PERCEPTION

In the section on color films, we touched on the deficiencies of the dye systems used in subtractive color photography. We should now consider some of the other reasons why a color photograph does not always turn out as we expect it to. At first glance, it might seem that if we had a color process capable of yielding a point for point reproduction of the subject, we could obtain a color photograph equivalent to the subject. Actually, however, such a color process, though physically perfect, could not take into account the psychophysical factors in our visual process, because the response of the film to the original scene must always be fixed, not variable like our visual response. Furthermore, the reproduction could not change itself to compensate for variations in the lighting conditions under which it, in turn, might be viewed. The following paragraphs discuss not only the more important of the visual effects which influence our judgement of a given scene, but also the photographic consequences which these phenomena entail. In this discussion, we shall confine ourselves to effects which are experienced by all observers having normal vision, disregarding effects which vary with individuals. On the other hand, it must be recognized that the perception of color is often affected by such factors as experience, emotional mood, stimulation of senses other than vision, and personal associations of colors and objects with ideas.

BRIGHTNESS ADAPTATION

There are three main types of brightness adaptation: general, local, and lateral. All three are constantly at work in the process of vision.

General Brightness Adaptation. One of the most remarkable characteristics of the visual mechanism is its ability to operate over a tremendous range of illumination levels. Dilation and contraction of the iris of the eye can account for a change in the light energy falling on the retina of only 16 times, at the most. The process which allows great extension of this range by changes in the sensitivity of the retina is called *brightness adaptation.* Sensitivity increases in dim light and decreases in bright light in such a way that the effective response of the eye is maintained more or less constant.

General brightness adaptation, or adaptation to the average brightness of the scene, is valuable in allowing us to see well at almost any given illumination level. From a photographic point of view, however, it has the disadvantage that we are unable, because of the variable sensitivity of our eyes, to estimate the actual intensity of the light.

Although the central patch is exactly the same in all cases, simultaneous brightness contrast makes it appear to vary from dark to light as the background is changed from light to dark.

For example, when we enter a room from outdoors, the lower illumination level causes a gradual increase in sensitivity, and we may eventually get the impression that the indoor scene is as bright as the outdoor one. Hence, we are often surprised at the relatively long exposures which must be given in making pictures under interior illumination. We may learn by experience what the exposures should be under conditions which are familiar and more or less reproducible, but we are at a loss when confronted with conditions which are out of the ordinary. We may then rely on some purely physical instrument such as an exposure meter. In any case, the necessary adjustments in camera lens settings can be considered as substitutes for the power of general brightness adaptation which the film lacks.

In connection with exposure determination, it is interesting to note that our judgment of the brightness of a scene is influenced to a considerable extent by the contrast of the lighting. For example, an outdoor scene on a gray day appears less bright than a contrasty stage scene, yet the average brightness is usually much higher in the case of the low contrast scene. Color effects also enter into the comparison. Overestimation of the brightness of the stage scene is due in part to our tendency to associate high saturation of colors with bright sunlight conditions.

Local Brightness Adaptation. In the process of viewing any given scene, the eye views one object after another, stopping for a brief interval at each point of interest. At each of these stops a readjustment of brightness adaptation takes place locally. The readjustment is very rapid, but sometimes we are aware of "afterimages" due to a lag in recovery of the local sensitivity of the retina. For example, if we look long enough at a bright light, we see a dark image of the light when we shift our gaze to a light-colored reflecting surface.

Lateral Brightness Adaptation. Sensitivity changes in local areas of the retina are often accompanied by similar changes in adjoining areas. This "sideways" or lateral brightness adaptation is exemplified by what happens when we look at a moderately dark object surrounded by considerably brighter ones. The sensitivity of the retina is decreased in the light areas of the image formed in the eye, but at the same time the decrease in sensitivity extends into the dark areas of the image, thus producing an apparent darkening of the dark object. Such changes in the appearance of adjoining objects are known as *simultaneous brightness contrast* effects. They depend to a considerable degree on the relative areas and positions of the objects; in extreme cases the amount of detail visible in a dark object may be decreased. The illustration on page 52 shows the differences in the appearance of the same gray patch when it is seen against different backgrounds.

