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# Comparison of Form and Color Fields*

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## PROBLEM

Many studies have been made of the color fields of the eye and some consideration has been given the form fields. With the invention of the microscope by Leeuwenhoeck in 1722, who first made a study of the retina of the frog, much interest has been shown in the structure and functions of the retina. Some of the world's greatest histologists such as Cajal, Mueller and others have studied the structural characteristics of the retina. Very little attention has been given the functions of the retina from the point of view of psychology.

As shown by Helmholtz and others the point of keenest vision is a very small area of the retina. Acuity drops off very rapidly in each direction as the distance from its center is increased. According to Bromback (1936) the fovea centralis measures from 1.7 mm. to 2.0 mm. along the horizontal axis and represents only about five degrees of the complete arc of the visual field. It contains only cones which are so closely packed that they assume a hexagonal shape. At from 1.2 mm. to 1.5 mm. from the center of the fovea the cones thin down and there are several layers of rods between them.

The ratio of rods to cones also increases directly with the distance from the center of the fovea. At four degrees away it is 10.1, at ten degrees this ratio is 20:1. The latter relationship holds out to the oro serrata where the rods diminish in number abruptly while the cones, altho widely separated, remain about the same.

According to Krause's early studies there are about 1,300,000 million cones in the human retina, altho there are only about 800,000 optic nerve fibres. Walls (1942) summarizes recent estimates as from 6,300,000 to 6,800,000 cones and from 110,000,000 to 125,000,000 rods. He also estimates there are 1,000,000 fibres in the human optic nerve. Authorities are not entirely in agreement that each cone has its own bipolar connection to the optic fibres proper, while several rods may be connected to one fibre through separate bipolar cells.

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Reports of the percentage of vision, as the stimulus is presented at different points in the periphery away from the fovea, seem to vary. Traquaire (1924) has summarized the data as follows:

A letter which is discriminable at foveal vision must be enlarged almost nine times to be discriminated at 25 degrees nasal. At a very much larger angle it cannot be discriminated at all. The temporal side extends considerable further. The field is not round but takes on the oval shape of the fovea.

It is well known that while acuity decreases as distance from the macular field is increased, sensitivity to movement increases. It is generally stated that form and color fields parallel closely, altho little experimental evidence has been presented to establish the facts. Many theoretical, clinical and practical problems arise from sketchily known facts concerning the nature and significance of variations in the size of the visual fields for color as well as for form.


The golf player gets his cue to accuracy by focusing directly on the ball since it is not moving, while the baseball player at bat keeps his eye on the pitcher and guides his bat to the ball by indirect vision. Likewise the automobile driver get most of his general cues from indirect or peripheral vision but must use macular vision for reading signs, markers and other details. The relationship and order of importance of these two functions of the retina in actual life situations has not been studied. That the cones are receptors for both color and form has been widely accepted. The evidence is not entirely conclusive.

The present study is an attempt to develop a satisfactory method of measuring and comparing the size of the color and form fields. As a preliminary study of the relationship between form and color fields the following hypothesis may be stated in the null form: The size of the form and color fields are not functionally related. It is here assumed that the measurements of the field in eight different meridians is adequate, as were made for the most part in these experiments. It is also assumed that the subjects use are normal as far as ocular pathology is concerned. Standard directions for campimetry were read to each subject and his fixation at a center point was constantly emphasized to secure uniform results. Constancy in appearance of the test objects was emphasized throughout the measurements. This is very important in perimetry and campimetry.

## Apparatus

A Maddox-Lloyd Cheiroscope as shown in Figure 1 was used as a campimeter. Special millimeter cross section charts were employed in making the measurements. The color targets were 9/32 inch in diameter. Five letter sizes of 19/32, 14/32, 11/32, 9/32 and 8/36 inches in diameter were constructed as the stimulus objects for form. Various Snellen Test letters were used.

A Keuffel and Esser Planimeter No. 4236 was used for determining the size of the fields plotted.

