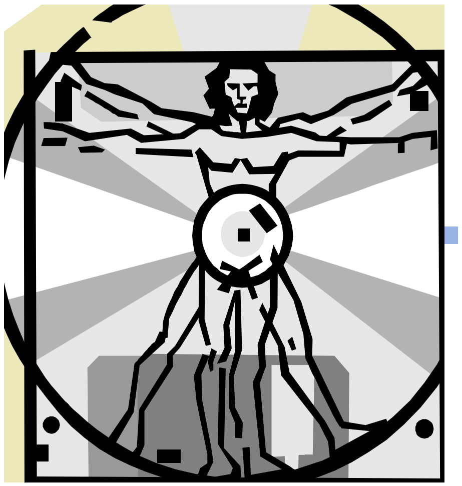


Depth Perception

Deep Blue See

Overview

- 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 Cues

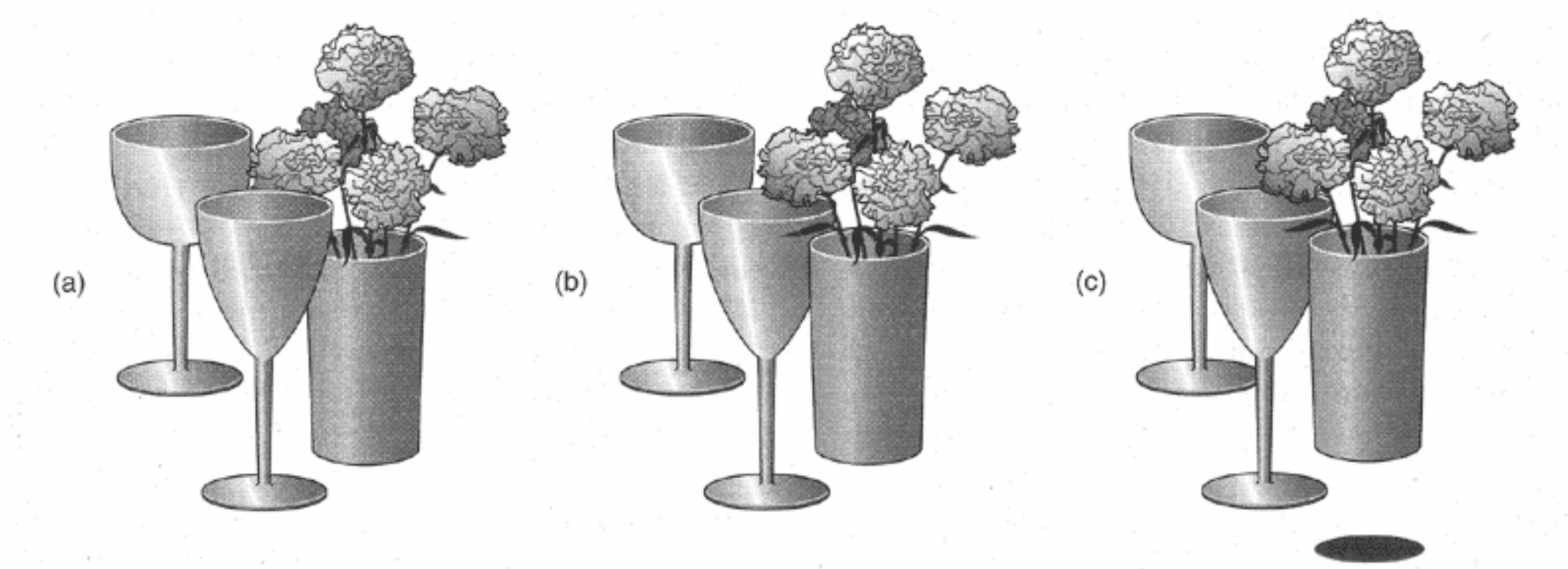
- Convergence
  - Inward movement of the eyes
  - Required to keep image on fovea
  - Muscular (afferent) signal cues distance
  - More convergence = closer object
- Accommodation
  - Change in shape of the lens
  - Required to keep objects at different distances in focus
  - Afferent signal

