Pattern Recognition

Intro Psychology
Georgia Tech
Instructor: Dr. Bruce Walker

Today

- Turning features into “things”
- Patterns
- Constancy
- Depth
- Illusions

Introduction

- We have focused on the detection of features (points of light, edges, lines, colors)
- Now consider some slightly more sophisticated shapes
- What aspects of the visual system allow us to extract shapes?

Perceptual processing

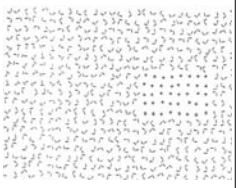
- Bottom-up vs./and top-down processes
- Attention
  - Focus processing detail in an “area”
  - Can be disk-shaped (a region) or even ring-shaped
  - Allows detailed extraction of features in a smaller region
  - Attention both selects and suppresses environmental stimulation

Feature Integration Theory (FIT)

- Describes processing of visual stimuli into information
- Two-stage process:
  1. Preattentive stage
  2. Focused attention stage

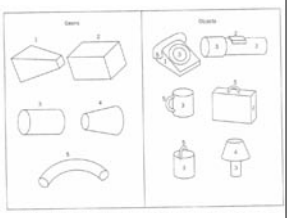
Feature Integration Theory, cont’d

- Preattentive stage (before attending)
  - Bottom-up, automatic
  - Extracts perceptual primitives
  - Parallel processing of all elements of a display
  - Leads to detection of textures, shapes, and objects
  - Textons
    - Specific 2D characteristics of a texture



Feature Integration Theory, cont'd

- Geons
  - 2D or 3D primitives that combine to make up object shapes
  - combination of geons leads to recognition & distinction of objects
  - more geons leads to…



Feature Integration Theory, cont'd

- Focused attention stage
  - Not instantaneous
  - Requires effort and conscious scrutiny
  - Often requires serial search to examine all elements of a display
  - Allows you to group (and separate) the immediate results of the preattentive stage
  - Use expectancies and knowledge to put the primitives together

Figure Versus Ground

- What is "figure"? "ground"? (tough question!)
- Figure = the attended object,
  - Relies on object perception (?)
  - Clear edges define the figure's shape (?)
  - Surrounded
  - Closed
  - Closer to the viewer (?)
- Ground = everything else
  - Fuzzy; indistinct
  - Behind the attended object

Figure-Ground Ambiguities

- Can arise when "figure" and "ground" properties are not clear or distinct
- Use more top-down processing in ambiguous situations
  - Why?
  - (see next slide)

Figure-Ground Ambiguities

Figure-Ground Ambiguities

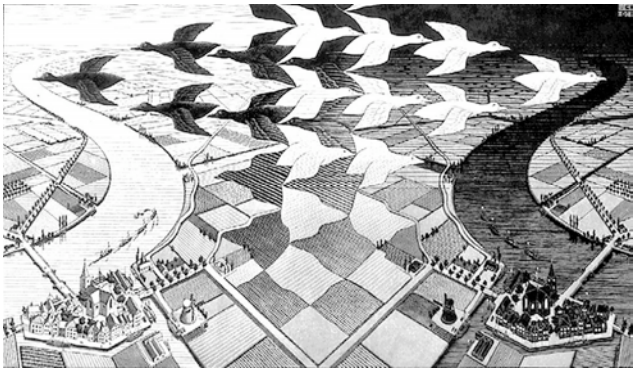
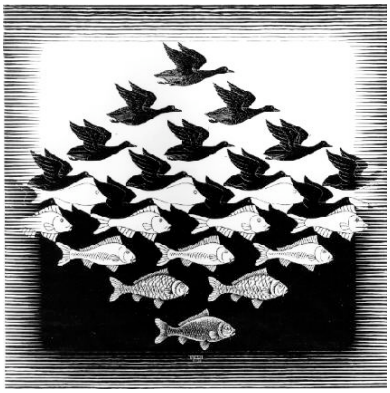


