Astronomy 80 B: Light

Lecture 17: binocular vision

27 May 2003

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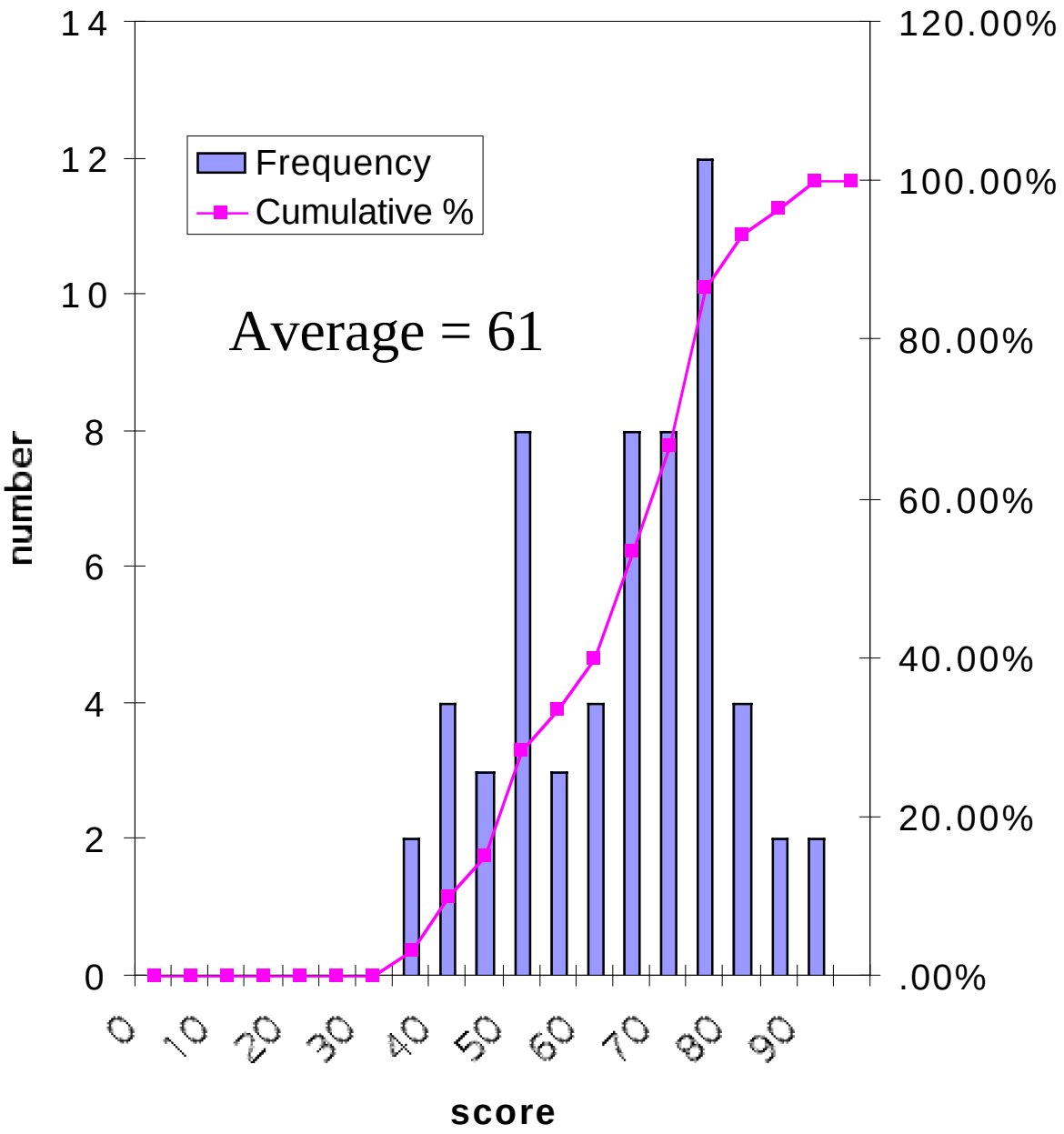
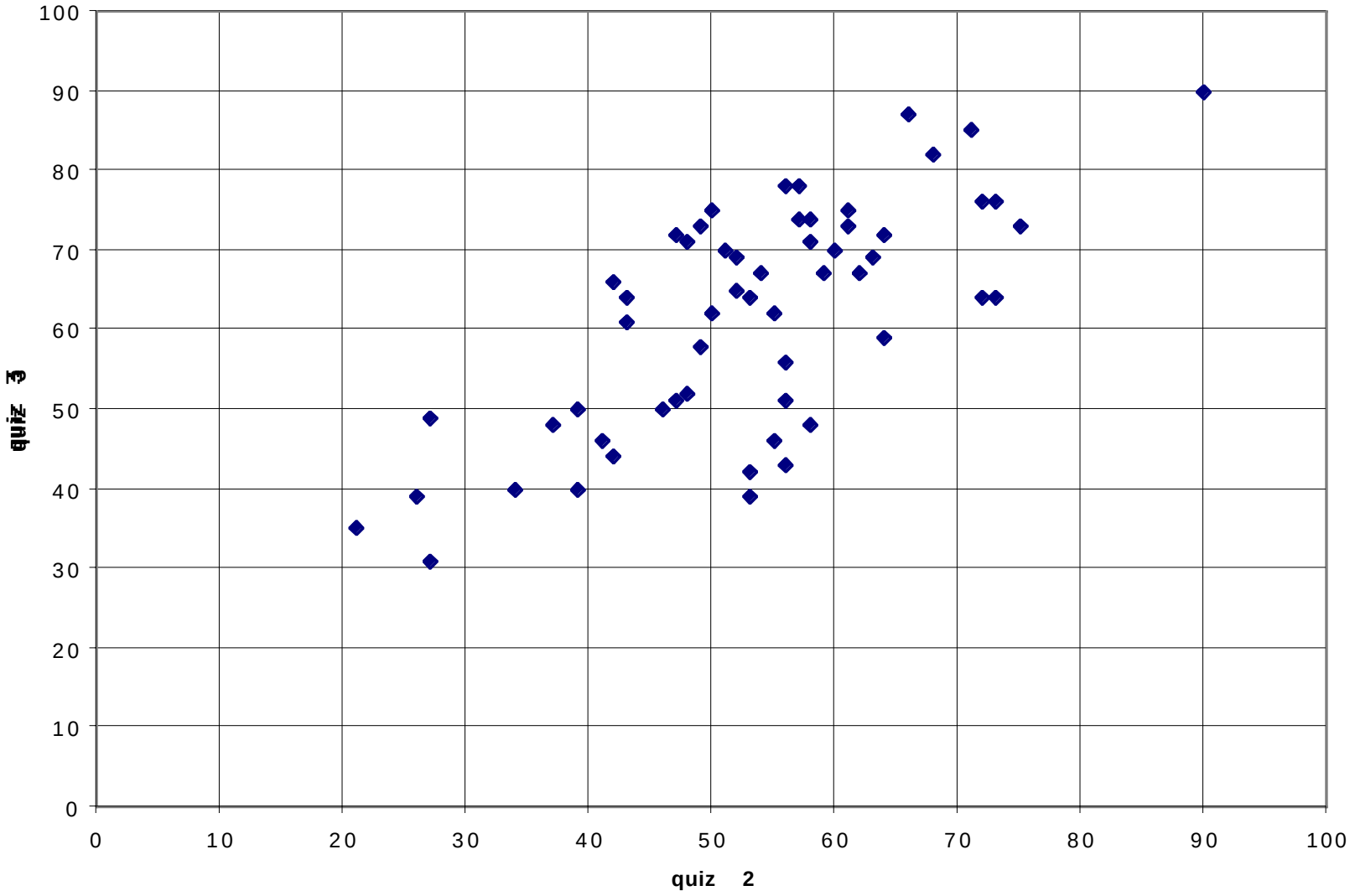
Topics for Today

- Research paper is due on or BEFORE 5 June
- Quiz statistics
- Students at risk of failing
- Review of quiz questions
- Binocular vision