Monocular 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

- One object hides another, it must be nearer



Occlusion

Occlusion

Occlusion

Relative vertical position

- Location in a frame
- Higher is usually farther

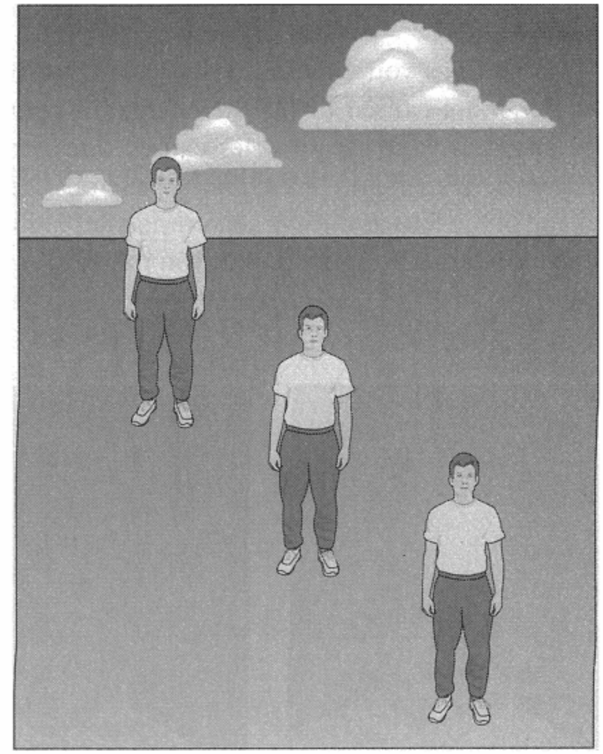


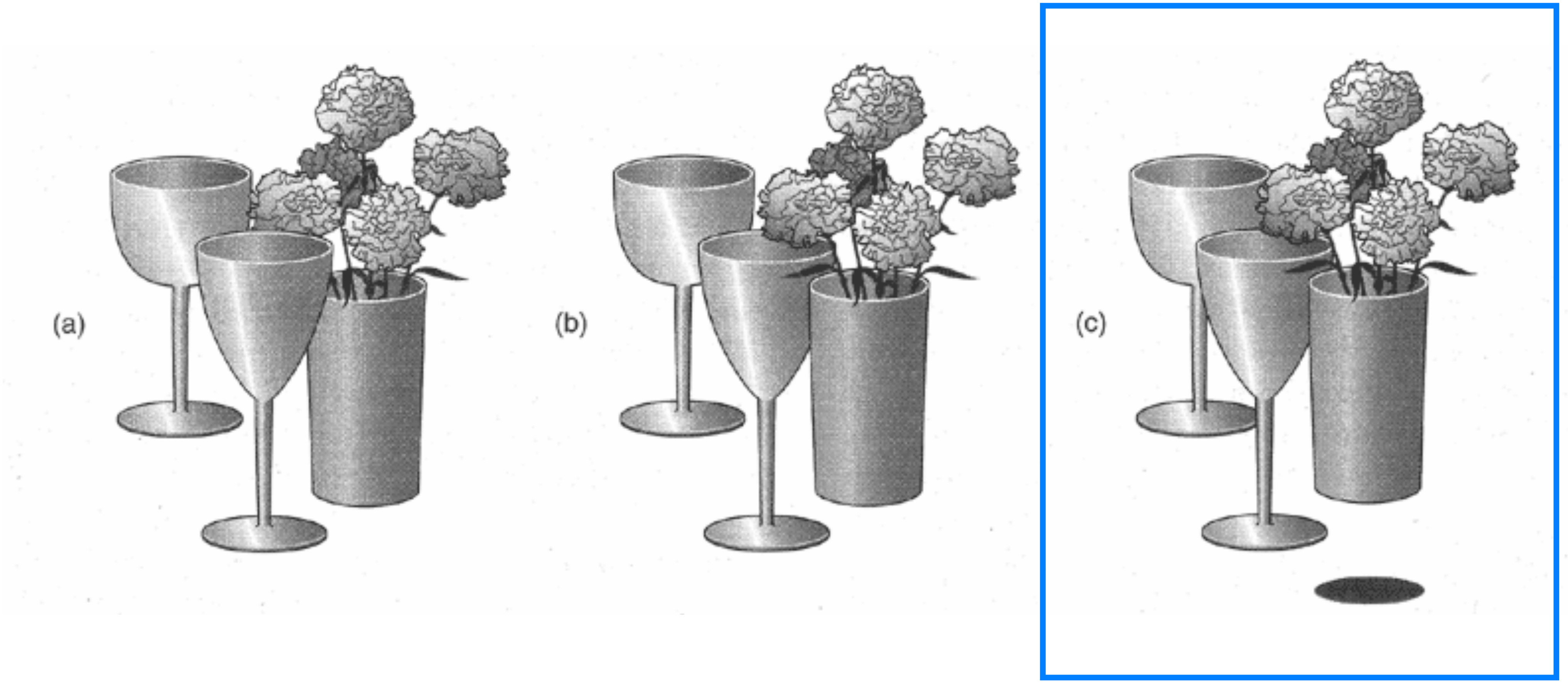
Figure 7.4
Relative height. Other things being equal, objects below the horizon that appear higher in the field of view are seen as being farther away. Objects above the horizon that appear lower in the field of view are seen as being farther away.

