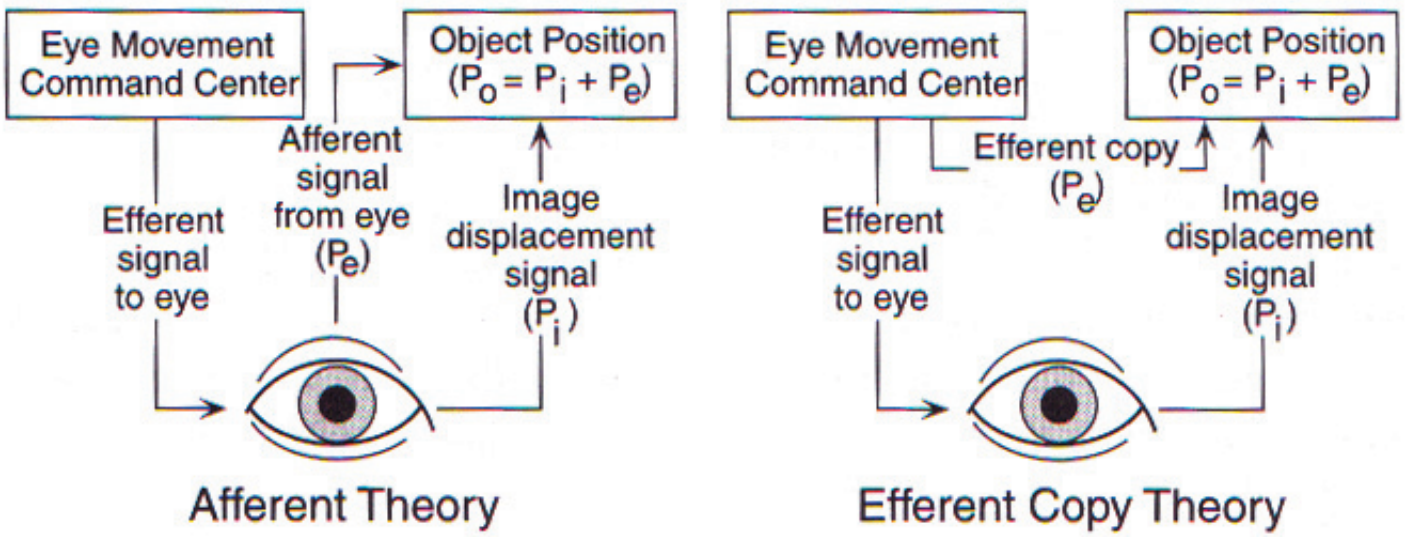
- ΔP_{object} - the change in environment direction of an object
- ΔP_{image} - the change in its image position on the retinal
- ΔP_{eye} - the change in direction of the eye

$$\Delta P_{object} = \Delta P_{image} + \Delta P_{eye}$$

Position Constancy



Indirect Theories of Position Constancy

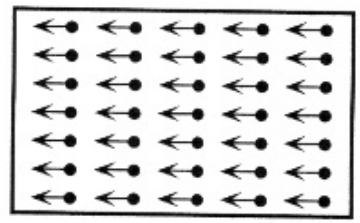


Direct Theories of Position Constancy

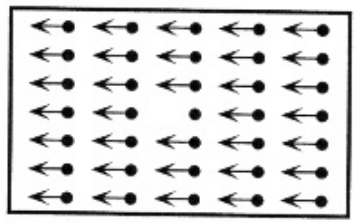
Gibson (1966)

Based entirely on the structure of optical flow

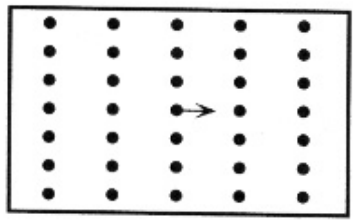
The visual system simply subtracts out any common motion vector in the flow field



A



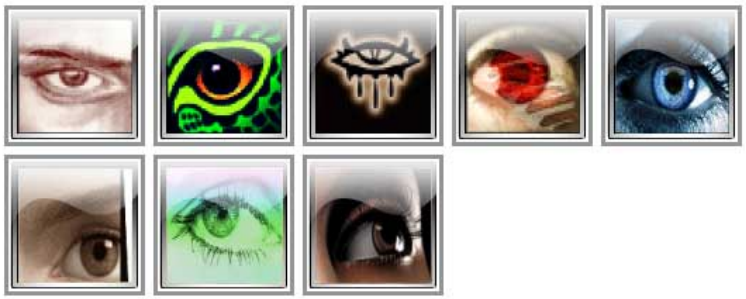
B



C

Position Illusions

Move the eye passively by an external force
The whole environment appear to move



Perceptual Adaptation

- We have roughly accurate perception of object properties such as size, shape, position, and orientation under a wide range of normal viewing conditions
- Computed from corresponding properties of their retinal projections plus a variety of other relevant factors (e.g., distance, head orientation)