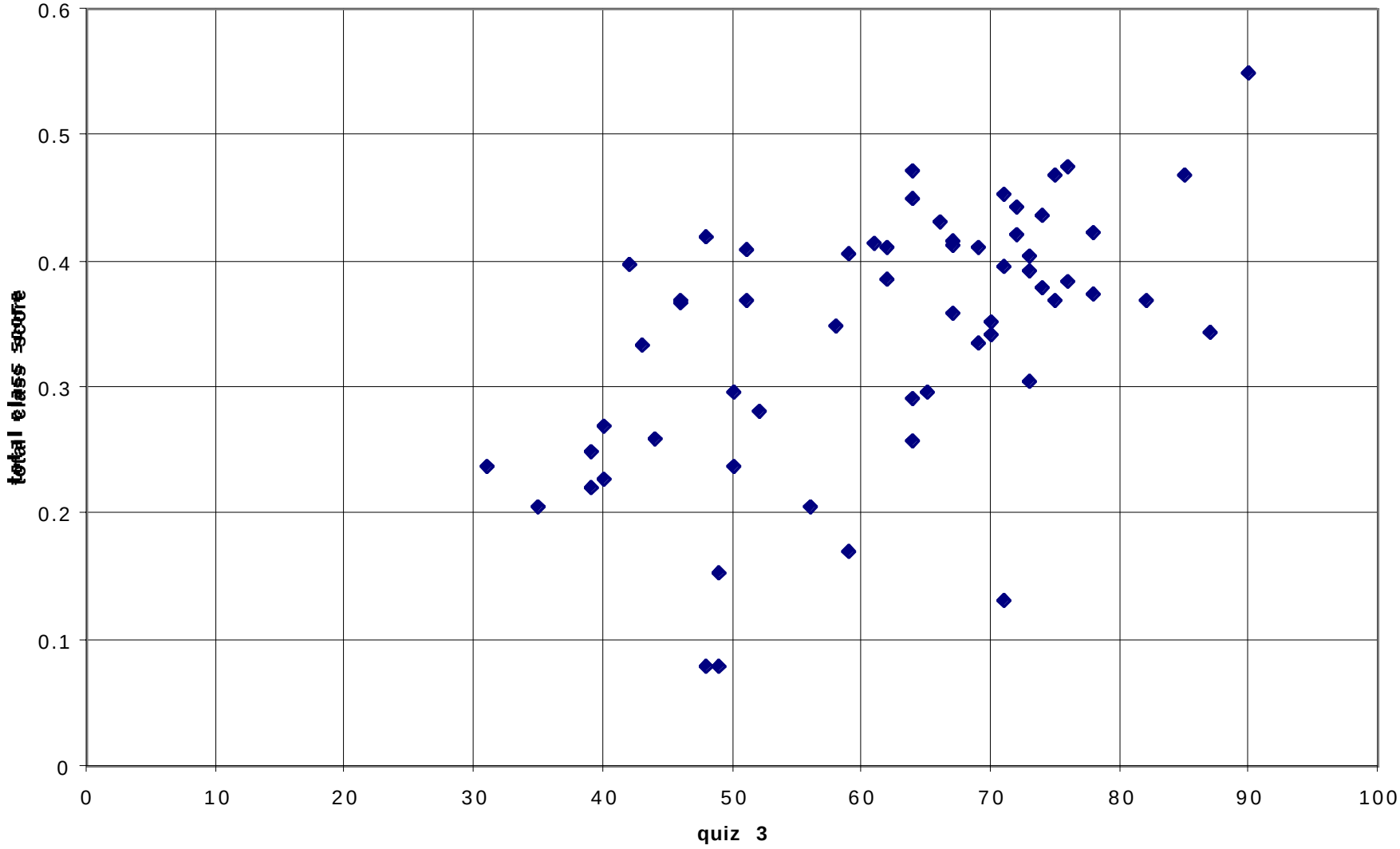
Quiz 3 results



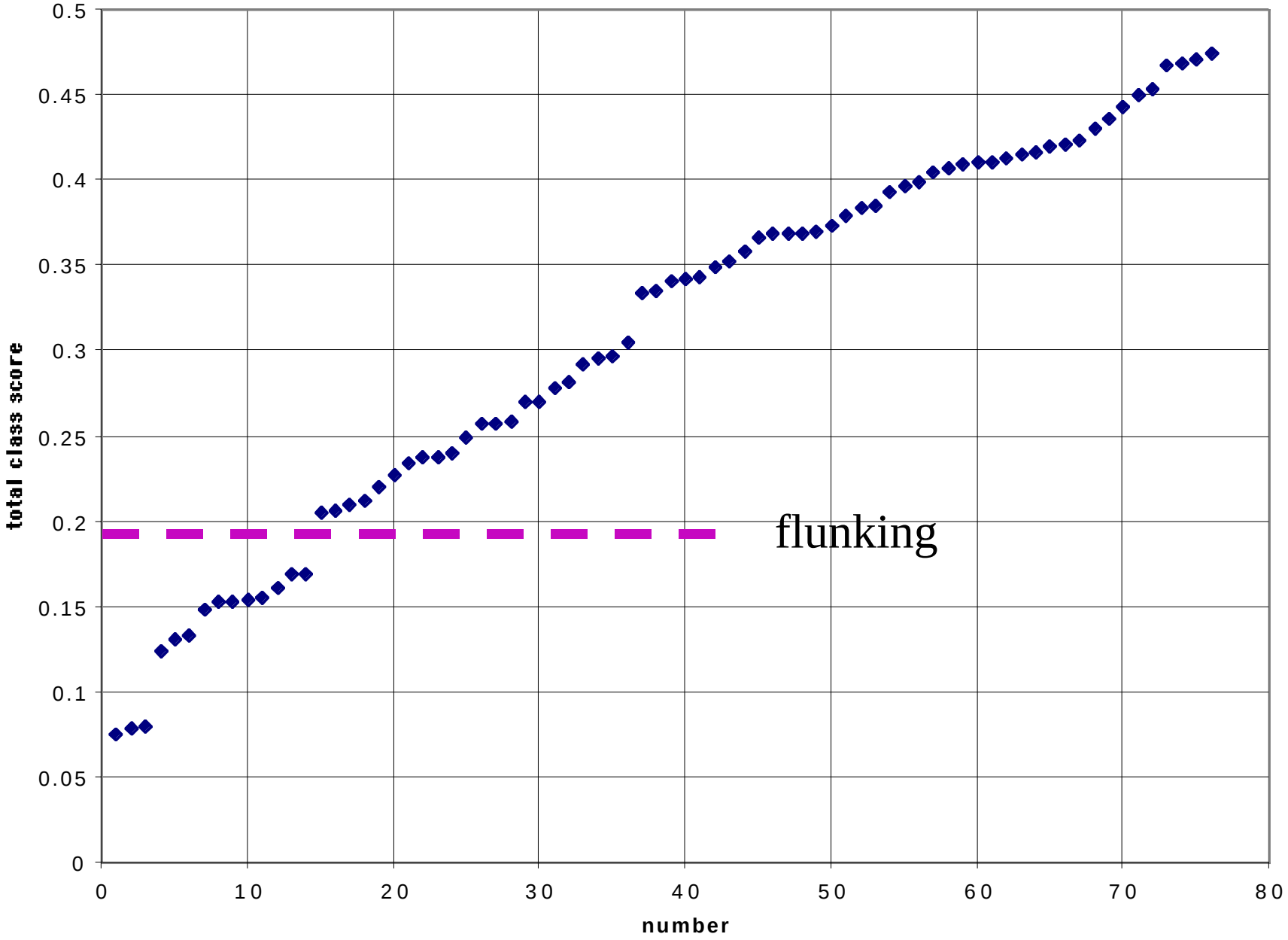
quiz 2 vs quiz 3



quiz 3 vs total



overall score



Students currently failing (by SSN)

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553837427
558817276
573731496
602092588
606249811
614205271
615349154
623481040
624326183
624465839
626098292

Techniques for measuring depth or distance

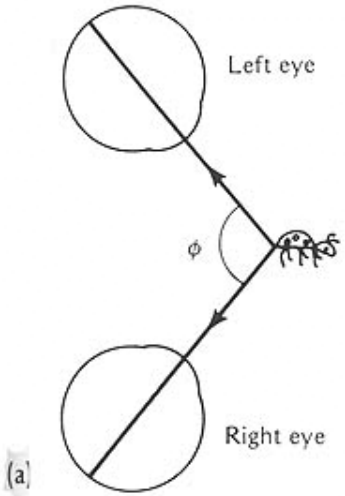
- **Accommodation**
  - Your eye focuses to make images sharp
  - The amount of focus added by your lens contains distance information
  - Used extensively by some animals
  - Only useful to humans for close objects
- **Convergence**
  - To view a nearby object, the angles between the optical axes of our eyes must change from zero (distant). This is called the angle of convergence.
  - Focus on your finger at arms length and bring your finger up to your nose
  - Useful for close objects