Figure-Ground Ambiguities



Evidence and Support

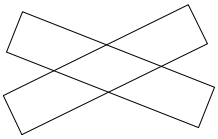
- Biophysical, neurological, neurophysiological support
  - Insects distinguish figure/ground (?)
  - Primate neurons exist that respond more to elements in the figure than the background
- Other modalities
  - Tactile figure/ground
  - Auditory figure/ground
    - Streams as figure

Gestalt Grouping Principles

- Proximity
- Similarity
- Uniform Connectedness/Common region
- Good continuation/Continuity
- Common fate
- Simplicity
- Closure

Measuring Grouping Effects

- Grouping affects perception of distance
  - What about color, texture, etc.
    - i.e., grouped items more homogeneous?
- "Goodness"
  - Inversely proportional to the amount of information needed to define a figure
  - A more "good" figure: Easier to define an organization, compared to alternatives



Subjective Contours

- We try to "impose" or construe figure and shape
  - Helps us parse out objects
  - Top down and bottom up
- Can happen even when there are few explicit cues to the figure/ground relationship
- No real explanation for all cases

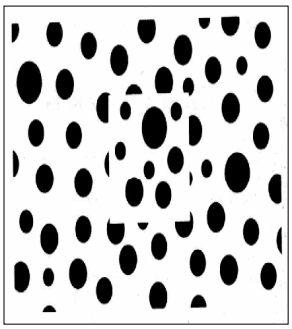
Complex Figures

- Texture
- Closure
- Illusory contours

figure 7.2 A central square is typically perceived, yet a design composed of diagonal lines at right angles may be seen as an alternative figure–ground organization (see Lawson et al., 1977).

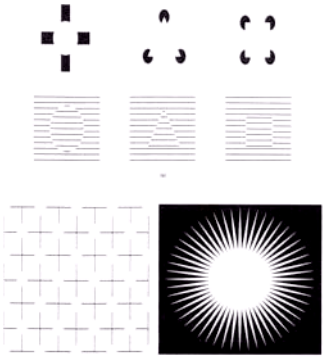
Kanizsa Squares

- Illusory contours
- Closure



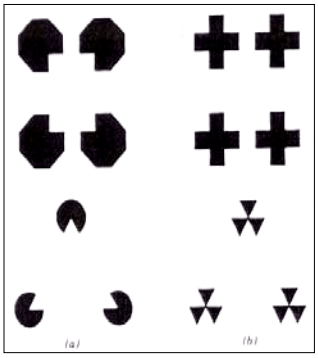
Kanizsa Squares

- Illusory contours
- Closure
- Texture



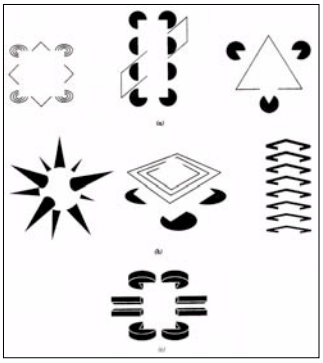
Kanizsa Squares

- Illusory contours are context specific
- Subjective contours disappear when cues indicate separate objects



Illusory Contours

- 3D effects provided by additional cues
- Perspective cues activate binocular percepts



Behavioral/Psychophysical Evidence

- Behavioral-subjective rating: Ss were more likely to group elements by proximity than similarity
- Psychophysical: RTs measured when Ss report horizontal or vertical organization of elements. Ss respond faster to stimuli grouped by proximity rather than similarity
- Evidence that proximal elements are perceived faster than elements grouped by similarity
- Inference: early selection for proximal stimuli?