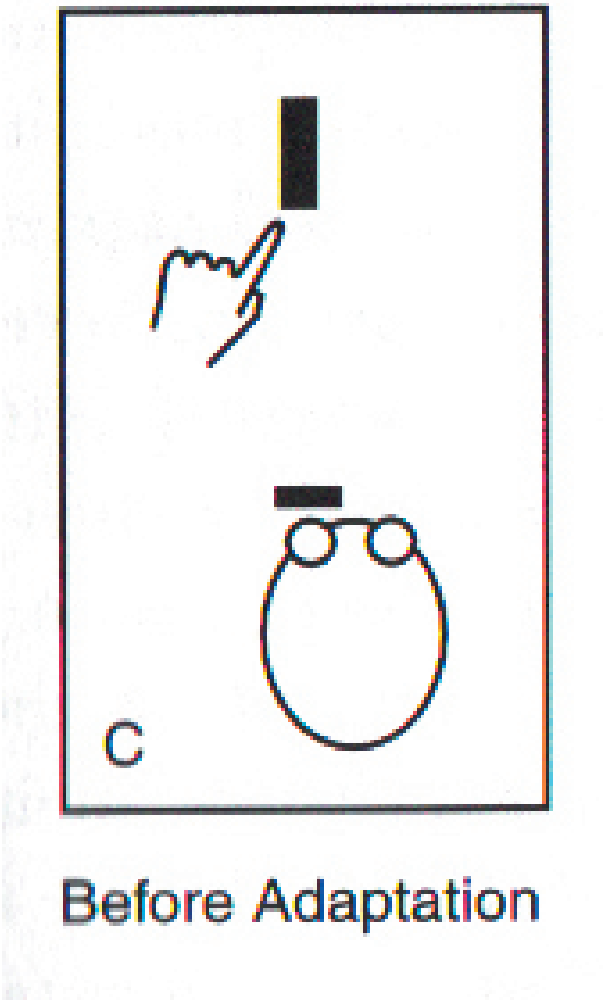
Perceptual Adaptation

Changing in conditions of viewing by optical transformations

- e.g., shifted, inverted, rotated, left-right reversals, enlargements and reductions