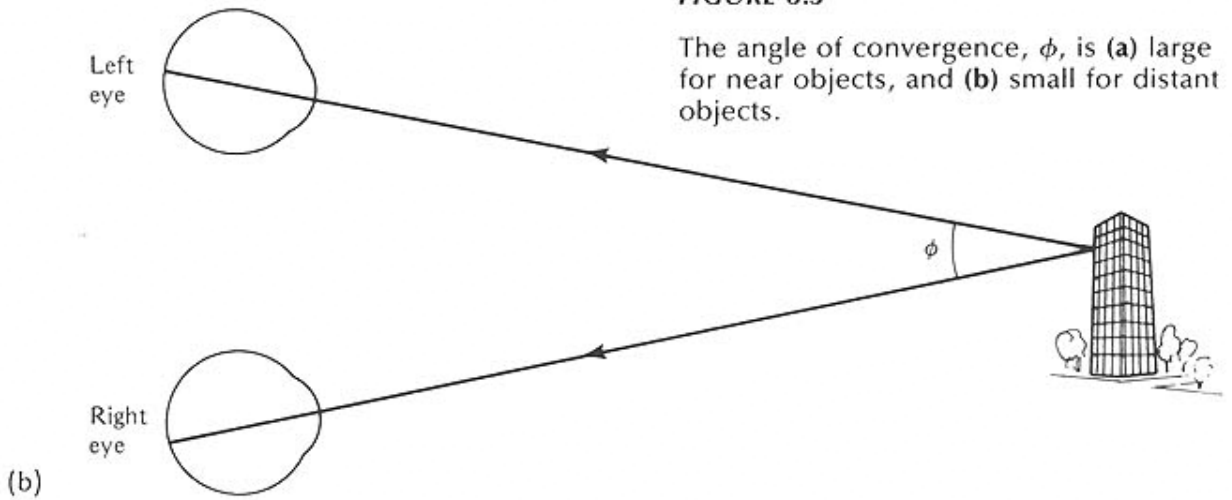
Angle of convergence

*Greek *parallaxis*, change.

FIGURE 8.3

The angle of convergence, ϕ, is **(a)** large for near objects, and **(b)** small for distant objects.





Techniques for measuring depth or distance-2

- **Parallax**
  - The differences in the two views is most important to humans. The view changes resulting from different positions produces parallax
  - look at a piece of paper and put your finger near it. Move your head around and notice you can then see what your finger otherwise blocked.
  - Different views might be from two eyes or from views changing with time
  - Movies generally look flat because our eyes see no parallax
  - 3-D movies give our eyes two different scenes and thus we perceive depth, using parallax

parallax

- **Different views of each eye**
- **Parallax and binocular disparity**

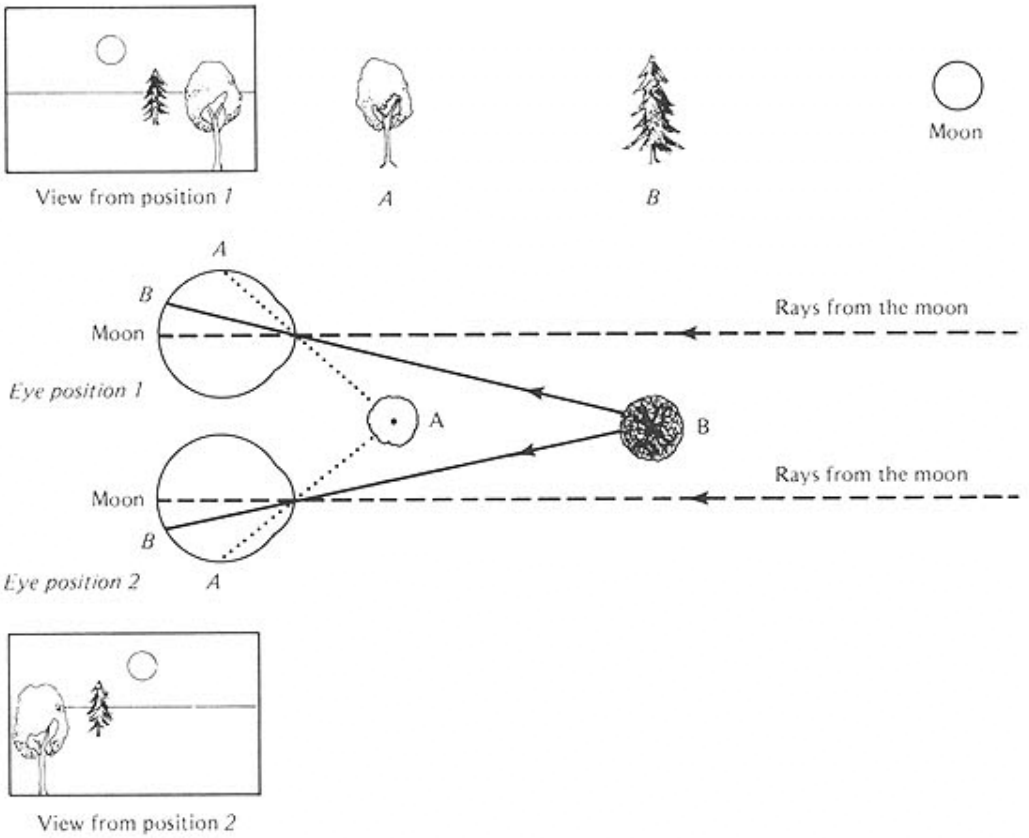


FIGURE 8.4

The locations of the images on the retina change as the eye moves from position *1* to position *2*. The location of the retinal image of the nearest object, *A*, changes the most—from one extreme to the other. The image of a more distant object, *B*, moves less, while the parallel rays of the very distant moon are always imaged on the same place on the retina. This is why the moon seems to follow you as you look at it, say, from the window of a moving car. The closer the object is to you, the more it appears to move in the direction opposite to your motion.

Binocular disparity

- **Two distinct views generated by the separation of our eyes is called binocular disparity. This is just a form of parallax**
  - Eyes are separated by about 6.5 cm
  - Generally our brain fuses the images together and we perceive a single image

Binocular disparity

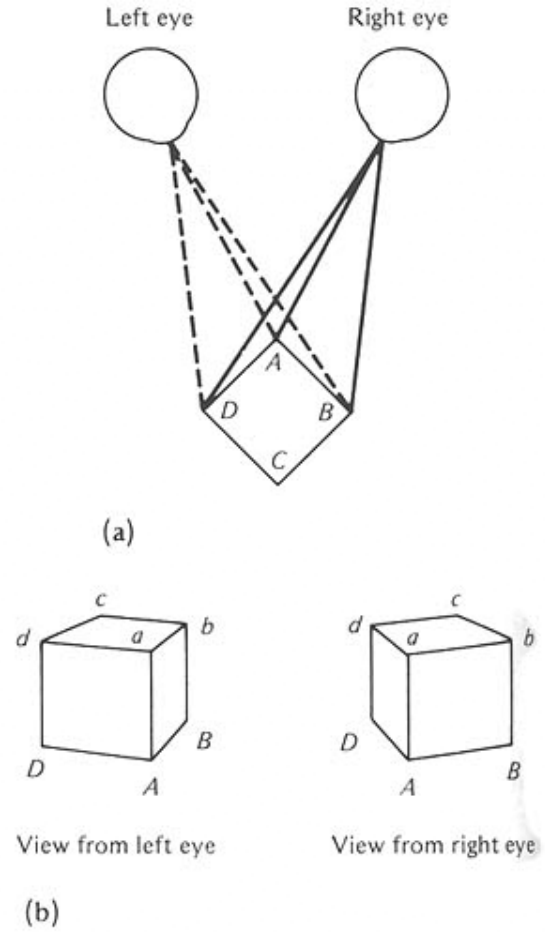


FIGURE 8.6

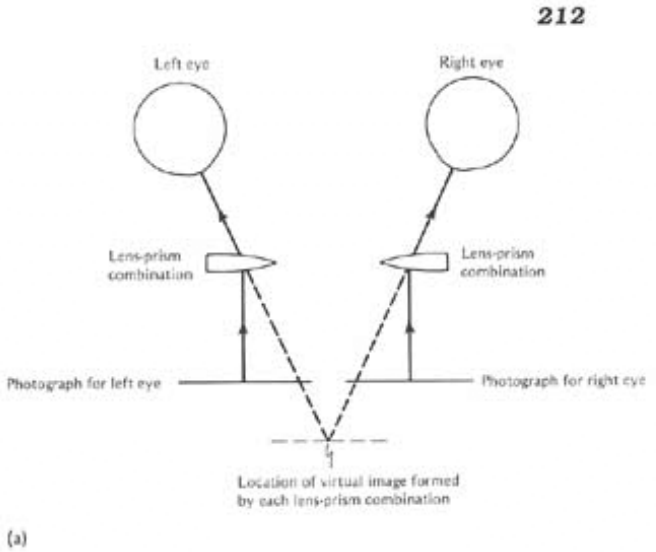
The two eyes looking at a cube see slightly different views of the cube. **(a)** View of eyes and cube. **(b)** Views seen by each eye. Note that the edge *da* subtends a smaller angle for the *right* eye than does *ab,* and consequently that eye sees *da* as shorter than *ab*. For the left eye, the situation is reversed.