Relative vertical position

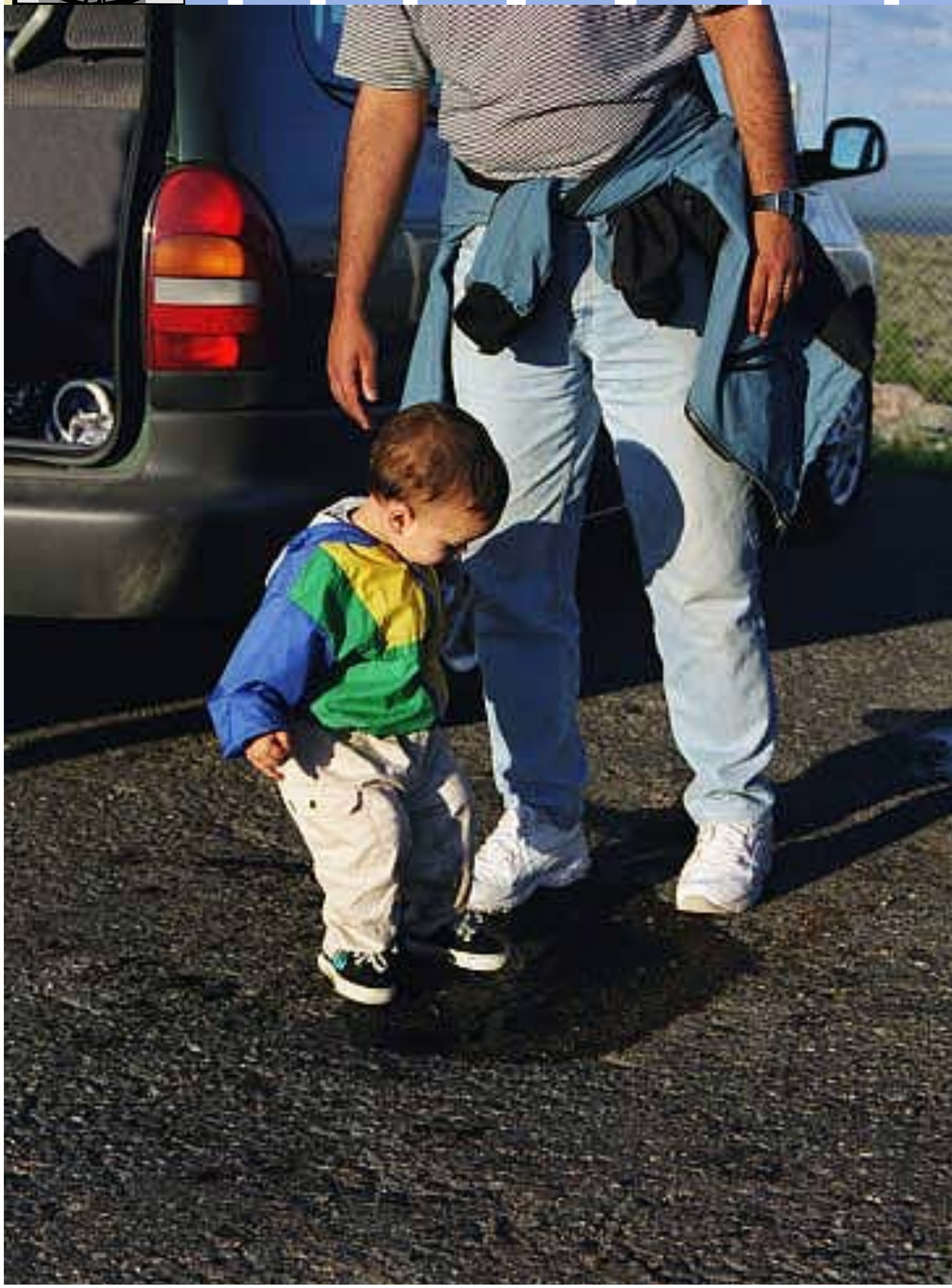
Relative vertical position

Shadows

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

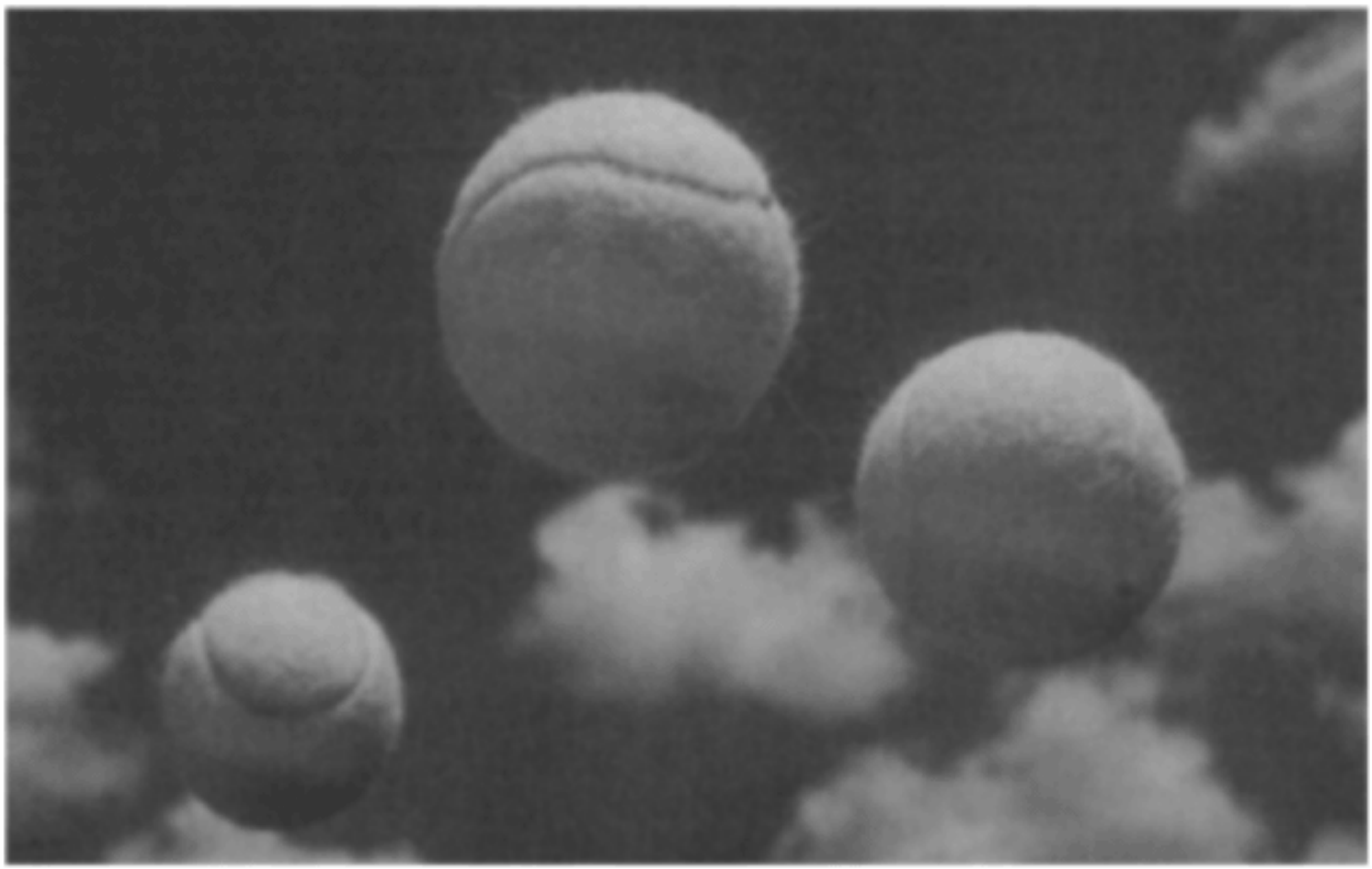


Shadows



Relative size

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



Relative size

Relative size

Familiar (template) size

- Knowledge of actual size differences can affect how we interpret relative distances

