<u>Wolfgang Metzger: Laws of Seeing</u>

<u>Chapter 6. Brightness and Spatial Form</u>

<u>Chapter 9. Gestalt Laws in the Spatial Effect of Brightness</u>

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An important cue in depth perception is the distribution of light by illumination. This is particularly true, when light hits the surface from the side. A road illuminated by the head lights of a car looks bumpy, whereas under day light it looks smooth (Figure 96). The effect produced by a glancing light can be seen in Figures 97 and 98, where you can read invisible script due to the indentations and elevations made visible by tangential light. Similarly, the surface structure of the two kinds of paper in Figure 99 is discerned by shining light at a shallow angle on the paper. Under diffuse illumination the same papers look smooth.

The effect of light for depth discrimination is easily observed under natural conditions when looking at a hilly landscape. In Figure 100, the upper photograph looks relatively smooth, whereas the lower photograph reveals the wavy profile produced by the shadows of the evening sun. Every skier knows that it is easier and safer to ski in the late afternoon than at noontime, because the uneven surface can be more clearly perceived.

Photographers also take advantage of light and shadow in the environment by photographing their objects preferably in the early or late hours of the day. In this way spatial detail is emphasized and the "atmosphere" of a picture enhanced. In Figure 101, the craters on the moon are only visible because of the distribution of light and shadow. When the moon is full, we only see different brightnesses on the surface, but no depth. This is also true for the sculptured head of Zeus and the frieze of letters (Figures 102 and 103). Both are much more expressive and stand out more strongly in glancing light than in diffuse light. Therefore, it is important to display sculptures in the museum in the right light. Automatic cameras for passport pictures use a frontal flash and produce pictures that are flat and without expression.

Similarly, objects that are self-illuminated loose much of their curvature as is shown by the hot-glowing key in Figure 104 and by the diffusely illuminated globe in Figure 105b (bottom). In comparison, Figure 105a (bottom) clearly appears three-dimensional due to the shadow.

Map makers utilize the distribution of light and shade in order to illustrate flat regions, mountains and valleys. In Figure 106b elevations are characterized by different amounts of shading. Light areas represent flats and mountain tops and dark areas valleys. The same information is given in Figure 106a by contour lines. Widely spaced lines indicate a gentle slope, whereas narrowly spaced slope suggest a steep slope. However, whereas depth is actually seen in the former figure, it is deduced or inferred in the latter. The topographical map in Figure 106c actually consists of a 3D-relief of the various features imprinted onto it.

Figure 107 shows that the apparent brightness of an object (i.e., a disk) depends on its context. The disk looks darker within a bright surround and lighter within a dark surround. The apparent change of brightness in the opposite direction is called *simultaneous contrast*. This effect helps us to discriminate subtle shades of grey more easily (contrast enhancement) than without the enhancement. An animation from the data base of Michael Bach shows two disks of identical luminance surrounded by a bipartite background whose luminance is gradually changing in opposite directions. As a consequence the disks appear to become brighter and darker, in counter-phase. Metzger writes: "In order to produce the impression of a black suit correctly, one must paint the black cloth facing toward the window brighter than the snow-white collar on the shadowed side." (p. 101)

Striking simultaneous contrast is observed in Koffka's ring when it is superimposed onto a bright and dark background. As soon as the two halves of the grey ring are separated by a black line or by sliding them out of register, one half looks brighter and the other darker. When the two halves are aligned, the ring looks uniformly grey. This testifies to the strength of figural coherence and belongingness. Koffka's ring was of interest to Jing-Ling who wanted to do a literature search.

Chinese painters around 1500 did not use light and shadow to emphasize depth in their paintings (Figure 108), whereas Italian painters used it widely (Figure 109). A similar difference is illustrated by Figures 110 and 111. In these examples depth is perceived immediately without any inference. Shading is therefore considered an important cue for depth perception.

Chickens can easily learn the difference between bright and dark and transfer this difference to different levels of illuminations. After they learned that bright grains are tasty and dark grains are not, they preferred the "good" grains, even when they were presented in the shade and thus reflected the same amount of light as the "bad" grains presented in sunlight, or even less. The choice of the grains was therefore made on the basis of their relative reflectance, independently of their actual luminance. This is called *brightness constancy*.

Metzger's statement "that even deeply shadowed surfaces can appear white, while brightly lit surfaces can appear to be black" (p. 102) is strikingly demonstrated by the *Gelb effec*t. Here a dark grey disk in a pitch-black room is illuminated by a projector with a small aperture and, as a consequence, looks white. No stray light whatsoever outside the disk is allowed. Then a second disk (medium grey), third (light grey) and fourth disk (white) are successively added, whereupon the brightness of each of the former disks changes to a darker shade. This observation demonstrates that the brightness or more correctly, *lightness*, of each disk depends on the *reference*. When the Gelb effect was shown by the young Alan Gilchrist in Sarasota, Fl., Leo Hurvich accused him of lying. (Feel free to set up this experiment at CMU.)

"Contrasts of light and shadow are extremely important to create a sense of depth and often are its only cue." (p. 105) Metzger asserts that elevations and depressions are immediately seen and that no interpretation is needed. In this sense depth from shading is comparable to depth from lateral disparity, i.e., stereo-depth.

Using a folded book in Figure 147, Metzger observes that "All parts of the surface of an apparently coherent structure tend toward that spatial configuration in which the intrinsic color of the perceived object becomes as uniform as possible, so that all extant differences in brightness can be attributed to mere differences in illumination." (p. 147/8). This is the case when the book is seen as convex, with the light coming from the left and the right half of the book appearing darker due to shadow. The tendency towards uniformity of a coherent surface is consistent with the Gestalt law of *similarity*.

Sun and Perona (1998) in *Nature Neuroscience* published an article entitled: "Where is the sun?" and concluded that it is in the upper left. Indeed, this is the direction of illumination when we read. It is therefore not surprising that the perceived depth in Figure 148 shows tracks, when the figure is viewed right-side up, and grooves, when it is viewed upside-down. In the latter case the highlights have changed from below to above. A similar reversal in perceived depth occurs in Figure 149 where the ammonite on the left appears to be protruding and on the right receding. Figure 151 demonstrates depth beautifully in a natural relief. The regular pattern of ripples caused by the running water is seen as furrows. In all these examples, the direction from which the light comes is important for the polarity of the perceived depth. This is, in the words of Metzger, "a consequence of experience" (p. 150).

Familiarity is also the reason why we see a human face in Figure 150 correctly as a solid form on the left, but falsely on the right, where the face is hollow. Illumination in both cases again comes from the upper left. Research has shown that it is impossible to perceive a human face as hollow, presumably because we never encounter a hollow face. Thus, experience dictates in this case what we see. When we move past an inverted face, its eyes appear to follow the observer due to the inverted optic flow field. This could beautifully be seen in Bernd Lingelbach's video.

Definitions:

Reflectance (%) = (Light reflected / Light emitted) x 100

Transmission (%) = (Light transmitted / light emitted) x 100

Density = log Transmission (%)