Binocular disparity-2

- **We can adjust the apparent separation of two images and thus change the binocular disparity**
  - Often pairs of aerial photographs are used to measure height changes on the ground. The separation of the camera locations for the two images determines the amount of disparity
- **Stereoscope is a simple optical instrument that gives us three dimensional images**
  - Each eye is allowed to only see a single image
- **Polarized light and different polarized filters can allow each eye to see different images (if movie projection system allows it)**
- **Color filters placed in front of each eye can allow each eye to see different images (if the movie scene is designed for it)**

stereograms

- **With aid of an optical viewing device, we can see two pictures, one per eye, and achieve the sense of 3-D**



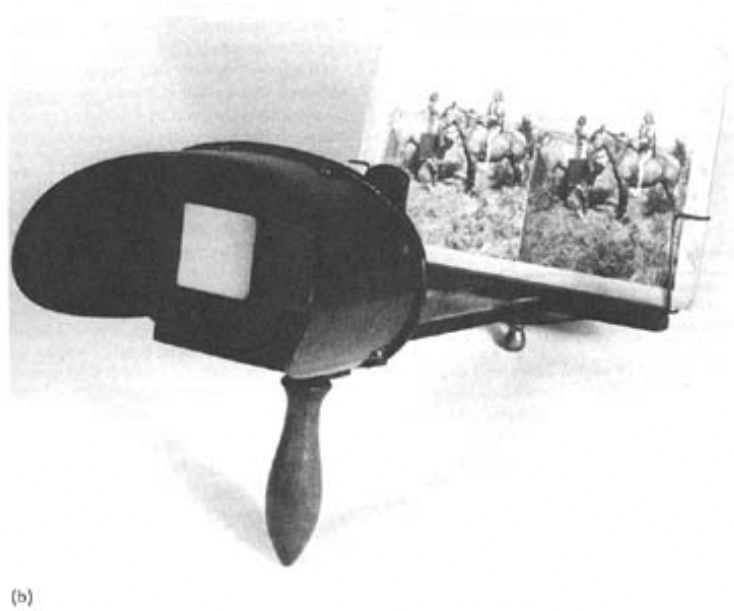


FIGURE 8.7

(a) The principle of the stereoscope. The amount of depth perceived depends on the disparity between the two photographs. (b) A stereoscope from the 1880s viewing a stereo pair of photographs of Indians.

Stereo photograph

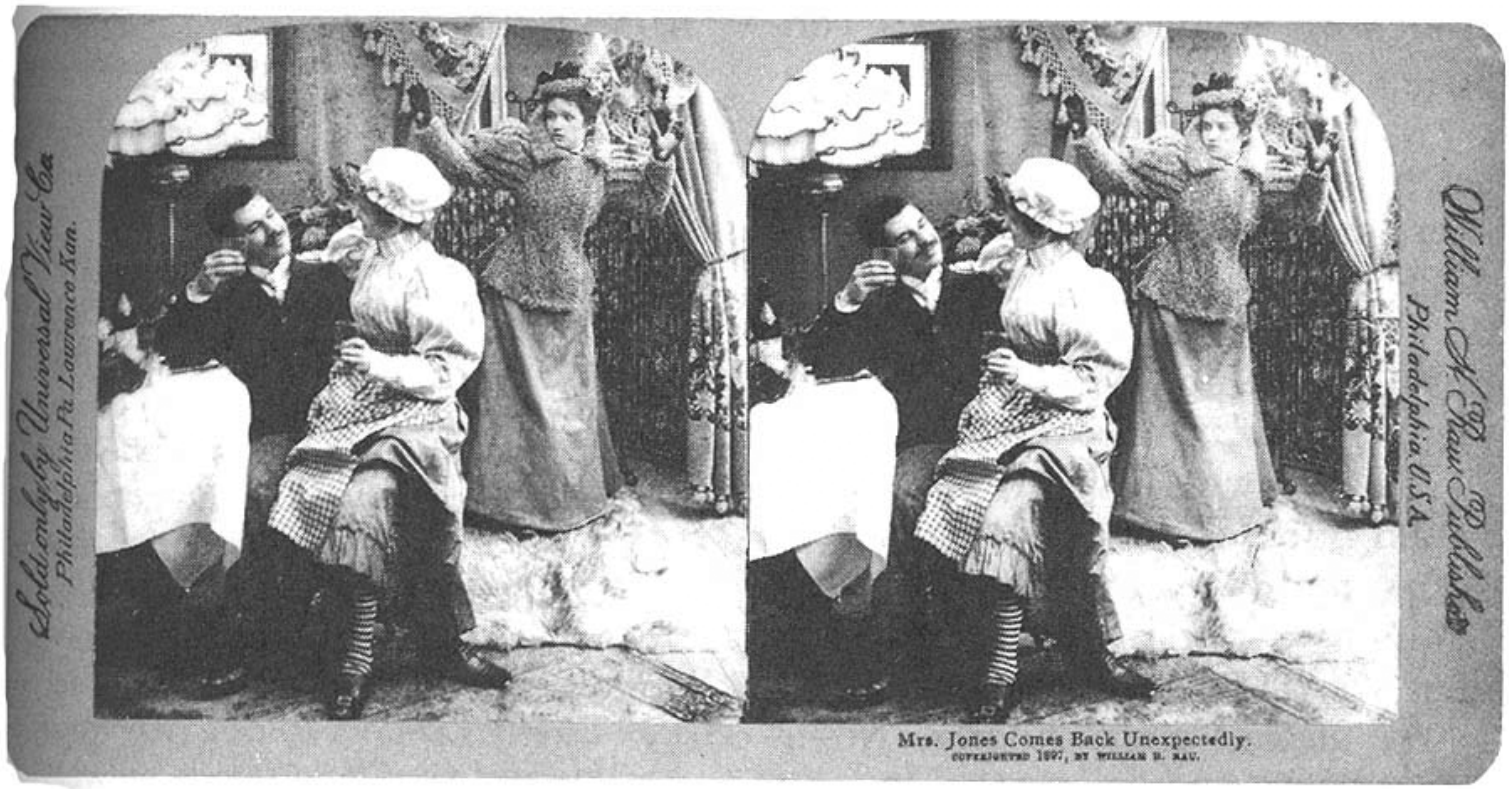


FIGURE 8.8

Stereoscopic photograph: "Mrs. Jones Comes Back Unexpectedly" (1897).

- **Effects of stereo vision**
- **What is in front, whats in back**

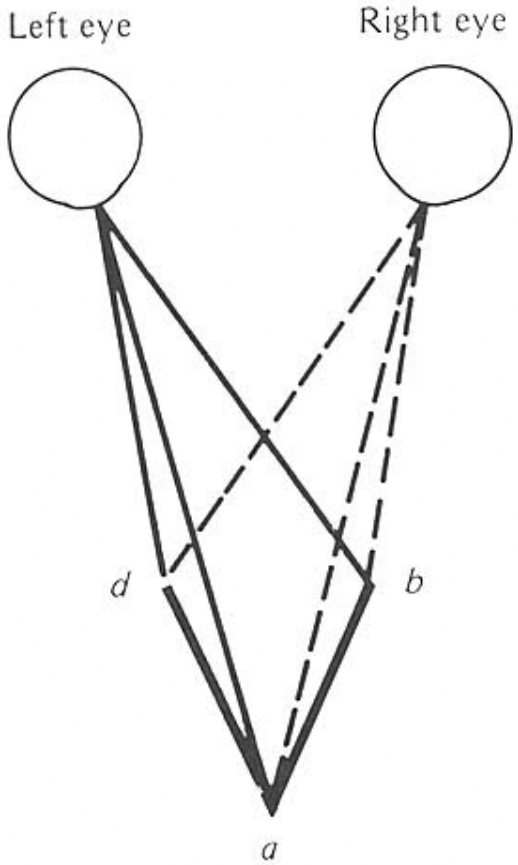


FIGURE 8.9

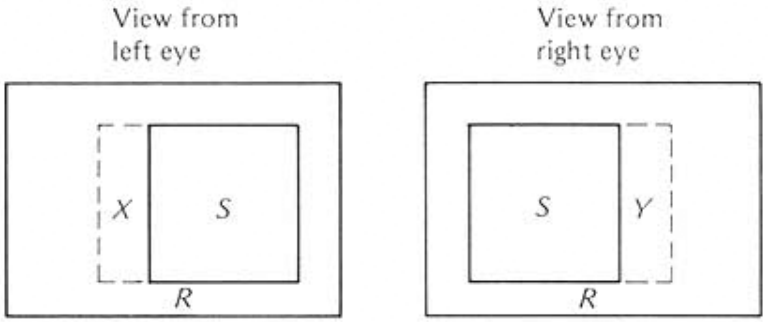
The two eyes looking at this object would have views corresponding to those shown in Figure 8.6b, but with the views interchanged. The edge *da* now subtends a smaller angle for the *left* eye, so that eye sees *da* as shorter than *ab*.