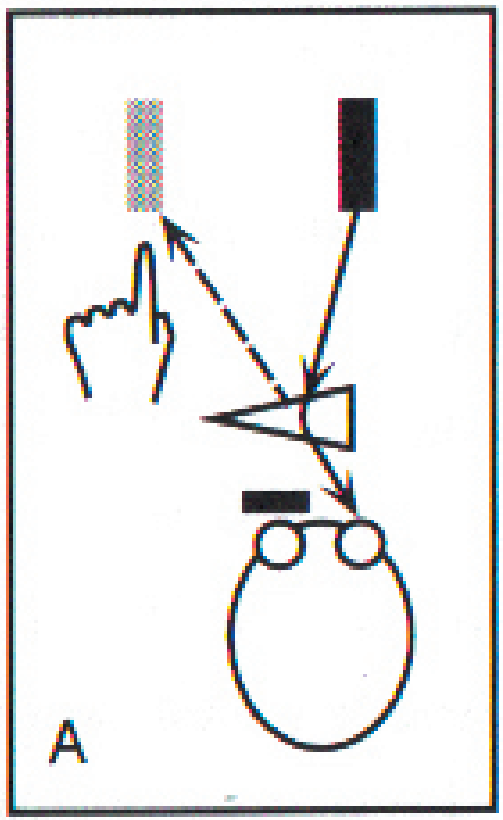
Perceptual Adaptation

Pointing without prism



Perceptual Adaptation

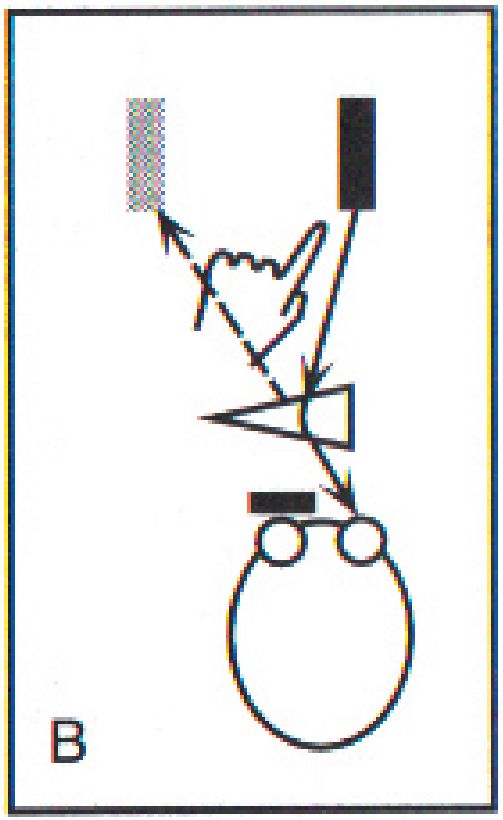
Pointing with prism



Before Adaptation

Perceptual Adaptation

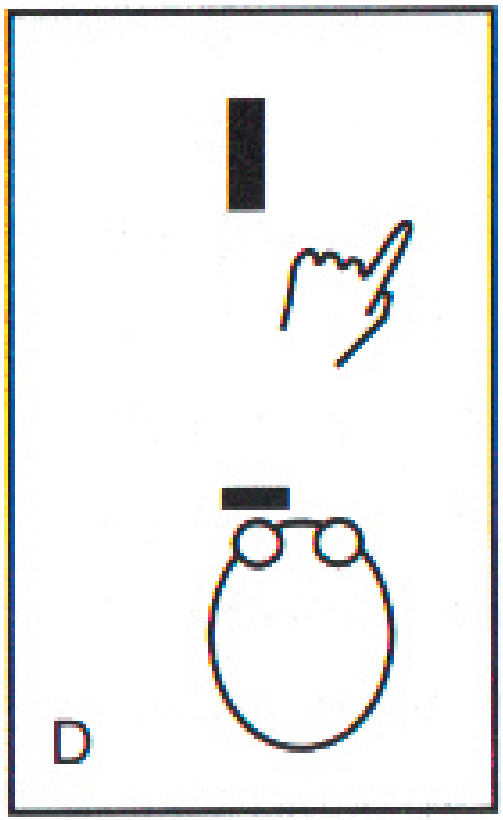
Pointing with prism



After Adaptation

Perceptual Adaptation

Pointing without prism



After Adaptation

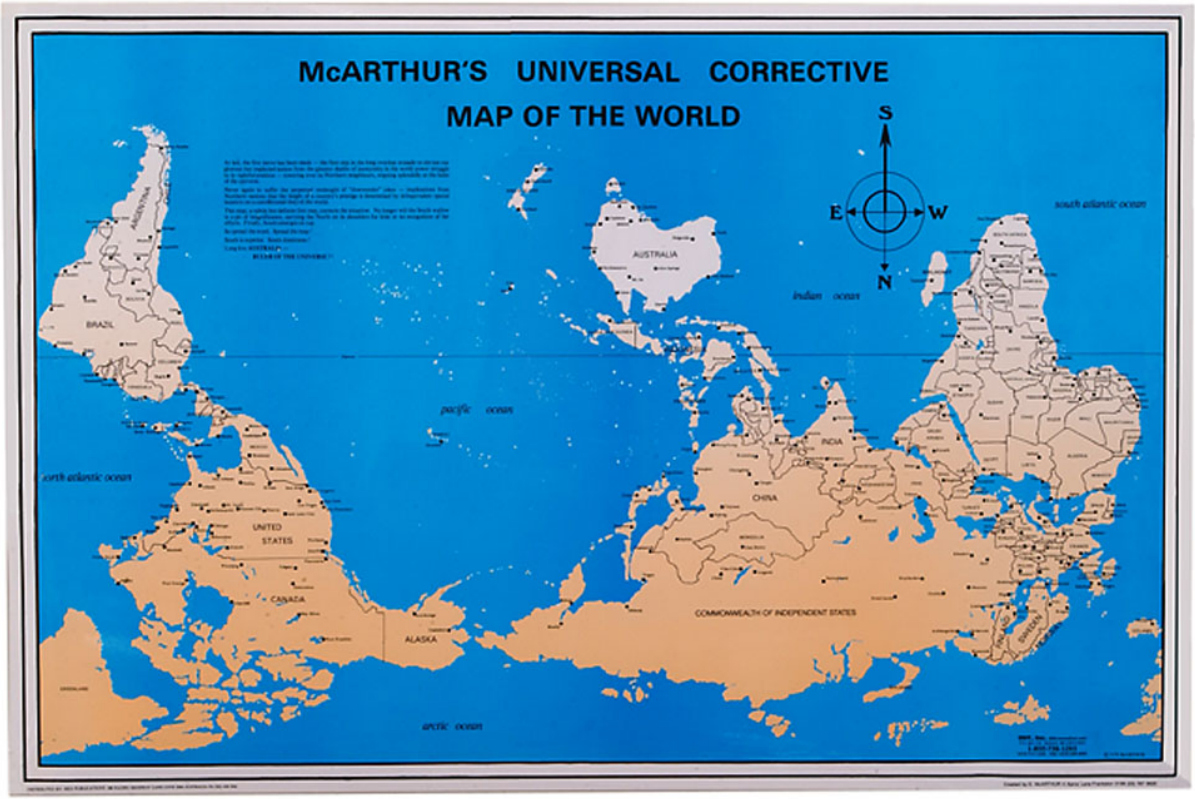
Perceptual Adaptation

Prism shifted the image of the visible world to the side

- Miss object by the prism's angle of displacement
- Caused by discrepency between visually perceived position and actual position
- Practice reaching objects reduce in motor error
- Negative aftereffect

Perceptual Adaptation

What would the world look like if retinal images were somehow transformed so that they were not inverted?



