[Proceedings of the Iowa Academy of Science](https://scholarworks.uni.edu/pias)

Volume 31 | Annual Issue Article 142

1924

Photochemical Distribution on the Retina as Shown by the Perimeter

Francis Marsh Baldwin

Recommended Citation
Baldwin, Francis Marsh (1924) "Photochemical Distribution on the Retina as Shown by the Perimeter," *Proceedings of the Iowa Academy of Science, 31(1),* 407-415.
Available at: https://scholarworks.uni.edu/pias/vol31/iss1/142

PHOTOCHEMICAL DISTRIBUTION ON THE RETINA AS SHOWN BY THE PERIMETER [1]

FRANCIS MARSH BALDWIN

Introduction. The extent of the visual field, as well as the distribution of photochemical substances upon it, has been a study of very great interest ever since the end of the eighteenth century, when the English chemist, Dalton, made the classical study upon himself. He was unable to distinguish the various shades of red and for a considerable time afterwards this particular deficiency in color discrimination was termed, "Daltonism." During the latter part of the nineteenth century the subject was given practical importance by a number of observers, especially by the researchers of Holmgren [2] the Sweedish physiologist who emphasized its bearing upon the cause of accidents by rail and on sea by a confusion of colored signals. As a result of these and other researches, it is now a practice in all civilized countries to require test for color blindness in the case of those who in railways or upon vessels may be responsible for the interpretation of signals.

From numerous statistics gathered, it has been shown that the defect is fairly prevalent among men while the proportion is very much smaller among women. The average is 2-4 per cent and 0.01-1.0 per cent in these respectively.

It is further stated that the defect is greater among the poor and uneducated peoples of the world than among the educated classes, and that it may exist in different degrees of completeness, from a total loss of color sensibility to feebleness in discrimination. From the biological side the problem becomes of interest since it appears to be congenital, being a factor transmitted from generation to generation which follows closely the Mendelian Law.

In view of these and other related facts, it was thought that a study of the distribution of the photochemical substances upon the retinae of a group of students enrolled in the physiology course of the home economics division might yield interesting results when correlated with certain factors, such as hereditary tendencies, near and far sightedness, binocular inequalities, diurnal variations, *et cetera.*

1 Some data cited are contributed by members of a class in advanced physiology.

2 Holmgren, Smithsonian Institute Reports, Washington, 1878.

Technique and Methods. Before describing in detail the instrument employed in subsequent experiments, a word should be said as to the extent of the retinal field. From the study of the dioptics of the eye it is obvious that the visual field is inverted upon the retina, and therefore objects in the upper field will be impressed upon the lower part of the retina and those on the right half of one eye ball upon the left half of the same eye and visa versa. Assuming that the retina is sensitive up to the *ora serrata,* it is apparent that if the eye were protruded sufficiently its projected field of vision would take the form of a circle upon a flat surface, the center corresponding to the *fovca centralis.* As a matter of fact, this is modified by the configuration of the face so that part of the field in the periphery of the retina is irregular. The projecting eye brows, the bridge of the nose and the cheek bones thus limit the field.

To obtain a delineation of the outline of the retinal field as well as to explore its sensitiveness to color in its various areas, an instrument known as a perimeter has been devised, Plate I. This consists of a semi-circular bar of considerable sweep, mounted upon a bearing so that it may be rotated into any meridian. Upon the bar is placed a rider that may carry the desired colored disk. The eye to be explored is placed so that it gazes over the top of a vertical rod provided for convenience with a chin rest. On the axis of the bar is placed a disk into which fits a blank chart with meridians marked off corresponding to the rotation plains of the bar.

In experiments throughout this series, a black background was used, so that the test color could not be blended with the background to give extention to the color fields under exploration. This precaution it would seem, is necessary and of great importance, as shown by Bush & McCrady [3] in a recent investigation, that red test was greatly extended on a blue background, and green field likewise, when either white or green background was used, while blue or yellow was greatest when red was the background.