Stereograms

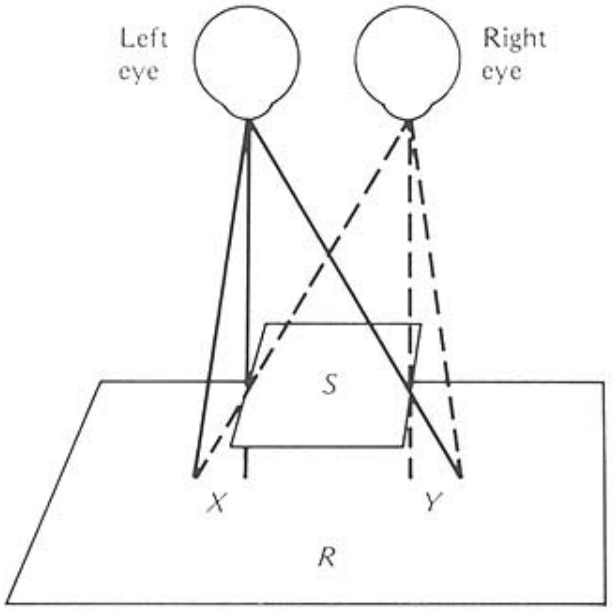
- **You can view stereo pairs in several ways**
  - Use an optical instrument to allow your relaxed eyes to see two images
  - If images are separated by your eye spacing (~ 6cm) you can bring your face close to the pair of images and look “through” the images (no convergence) and focus each eye on its image (accommodate)
    - We have brought convergence and accommodation into conflict
  - Cross your eyes so each eye sees the two images and the their separation is such that the “central” pair of images fuse together. Thus only 3 images are seen.
    - When this fusion occurs, adjust the focus of your eyes so the images are sharply focused
    - We have brought convergence and accommodation into conflict

FIGURE 8.11

Constructing a stereogram. **(a)** The views of the two eyes. The left eye sees *X* but not *Y*. Everything else in the rectangle *R* is the same for the two views. Properly viewed stereoscopically, the two eyes will fuse these views into a three-dimensional image even if *R* and *S* are covered with random arrays of dots. **(b)** The three-dimensional view is that of a square *S* floating above the rectangle *R*. For the left eye, *S* obscures the region *Y* of *R*. For the right eye, *S* obscures the region *X* of *R*.



(a)



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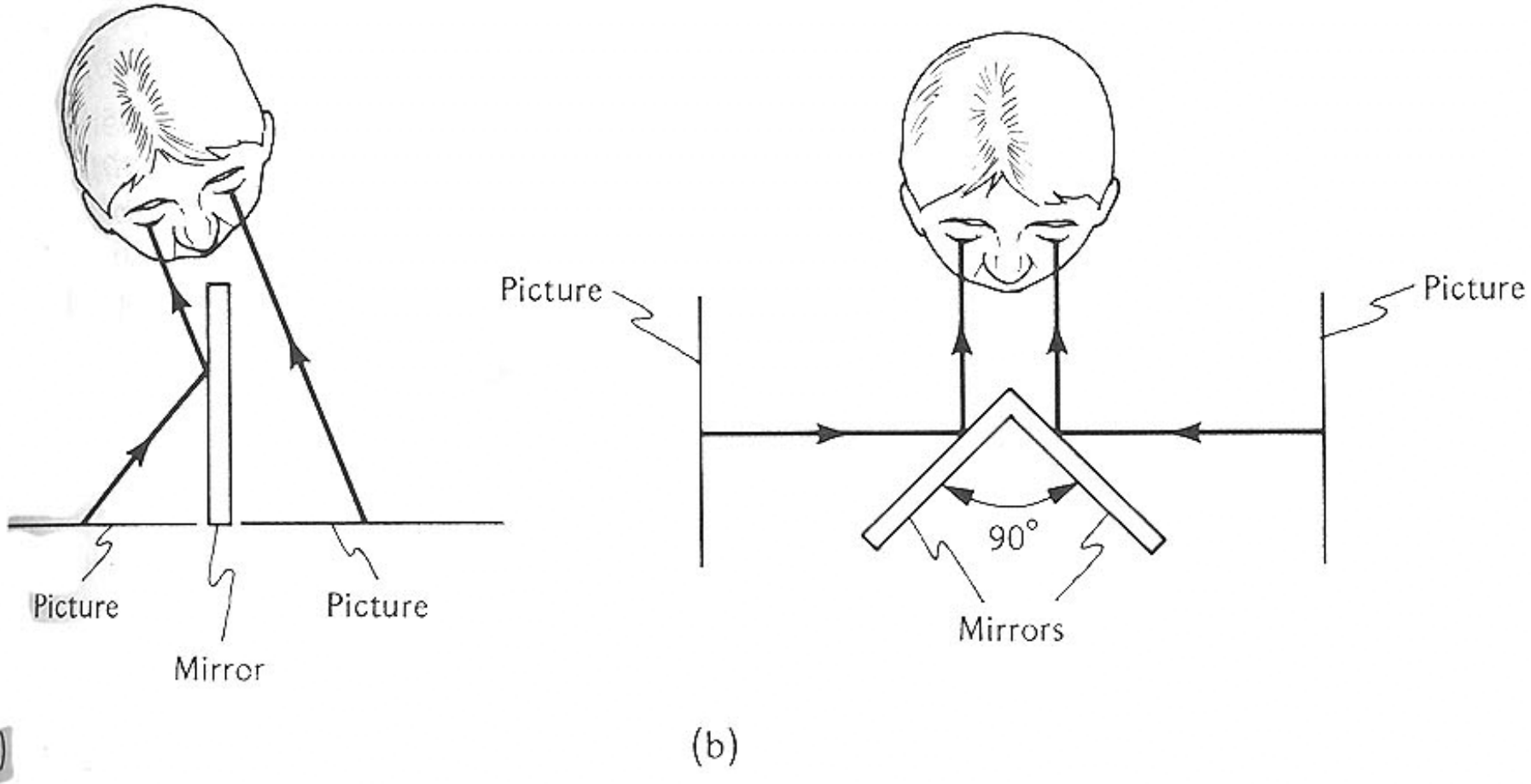


FIGURE 8.12

(a) Single-mirror stereoscope.
(b) Wheatstone's stereoscope.

