THE COLOR SENSE

(Om farvesans.)

BIRGER MALLING.

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Abstract translation of a contribution from the University Physiologic Institute, from the Norsk Magazin for Laegevidenskaben, January, 1918, p. 1, by William H. Crisp, M. D. This reports an analytic study of twenty-five cases of slight anomalies of color perception.

The first color-blind patient was described in 1777, and in 1794 Dalton gave a thoro description of himself as color-blind. The study of color-blindness acquired real practical significance when Holmgren demonstrated that a railroad accident at Lagerlunda, Sweden, in 1875 was caused by a color-blind engine driver.

The classic grouping of defects of color vision is based upon Helmholtz's observation that mixture of the spectrum's three colors red, green and blue in various proportions is capable of giving a color impression corresponding to any given color of the spectrum, as these colors appear to the normal individual.

By means of the Rayleigh equation the relation between red and green components in trichromatic subjects (those capable of perceiving all three of the principal colors) has been studied; and it was shown that in a number of apparently normal trichromatics there were distinct variations from the normal in two directions, in that one group needed more of the red component to produce equality, while another group needed more green, that is to say the first group must be regarded as less irritable toward red, the other for green. Inasmuch as the individuals belonging to these two groups require the three usual components in order to see the various colors of the spectrum, but in a proportion differing from that of normal trichromatics, these individuals have been designated as protanomalous or deuteranomalous, according to whether they belong to the first or second group. This classification corresponds to the division of dichromatics, or individuals seeing only two component colors, into protanopes, whose so-called "warm" component's maximum lies nearer the green, and deuteranopes, whose "warm" maximum lies nearer the red. The protanomalous and deuteranomalous cases represent a transition toward the protanopes and deuteranopes.

The normal trichromatic sees the spectrum as a series of colors shading into one another from the extreme red to the extreme violet. Dichromatics, on the other hand, see the spectrum quite differently: protanopes and deuteranopes see merely two different-colored parts, a "warm" long-waved part, the conception of which approaches yellow, and a "cold" short-waved part, the conception of which approaches blue: these two parts are separated in the green by a so-called neutral region where no color is recognized. Protanopes further show a very characteristic relation in that the spectrum is shortened in the warm part, so that the conception of color and light out in the red part stops sooner than in normal individuals. Tritanopes see a marked shortening in the blue part. Monochromatics see the whole spectrum as one color—colorless—with a maximum intensity in the green, and show a shortening of the spectrum both in the red and in the violet part.

The object of Malling's study was originally to investigate anomalous cases more closely, in order if possible to show more clearly how far they were to be regarded as color-blind or not. Just as with the Rayleigh equation one obtains an expression of the irritability toward green in relation to red, so Malling wished to clear up the comparison between other parts of the spectrum, so as to obtain a more complete picture of the variations in color perception from individual to individual. For this purpose he studied twenty-five cases, eight women and seventeen men, most of whom were medical students and two graduate physicians; first by means of five "equations" between different parts of the spectrum, second as to the length of the spectrum both in the red and in the violet part, and third as to the "neutral" region.

Malling used for his experiments a modified Helmholtz color mixture apparatus which he describes in some detail. A detailed account of the individual investigations and their results in each subject is also given.

Malling's experiments indicate that there are greater and lesser departures from the normal in a large proportion of the cases examined, and these variations are not only in degree, but also in the nature of the disturbance. The suggestion is made that sooner or later it may be possible to demonstrate transitions from the normal through all forms of color-blindness in an unbroken series to complete color-blindness.

Tables corresponding to variations in perception of the same color from individual to individual show a steady diminution in the perception of nine spectral colors, reaching from the normal to the completely color-blind. The result must be regarded as applicable to every color of the spectrum. The slighter disturbances are as a rule isolated; the severer ones are more frequently present simultaneously at several parts of the spectrum.

The frequency of the various abnormalities is indicated by the following figures: Out of twenty-five cases, there was a reduction in color sense for red of wave length 660 in four cases, for red of wave length 658 in thirteen cases, for orange 600 in five cases, for yellow 576 in one case, for green 524 in five cases, for blue-green 502 in twelve cases, for blue 480 in five cases, for blue-violet 458 in one case, for violet 445 in one case. Out of nine cases there was a reduction for yellow 576 in three cases, for blue 458 in six cases.