BRIGHTNESS CONSTANCY

Though we seldom stop to think about them, we are continually making mental adjustments in what we see. By making such adjustments, we become aware of the "true" characteristics of an object, and are not misled by the purely physical aspects of the light reaching our eyes.

Various "constancy phenomena" are prominent among the mental adjustments we make. Size constancy, for example, is illustrated by the fact that people at a distance do not *look* smaller than those close at hand. A man at 100 yards forms a retinal image which is one-tenth the size formed at 10 yards, and yet he doesn't look smaller– he simply looks further away.

Approximate brightness constancy, a similar effect, makes us tend to see objects in terms of their *reflecting power rather than the amount of light they actually reflect*. Thus we can almost always identify a piece of white paper as white even though it is placed in shadow where it actually reflects much less light to the eye than a piece of gray paper in full illumination. In its psychophysical basis, brightness constancy is closely related to general and lateral brightness adaption.

Although brightness constancy effects are very strong in viewing the original scene, they are usually much weaker in viewing a reproduction of the scene. This fact is extremely important to the photographer, because it means that to obtain the most realistic effect, he or she must almost always make compensating adjustments in the lighting of the scene.

The problem of photographing an indoor scene furnishes excellent illustrations of the adjustments that must be made. Before considering the effects involved, however, we should have clearly in mind the basic difference between sunlight and most types of artificial light.

An outdoor scene, illuminated by sunlight, has the same amount of light falling on all unshadowed areas, assuming that no reflector or supplementary light is used. The illumination is the same over all parts of the scene area, because the sun is such a tremendous distance away that any differences in the distances of various objects from the light source are negligible. Indoors, the situation is entirely different. Here the light sources are usually close to objects in the scene and the decrease in illumination with distance from a light source assumes vastly greater importance, especially since this decrease is roughly proportional *to the square of the distance*.

With an indoor scene which has considerable depth, the falling away of light from the front to the back of the set is a serious problem. Unless corrective measures are employed, it will show up very strongly in the reproduction, even though brightness constancy makes it difficult to see at the time the picture is taken. Brightness constancy tends to make all objects in the set and immediate surroundings appear normal to the eye, in spite of the fact that some of them may be illuminated to far too low a level for proper rendering in a photograph.

Background Rendering. Proper rendering of the background is very important in color work. When the subject is close to the background, say within two feet of it, separate illumination of the background is usually unnecessary. When, however, the background is several feet behind the subject, separate background illumination may be employed, because the falling away of illumination with distance is more serious and because the farther the background is from the principal subject, the more it will tend to be seen as an unrelated area in the reproduction. The more unrelated the background appears, that is, the less it is connected to the principal subject by the shadows falling on it, the weaker will be the brightness constancy effect carried over into the reproduction. Accurate color representation of the background will be obtained when the illumination falling on that background is equal to the key light falling on the subject in the foreground.

Shadow Effects. The effects of brightness adaptation and brightness constancy are pronounced in large shadowed areas of a scene. Such areas may be perceived in three ways: first, as part of the scene as a whole (general brightness adaptation): second, with the intent of seeing as much detail as possible within the shadow (local brightness adaptation); and third, the shadow goes completely unnoticed as being a shadow (local brightness adaptation and the maximum brightness constancy effect). These variations in the perception of shadows are not theoretical but thoroughly practical, as will be apparent from examination of the illustrations on the next page.

(Upper Left) This photo approximates the actual tonal range of the location. The lighting contrast between the sunny areas and the shadows is so great that very little shadow detail is visible.

(Upper Right) This photo illustrates how our perception uses the brightness constancy effect. We will tend to interpret objects in the shadow areas brighter than they really are based on our knowledge of their customary brightness not their measured brightness in this location.

(Lower Left) When the viewer approaches the subject and eliminates the bright sunlight, the iris of the eye opens up and the shadow detail becomes truely visible and the brightness constancy effect diminishes. The shadow which was acting as a fill light in the other two photos is now the key light.