- **Depth clues and the sense of three dimensions**

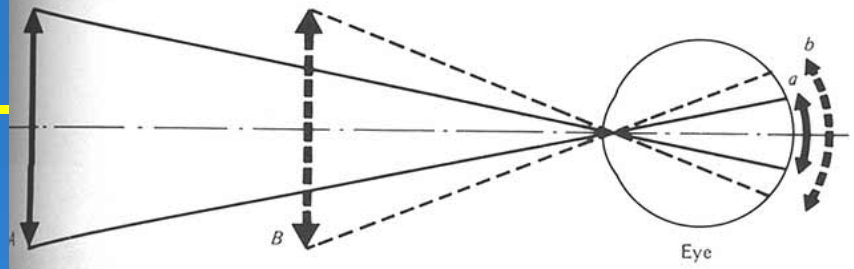
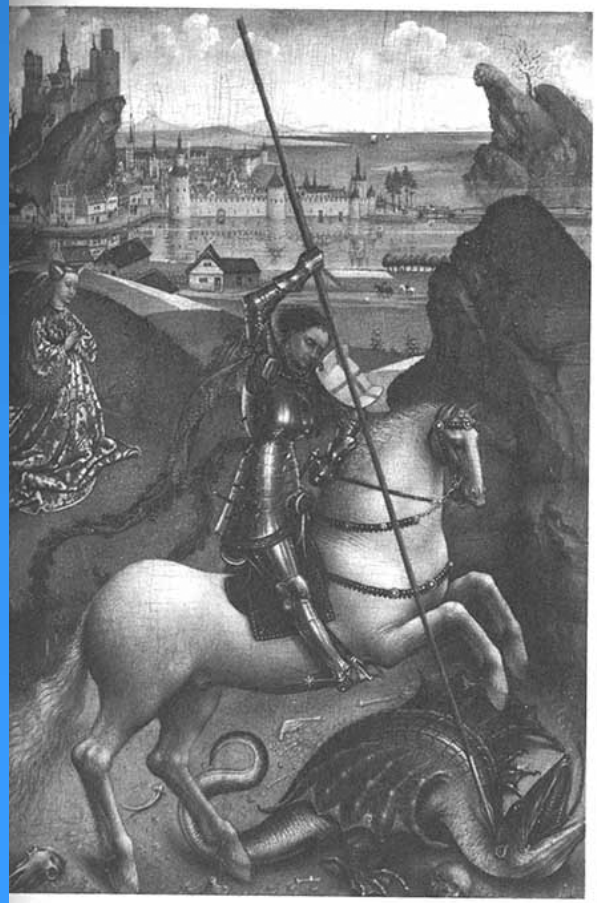
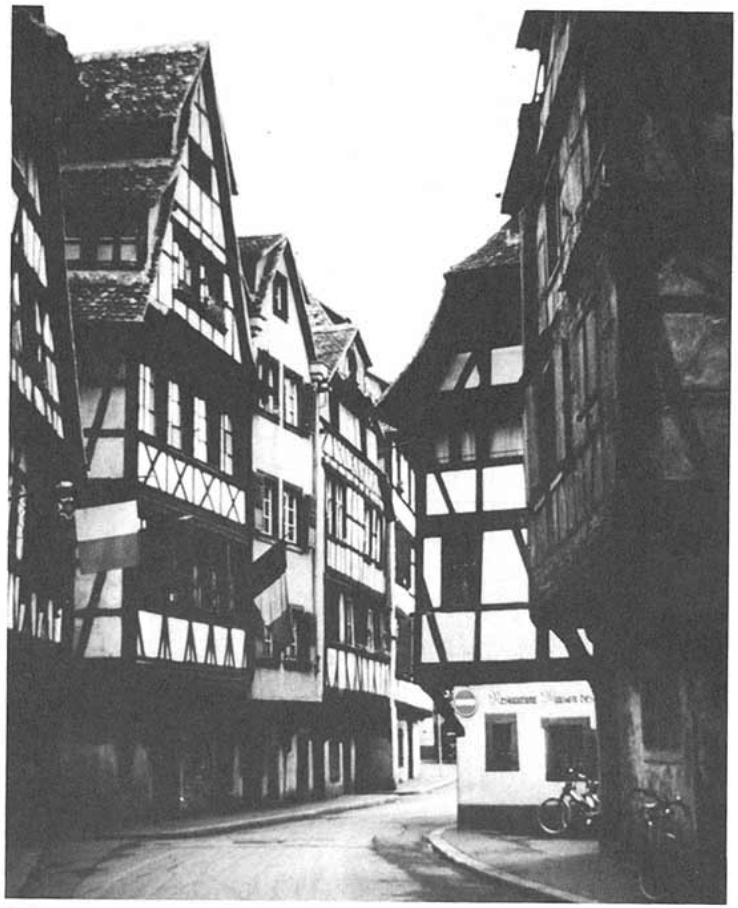


FIGURE 8.18

(a) Objects *A* and *B* are the same size but *B*, being closer, subtends a greater angle. The image *b* of the closer object is therefore larger than the image *a* of the more distant one. As usual, we have used only the central rays because we know that the lens of the eye will focus all the rays on the retina. **(b)** Roger van der Weyden's "Saint George and the Dragon" has smaller figures in the background. (Earlier art used smaller figures for less important people, no matter where they were located.) **(c)** Half-timbered buildings in Strasbourg.





(c)

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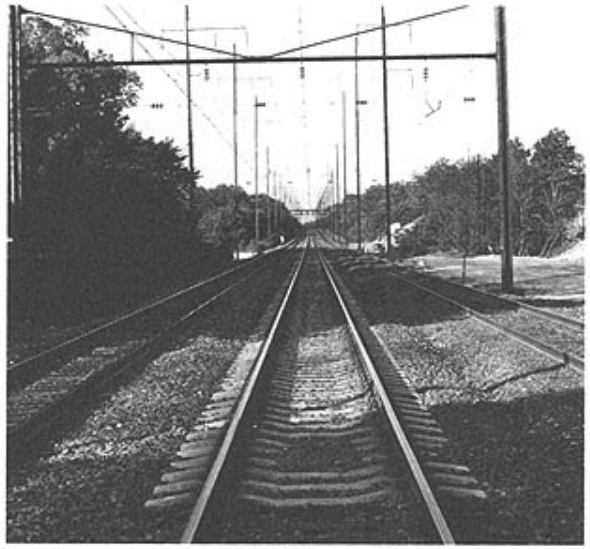
- **Perspective**
- **convergent lines**



(a)

(b)

FIGURE 8.19

(a) Photograph of seemingly convergent railroad tracks. **(b)** Photograph of crepuscular rays of the setting sun (sometimes called Rays of Buddha).

FIGURE 8.20

(a) Same tracks as in Figure 8.19a, photographed in the opposite direction. **(b)** Photograph of anticrepuscular rays. The sun is behind the camera.

(a)

(b)

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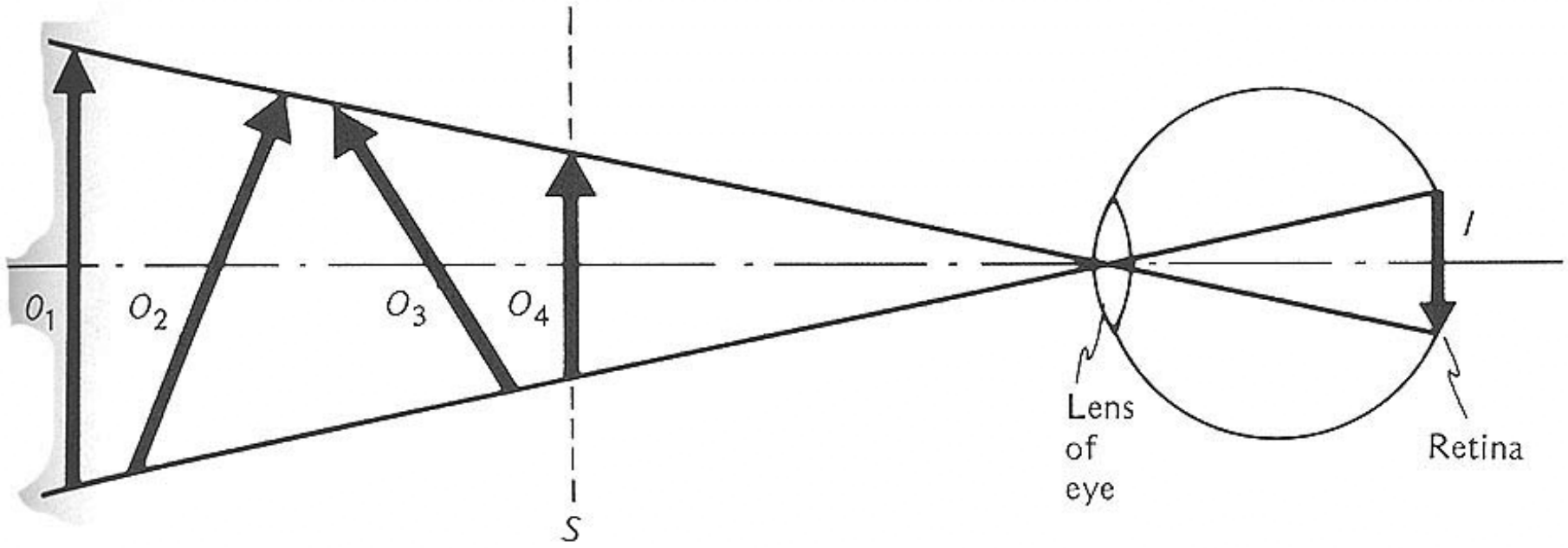


FIGURE 8.21

The ambiguity of perspective. Objects O_1, O_2, O_3, and O_4 all cast the same image I on the retina. A two-dimensional image on a screen at S would also create the same image I.