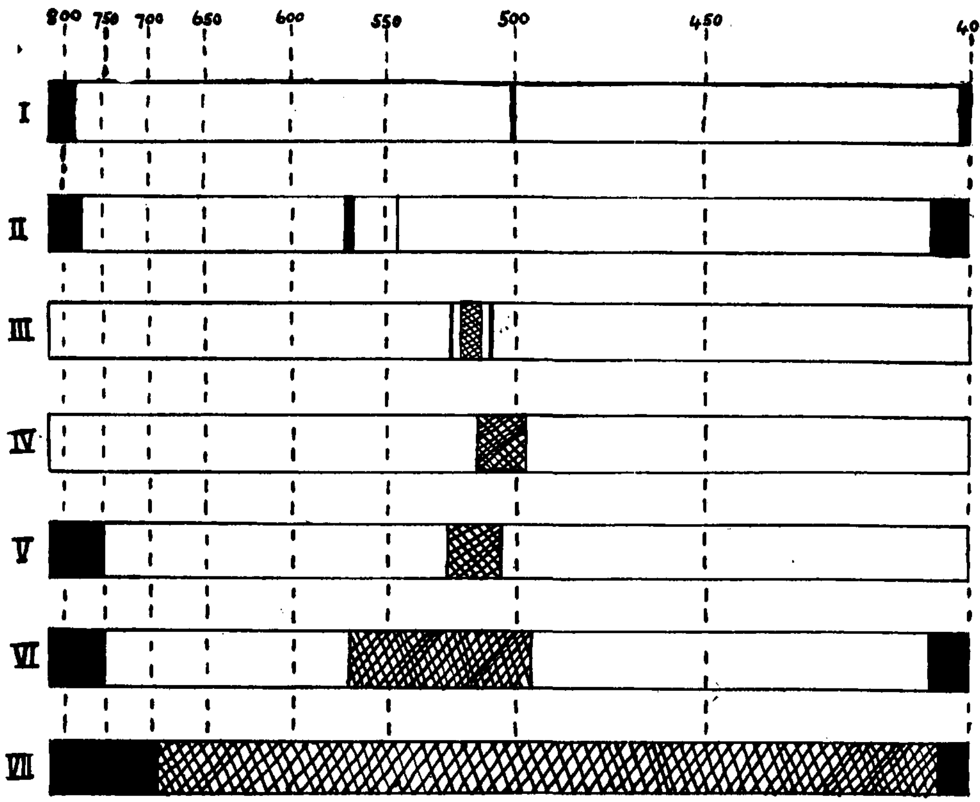
There thus appear to be two relatively weak points, one about 658 and one about 502, with diminishing weakness toward both sides. The greatest weakness is at 502 and upward, where the neutral spot usually appears. Thus the most frequent disturbances are in the red and in the green, in agreement with the relation found in practice, defects in these regions being so common that in using the word color-blind, for practical purposes, one thinks only of red-green blindness.

The numbers also throw an excellent light on the manner in which the red-green blind person's perception of the spectrum arises. In the green toward the blue-green the trouble is worse, and here we have the neutral spot, where the perception of color is entirely absent. From here the trouble has spread in both directions. Toward the blue it is soon arrested, so that as a rule the color-blind person can recognize the difference between blue and violet as two colors. But the relation is otherwise toward the red end, in that here the neighboring green section is markedly affected, the yellow is well recognized, but further along the red section is disturbed. Hence arises the difficulty in distinguishing the different colors in the long-waved portion of the spectrum: since the yellow is most definitely perceived, it happens naturally that the neighboring colors are confused with and approach yellow in their perception, and this part of the spectrum is seen as yellow.

In six of the subjects examined a neutral spot was found. This was far from being the same spot in all subjects, but varied distinctly both in position and extent. It also varied in intensity, in that in some subjects there could be traced a slight indication of color, what Malling calls an incomplete neutral spot, in distinction from the complete where the normal color is merely seen as gray. These areas are always seen by the normal person as possessing an intense color.