Familiar (template) size

Atmospheric perspective

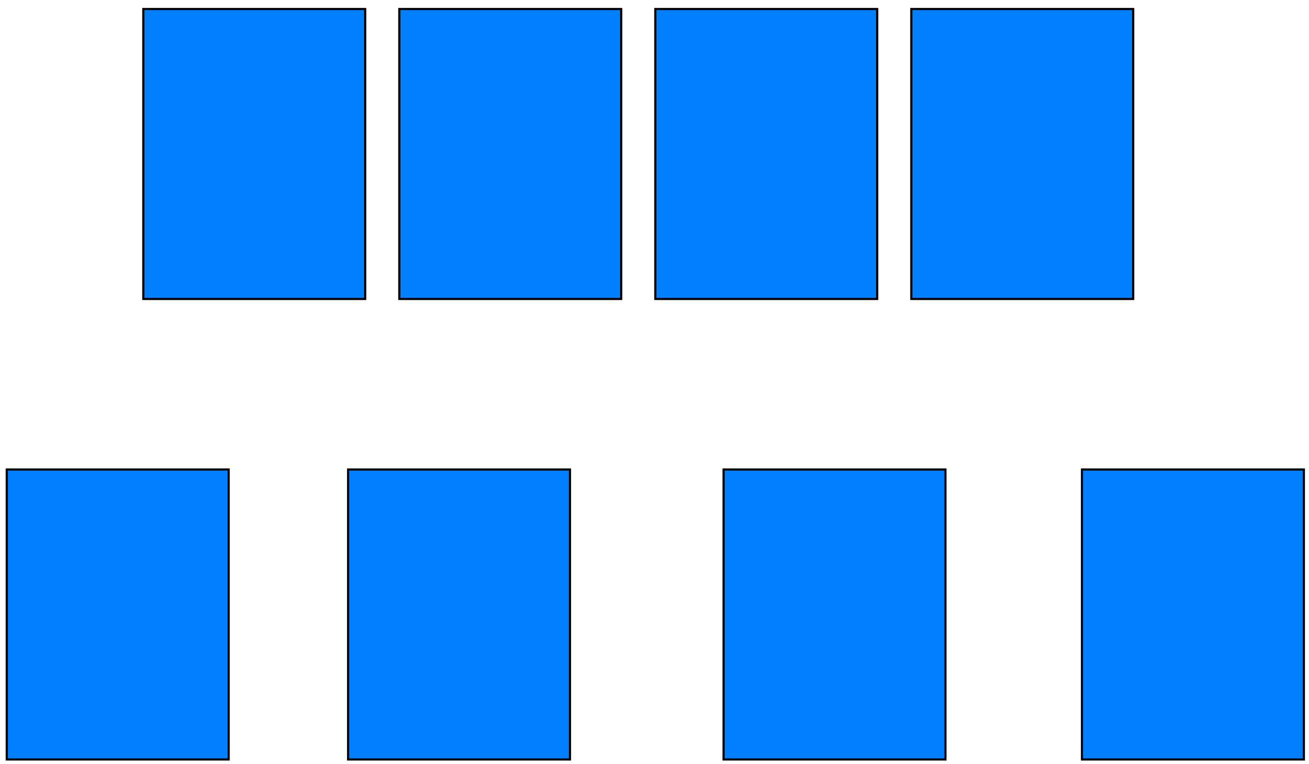
- Distant objects appear blurry, and also more blue, due to Rayleigh scattering