Perceptual Adaptation

Viewing the world through a prism that uninverted the retinal image

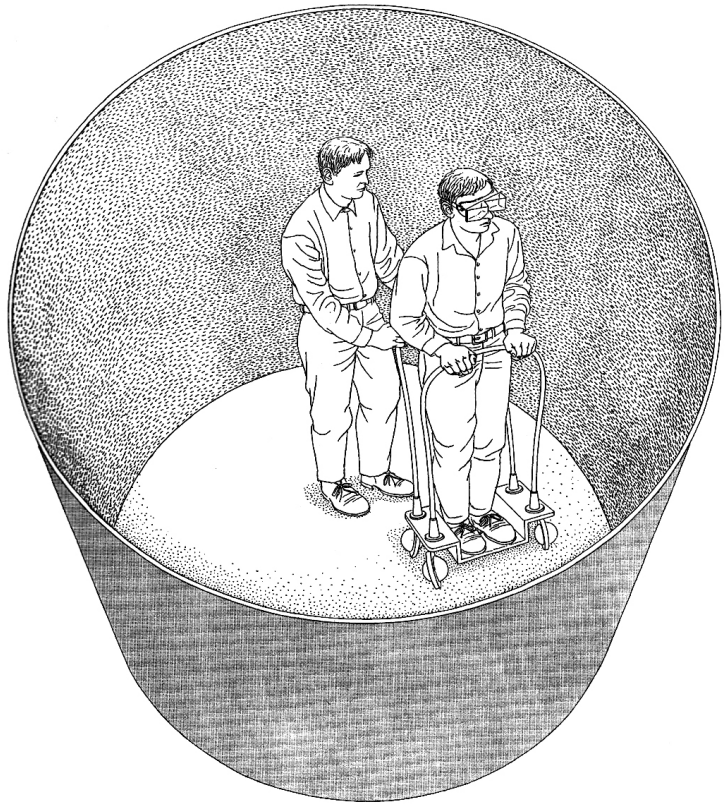
Perceptual Adaptation

Effects of uninverting the retinal image

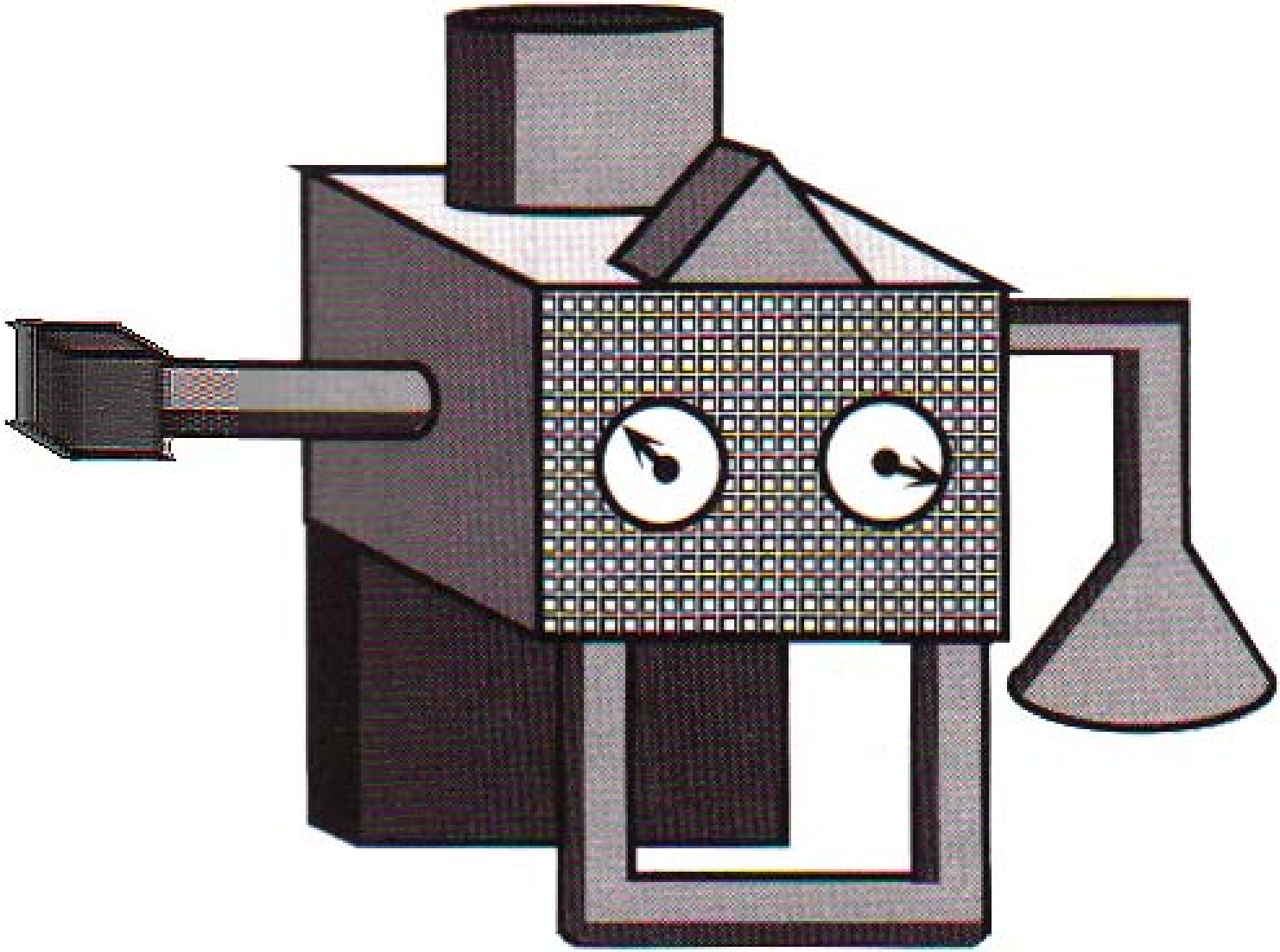
- Initially the world looked completely upside-down
- Severe difficulties at first
- Several days, able to do daily activities
- No negative aftereffect

Adaptation in active versus passive observers

- Actively walked versus passively on a wheel cart
- Active observers adapted more fully transforming effects
- Controlling play important role in adaptation