Neural Substrates for Perceptual Grouping

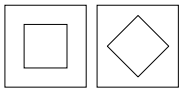
- Agnosias
  - Specific types of groupings can be selectively impaired
  - Evidence of neural substrate/pathway
- ERP evidence for early selection of proximally grouped stimuli, compared to elements grouped by similarity
  - P1 latencies earlier for proximity
  - Enhanced N2 amplitudes in R parietal cortex for proximity

Role of Experience on Grouping

- Percept of continuity over proximity given prior experience
  - i.e., prior learning/training reverses the dominant grouping percept from proximity to continuity of form
- Prior experience modifies perception in a top-down fashion, causing facilitation of less dominant modes of neural pattern coding

Situational Effects

- Orientation of Figure/Ground
  - Perception favors parsimony



- Perceptual "Set"
  - Priming, expectancies
  - Info not in the stimulus target influences our perception and grouping
- Take home message: Both bottom up and top-down processing are active.

Depth Perception

- Cue Theory
- Monocular Cues
- Binocular Cues
- Neural Basis
- Interaction of Cues

Cue Theory

- We learn to associate a cue (or retinal or image element) with our experience of depth in the environment
- Types of cues:
  - Oculomotor
  - Monocular
  - Binocular

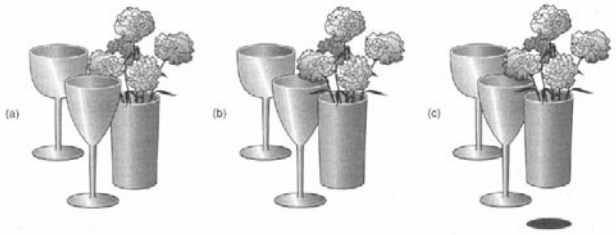
Oculomotor Depth Cues

- Convergence
  - Inward movement of the eyes
  - Required to keep image on fovea
  - Muscular (afferent) signal cues distance
  - More convergence = closer object
- Accommodation
  - Change in shape of the lens
  - Required to keep objects at different distances in focus
  - Afferent signal

Monocular Depth Cues

- Using information provided by only one eye (or at least not requiring two eyes) leads to many reliable depth cues
- Some are mechanical/muscular/bottom up
- Some require top-down processing
- Learning plays a major role in all depth cues

Occlusion



Occlusion

Relative Vertical Position

- Location in a frame
- Higher is usually farther

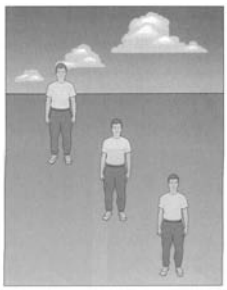
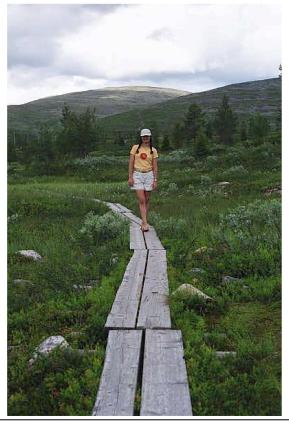


Figure 7.4
Relative height. Other things being equal, objects below the horizon that appear higher in the field of view are seen as being farther away. Objects above the horizon that appear lower in the field of view are seen as being farther away.

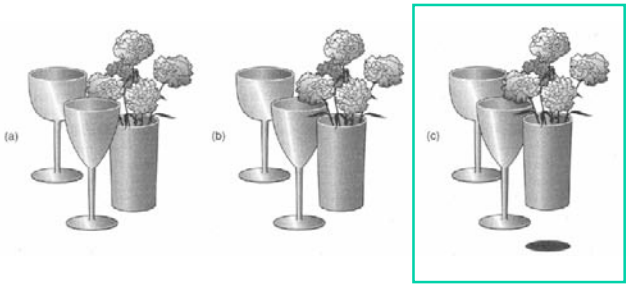
Relative Vertical Position

Relative Vertical Position

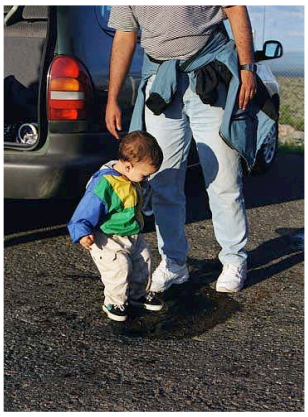


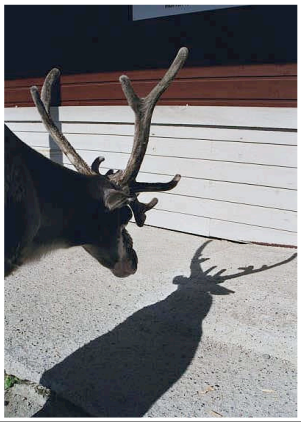
Shadows

- Where an object casts a shadow can determine its distance (and height)