Chart I in the illustration shows a quite small incomplete or almost complete neutral spot at 500. Chart II shows two narrow incomplete neutral spots at 542 and 566, of which the latter is most pronounced and is almost complete. Chart III shows a somewhat broad complete neutral spot between 508 and 512: at the immediate boundaries of this spot color is recognized, but beyond these boundaries again there appears a narrow, incomplete neutral spot at 506 and one at 515: beyond these two color perception rapidly increases. Chart IV shows a broad, complete neutral spot from 508 to 498. Chart V shows a complete neutral spot from 517 to 503. Chart VII is the spectrum of a completely colorblind person, and may be considered as a single neutral spot. There is nothing to prevent our imagining all the neutral spots shown in figures I to V as occurring in the same person and turbances of similar nature with the neutral spot.

It is thus seen that the neutral spot may occur incomplete or complete, may be singular or plural in number, and may vary in location and extent. The pseudo-monochromatic must certainly be regarded as an intermediate step between Chart VI and Chart VII since he is characterized by being able to recognize colors only in the outer parts of the spectrum, and this only to so slight an extent that he may give the impression of being monochromatic.



Charts showing neutral zones in the spectrum in cases of anomalous color perception. (Malling) Roman numerals on the left indicate numbers of the charts as referred to in the text. Arabic figures at top indicate wave-lengths in different portions of spectrum.

also extending to the intermediate parts of the spectrum. The neutral spot which would thus be formed is indicated in Chart VI. The figures also show shortenings of the spectrum, which must merely be regarded as disturbances ...

The so-called anomalous cases are to be regarded as cases of color disturbance with defect chiefly in the red or in the green, but without either of these colors losing its specific color. Whether these cases shall be called a type or not is merely a question of words. They are a frequently occurring departure from the normal, with all transitions on the one side to the normal, on the other to the completely red-green blind; so that the boundaries of the group will always be variable. If the anomalous person's defect in red or green goes so far that one of these lacks its specific color impression, one has the case described as extreme anomalous, and characterized by being able to establish an equation between green and yellow or red and yellow, but never both equations at the same time. If the defect goes still further so that in addition to the green (or red) the red (or green) part of the spectrum also loses its specific color, the power to distinguish the colors of the long-waved portion of the spectrum will be completely lost and one has the completely red-green blind.

Malling traces through a series of illustrative cases the stepwise departure from the normal toward the pathologic. One case, a definite anomalous with defect principally in the green, although still retaining specific green perception of inferior quality, is compared with another case showing a similar defect in the red. In a third case, green perception is extremely reduced and this case approaches the so-called extreme anomalous, in that it can form an equation between a yellow and a green which are not too widely separated from one another in the spectrum (582 and 540). A fourth case lacks specific green and red perception, is a typical red-green blind, and can form an equation between all colors in the long-waved part of the spectrum. This group is of great practical importance in daily life, and the moderate degrees of this color disturbance present material difficulties in the determination of the problem whether they are practically competent as to color or not. For example cases unsuitable for purposes of navigation may succeed in passing the ordinary color tests; while on the other hand the various anomaloscopes, while furnishing information as to even small departures from the normal in green and red perception, do not necessarily indicate the proper boundary line between those who may and those who may not be properly employed in special services.

TOTAL ACHROMATOPSIA.

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Abstract translation from the Boletin de la Sociedad de Oftalmologia de Buenos Aires, Ano IV, p. 159, by M. Uribe-Troncoso, M. D. This reports the cases of two brothers, and gives a general review of the subject.

Altho partial blindness for colors is of common occurrence, total achromatopsia is very rare. The number of cases reported has increased recently since we have learned to suspect the condition by other and more noticeable symptoms than the color tests.

Achromatopes learn to distinguish colors and even to name them by their respective differences in brightness, by the presence or absence of reflexes on the surface, by the form of the objects and by habit. But for them the world is only an engraving with shades of gray and white. They generally go to the oculist to be relieved of three important symptoms, viz., low visual acuity, photophobia and nystagmus.

Visual acuity generally varies from 1/10 to 1/5; rarely reaches 1/3. Only one case is reported in the literature (Raehlmann) in which acuity of vision