

Colour Vision of the Fovea Centralis

MR. E. N. WILLMER¹ in his communication in *Nature* of May 11, 1944, and in his recent address to the Colour Group of the Physical Society (November 22), directed attention to the defective colour vision of the fovea centralis in the normal eye. He pointed out that the colour confusions which occur there are similar to those experienced by blue-blinds (tritanopes).

It is worth recalling that fifty years ago König² came to a like conclusion from careful experiments on his own and other normal eyes. Describing his work, he wrote: "I have established the complete dichromatism of my fovea by setting up foveal colour matches between mixtures of 650 m μ and 475 m μ on the one hand and all intermediate spectral regions on the other. The matching field could, it is true, be held in the fovea for only a few seconds, frequently for only a fraction of a second". Despite these fixation difficulties, König was able to determine the green and red *Elementarempfindungen* for the central fovea, and to compare them with the corresponding curves for a larger matching field extending into the truly trichromatic region of the macular retina. He explained the observations in terms of his theory of the function of visual purple and visual yellow. The theory has not thrived and the experimental result just described may in consequence have attracted less attention than it deserves. Parsons³ refers to it, however.

It may be well to emphasize that partial or complete blue-blindness of the fovea centralis can be accommodated in various visual theories (König's own, for example) and does not provide a crucial test of Mr. Willmer's.

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¹ Willmer, E. N., *Nature*, **153**, 774 (1944).

² König, A., "Human Visual Purple and its Role in Vision". *Sitz. Akad. Wiss. Berlin*, 577 (June 21, 1894). "Blue Blindness", *Sitz. Akad. Wiss. Berlin*, 718 (July 8, 1897) (reprinted in König's Collected Papers on Physiological Optics).

³ Parsons, J. H., "Colour Vision"

DR. M. H. PIRENNE's experiment on colour vision¹ seems to be designed to test Willmer's suggestion that the rods are the end organs which are mainly responsible for the sensations of blue and violet², and he reaches the conclusion that "The rods are not necessary for colour vision".

Such a conclusion from this experiment (much of the substance of which is reported by Parsons and attributed to Gotch³) is scarcely justified. Pirenne's curve for violet light shows three 'coloured' points, two of which, those at 0.75° and at 0.34°, would, on the basis of Østerberg's data, fall on rod-containing retina. The third, if accurately focused, seems to utilize a portion of retina free from rods, but when astigmatic and other aberrations are considered, even this test area might fall partly on the rods. Thus the 10' test field used could have stimulated the rods; and therefore if one postulates, as Willmer has done, that the rods are mainly concerned in blue and violet vision, the results given are not contradictory to this suggestion.

Objects which subtend a much smaller visual angle than 10' would seem to be necessary if evidence is

to be collected on this point. One such object is used in the following experiment, which demonstrates the blue blindness of the fovea noticed by König (ref. 3, p. 84). A hole 2 mm. in diameter was drilled in sheet metal and covered with an Ilford spectrum-violet filter which is stated to transmit only wave-lengths less than 4800 Å. This was then viewed at a distance of 10 metres with a strong source of illumination behind it. By looking directly at the violet spot and so using foveal vision, the small star-like image could be made to disappear entirely; whereas on viewing the test object with the parafoveal retina the deep violet colour could be easily seen. If the Ilford spectrum-red filter was used (stated to pass only wave-lengths greater than 6200 Å.), no such disappearance with foveal and re-appearance with parafoveal vision was possible at any distance. The test object subtends an angle of about 1' at the eye in this experiment, but owing to aberrations of the optical system the area of the retina illuminated in practice would be larger than that calculated from this visual angle; it is probably not larger than the size of the rod-free area given by Østerberg.

The blue blindness of foveal vision can be explained in two ways:

1. The test object disappears because its image lies wholly within the rod-free area of the retina, and thus according to Willmer's theory on receptors which are insensitive to violet light.

2. At the fovea there is an increase in the amount of macular pigmentation sufficient to absorb the whole of the violet light.

This latter view is commonly held; but it does not agree with anatomical data, which show that the amount of yellow macular pigment present is actually less at the fovea than it is at other parts of the central area, and it may possibly be absent altogether⁴. The absence of violet receptors in this region would explain the above result quite as well.

It might be argued that if indeed there was a violet-blind foveal area, one would see a dark spot at the centre of an evenly illuminated violet field. In fact, one would not see such an area, because one would disregard it in the same way that one disregards the shadows on the retina of the retinal vessels. Hence it appears that the rods may be necessary for colour vision and may be, as Willmer postulates, the receptors most concerned with violet vision.

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¹ Pirenne, M. H., *Nature*, **154**, 741 (1944).

² Willmer, E. N., *Nature*, **151**, 213 and 632 (1943).

³ Parsons, J. H., "Colour Vision", 2nd ed., 85 (Cambridge, 1924).

⁴ Polyak, "The Retina", 198 (Chicago, 1941).

MR. L. C. THOMSON says in his communication that my experiments¹ on colour vision in the dark-adapted eye do not prove that the rods are not necessary for colour vision, because in all cases the blue light of the test field might (according to Mr. Thomson) have stimulated rods—which in Willmer's² theory are supposed to be mainly responsible for blue and violet vision. It must first be pointed out that my statement "The rods are not necessary for colour vision" is not a general conclusion, as it may appear to be in the quotation given by Thomson. Its context