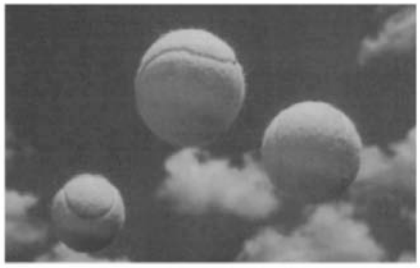
Shadows





Relative Size

- Smaller retinal image for same size object means the object is farther away



Relative Size

Various Depth Cues

Familiar (Template) Size

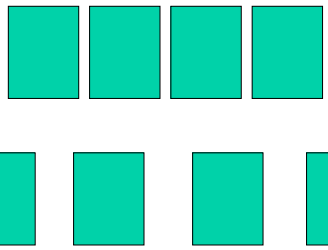
- Knowledge of actual size differences can

Atmospheric Perspective

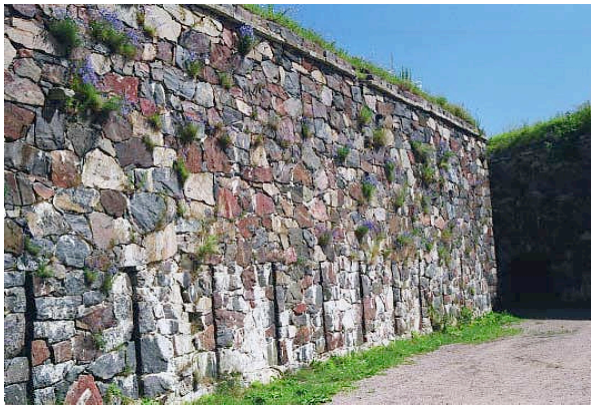
- Distant objects appear blurry, and also more blue, due to Rayleigh scattering

Texture Gradient

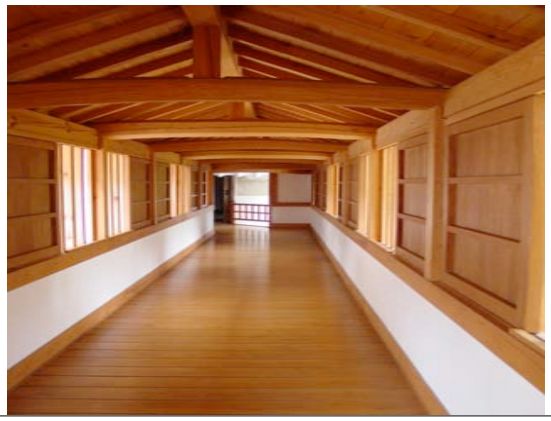
- Evenly spaced items appear more closely packed in the distance



Texture Gradient



Texture Gradient



Various Depth Cues

Highlight Cues

- Areas of light (or dark) signal depth of objects
- Similar to shadows cueing interposition

Highlight Cues

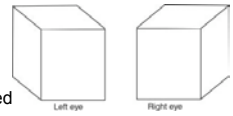
Deletion/Accretion (Occlusion)

- Objects that appear and take the place of objects previously in the scene must be moving in front of the original objects

Deletion/Accretion (Occlusion)

Binocular Cues

- Convergence of eyes
  - Both oculomotor and retinal cues come from convergence
- Binocular disparity
  - Difference in the image seen in the left and right eye
  - A retinal effect
  - Disparity leads to stereopsis
  - Separation can be done by
    - Physically separate images presented
    - Different colored images
    - Polarization



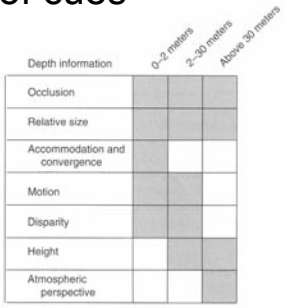
Stereo Vision

Development of Stereopsis

- Binocular input required early in life to develop stereo vision
- Infants whose eyes are not focused on same point (crossed or lazy eyes) may not develop proper stereopsis
  - Even if eye condition is later fixed (surgically)
- Critical period: ~1-3 years
- What does this imply about locus of stereo vision?