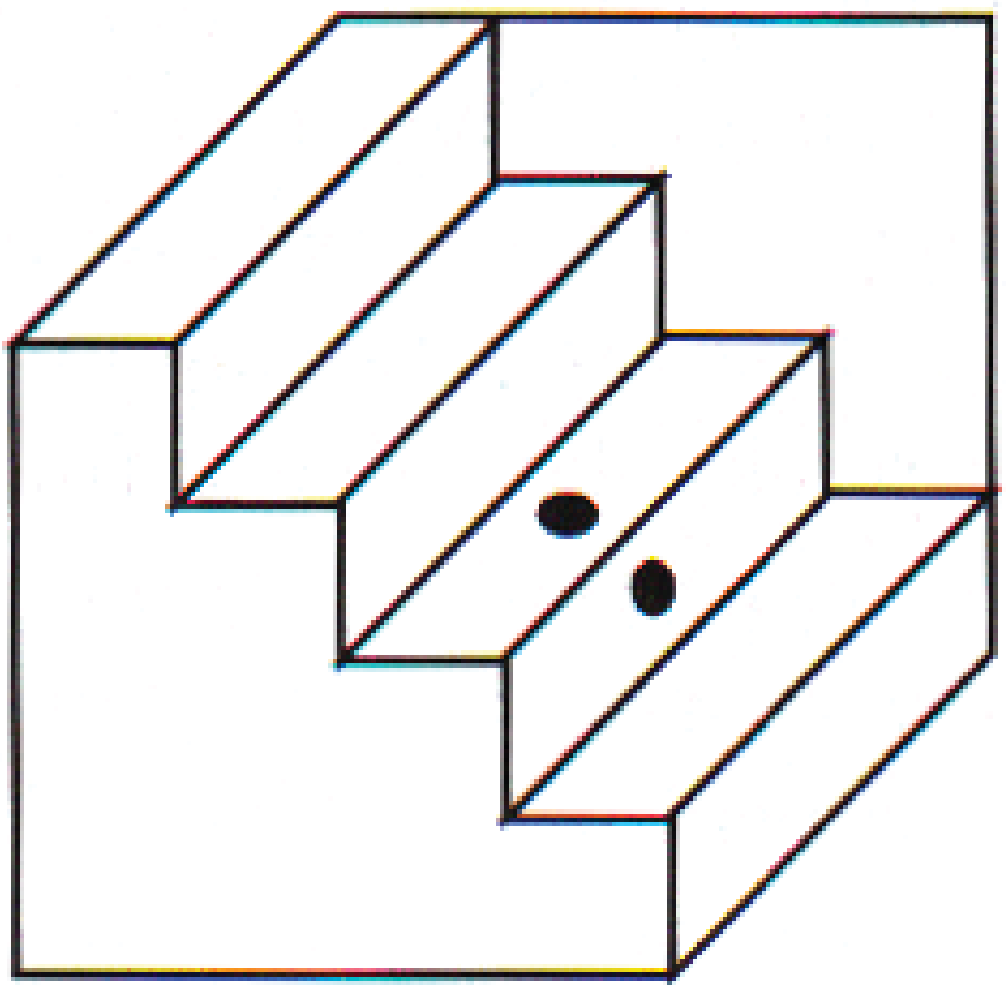


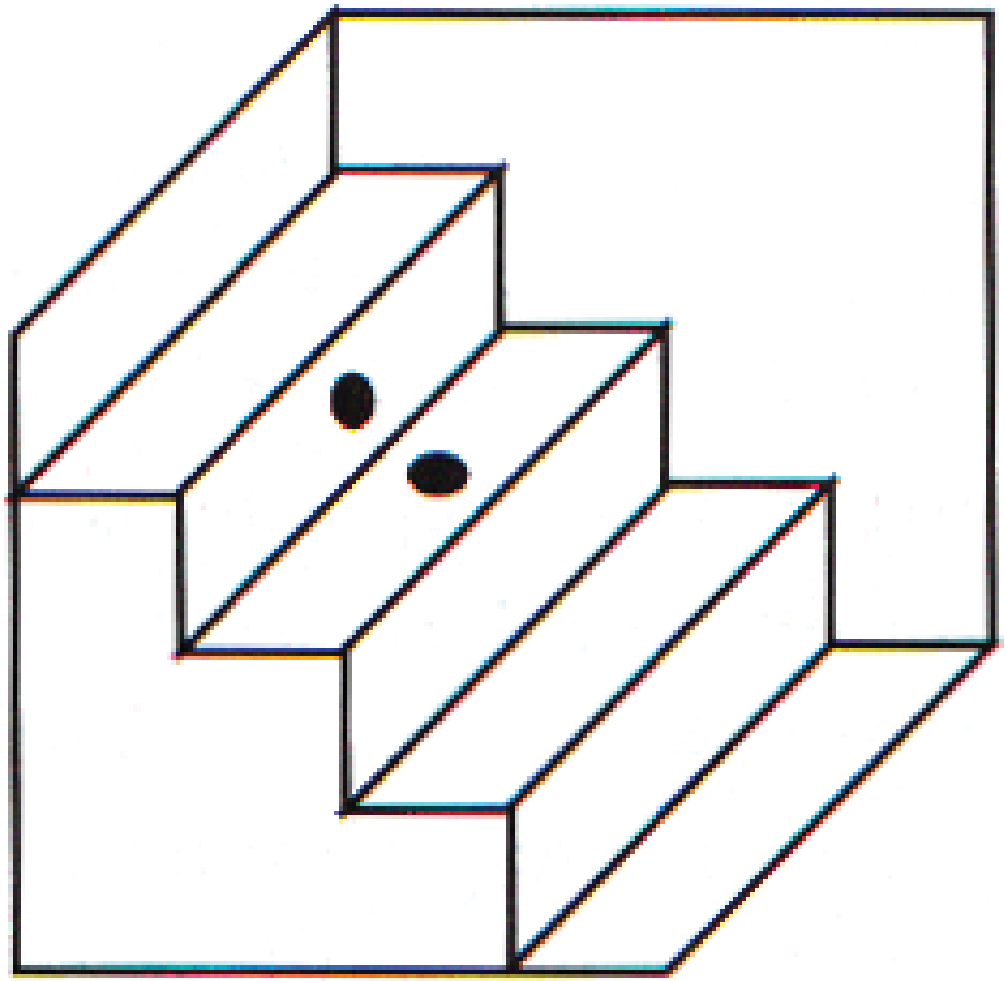
Parts



Parts

- We perceive size, shape, orientation and parts
- Linguistic evidence
- Phenomenological evidence