Atmospheric perspective

Atmospheric perspective

Texture gradient

- Evenly spaced items appear more closely packed in the distance



Texture gradient

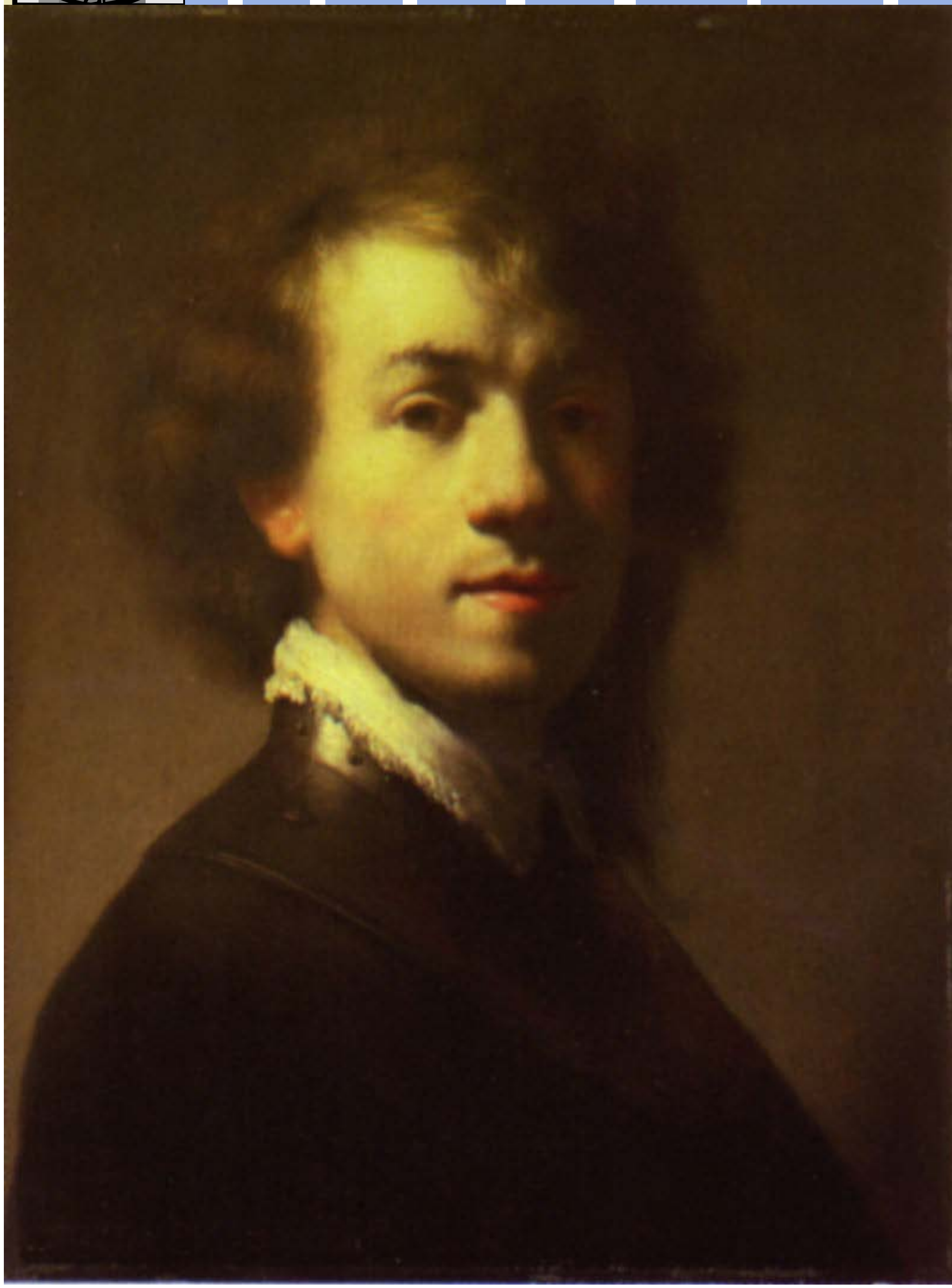
Texture gradient

Gradients and Texture?

Highlight cues

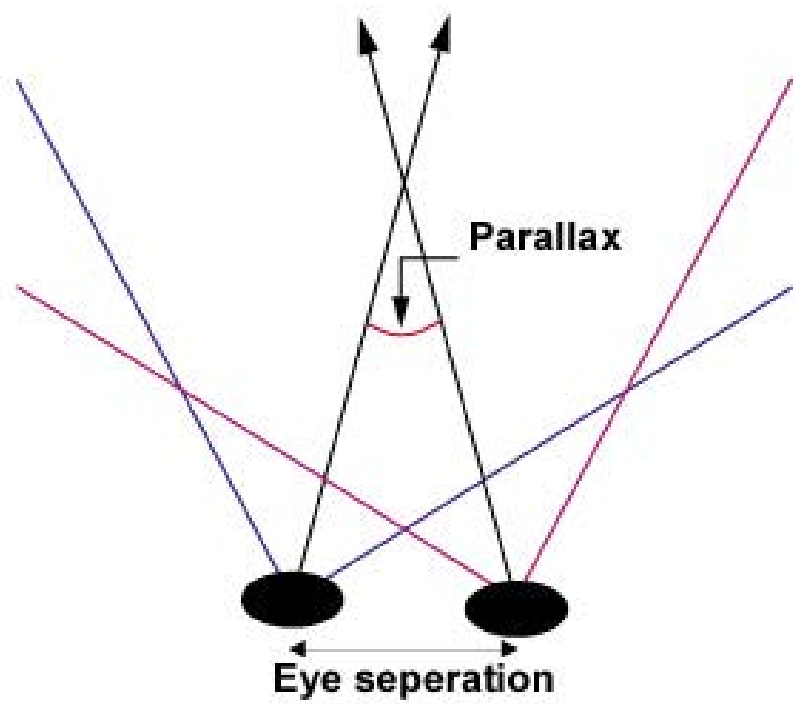
- Areas of light (or dark) signal depth of objects
- Similar to shadows cueing interposition

Highlight cues



Parallax

- Changes in movement speed due to distance
- Closer objects move faster
- Farther objects move slower



Parallax

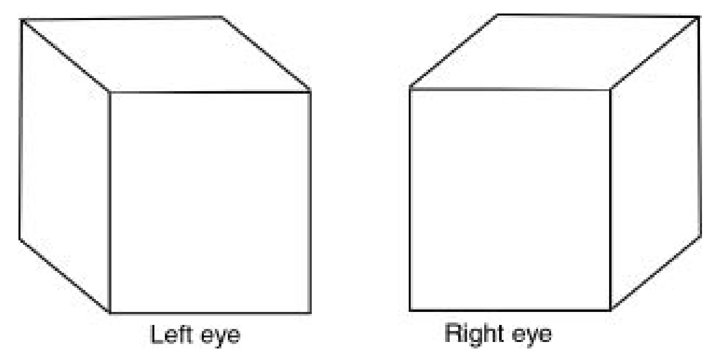
Deletion/accretion (occlusion)

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

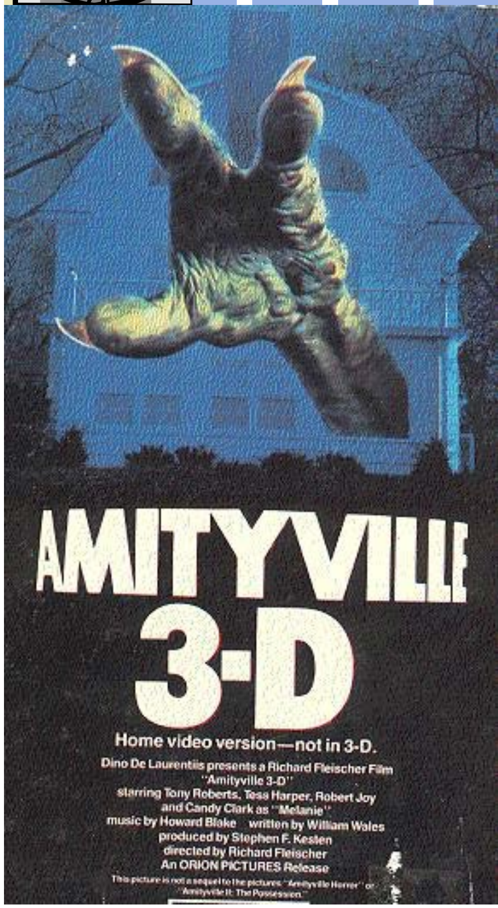
Deletion/accretion (occlusion)

