

The new physiology of vision—Chapter XXXIII. The testing of colour-vision

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The lectures delivered under the auspices of the Indian Academy of Sciences on the 21st and 22nd December 1965 in the Chemistry Theatre of the Osmania University at Hyderabad were attended by the students of the University in large numbers. After the lectures given on the forenoon of the second day, there was an hour left free for other activities. The author decided to make use of this opportunity for an examination of the colour-vision of those who had attended the lectures. The suggestion met with an enthusiastic response. Those volunteering for the test moved to an adjoining lecture theatre which was much better lighted and the examination then proceeded.

The aim was, in the first instance, to pick out those whose colour-vision was defective and then to examine their colour sense in greater detail. The number of persons to be examined being large, the preliminary selection had to be made quite speedily. One after another, they were shown two sheets of a test-chart and asked to read the numbers shown therein. The first sheet contained the number 12 printed in orange surrounded by a field of dots of a bluish colour. The second sheet was selected at random from amongst those contained in the chart. All read the first sheet without any difficulty or hesitation. Those who read the second sheet shown to them without hesitation or error were also eliminated from the test. Only eight of the men students were thus left over and they were then tested more fully. It emerged that four of the eight chosen in the preliminary selection were not really defective in their colour-vision. The remaining four were then more carefully examined. They will be referred to in what follows as Suryan, Chandran, Shukla and Krishna respectively. These, of course, were not their real names.

Something should be said here about the nature of the charts used for the testing. Those were the well-known Ishihara Charts of which the 1958 edition was available containing 38 plates. Of these, only 25 are intended for general use. These again may be divided into five groups. Charts 2 to 9 are designed so that the numbers would be read wrongly by colour-blind persons, while charts 10 to 17 could not be read at all by them. Of the remaining charts, 22 to 25 are of special interest, as they have been designed to distinguish between three groups, "the

completely red-blind", "the completely green blind" and "the normal and incompletely red-green blind" persons from each other.

Suryan, Chandran and Shukla were unable to read charts 9 to 17. Krishna, on the other hand, could read some of them correctly, some incorrectly and others not at all. All four of them, however, had difficulties with charts 2 to 8. From these findings it was evident that while Suryan, Chandran and Shukla were definitely colour-blind, Krishna could not be definitely classed as such. Each of the four were then shown the two exhibits of interference colours and were given sufficient time to observe them carefully and to write down in their words what they could notice in them. This was done in a verandah, the exhibits being placed on a low parapet, so that the interference patterns could be seen by reflected sky-light incident nearly normally on the air-films exhibiting the colours. One of the exhibits was a set of circular rings of the well-known Newtonian type. But the air-film at the centre was not of zero thickness, so that a blue patch appeared at the centre of the pattern. This was surrounded by a ring of yellow beyond which again appeared other interferences exhibiting cycles of colour in which red and green were predominant, alternately following each other. The other exhibit showed the interferences in the opposite order. Red and green were the principal colours in the innermost region and they were followed by other colour sequences of the same nature as in Newton's rings. But the colour progression began at the outer margins where the interferences of lowest order were observed. In these latter regions, the fluctuations of brightness were the principal features of the pattern.

The weight to be attached respectively to the observations reported by the four observers depends on their ability to observe correctly and express themselves clearly and to some extent also on the extent of their experience of laboratory work. It should therefore be mentioned that Suryan had already taken his Bachelor's degree and was engaged in postgraduate studies in physics. Chandran had not yet taken his degree, but his record of observations is clear and systematic. Shukla and Krishna were both undergraduates.

Suryan described the Newtonian pattern as a succession of rings, beginning with blue at the centre and followed by yellow and by blue rings alternately. But he stressed the fact that the outer rings did not exhibit such full colours as the earlier ones and that the outermost rings could be described as being alternately dark and bright, the differences in brightness however not being much. Chandran reported observing that in the Newtonian pattern, the rings appeared as alternately violet and yellow, beginning with violet. He counted nine such rings in all and stressed the fact that the colours become progressively lighter as we proceed outwards in the pattern. Shukla also reported a succession of rings, of which he could see several. But he evidently found some difficulty in naming the colours which he observed. Krishna's descriptions of the Newtonian ring pattern resemble closely with that of a normal observer.

The reports of their observations by Suryan and by Chandran on the colours observed in the second exhibit of interferences agree closely. Near the margin of

the pattern where the interferences are of low order, they both reported that the rings appeared alternately yellow and blue. Suryan stressed that the yellow rings of low order appeared brighter than those of lower order. Shukla observed the succession of interferences but here again, he had some difficulty in naming the colours he observed. Krishna's description of this pattern closely resembles that of a normal observer.

Thus, the first two of the four subjects whose vision has been studied can be recognised on the basis of their own reports as cases of daltonism, in other words, as persons who observe a two-colour spectrum of yellow and blue. It would, of course, have been desirable to examine their ability to observe and distinguish colours in greater detail, using the methods described in the preceding chapter, viz., by exhibiting a spectrum of sufficient intensity on a ground glass screen and examining their perception of luminosity and colour in its different parts. But the opportunity for such examination did not exist in the circumstances of the case.

A few remarks may be appropriately made here regarding the manner in which a pattern of interference colours would present itself to the vision of a person whose colour sense is daltonian. In the case of a normal individual, the nature of the pattern is essentially that determined by the yellow sector of the spectrum, viz., a succession of maxima and minima of illumination whose positions are determined by the wavelength $579 \text{ m}\mu$ in the spectrum at which the sensation is a pure yellow. The contrast between the maxima and minima would fall off progressively, but some five or six of each would be perceivable. Superposed on this pattern which would be of a yellow colour, appear the effects arising from the green and red sectors of the spectrum, and to a lesser extent also of the blue sector of the spectrum. The daltonian, on the other hand, would only perceive the blue sector of the spectrum, this appearing superposed on the effect of the yellow sector. The blue sector and the yellow sector would each individually exhibit a series of maxima and minima of illumination. But their superposition would result in the blue being visible only where it is very bright and the yellow is very feeble. *Per contra*, where the blue is very feeble and the yellow very bright, the latter colour alone would be perceived. Elsewhere, the superposition would result in effacing colour, but the maxima and minima of illumination due to the predominant yellow colour would continue to be observable. These consequences appear to be borne out by the observations by the two persons with daltonian colour sense reported above. So far as it is possible to draw any valid conclusions from the somewhat cursory studies which alone were possible in the circumstances, it would seem that both of them could be described as completely colour-blind, in the sense that they could not perceive either the red or the green colours which are such a conspicuous feature to a normal observer in the interference patterns.