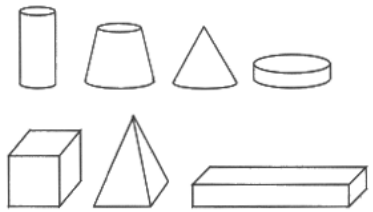
Parsing

How does visual system determine what the parts are?

- shape primitive
- boundary rules

Shape Primitives

Define atomic shapes



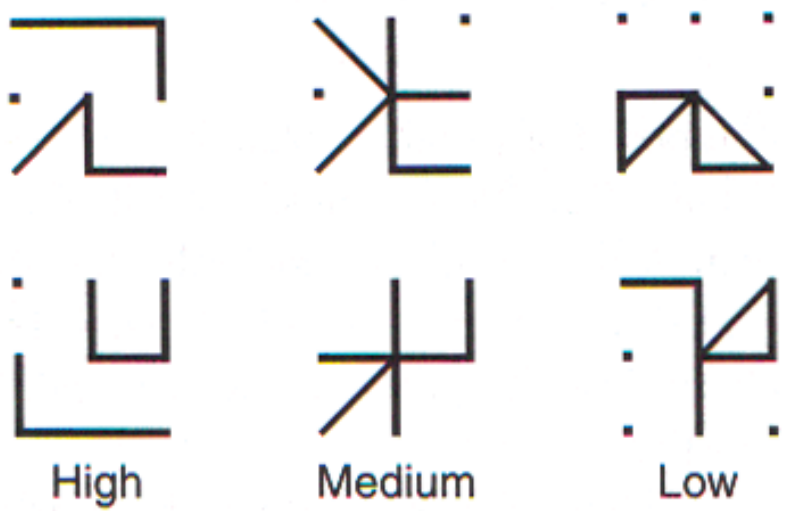
A

B

e.g. Generalized cylinders

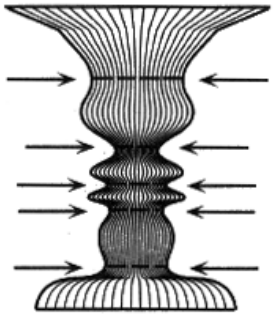
Problems

1. contextual effect
2. part/whole hierarchy



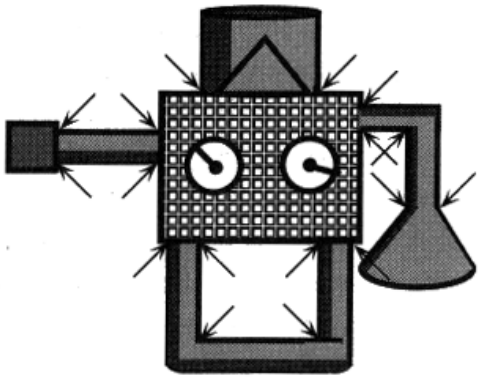
Boundary Rules

Define general rules about boundaries between parts



A

- maximal concavities
- concave discontinuities

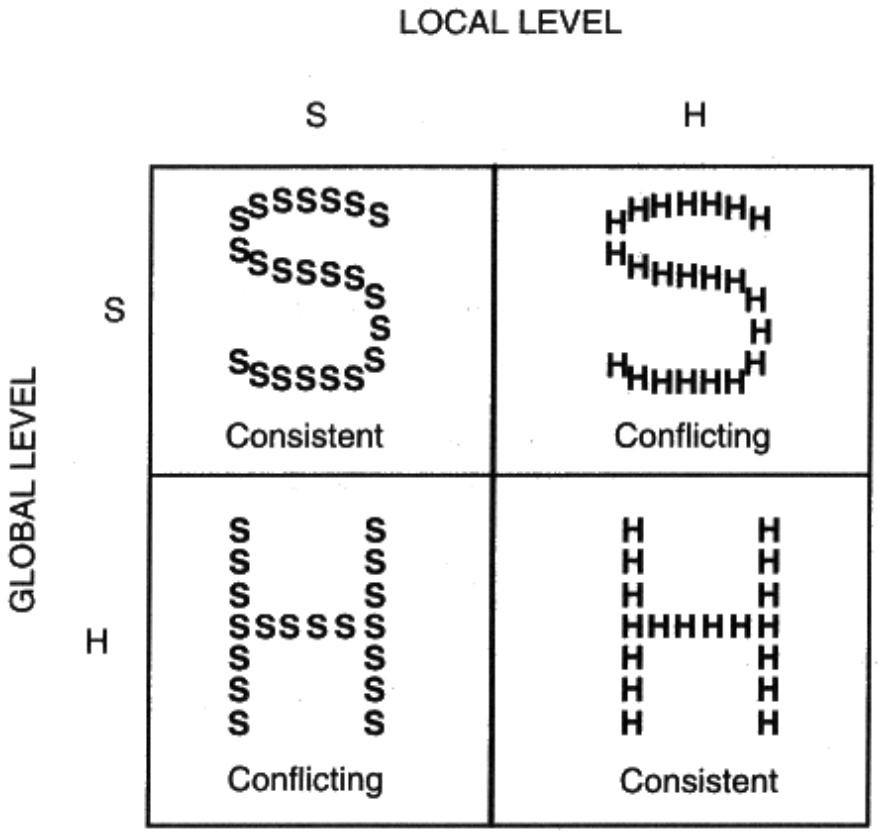


B

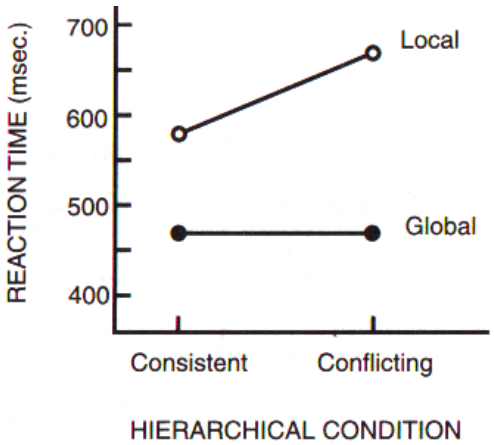
Global & Local Processing

What comes first, Whole or Parts?