When we see a familiar face, we seldom notice the shadow of the nose or whether the eyes are hidden in shadow. Instead, we picture that face mentally as if it were lighted in such a way that no shadows existed. Consequently we are surprised, and perhaps blame the limited latitude of the film, when we look at our first images and find the face half buried in deep shadow. Brightness constancy has caused us to see a scene that was not there at all.

The strength of the brightness constancy effect carried over into a still photographic print (either a black and white or color) depends strongly on the degree to which the nonuniformity of the illumination falling on the original scene is evident in viewing the print, as shown below. However, in a two-dimensional print, there is always a serious loss of brightness constancy, because the print is viewed as an object in its own surroundings. *Hence shadows always appear darker than they did in the original scene.* As a consequence, the most realistic results are obtained only when the lighting is arranged in such a manner that the *lighting contrast* of the scene as viewed by the eye is very much *less in all respects* than is desired in the final picture. This statement indicates the true meaning of the term “flat lighting,” which was so often recommended for color photography.

It should be noted that flat lighting cannot be produced with a single light unless the light is placed over the camera lens, and that this procedure fails completely if there are objects at various distances from the lens.

In the left photo, the left-hand gray scale looks darker than the right-hand scale. When seen from a different angle in the center photo, its clear that the left-hand scale is darker because it’s in shadow. In the right photo showing the partition removed, both scales are revealed as being identical.

Lighting Distribution. We have already seen that a background far enough behind the subject to appear unrelated to it must be illuminated to approximately the same level as the subject if normal color rendering is to be obtained. Otherwise we may find that a poorly illuminated light background, for example, comes out darker in the reproduction than a strongly lighted dark object in the scene.

Actually, the same precaution applies to all parts of an indoor scene which are not visibly related to the principle subject in their lighting. Thus normal color rendering in all areas of the scene will be obtained *only when the whole scene is adequately illuminated.* If the lighting is not carefully distributed, there may be areas that will be reproduced so dark that color and detail are lost. Such areas will be plainly visible in the transparency or print, even though the visual effects already described make them difficult to recognize in viewing the original scene at the time the photograph is made.

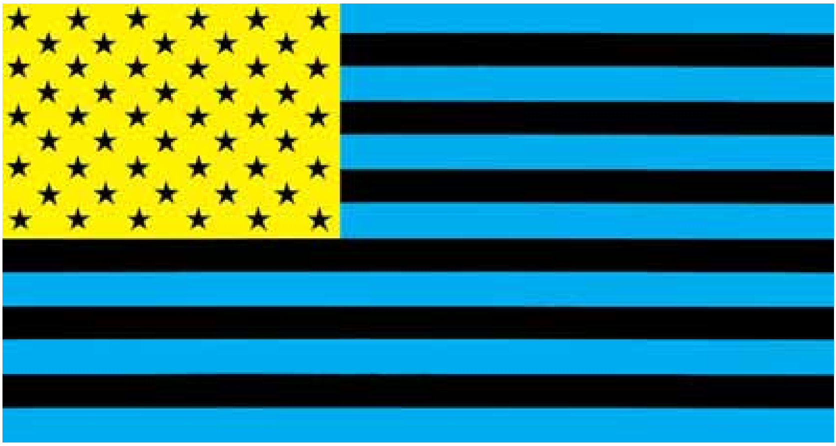
COLOR ADAPTATION

Like brightness adaptation, color adaptation can be classified into three main types which operate simultaneously in the process of seeing. To a considerable extent, all three function independently of brightness-adaptation effects.