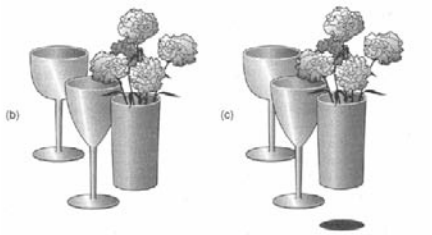
Interaction of cues

- Thoughts…
  - There are lots of cues, both monocular and binocular. How do they interact?
  - How does depth perception develop/evolve?
  - Can one eye work well?



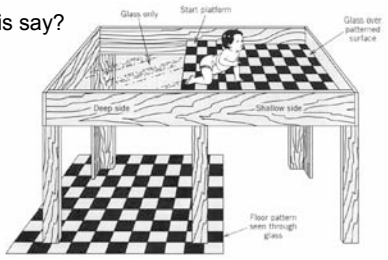
One Cue vs. Another?

- How can we determine if/when one cue will override another?
  - Recall shadow and shading on vase



Visual Cliff

- Test to see which visual cues dominate
  - Parallax seemed to be only dominant cue
  - Note: Monocular cue
    - What does this say?

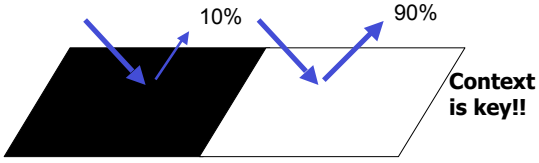


Constancy

- Despite great variations, we perceive the world as largely constant
- Heuristics help us simplify our world
- Constancies are the result of several of these heuristics
- Illusions are often consistencies (or heuristics) gone wrong

Constancy

- Lightness Constancy
  - Lightness of an object appears constant, even in changing lighting
    - e.g. snow in daylight, snow in shadows, still white
    - e.g. coal in the sunshine is still black
  - Albedo
    - *Proportion* of reflected light remains constant



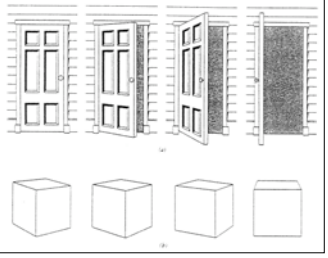
Constancy, cont'd

- Size Constancy
  - Objects of a known size tend to be perceived as unchanged in size when they change distance
    - e.g. people seen from 5 story building
    - Note: "within limits"
  - Emmert's Law

    $Size_{(perceived)} = Size_{(retinal)} \times Distance_{(perceived)}$
  - Limits of size constancy
    - Great distances do not support constancy
    - Not surprising

Constancy, cont'd

- Shape Constancy
  - Object is seen to have the same shape, despite different retinal shapes
    - Other cues provide context (doors, windows, etc.)
  - We tend to see objects and assume depth



Constancy, cont'd

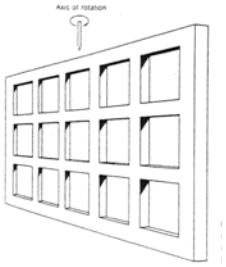
- Summary of Constancy
  - Constancy enables perceptual world to correspond to physical world
  - Helps us survive
  - Under some conditions, these (beneficial) heuristics break down
  - Result is illusions

Illusions

- Visual illusions are often the result of heuristic perceptual processes trying to deal with rare, ambiguous, or contrived stimuli
- Countless illusions (will see just a few)
- Note that experience is often partly to blame for illusory perception
  - "garden path"