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



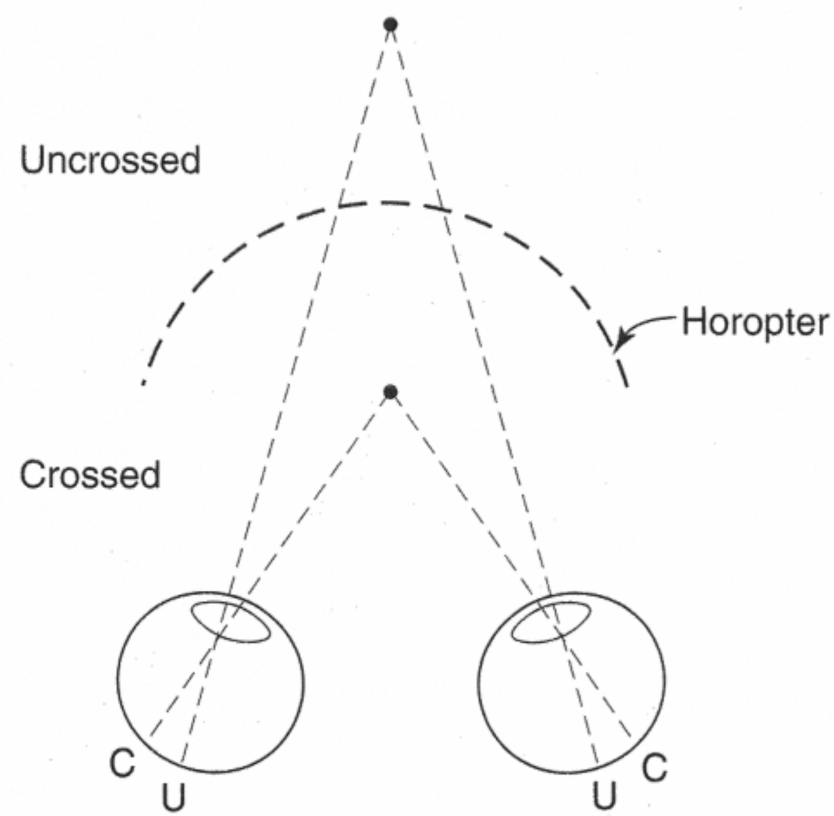
Stereo Vision



April 5, 2020

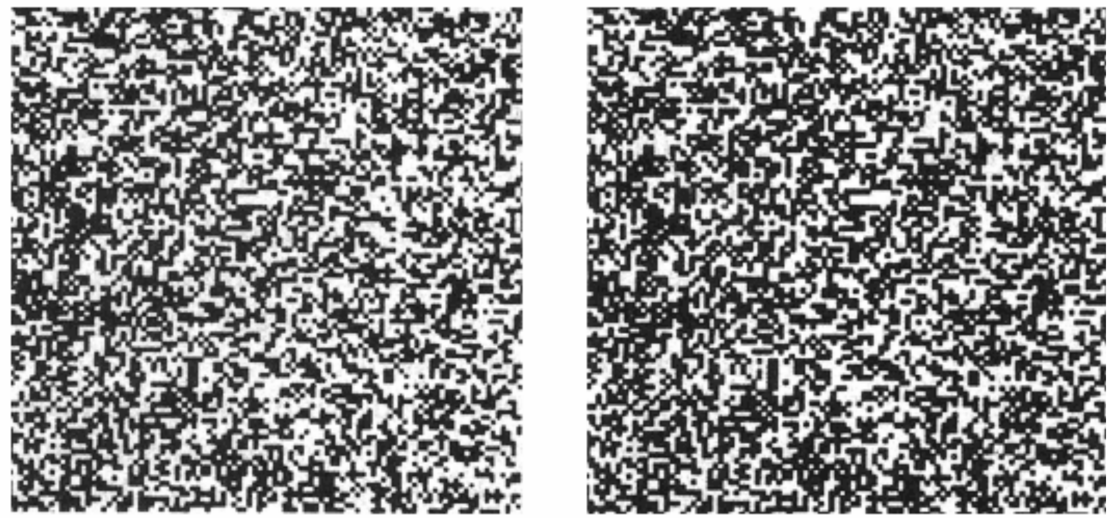
Binocular Disparity, cont' d

- Horopter
  - From horizon + optical
  - All points on this line (surface) are same distance as objects at fixation
- Computation of depth from disparity
  - Direction (laterally/nasally) of disparity determines if object is in front of or behind the horopter
  - Amount of disparity determines distance from the horopter



Random dot stereogram

- Only disparity information is available
  - Therefore purely bottom-up



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0	0	1	1	0	1	1	0	1	0
0	1	0	A	A	B	B	1	0	1
1	1	1	B	A	B	A	0	0	1
0	0	1	A	A	B	A	0	1	0
1	1	1	B	B	A	B	1	0	1
1	0	0	1	1	0	1	1	0	1
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0	1	0	0	0	1	1	1	1	0

1	0	1	0	1	0	0	1	0	1
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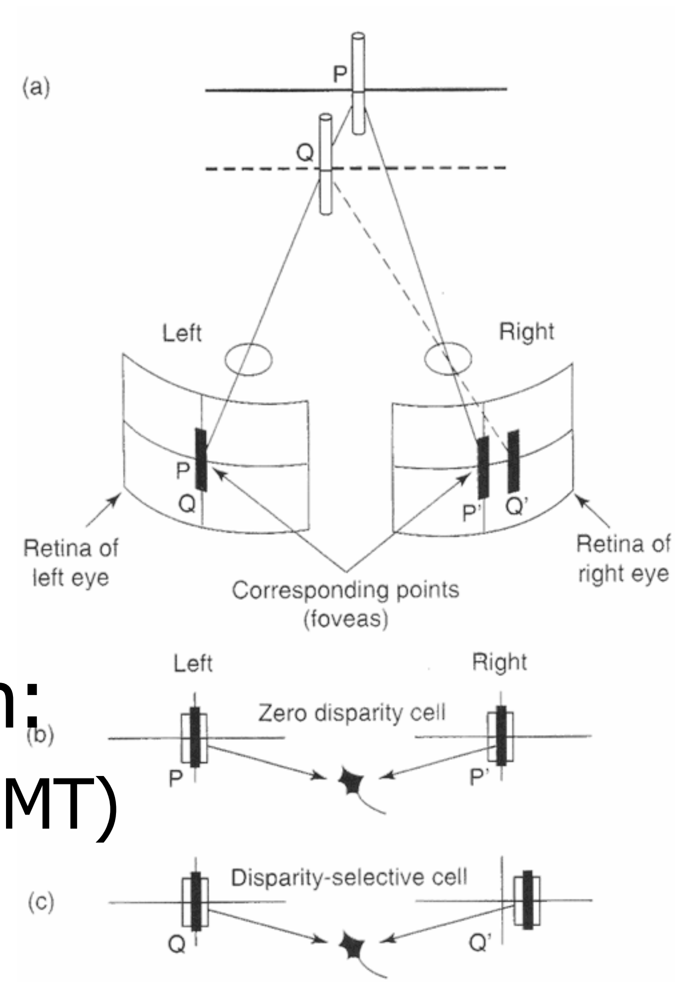
1	0	0	1	1	0	1	1	0	1
1	1	0	0	1	1	0	1	1	1
0	1	0	0	0	1	1	1	1	0