Usual Distribution. Without an attempt to state the limits accurately, it is probable that in the majority of average, normal eyes, the extent of the color distribution from the fovea outward would be about as follows: Green field between 20° and 30°; red between 40° and 60°; and the blue between 50° and 70°, with white or gray in the extreme limits. Usually the respective fields are more restricted on the cheek and forehead sides than on the

3 Bush, A. D., and McCradie, R. S., Am. Jour. Physiol. V. 68, p. 103.

nose side. The right eye chart of Miss M., Figue 1, is fairly representative of this.

Among the differences noted in several score of charts may be listed the following classes: those in which there is a conspicuous reversal in the order of color distribution; restriction of distribution bordering upon complete lack of peripheral sensibility; irregularities causing a "patchy" distribution; binocular irregularities; diurnal variations in same individuals, and correlaton between eye defects, as near and far sightedness.

Reversal: A typical example in this class is seen in the binocular charts of Miss S. Here it is noted that in the case of the left eye, the field red is less extensive than the green, and that the blue field which normally is the greatest, is restricted to an area approximately equal only to that of red, while on the right eye the three colors are more equally distributed, but with reversal, as shown in Figure 2.

Restriction: Some individuals have been tested whose binocular charts show marked color restriction. In the typical case of Miss W., Figure 3, in this class this is accompanied by a reversal of order as in the preceding case, while in another case of Miss Z., Figure 4, the normal order was present, but the peripheral field so restricted that none exceeded the 10° circle. In the first instance, the greatest distribution of the blue field except for one small angular projection was within the 40° circle. Testing Miss Z for color discrimination by the Jennings test, showed that she possessed sufficient photo-chemical distribution in the *fovea* to enable her to pass the test, but the margin of safety in judgment in colored signal discrimination might not be great.

Patchy fields: No individuals have so far been found whose charts show a complete lack of photochemical substances in definite areas in the peripheral zones. In the binocular charts of Miss O, Figure 6, the left eye shows three such patches within the 30° circles on the cheek area, and two smaller areas close together within the 20° circle on the forehead side. In the right eye three such patches are delineated, and all fall within the 20° circle, two on the nose-cheek side and one on the forehead. What the physiological significance of these areas is, is problematical, and as yet no opinion can be expressed.

Binocular inequalities: Even in so-called normal eyes, great differences in the perimetric charts have been noted, in some cases these differences are expressed as differences in extent, more often they are expressed in both order of distribution and extent.

Illustrating these facts, the binocular charts of Miss C. are taken. In the right eye, Figure 7, the fields are comparatively limited, none of them going beyond the 40° circle, with the red zone the most extensive, and the blue the most restricted. On the other hand, Figure 8, the chart of the left eye shows the blue field extensive and the red falling between the inner green and outer blue areas typical of normal eyes. In such cases, one is tempted to believe that what one eye lacks, the other eye supplies, so that the resulting cortical picture is not seriously impaired.

Diurnal and other variations: In the study of diurnal variations, and the relations between various eye defects, not enough data has accumulated to warrant any far reaching generalizations. In the limited number of cases at hand, it would seem that the extent of the fields is not constant. In the three cases, where tests have been made on the same individuals in the morning and afternoon, it appears that as the day wears on, the fields become a little less extensive. Typically the binocular charts of Miss F, Figures 9 and 10, show these differences the first taken in the morning and the second late in the afternoon. Doubtless, factors enter here which are not easily analyzed if true, the one suggests itself of course as being closely akin to the phenomena of fatigue in other physiological processes.[4]

Another fact which seems conspicuous in its constancy is the relationship between extensive fields in near sighted and limited fields in far sighted persons. Without exception, where valid data were at hand, this seems to be the case. Two typical cases are here set in contrast. Miss D., Figure 11, is very near sighted and on her binocular charts the distribution of photochemical substances for the three colors is correspondingly extensive. Miss K., Figure 12 on the other hand, knows herself to be far sighted, and the binocular fields of her chart are comparatively restricted. Between these extremes have been found individuals whose binocular charts correlate definitely.