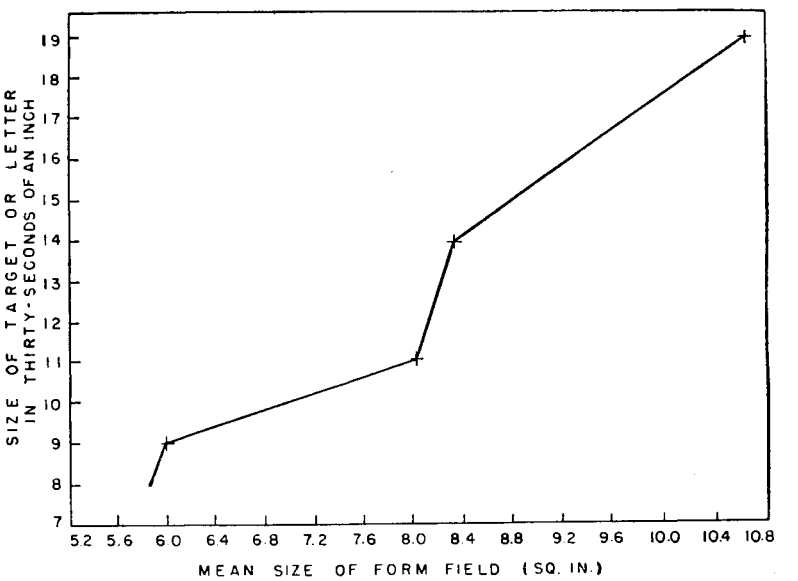
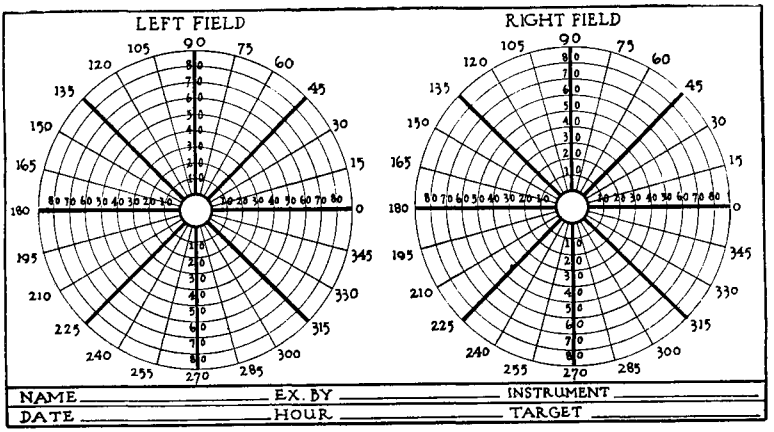



Figure 1.




| Direction Examiner | | | DOWN-R | UP-L | LEFT | RIGHT | UP-R | DOWN-L | DOWN | UP | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Direction Patient | | | DOWN-L | UP-R | RIGHT | LEFT | UP-L | DOWN-R | DOWN | UP | |
| Meridian in Degrees | | | 225 | 45 | 0 | 180 | 135 | 315 | 270 | 90 | |
| RIGHT EYE-O.D. | GREEN | ⇨ | Green | Yellow | Red | Green | Blue | Red | Blue | Blue | ⇨ |
| | RED | | Red | Green | Blue | Blue | Red | Green | Red | Yellow | |
| | BLUE | | Blue | Blue | Yellow | Yellow | Yellow | Blue | Yellow | Red | ⇨ |
| | Yellow | | Yellow | Red | Green | Red | Green | Yellow | Green | Green | |
| LEFT EYE-O.S. | GREEN | ⇨ | Green | Green | Yellow | Green | Red | Green | Red | Yellow | ⇨ |
| | RED | | Red | Yellow | Blue | Yellow | Yellow | Yellow | Blue | Blue | |
| | BLUE | | Yellow | Red | Green | Red | Blue | Blue | Green | Red | ⇨ |
| | Yellow | | Blue | Blue | Red | Blue | Green | Red | Yellow | Green | |

Figure 2.

## Method and Procedure

The method is essentially that of measuring the form fields by the conventional campimetry technique using eight meridians as found on the Hutchinson Chart in random order as shown. At the completion of measurements the points were connected and the area measured by the planimeter. The areas of the various fields were then correlated by the standard Spearman Rank Formula which seemed most appropriate to the number of cases used.

In all 14 eyes of 7 different subjects were measured.

## Results

The results are presented in tabular form after which rank correlation between the various indices are shown.

**Table 1**

Relative Areas of Color and Form Shields in Square Inches.