Neural Basis of Depth Perception

- Disparity detectors in striate cortex (V1)
  - Fixation plane
    - No disparity
  - "nearer" detectors
    - Crossed disparity
  - "farther" detectors
    - Uncrossed disparity
  - Detection circuits also present in:
    - dorsal (where/how) pathway (V2, MT)
    - ventral (what) pathway



Neural Basis, cont'd

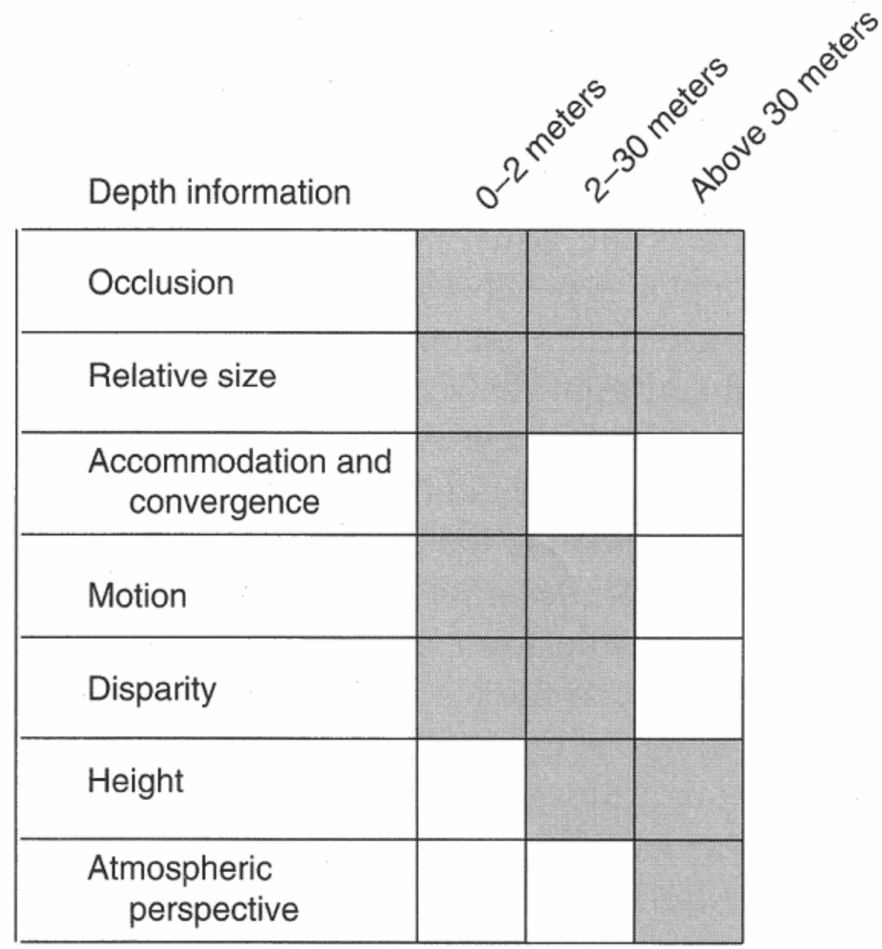
- Stereoblindness
  - Cannot detect/localize the depth of objects using disparity at all
    - Other monocular cues can still be used
  - Partial stereoblindness: cannot detect depth of objects that are either at, in front, or behind horopter
    - Evidence for 3 sets of disparity detectors

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?