SUMMARY

1. Among the differences noted in the binocular perimetric charts from several score of young lady students as subjects, are

4 Bush, H. D., and McCradie, R. S., The effect of colored backgrounds on the area of color fields. Am. Jour. Physiol. V. 68, p. 103.

One must not lose sight of the fact also that differences in intensity of illumination has marked effect subjectively. This factor has been taken care of in these experiments by first, having the background of the field a uniform black, and second, by making the tests in a room where none but reflected north light could enter. Ther perimeter always being placed on a table approximately at right angles to the light source.

those in which there is a conspicuous reversal in order of color distribution; restriction of distribution bordering upon complete lack of peripheral sensibility; irregularities in retinal area, causing "patchy" distribution; certain binocular irregularities; diurnal differences in the same individuals, and a correlation between the extent of the field and certain eye defects such as near- and far-sightedness. Normally, the periphery of the retina shows photochemical distribution for green limited from the *fovea* outwards to about the 20° circle; for red, outwards to 40° circle and for blue, outwards to about the 60° circle, while beyond these limits, is a gray-black field.

2. Not infrequently do we find individuals where these limits are either extended or very much restricted and in addition accompanied by reversal, of the order of one or all of the colors. In some cases, the distribution is so limited to the locality of the *fovea*, that the peripheral retina is to all intenses color-blind. Again certain spots occur on the periphera in some individuals where apparently there is a complete lack of photochemical substances. This gives a "patchy" chart, the significance of which has as yet not been fully analyzed. So far as records have been obtained, near-sightedness is usually accompanied by a rather extended color field, whereas far-sightedness shows a very greatly restricted area. A large variety of binocular differences have been found, both as to order of colors, their contours, and their extent.

PLATE I.

A Perimeter, the instrument used in exploring the color fields of the retina. The semicircular bar may be placed in any meridian, and the colored object may then be placed in a "rider", and moved along the bar from inside outwards until it can no longer be distinguished. The angular distance is then noted and marked off on the recording chart shown on the round disk. The eye gazes over the chin rest supported by the bar in the background.

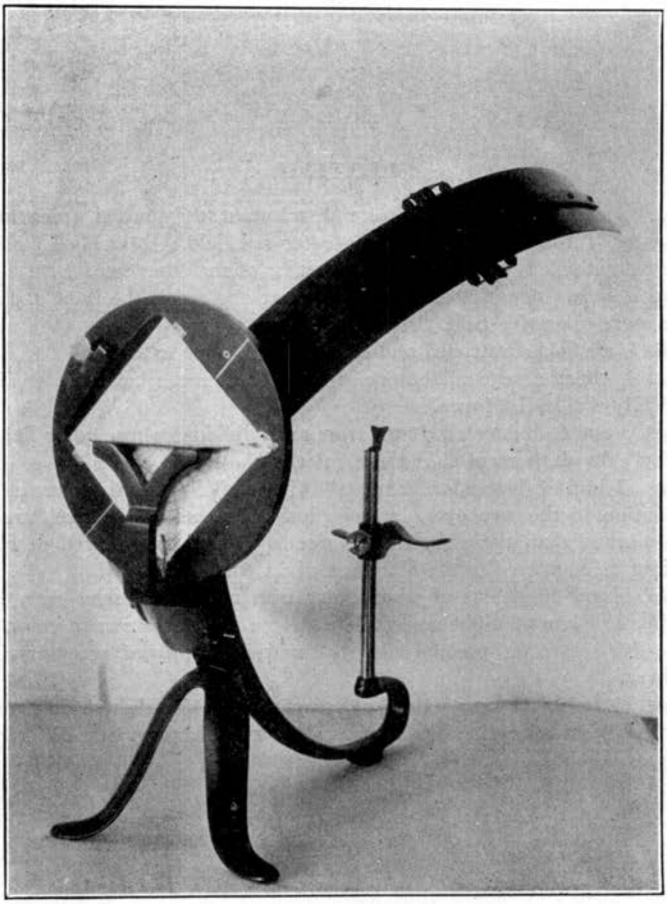

Plate I.