Ames Illusions

- Trapezoidal window
  - Assumed rectangularity
  - Actual trapezoidal shape
  - Assume regular object that is rotated, rather than irregular object



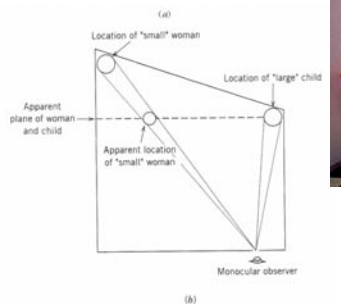
  - Demo

Ames Illusions, cont'd

- Ames room
  - Assume rectilinear room--actually very unusual!

Ames Illusions, cont'd

- Ames room

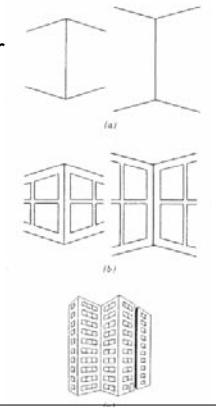


Moon Illusion

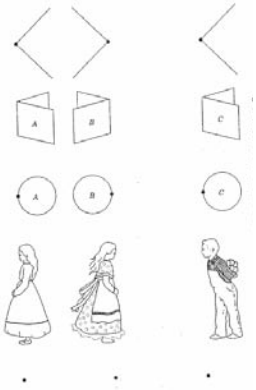
- Moon near horizon appears larger
- Possible explanations
  - Angle of regard
    - Eye position relative to body
    - Not supported by physiology
  - Apparent distance
    - Since perc'd size is proportional to perc'd distance, then if perc'd distance were greater for the horizon moon it would seem larger
    - But… distance paradox
  - Others
    - e.g. "relative size hypothesis"

Muller-Lyer Illusion

- Lines of equal length appear different, depending on tarrow-head context
  - Spatial cues “force” depth interpretation (?)

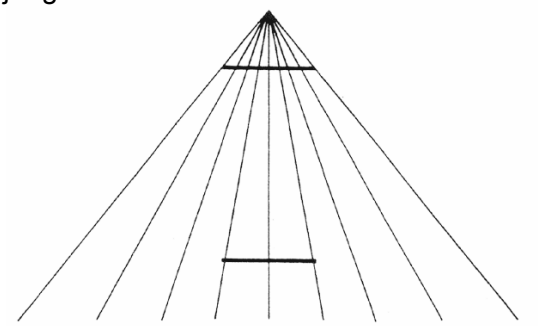


Muller-Lyer Illusion



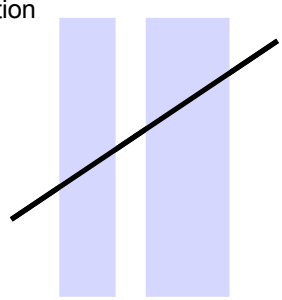
Ponzo Illusion

- Depth cues dominate, cause errors in size judgments



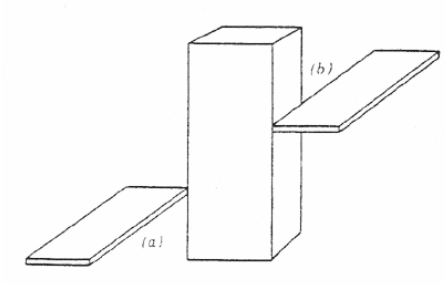
Poggendorff Illusion

- Colinear line segments appear misaligned
  - Perhaps due to assumption about depth of objects
  - Perspective constancy could explain some examples of this illusion (but not all)



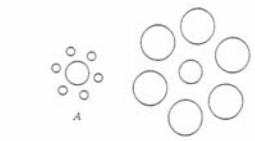
Poggendorff Illusion

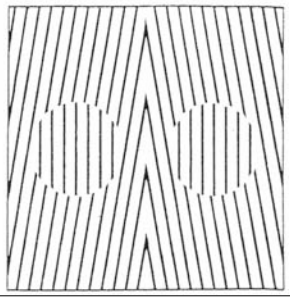
- Context can make it worse (or better)