Global objects Procede Local parts

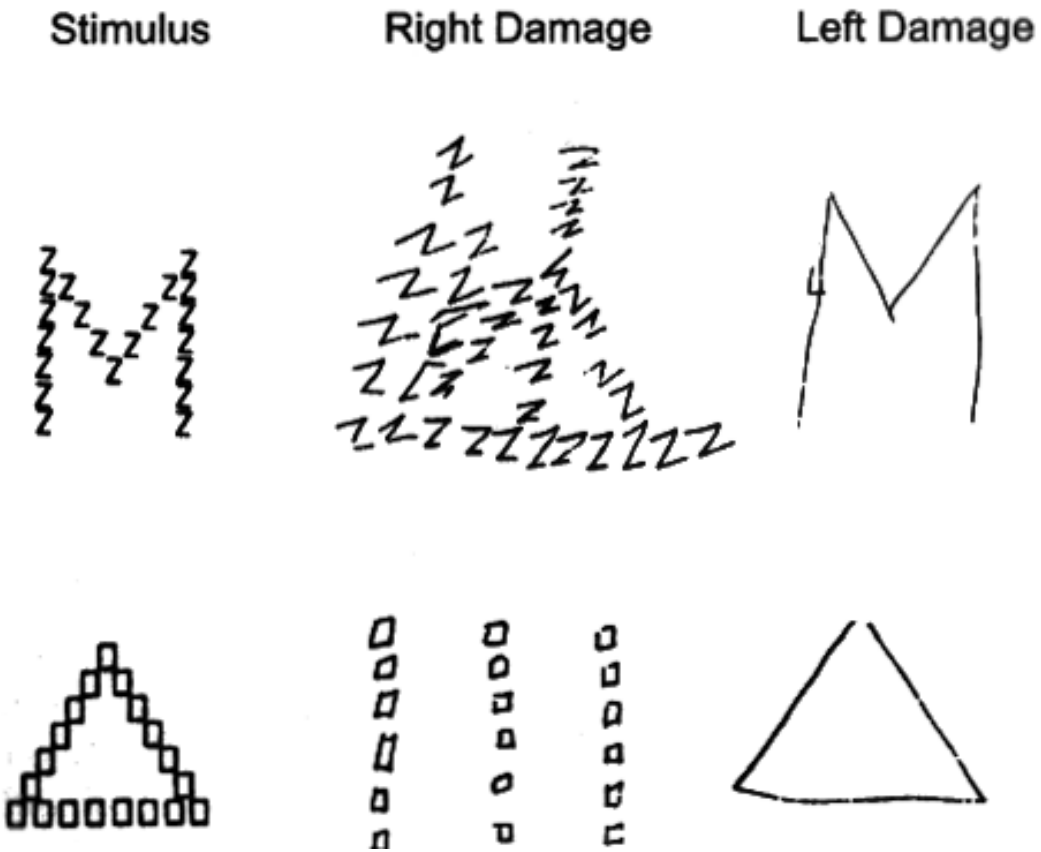


Results

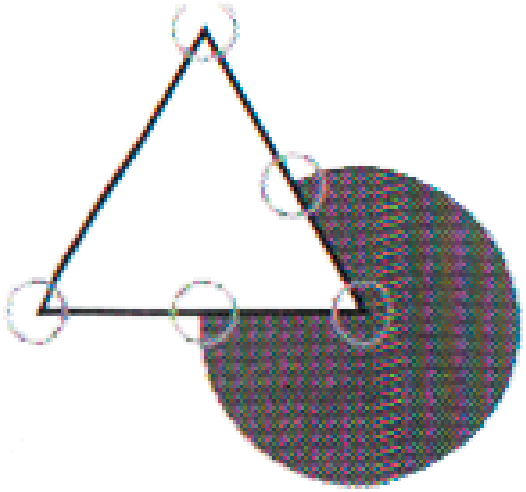


1. Global precedence
2. Global-to-local interference
3. Lack of local-to-global interference

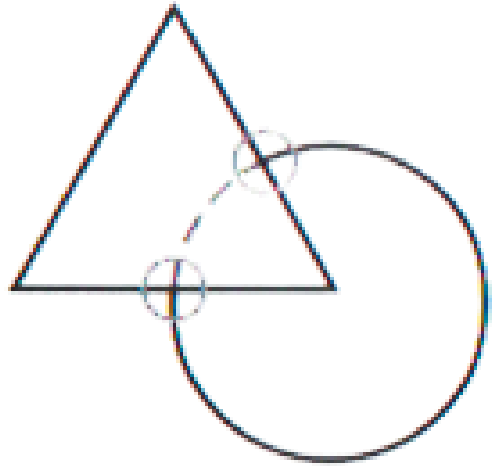
Processing of Global/Local information



End