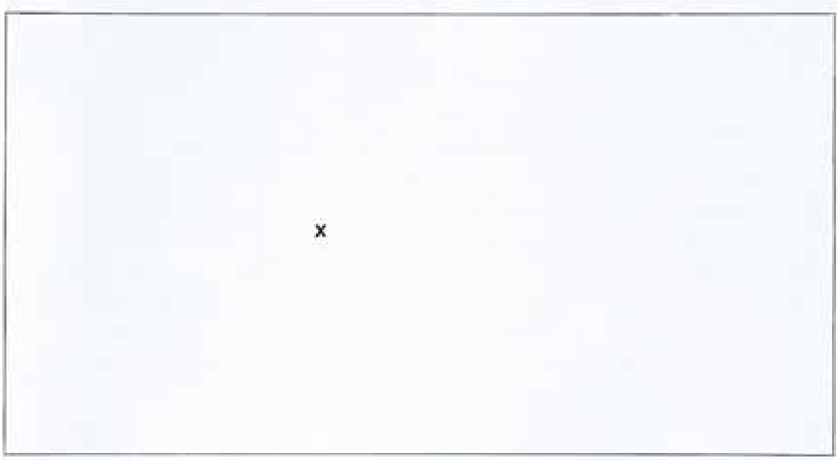
General Color Adaptation. In viewing any given scene, the visual mechanism adapts its color sensitivity in such a way that the illumination tends to appear colorless. This power of adapting to the color quality of the prevailing illumination is known as general color adaptation. By means of it, we become less aware of the physical conditions existing at the time and gain a better idea of how the scene would appear if viewed under conditions of our own choice. Thus we are not "misled" for example, to the conclusion that objects seen at sunset are actually ruddy in hue. As previously emphasized, however, a color film, having no powers of adaptation, will reproduce the over-all color balance of the scene as the eye sees it only when exposed under illumination of the quality for which the film is balanced.

If the scene is illuminated by two light sources which differ in color quality, the eye minimizes the color differences by adapting to an intermediate illumination color. Thus the effect of a greenish condenser lens, a reflector which is not neutral, or a lamp of the wrong type is difficult to see in viewing the original scene.

Local Color Adaptation. When there are fairly intense colored areas in the field of view, sufficient exposure of the eye affects subsequent vision in the corresponding areas of the retina. Fixation of the eye on a particular area for a brief time, followed by a fixation on another surface, gives rise to characteristic colored afterimages. A familiar example is shown on the page 58.



With this page illuminated by a fairly strong light, stare fixedly at the star in the lower right corner of the yellow field while counting 20 seconds. Then quickly shift your gaze to the black cross in the rectangle below. The flag will immediately appear in colors complementary to those printed above. The afterimage seen in this way is due to local color adaptation. In the area of the retina where the yellow field is first imaged, for example, the sensitivities of the red and green receptor systems are reduced by prolonged exposure to a mixture of red and green light. Thus, when the yellow field is replaced by white paper, red and green are subtracted from the neutral white, and a blue image results. As the receptor systems recover their sensitivities, the afterimage fades.



Lateral Color Adaptation. The effect of colored areas on the appearance of an adjacent colored area is similar to that induced by lateral brightness adaptation, except that here the result is an enhancement of color contrast, known as *simultaneous color contrast*. The group of four illustrations on page 21 demonstrates both brightness-contrast and color-contrast effects. The bluer appearance of the central patch at the lower left is due to simultaneous color contrast.

COLOR CONSTANCY

Perhaps the most important of all effects due to visual adaptation is the phenomenon known as *approximate color constancy*. Although, as previously mentioned, the character of the radiant energy reflected from a colored object varies considerably, depending on the spectral energy distribution of the illumination, we are not ordinarily aware that there is much difference in the appearance of the object. In fact, we are accustomed to think of most colors as not changing at all. This effect is due in large part to our tendency to remember colors rather than to look at them closely.

We do at times *fear* that the color of an object may look different in daylight from the way it appears under tungsten light. For example, in buying clothing, we may take it to a window. There we form a mental impression of its appearance in daylight, and this appearance becomes the "real" color, which remains approximately constant even if we later see the clothing under a wide variety of illumination conditions. Our tendency to accept the daylight color of an object as our mental standard may be based on the fact that humans have always depended on the sun as the most important source of illumination.

Although the color constancy effect is strong for most colors and most light sources, under certain conditions the color of an object may change decidedly. The conditions under which color constancy fails were described on page 19.

SUGGESTED READING on Color and Color Cinematography

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Includes:

- Light and color
- Characteristics of colors
- Kodak color films
- Problems in color photography
- Perception
- Suggested reading

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