The Hunterian Lectures

COLOUR VISION AND COLOUR BLINDNESS.

Delivered at the Royal College of Surgeons of England,

BY

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[ABSTRACT]

Colour blindness is not a good name for the condition to which it is applied, and still worse is the use of the term "red blindness" or "green blindness." In the majority of cases of colour blindness there is no blindness to colours in the ordinary sense, and on this account yellow light produces a very definite sensation of colour. Those who confuse red and green do so because they see red as green or as red, as the case may be. It is the function of the retina to give a retinal impression of the light, and the remaining parts of the brain to give a sensation of colour. The red light is conveyed to the brain by the optic nerve fibres, and the signal which is given is that the retina is sensitive to red light. This is not the case with the other retinal impressions, which are conveyed by the optic nerve fibres to the brain, and the sensation of colour is obtained from the brain. The colour seen is not the same as the light seen, but is determined by the brain. The sensation of colour is obtained from the brain, and the light seen is determined by the brain. The sensation of colour is obtained from the brain, and the light seen is determined by the brain. The sensation of colour is obtained from the brain, and the light seen is determined by the brain. The sensation of colour is obtained from the brain, and the light seen is determined by the brain.

I. THE THEORY AND FACTS OF COLOUR VISION AND COLOUR BLINDNESS.

The following is the theory which I have propounded in order to explain vision and colour vision.

A ray of light impinging on the retina liberates the visual purple from the rods and a photograph is formed. The rods are concerned with the form and distribution of the visual purple, not with the conveyance of light impulses to the brain. The ends of the cones are stimulated through the photo-chemical decomposition of the visual purple by light (very probably through the electricity which is produced), and a visual impulse is set up which is conveyed through the optic nerve fibres to the brain. The character of the stimulus differs according to the wave length of the light causing it. The impulse itself has the physiological basis of the sensation of light, and in the quality of the impulse the physiological basis of the sensation of colour. The impulse being conveyed along the optic nerve to the brain stimulates the visual cortex, causing a sensation of colour. But though the impulses vary in character according to the wave length of the light causing them, the retina itself is not able to discriminate between the character of adjacent stimuli, not being sufficiently developed for the purpose. At most seven distinct colours are seen, whilst others are in proportion to the development of their colour-perceiving centres—only six, five, four, three, or two. This causes colour blindness, the person seeing only two or three colours instead of the normal six, putting colours together as alike which are seen by the normal sighted to be different. In the degree of colour blindness just preceding total, only the colours at the extremes of the spectrum are recognized as different, the remainder of the spectrum appearing grey.

2. Physiological Analogy with other Body Cells.—It is far more probable that the rods should affect other cells rather than themselves. The liver cells do not form bile in order to stimulate themselves, but the internal secretions are produced to affect other parts of the body. The rods are not alone in producing the secretion, for in the fovea there are very long outer segments which would present a greater surface for photo-chemical stimulation. The visual purple is only to be found in the rods and not in the cones. In determining to ascertain whether the visual purple could be seen between the cones in the fovea. I have examined under the microscope the retinas of two monkeys which had been kept previously in a dark room for forty-eight hours. The yellow spot was the reddest part of the whole retina, and the visual purple was seen to be between and not in the cones.

3. The Relation between the Foveal and the Extra-foveal Regions.—As the fovea only contains cones, if any of the older theories of the relative functions of the rods and cones were true, we should find qualitative differences between the foveal and extra-foveal regions. This is not the case, but, as we should expect if the visual purple were the visual substance, all the phenomena which have been attributed to it should be found in the fovea. Von Tschermak, Heising, Hess, Garkey, and others have found the Purkinje phenomenon, the variation in optical white equations by a state of light and dark adaptation, the colourless interval for spectral lights of increasing intensity and the varying phases of the after-image in the fovea only gradually diminished.

