The physical aspects of a theory of colour vision / by F.W. Edridge-Green.

From the author.

The Physical Aspects of a Theory of Colour Vision.

By F. W. Edridge-Green, *M.D., F.R.C.S.*

The view which I wish to bring forward is that each optic nerve fibre is able to convey impulses corresponding to all kinds of light; that is to say, a very similar condition exists in the impulses which are transmitted along the optic nerve to that which is accepted for waves of light previous to their entering the eye. The limitation of the number of colour sensations was thought to be necessary because it seemed physically impossible that a single fibre of the optic nerve could convey all waves of light. The facts of colour vision can only be satisfactorily explained on the assumption that each optic nerve fibre does convey impulses corresponding to all waves of light. It occurred to me that if there were a transforming apparatus in the eye we could explain the facts. The telephone shows how this may be accomplished in the case of sound. I saw that the retina was constructed in a manner theoretically perfect from this point of view. The percipient layer of the retina is made up of two kinds of elements, the rods and the cones. The portion of the retina corresponding to the central portion of the field of vision contains only cones. External to this spot the cones are arranged with one or more rings of rods round them, the single ring being round those cones which are nearest to the central portion. In the rods there is a rose-coloured substance, the visual purple, which is very sensitive to light. This photo-chemical substance is found exclusively in the rods. I assumed that light falling upon the eye liberated the visual purple from the rods, just as heat would an ointment, and a photograph is formed. The decomposition of the visual purple by light chemically stimulates the ends of the cones, and a visual impulse is set up which is conveyed through the optic nerve fibres to the brain. I have examined the retinas of several monkeys after they had been kept in a dark room, and found that the visual purple was to be seen in the yellow spot, but situated between, and not in, the cones. This view gives a reason for a great many facts which were previously inexplicable. For instance, a bright light may fall upon the fovea (the centre of the yellow spot) without producing any sensation, and a perceptible interval elapses before we are able to see with the yellow spot, after the remainder of the retina, the fovea being the last point to convey a sensation of light. The first fact we should expect, the cones being insensitive to light; the second corresponds to the diffusion into the yellow spot of the visual purple. All the facts of colour mixing, contrast, and after-images can be explained by the hypothesis that the visual purple is the visual substance. A positive rose-coloured after-image can be obtained after white light or any spectral colour. The ordinary explanation of this, namely, that the action of the hypothetical red and violet fibres persists longer than those for green, cannot be true, because it is exceedingly difficult to obtain this after-image after spectral red, and very easy to see it after green. It would be against the whole principle of the theory that the red fibres should be excited most efficiently by green. But if we assume that the visual purple is the visual substance, then we have an easy explanation of the facts.

The fibres of the optic nerve pass to the visual centre. I have assumed that the visual centre transmits to the mind impressions of white light, and that by it objects are seen monochromatically, as in a photograph. The visual centre is, therefore, acted upon by impulses caused by all rays of light, the colour-perceiving centre being concerned with the quality of the impulse within the power of perceiving differences possessed by that centre, or portions of that centre.

I will now apply this theory to colour-blindness, and it will be seen that it gives a simple explanation of the facts.

Cases of colour-blindness may be divided into two classes, which are quite separate and distinct from each other, though both may be present in the same person. In the first class there is light as well as colour loss. In the second class the perception of light is the same as the normal sighted, but there is a

defect in the perception of colour. In the first class certain rays are either not perceived at all or very imperfectly. Both these classes are represented by analogous conditions in the perception of sounds. The first class of the colour-blind is represented by those who are unable to hear very high or very low notes. The second class of the colour-blind is represented by those who possess what is commonly called a defective musical ear. Colour-blind individuals belonging to this class can be arranged in a series. At one end of this series are the normal sighted, and at the other the totally colour-blind. The colours appear at the points of greatest difference, and I have classified the colour-blind in accordance with the number of colours which they see in the spectrum. If the normal sighted be designated hexachromic, those who see five colours may be called pentachromic; those who see four, tetrachromic; those who see three, trichromic; those who see two, dichromic; and the totally colour-blind, monochromic. There are many degrees included in the dichromic class. There may or may not be a neutral band, and this is widest in those cases approaching most nearly to total colour-blindness. I have recorded a case of a patient who was colour-blind with one eye. It is an interesting fact that for form vision the colour-blind eye was much the better of the two, and he could recognise fine lines in the spectrum with this eye which were not visible to the other. He saw the two ends of the spectrum tinged with colour and the remainder grey. It will be noticed that his colour sensations were limited to the extreme red and the extreme violet, namely, those colours which present the greatest physical contrast to each other. Neither the red nor the violet appeared of the nature of a primary colour, but gave the impression that they were largely diluted with grey. A theory of colour vision must account for a case of this kind and also for the other varieties and degrees of colour-blindness. The trichromic are a very important class, and any theory must account for the fact that they see yellow as red-green and blue as violet-green. As we should theoretically expect, when there is shortening of the spectrum the centres of the colours are moved towards the unshortened side.

I will conclude by showing how this theory will explain the trichromatism of normal colour vision. It also explains why certain persons see spectral yellow as red-green and spectral blue as green-violet. In past ages all saw the rainbow made up of only three colours, red, green, and violet. When a new colour appeared between the red and green (yellow) it is obvious that a mixture of red and green would give rise, not to red-green, but to the colour which had replaced it, namely, yellow.

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THE BOARD OF TRADE TESTS FOR COLOUR BLINDNESS.

SIR,—I cannot allow Mr. Gerald Balfour's reply to Mr. Bousfield on the above subject to pass without comment. The inefficiency of the Board of Trade tests for colour blindness is well known to all medical specialists on the subject, and numerous cases have been recorded in the medical journals of colour-blind persons who have escaped detection by the test of normal-sighted persons who have been rejected by it. A reference to the Report of the Board of Trade will show that one year 38 per cent. of those who appealed, and another year over 42 per cent., were found to be normal sighted, and to have been rejected wrongly. Six varieties of colour blindness may escape detection by the test used and three of these varieties are dangerous, namely, those who cannot see a red light at a distance at all and have no other colour defect, those who cannot distinguish a red light from a green at a distance, and those who cannot distinguish yellow as a colour, therefore cannot recognize the difference between the mast-head light and the side lights. I am well aware that a well-known physicist advises in doubtful cases, and that not a single medical man is employed for the examinations. I must say that I do not consider a physicist to be a proper person to be a referee on an important medical question any more than it would be advisable to consult a physician on some electrical problem.—I am, etc.,

Welbeck Street, W., Dec. 22nd. F. W. EDRIDGE-GREEN.

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