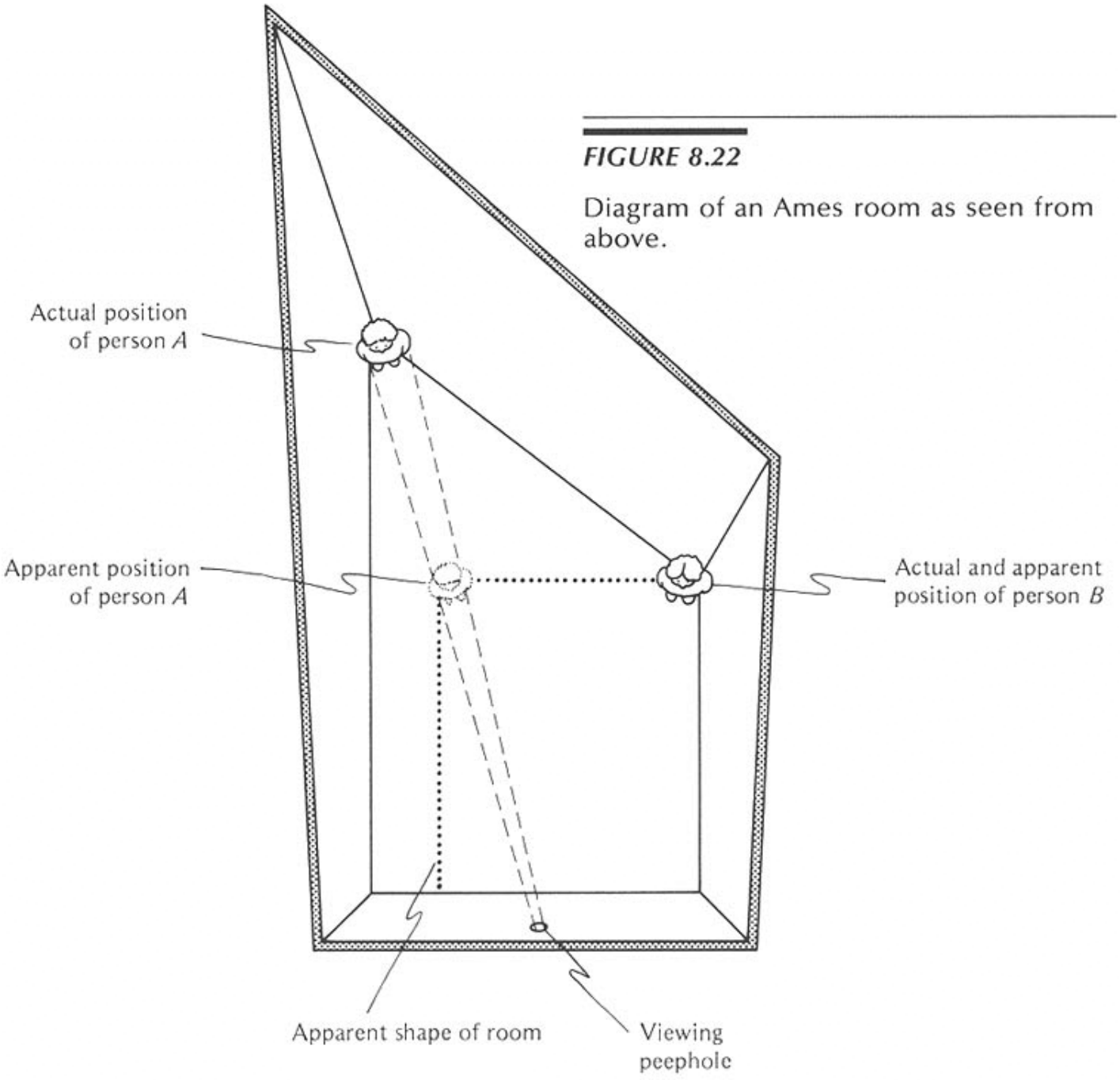


FIGURE 8.22

Diagram of an Ames room as seen from above.

FIGURE 8.23

A photograph of three normal-size people in an Ames room. The room is not rectangular; the apparently smallest person is actually most distant.

FIGURE 8.24

Perspective illusion. These three figures, which are actually the same size, appear to be of different sizes because the converging lines cause us to interpret the figures as being at different distances.

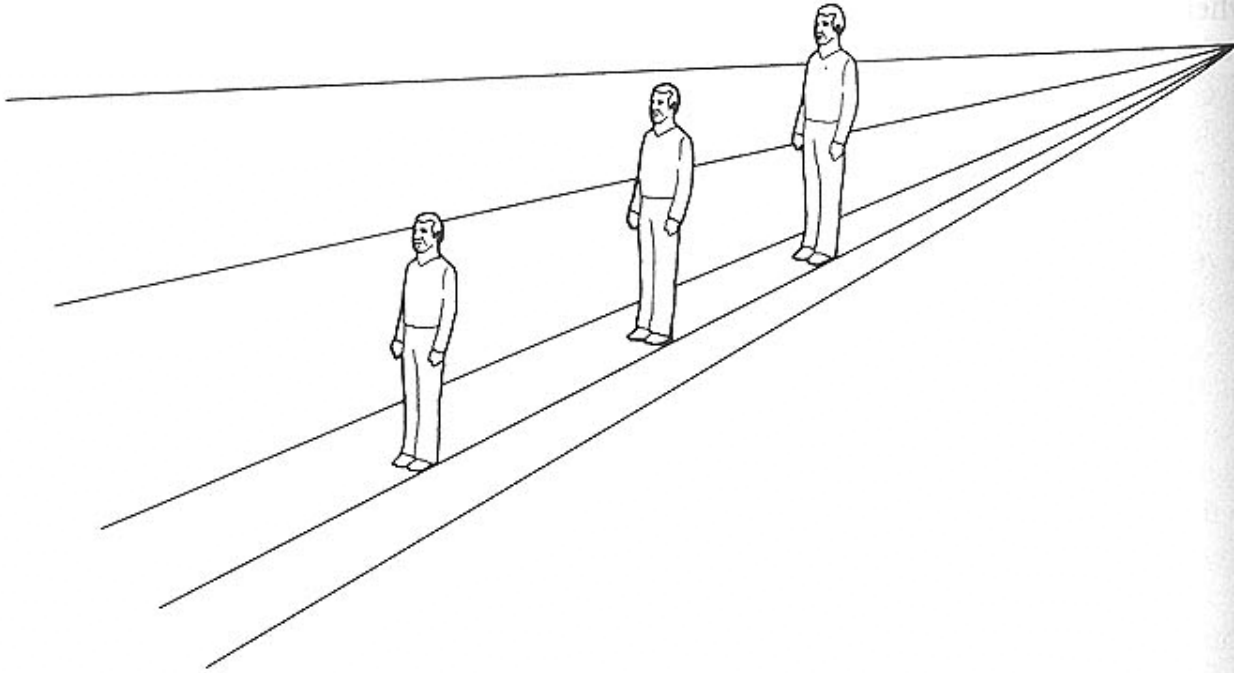
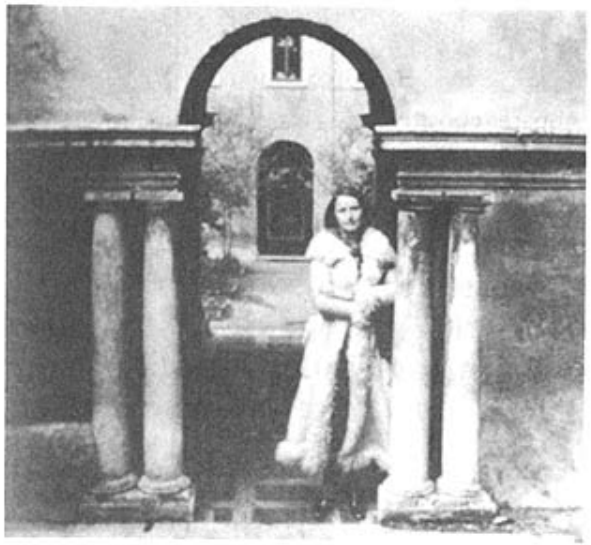
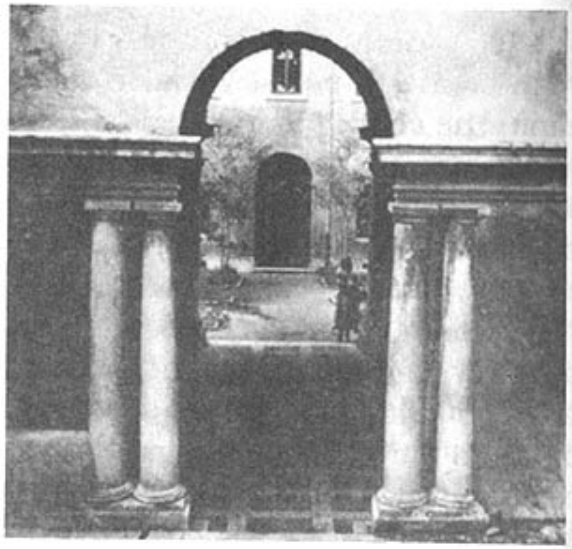


FIGURE 8.25

Palazzo Spada, Rome. **(a)** View through colonnade. **(b)** Views from other end of colonnade, showing the deception.