The Varying Sensibility of the Fovea.—The fovea is in some conditions the most sensitive part of the whole retina, and with other conditions the least. Heimholtz has recorded some of these facts and regarded them as inexplicable. We have, however, an easy explanation of the facts on the assumption that when there is visual purple in the fovea this is the most sensitive part of the whole retina, but when there is no visual purple the parts before can diffuse into the spot, and in the meantime it is insensitive to light. I have devised several experiments which show the visual purple flowing into the foveal region. The following simple experiment shows this very well. On awaking in the morning the eyes are directed to a dull white surface, as for instance the ceiling, the regions of the yellow spot will appear as an irregular black spot and light will appear to invade this spot from without inwards. If the eyes are now closed and covered with the hands purple circles will form round the centre of the field of vision, and gradually contracting, reach the fovea. When the circle reaches the fovea the coloured figure becomes much brighter. It then disappears and is followed by another contracting circle. Now it will be noticed that if one eye be opened when the circle has broken up a brilliant flash of light much brighter than any other part will be seen in the centre of the field of vision. This has the exact hue of the visual purple. If we wait until the stars are disappeared, but after closing one eye the macular or other black spot appears before. This conclusively shows that the central portion of the retina is sensitized to the peripheral portions.

Chemical Analogy.—The visual purple gives a curve which is very similar to that of many other photo chemical substances. We know that with photo chemical substances the chemical effect is not proportional to the intensity of...
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II. THE DETECTION OF COLOUR BLINDNESS FROM A PRACTICAL POINT OF VIEW.

requirement of a test for colour blindness.

A test for colour blindness, when it is to be employed for some definite and specific purpose as, for instance, excluding dangerous persons from certain callings, should be as such to show definitely that the persons rejected are dangerous apparently so close that it could be grasped by the eye, and their fellows that a rejected candidate is dangerous.

The colleagues of a rejected candidate would refuse to risk their lives with a man who before their eyes called a red light green.

B. The superintendent of a railway company who is using my lamp told me that he had adopted this method with great satisfaction to himself and to the men. A man, for instance, who sees the green light on the railway, has been rejected for colour blindness. He has complained bitterly to the superintendent, at the same time declaring emphatically that he is normal red.

The superintendent has told him: "You cannot be red?"

"Yes," and you know green?" "Yes." You will therefore he that if you would green light, or red green, you ought to be rejected. Bring me another of the men in with you and I will test you." The man has readily agreed to this. The superintendent has then tested him by asking him to name various coloured objects in the room, and knowing by experience exactly the coloured objects which are misnamed by the colour blind, readily exposes his defect. It is noteworthy that on some occasions a colour-blind man has been tested by another man in the same room without making any of the mistakes which he subsequently made, because none but coloured objects which he could readily recognize were shown to him. This is an example of the necessity of practical knowledge of colour blindness in an examiner.

On account of the arrangement of signals by sea and land it is necessary that persons employed in the marine service should be able to distinguish between the standard red, green, and white lights in all conditions in which they are likely to be placed. An engine driver or sailor has to name a coloured light when he sees it, not to match it. He has to say to himself, "This is a red light, therefore there is danger"; and this is practically the same if he made the observation out loud. Therefore, from the very commencement we have colour names in mind, and it is impossible and impossible to exclude them. The engine-driver is told that red is a "danger" signal, green a "caution" signal, and white an "all right" signal. Therefore it is absolutely necessary that he should know what each of these means and be able to exclude them.

A test should be such as to make it impossible for the examinee to be coached through it. This is one of the most important requirements of a test for colour blindness, and one that is rarely fulfilled. Nearly every one of the tests in general use will fail on this account.

A test should be one which can be carried out as rapidly as is possible with absolute efficiency; of two equally efficient tests the one which takes the least time must be selected. A test, therefore, should have no unnecessary details which, though of theoretical interest, are not connected with the object in hand. The test should be made as easy and as little complicated for the examinee as possible.

Persons to be Excluded.

We wish to exclude all those individuals who are included in the following cases: (1) those who can see three or less colours in the spectrum; (2) those, whilst being able to perceive a greater number of colours than three, have the red end of the spectrum shortened to a degree incompatible with their recognition of a red light at a distance of two miles; (3) those who are unable to distinguish between the red, green, and white lights at the normal distance through defect in insensitiveness of the cerebro-retinal apparatus when the image on the retina is diminished in size.

