Recorded sorties at the surface are checked by inspection of the surface sand for tracks. Such tracks are smoothed so that subsequent sojourns at the surface can also be verified. It is interesting to note that smoothing surface sand does not disturb an animal resting within a fraction of an inch of the surface unless its body is actually touched.

Both *Chilomeniscus stramineus* and *Chionactis occipitalis* were often seen to rest near the surface with only an inch or so of the tail exposed. Similar behavior reported for *A. pulchra* (*2*) was not noted by us. Although its significance has not been established, a temperature-sensing function served by this behavior seems possible.

Future reports will deal with detailed records of movements and with the effects of thermal gradients (*6*).

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Color Induction and Hue Discrimination

Abstract. A very close relationship has been found between hue discrimination thresholds and the differences in wavelength necessary to produce "full color" from two monochromatic light sources. This finding suggests a need for certain research in the area of color induction.

The experiments of E. H. Land (*1*, *2*) demonstrating that many of the natural colors of the spectrum can be produced with only two monochromatic light sources, or one monochromatic source and white light, have stimulated much spirited discussion among persons interested in the study of color vision. The opinion held by most psychologists is that the effects produced by Land are not new and can be explained by mechanisms known to color theorists for many years. G. L. Walls (*3*) has pointed out that most of the colors which Land

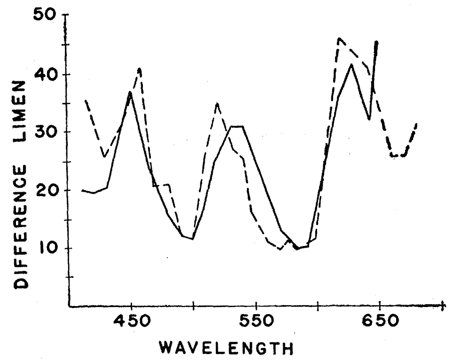

Fig. 1. Wavelength differences between projection primaries for a good effect (Land), dashed line, and hue discrimination thresholds (× 10) (Hecht), solid line. The units of both axes are millimicrons.

produced can be explained by simultaneous color contrast or spatial induction—phenomena which have been familiar to psychologists for over 100 years. Viewed in this light, the Land effect loses much of its dramatic appeal as a possible source of a new theory of color vision.

There is one aspect of Land's work which does seem surprising to many psychologists: The wavelength separation between the two sources of monochromatic light which is necessary for the perception of colors other than the colors projected is surprisingly small. A difference in wavelength of about 45 mμ seems to be sufficient to produce "full color" regardless of the position on the visible spectrum from which the two light sources are selected.

I decided to see what relationship these spectral separations have to difference thresholds for wavelength discriminations. When two monochromatic lights of the same wavelength are presented to a human subject and the wavelength of one light is increased or decreased until the subject is able to discern a difference in hue between the lights, it is found that the amount of variation necessary is different for different points along the spectrum. These thresholds have been reproduced by Hecht (*4*) (using the data of Steindler, 1906) and show that the maximum difference limen is about 4 mμ and occurs in the red region of the visible spectrum.

Land (*2*) has given in his Fig. 3 a graph showing the color arrays obtainable with various combinations of wavelengths used in projecting two superimposed images on a screen. From this graph one can obtain the minimal separation of longer and shorter wavelengths required in different spectral regions for a greater or lesser approach to "full color" in the projected picture.

The solid line in Fig. 1 shows the hue discrimination thresholds as reproduced by Hecht. These thresholds have been multiplied by 10. The dashed line represents the wavelength differences between projection primaries for a good effect as derived from Land's graph. These values are not multiplied by a constant.

One can see that there is a striking similarity between these two functions. The most obvious conclusion that can be drawn from this concomitant variation is that the production of "full color" from two monochromatic lights is dependent upon the existence of a sizable subjective difference in color between the two projection primaries. Thus, the three maxima of both functions correspond to regions of the spectrum in which a relatively large difference in wavelength is necessary to produce a subjective color difference. The interesting point to be made here is that it would appear from the graph that the wavelength separation necessary for "full-color" perception is some ten times as great as that necessary for a noticeable difference in hue.

Suppose that an annulus or ring of monochromatic light were projected upon a screen and that a second projector cast a spot of light of the same wavelength which filled the center of the annulus. If the wavelength of the surrounding annulus were varied, a point would be reached at which there would occur a noticeable change in the hue of the spot, despite the fact that the wavelength of the spot remained constant. On the basis of Walls's explanation of Land's findings and the relationship between the functions plotted in Fig. 1, one might expect that the change in wavelength of the annulus required to produce a change in the spot would be ten times that change required to cause a subjective difference in the hues of the spot and annulus (with each viewed through a mask which would prevent spatial induction).

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