A



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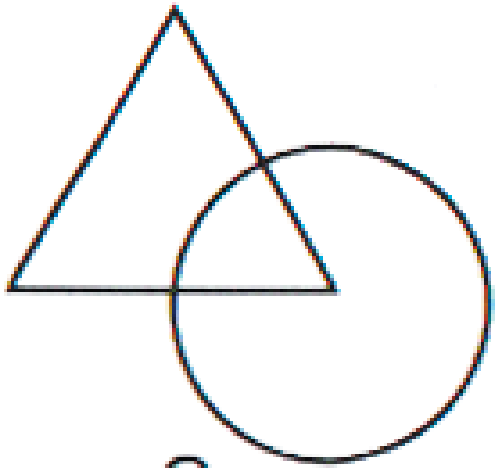

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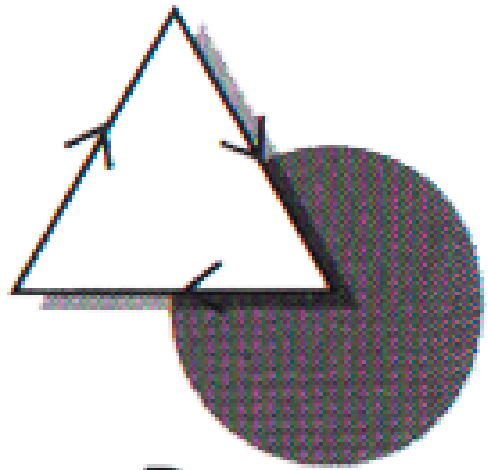
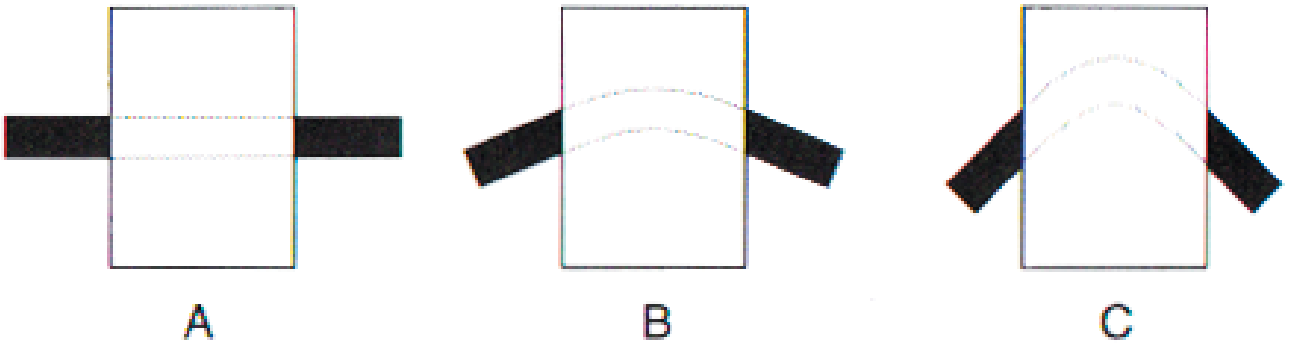
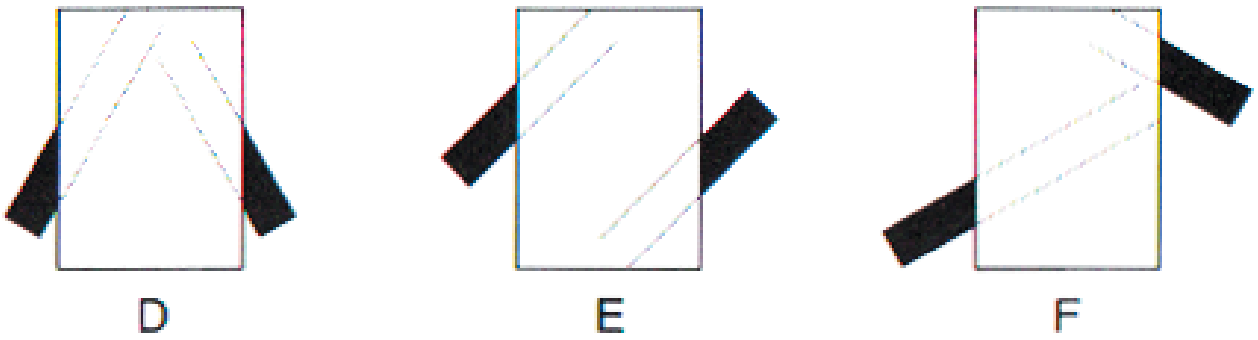


D



Relatable Edges



Unrelatable Edges