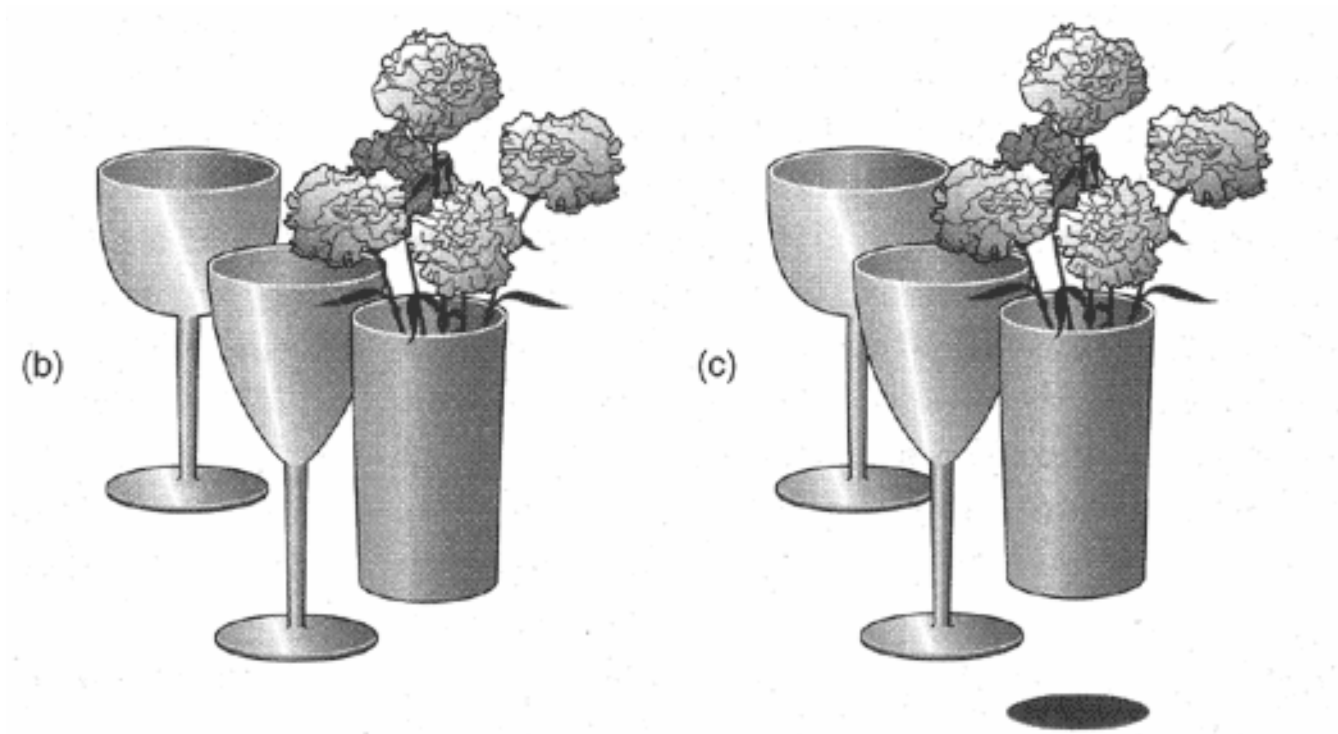


Interaction of Cues, cont'd

- Constructivist approach
  - Experience enables inferences about distances and spatial layout
  - We "construct" our environment (mentally) based on images and cues
  - Somewhat computational
- Gibson's Direct Perception approach
  - Spatial layout is directly picked up - not the result of analysis or computation
  - Too bottom-up?

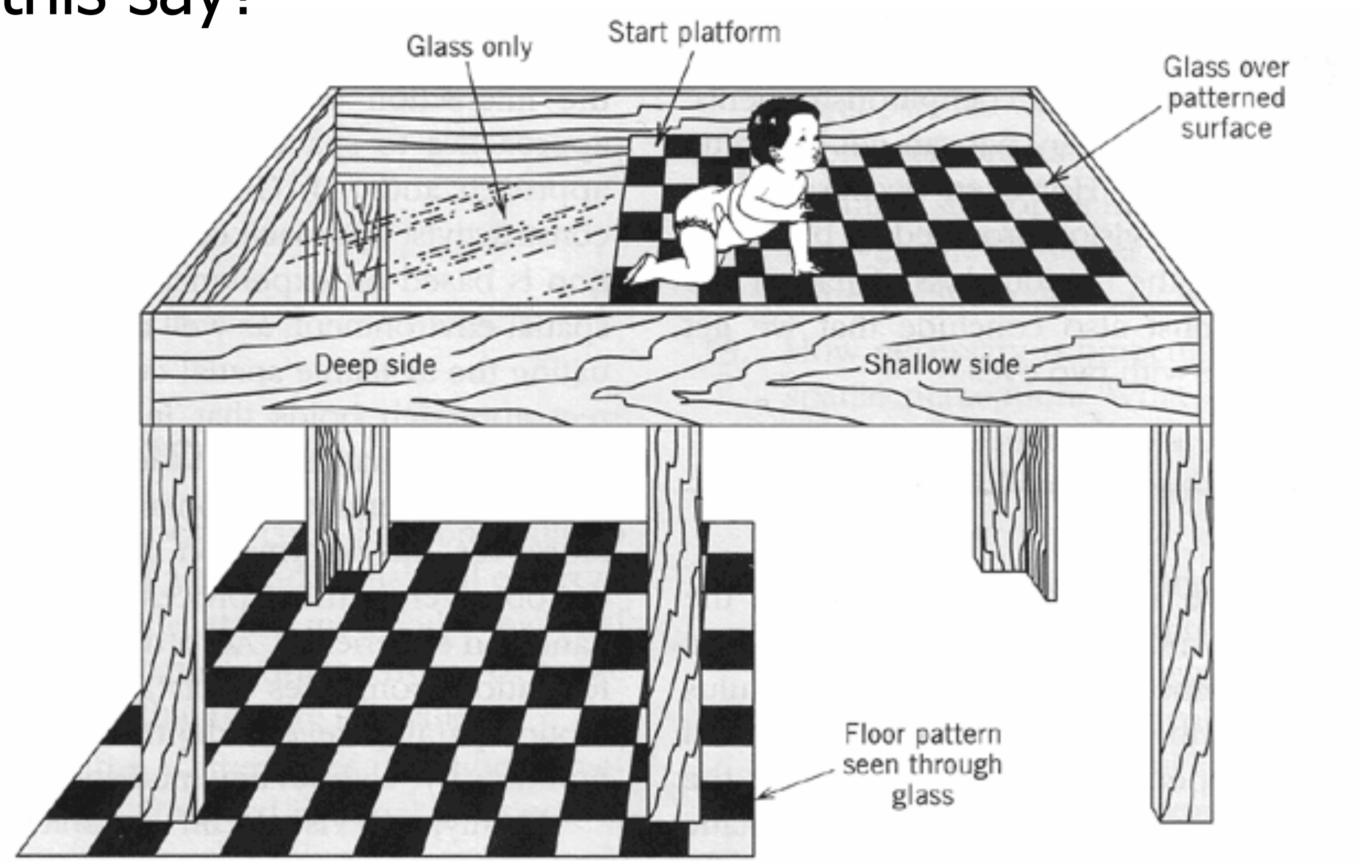
One Cue vs. Another?

- 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?



Upcoming

- Constancy & illusions
- Camouflage