(a)



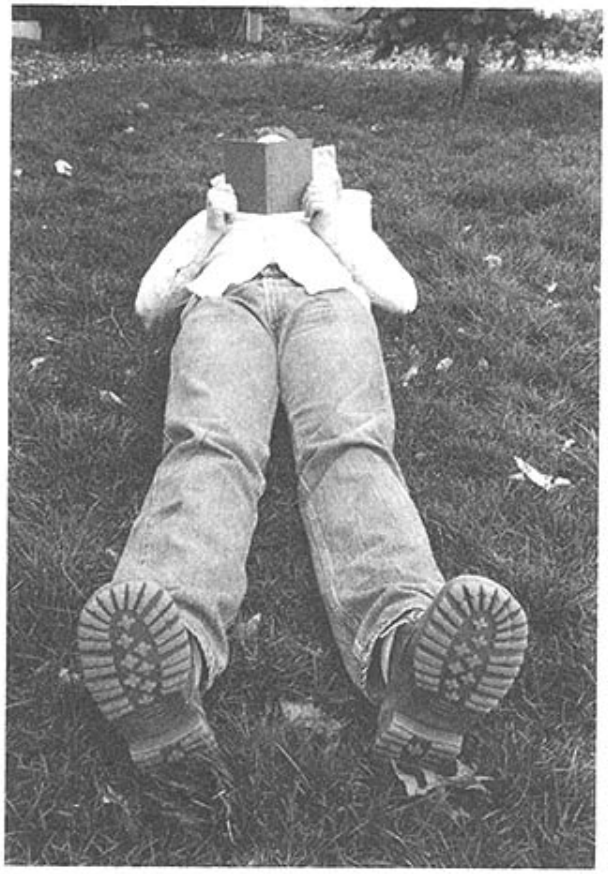


(b)

FIGURE 8.27

(a) Side view of tennis ball and basketball. **(b)** Views of balls as seen from *P* and *Q*. **(c)** View from close up, appears distorted. **(d)** Photograph of nude found in Delacroix's album. **(e)** "Odalisque" by Delacroix (1857).

(a) (b)



(c)

(d)

(e)

Color

- **Complex phenomenon**
- **Our visual tools are our three cone receptors**
  - Short
  - Medium
  - Long
- **A variety of light sources can be viewed by us**
- **Nature of source and background determines our perception**
- **Great variety of sources and light mechanisms**

- **Intensity distribution curve**
  - This plot or graph is key tool for understanding color and for representing it
  - This graph is quantitative and thus less ambiguous than words

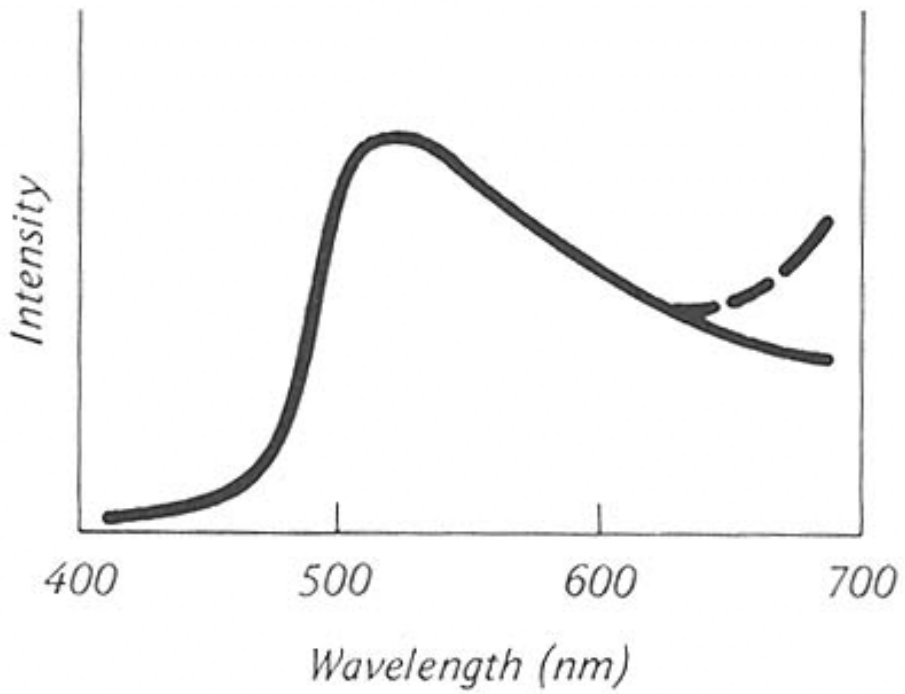


FIGURE 9.2

Intensity-distribution curve. Solid line: the intensity of light, at each visible wavelength, obtained when white light is reflected from a greenish region of Plate 8.4. Dashed line: the same light with a little extra red light mixed in.

Saturation

- **Saturation is the word that describes the degree to which the light source is monochromatic**

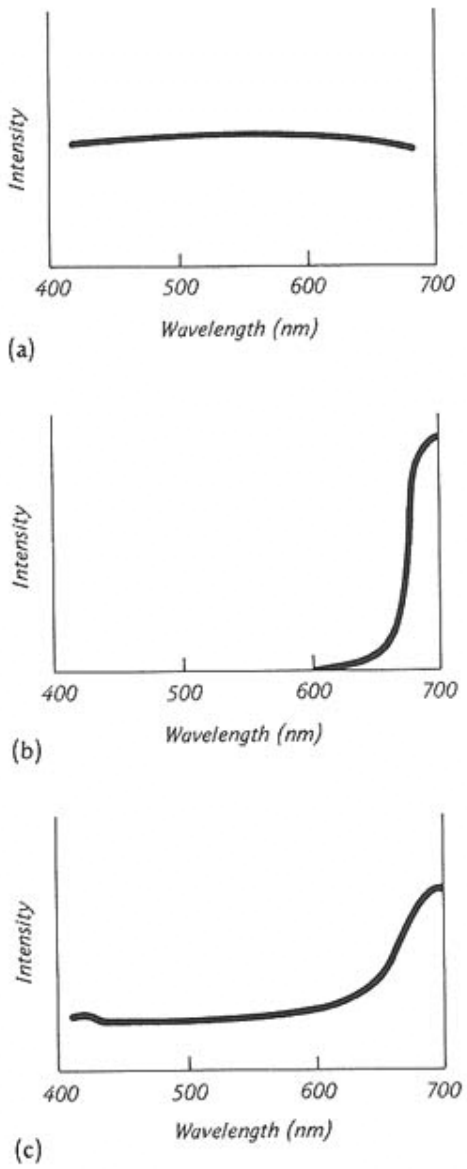


FIGURE 9.3

Saturation. **(a)** White light is completely unsaturated. **(b)** A saturated red light. **(c)** A less saturated red light—pink.

Brightness and Lightness

- **Brightness**
  - Amount of light from light source
- **Lightness**
  - Fraction of light reflected from surface

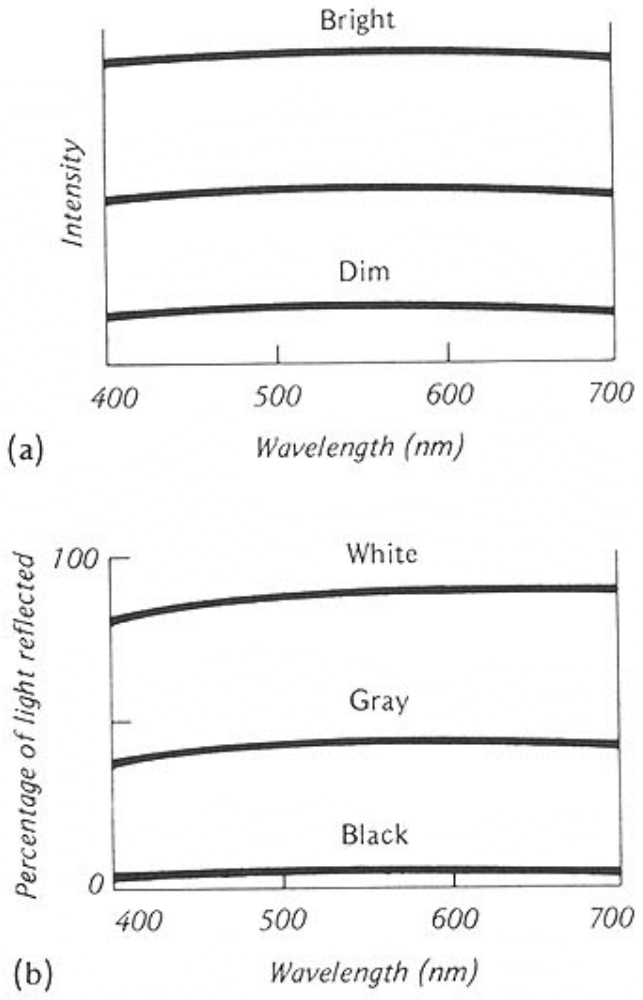


FIGURE 9.4

(a) Brightness of a light. The intensity-distribution curves for three different brightnesses. **(b)** Lightness of a surface. The curves correspond to the percentage of incident light reflected at each wavelength.