PLATE II.

Fig. 1, shows usual normal color distribution, the limited green field in the center, (crosshatched) a little greater red field, (solid black) and the blue field (stippled) extending beyond either of the other two.

Fig. 2, shows remarkable difference where the red is the limit and green is the more extensive field.

Fig. 3, all fields restricted and of about the same extent.

Fig. 4, chart of eye all but color blind, notice the color fields all fall practically within the fovea.

Figs. 5 and 6, Binocular charts from an individual whose color fields are "patchy", the dark areas shown are colorblind.

Figs. 7 and 8, binocular charts showing individual variations in color distribution in the two eyes, in some instances these differences are even more marked than these shown. Notice a very restricted area of blue in the right as compared to the blue area of its partner.

Figs. 9 and 10, charts of same eyes of an individual taken early in the morning and late at night respectively. Note the restriction in color fields as the day wears on, probably due to rapid fatigueing of receptors in the periphera.

Figs. 11 and 12, A near-sighted as compared to a far-sighted field respectively. Without exception our records show this characteristic difference in field extensibility.

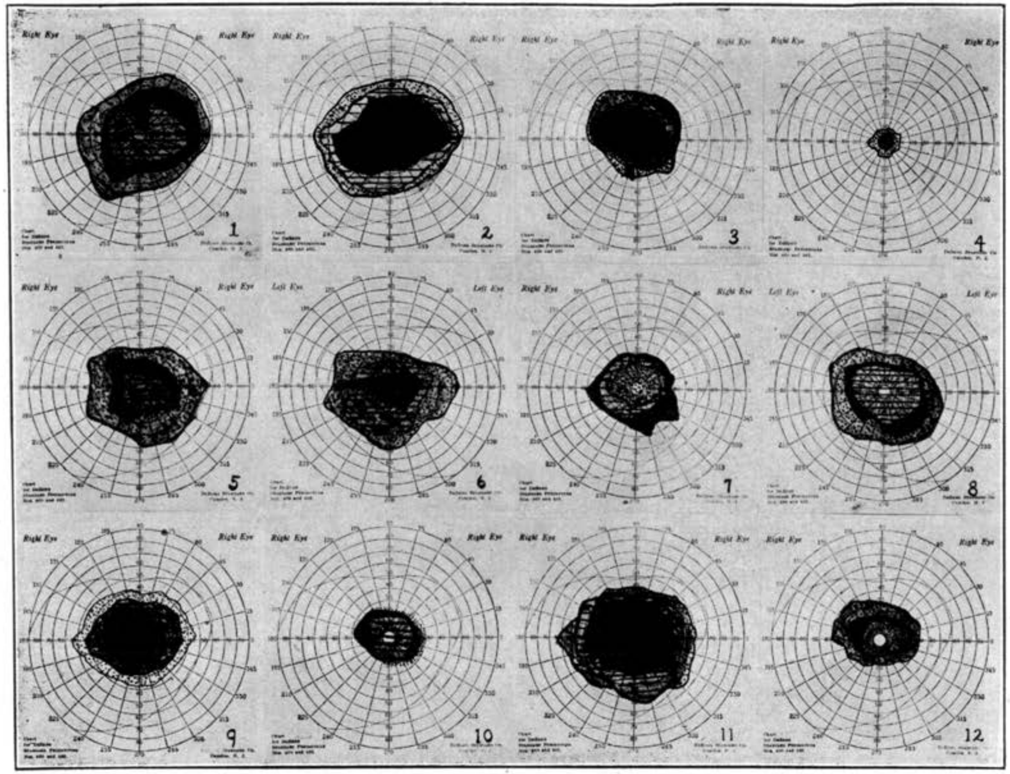

Plate II.