The Discrimination of Colour.

By F. W. Edridge-Green, M.D., F.R.C.S., Beit Medical Research Fellow.

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(From the Institute of Physiology, University College.)

In a paper on the relation of light perception to colour perception,* and in previous writings,† I have stated that if a portion of the spectrum be isolated, it will appear monochromatic, the length of the monochromatic region varying with the intensity and wave-length of the light and the colour perception of the observer. Most normal sighted persons make about eighteen such divisions in a bright spectrum.

In a paper in the 'Proceedings of the Royal Society,'‡ Lord Rayleigh, whilst agreeing that the facts were as I stated in the conditions described by me, expressed the opinion that he could distinguish between the wave-lengths included in a monochromatic division to the extent of discriminating between the colours of the two D lines. Lord Rayleigh kindly lent me the colour box with which he had made the experiments, and, on repeating them in the manner described by him, I arrived at similar results. I hope, however, to be able to show that the results obtained by Lord Rayleigh were due to the admixture of small quantities of white and coloured light and to certain physiological influences which had not been taken into consideration, and which prevented him from arriving at a correct interpretation of the colours.

If a prism, even of the finest polish, be examined with a strong light against a dark background, numerous small particles and irregularities of the surface, which irregularly disperse the light, will be seen. The reflections from the sides of the prisms, lenses, and sides of the box have also to be taken into consideration. The amount of this irregularly dispersed light is small, but is a very important factor taken in conjunction with other facts. It is necessary, therefore, in order to get rid of the greater part of this irregularly dispersed light, to allow the light included in a monochromatic region to pass through a second aperture, such as that in my spectrometer. When this is done, I have found it impossible by any method which I have adopted to distinguish between the various waves included in the mono-

* 'Roy. Soc. Proc.,' B, 1910, vol. 82, p. 458.

† 'Colour Blindness and Colour Perception,' International Scientific Series.

‡ December, 1910.

chromatic region. I have magnified the image of this region with eyepieces of different power, making a corresponding increase in the light to make up for the loss of luminosity caused by the magnification. I have also obstructed the central portion of the monochromatic region with a screen, and the remaining portions have still appeared monochromatic. The most conclusive experiment, however, is the examination of the monochromatic region with an achromatic double image prism, the intensity of the source of light being increased as before. By this method two rectangular monochromatic fields are seen, and can be arranged so that they are side by side and just touch. The portion belonging to the red side of the spectrum of one can be made to touch the portion belonging to the violet side of the spectrum of the other. This position is therefore most favourable for the detection of any difference, and yet I cannot detect any, neither can any other observer to whom I have shown the experiment. The experiment can be observed objectively in the following manner: An arc light being used for the illuminating source, a pure spectrum is obtained; a portion of this spectrum, forming a monochromatic region, is allowed to pass through an adjustable slit. Two images of this monochromatic region can be thrown with the aid of a double image prism upon a screen and made of any required size. The varying size of the monochromatic regions with different persons can by this means be demonstrated to a large number.

Another point which I found with Lord Rayleigh's apparatus is the difficulty of obtaining both fields of similar intensity. The slightest movement of the eye also causes an alteration in the number and kind of rays which enter the eye. When two fields are of unequal intensity the physiological effect of contrast is evoked, which causes an erroneous judgment of the colours under observation. In fact, weak orange light may, by contrast with bright red light, appear green. In making experiments on the discrimination of colour, the rays of light from the two regions to be compared should strike the eye at as nearly as possible the same angle; the fixation point of the eye should be in the centre between the two regions, so that one region may not be more influenced by the pigment of the yellow spot, or the blood in the retina, than the other; and equal amounts of light from each region should enter the eye.

The importance of the irregularly dispersed light in association with contrast in dealing with questions of colour has been overlooked by many physicists, as several instruments have been constructed for the investigation of colour and colour-vision, which are defective on this ground. It was this irregularly dispersed light, as shown by Helmholtz,* which caused the apparent

* 'Poggendorff's Annalen,' 1852, No. 8.

change in the colours of the spectrum observed by Brewster, and which led him to suppose erroneously that there were three kinds of solar light.

In conclusion, when special means are taken to have as pure a spectrum as possible, I can find no method which will enable me to distinguish as distinct colours the wave-lengths in a monochromatic region. I therefore regard the appearance of the monochromatic region as a fundamental physiological fact, as I stated over 20 years ago.

Note on the Sensibility of the Eye to Variations of Wave-length.

By W. WATSON, D.Sc., F.R.S.

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In a recent communication to the Royal Society, Dr. Edridge-Green has suggested that the reason Lord Rayleigh found he was able to distinguish a difference in hue between two monochromatic patches of yellow (D) light, when they differ in wave-length by about the distance between the sodium lines (0·6 $\mu\mu$), is that (*a*) the spectrum used was not pure, and hence the patches were not monochromatic; and (*b*) that the difference in wave-length was apparent because of admixture with white light. Some experiments made by the author seem so conclusively to show that at any rate the second of the above reasons cannot be correct that it seems worth while to put them on record.

By means of Sir William Abney's double spectrum apparatus,* two patches of monochromatic light were thrown side by side on a magnesium carbonate screen, and matters were so arranged that no line of separation was observable when the patches were of the same colour. Each patch was 9 mm. by 18 mm., and the observer was at a distance of 60 cm. The intensity of the illumination on the screen was throughout 3·5 candle-metres. The slit in the second spectrum apparatus was kept at a fixed point in the spectrum, while that in the first spectrum was moved by means of a micrometer screw, the movement being read on a scale on which a millimetre represents in the yellow a difference in wave-length of 3·7 $\mu\mu$.

By cutting off the light from one slit and placing a short focus lens in front of the other an enlarged image of the slit would be formed on the screen. Thus by watching this image and gradually opening the slit the width of the Edridge-Green monochromatic patch could be determined.

* 'Phil. Trans.,' A, 1905, vol. 205, p. 333.