Contrast Illusions

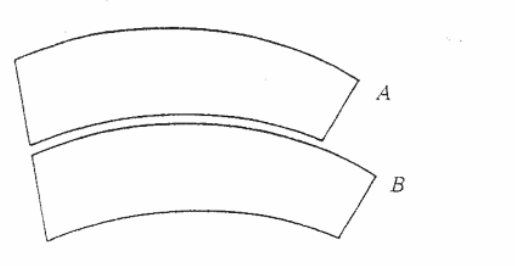
- Surrounding objects (context) affects our judgment of size, alignment, color, etc.



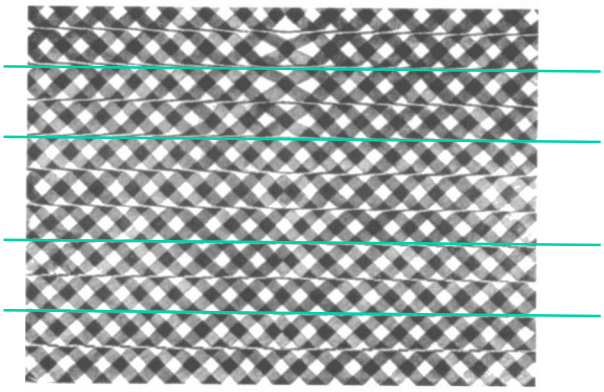


Contrast Illusions

- A variety of examples

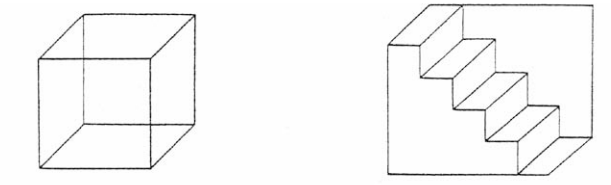


Contrast Illusions



Reversible & Multistable Images

- Some shapes can be seen in multiple orientations
  - Flips may be result of fatigue

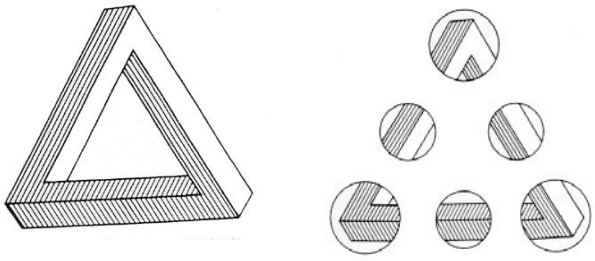


Factors in Illusory Perception

- Optical and retinal factors
  - e.g. subjective curvature
- Cognitive components
  - e.g. learning, experience, expectation

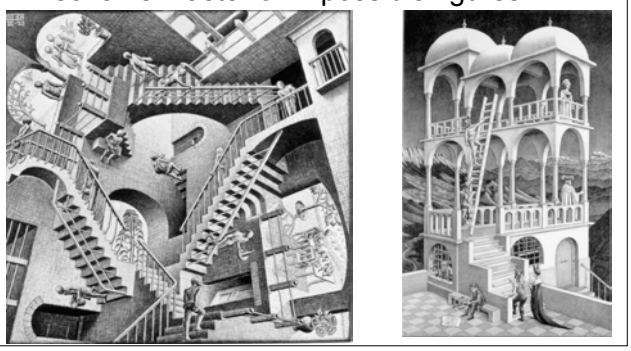
Impossible Figures

- Curious…but not really illusory
  - We accept them when examined locally, but



Impossible Figures

- Escher is master of impossible figures



Summary of Illusions

- No satisfactory single explanation, in general
- Constancy (of various types) and learning, expectation, and experience are all major contributors to illusory perceptions at times

Upcoming

- Memory
- Thoughts and concepts
- Reasoning and decision making