| Name | Color Field | | | | | Form Field | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Red | Green | Yellow | Blue | Total | Largest | Large | Medium | Smaller | Smallest | Total |
| | (Targets 9/32 in. in diameter) | | | | | (Letter size in inches) | | | | | |
| | | | | | | 19/32 | 14/32 | 11/32 | 9/32 | 8/32 | |
| Binder, Ronald | | | | | | | | | | | |
| Right eye | 3.39 | 9.55 | 11.87 | 14.66 | 39.47 | 3.31 | 2.12 | 2.10 | 1.42 | 1.25 | 10.20 |
| Left eye | 4.65 | 8.25 | 12.75 | 16.67 | 42.32 | 2.64 | 2.25 | 1.50 | 1.05 | 0.81 | 8.25 |
| Lincoln, Deborah | | | | | | | | | | | |
| Right eye | 6.97 | 11.43 | 16.26 | 22.81 | 57.47 | 5.58 | 4.95 | 5.01 | 4.41 | 3.45 | 23.40 |
| Left eye | 4.31 | 11.53 | 19.18 | 20.50 | 55.52 | 4.98 | 4.01 | 3.92 | 4.84 | 4.08 | 21.83 |
| Lindstrom, Glenn | | | | | | | | | | | |
| Right eye | 14.41 | 14.56 | 17.28 | 19.45 | 65.70 | 11.96 | 13.90 | 10.88 | 11.02 | 9.95 | 57.71 |
| Left eye | 11.45 | 12.36 | 17.56 | 17.13 | 58.50 | 18.60 | 13.24 | 15.36 | 11.62 | 13.25 | 72.07 |
| Rostenbach, Albert | | | | | | | | | | | |
| Right eye | 4.69 | 6.90 | 6.18 | 10.18 | 27.95 | 9.33 | 8.05 | 7.17 | 5.03 | 4.43 | 34.01 |
| Left eye | 4.36 | 9.20 | 8.35 | 14.52 | 36.43 | 7.25 | 7.25 | 7.36 | 4.70 | 4.20 | 30.76 |
| Tilton, T. W. | | | | | | | | | | | |
| Right eye | 8.40 | 13.45 | 12.00 | 16.65 | 50.50 | 11.00 | 8.65 | 6.31 | 3.73 | 4.50 | 34.19 |
| Left eye | 8.10 | 11.65 | 8.95 | 12.78 | 41.48 | 9.90 | 11.29 | 9.46 | 8.49 | 9.46 | 48.60 |
| Stinogel, Dick | | | | | | | | | | | |
| Right eye | 8.07 | 9.91 | 16.91 | 11.12 | 46.01 | 12.25 | 4.37 | 3.51 | 2.37 | 2.70 | 25.20 |
| Left eye | 4.83 | 8.35 | 14.40 | 12.75 | 40.33 | 13.00 | 8.44 | 7.16 | 3.09 | 2.90 | 34.59 |
| Thompson, R. M. | | | | | | | | | | | |
| Right eye | 22.12 | 21.72 | 28.40 | 25.32 | 97.56 | 22.40 | 21.30 | 18.54 | 14.60 | 13.07 | 89.91 |
| Left eye | 25.62 | 23.80 | 25.20 | 26.68 | 101.30 | 16.54 | 12.19 | 13.97 | 7.13 | 7.66 | 57.49 |
| Total | 131.37 | 172.66 | 215.29 | 241.22 | 760.54 | 148.74 | 117.51 | 112.25 | 83.50 | 81.71 | |
| Mean | 9.383 | 12.332 | 15.377 | 17.23 | 54.324 | 10.624 | 8.393 | 8.017 | 5.964 | 5.836 | |
| N = 14 | | | | | | | | | | | |

**Table II**

Correlations Between Color and Form Shields—All Data.

The total field for form was calculated by adding all five sets of letter measurements. The average size in square inches would be 1/5 of each figure given in Table I. This would in no way affect the correlations except to stabilize the indices or values for correlation purposes.

| Rho | | |
|---|---|---|
| Right Eye | Left Eye | Variables |
| +.89 | +.86 | Red and Total Form Field |
| +.75 | +.82 | Green and Total Form Field |
| +.43 | +.14 | Blue and Total Form Field |
| +.61 | +.32 | Yellow and Total Form Field |
| +.64 | +.43 | Total Color and Total Form Field |

The mean of all correlations for all measurements of form and color was +.589. No checks were made of the reliability of the field charting technique but it could not be lower than the correlations obtained hence may be considered satisfactory. The planimeter measurements have a very high reliability. The average of several tracings were made for each value used.

## Conclusions

The methodology used appears to have some merits for the quantitative comparison of visual fields for experimental or clinical purposes. The hypothesis as stated is not sustained altho it would appear that red and green are more closely related to form fields than are blue and yellow. This may mean only that measurements near the fovea can be made with greater precision and consistency. The present paper is to be considered as a description of a pilot study and further investigation is in progress.

### References

Bromback, T. A., Visual Fields. Tuttle Publishing Co., Inc., 1936, pp. 238.

Helmholtz, Herman L. F. von, Treatise of Physiological Optics. (3rd Ed.), 3 Vol. Optical Society of America, 1924-25.

Lloyd, R. I., Visual Field Studies. (Medical Library)

Traquaire, H. M., Clinical Perimetry. (Medical Library)

Walls, Gordon L., The Invertebrate Eye. Cranbrook Institute of Science Bull. 1942, No. 19; pp. 689.

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