I will now explain why these three classes of persons should be excluded. The first class includes the trichromic, the dichromats, and the monochromats, in accordance with the facts previously stated. The trichromic, in ordinary circumstances, mistake green for red, but confuse yellow with green or red. Colour is a valuable quality of objects, and any improvement may reduce them to the condition of the dichromat. The dichromat is liable to mistake a green light for red and vice versa. It is a test for colour blindness.

requirements belonging to the second class should be excluded, and yet none of the ordinarily used tests detect them. The rays of red at the extreme left of the spectrum are the most penetrating, as light is at its best on a foggy day, or through several thicknesses of neutral glass. It is chiefly by these rays that we recognize a red light at a distance;
and it is therefore of greater importance that a seaman or engine-driver should be able to perceive them. The third class contains persons who are able to distinguish colours easily when they are close to, but fail to distinguish them at a distance owing to the nerve fibres supplying the central portion of the retina being impaired. As a light at a distance occupies the central portion of the visual field it is essential that the corresponding portion of the retina should be normal. There are cases of central scotoma for colour with perfect form vision; these would, therefore, not be detected by the test for visual acuity. This class also includes those who, without having a scotoma, are unable to distinguish between colours at the normal distance when the image on the retina is diminished in size.

The lantern shown has been constructed conformably to the requirements and facts of colour blindness. All the facts of colour blindness have been considered in constructing the lantern.

Objections to other Tests for Colour Blindness.

The tests which have been proposed for colour blindness are very numerous, but some are so defective that it is rare to detect a single colour-blind person with them. I have, for instance, found many of those who are colour-blind in certain lanterns, with the result that not a single one was detected. In these so-called tests all the requirements of a test and facts of colour blindness have been neglected. I must refer to three tests constructed by exceptionally able men, each with considerable knowledge of the subject. I refer to the tests of Professor Holmgren, Professor Stilling, and Professor Nagel.

At these tests can be passed at the first attempt and without coaching by certain dangerously colour-blind persons, chiefly varieties not known to the inventors; but the chief defect of each is that it is very easy to coach a colour-blind person to pass it. The surgeon to one of our largest railway companies told me that when they used Holmgren's test they rejected 1 man in 300, but with Nagel's test only one in the same number. All these three tests are much better tests when the persons to be examined have not seen them before. A colour-blind man may make only one mistake; say, for instance, as in a case I examined the other day with Nagel's test (last edition), he passes the test perfectly with the exception of one mistake, that of calling a grey on one card, green. All he has to do is to look for some distinguishing mark on this card in order to pass the test with the case and certainty of a normal-sighted person. It is the same with Stilling's letters, he has only to note the letter which he was not able to read and the appearance that it made to him. As I was interested in this man compared to him, a colour-blind person, I would readily help him. The confusion of green and grey does not appeal to the average man as a serious defect, especially when he sees his friend go through the rest of the test. So says to himself; 'I suppose he sees a tinge of green in that grey.'

The same man would readily regard it as a most iniquitous proceeding to endeavour to coach his friend through a test when he had seen him mistake a red for a green light.

Holmgren's test rejects a large number of normal-sighted persons, as may be seen by the reports of the Board of Trade; about 50 per cent. of those who appeal are found to be normal sighted and have been rejected wrongly.

REFERENCES.

The French Medical Parliamentary Group, among its other activities, watches over the interests of the thermal and climatic stations of France. It has decided to take steps to secure speedy promulgation of the Governmental decree of 2 December 1910. In this, it is hoped that this will be put into force during the coming season, and that in this way funds will be collected in sufficient amount to enable improvements to be made which will attract foreigners. It has also been decided to found a chair for the instruction in hydrology and climatology in the University of Paris. It appears that the syndicates of the various spas are quite willing to bear the expense on the understanding that the chair is established solely in the general interests of the country.

THE HISTORY OF YELLOW FEVER IN WEST AFRICA.

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VII.

HISTORY OF YELLOW FEVER IN THE GOLD COAST COLONY.

There can be little doubt that yellow fever was prevalent on the Gold Coast in the early part of the nineteenth century as in Sierra Leone.

From the report of Staff Surgeon Tidie, quoted by Boyle, it appears that in 1819, out of 9 new arrivals, 3 died; in 1820, out of 4 new arrivals, 2 died; and in 1821, out of 7 new arrivals, 2 died, or two-thirds of all new-comers within twelve months of arrival. In the same period 15 of the African Company had died. It is most probable that this fatal disease which attacked the newcomers was here, as elsewhere in the tropics, yellow fever.

In a report by Bell, upon the garrison at Cape Coast Castle for 1824, it is stated that 217 deaths occurred in the regiments, exclusive of women and children.

Of the first detachment of Europeans, numbering 128, which arrived in April, 1823, only 1 survived; out of 109 women and children who had arrived since October, 1823, 70 had died.

It is stated in the report that the cause of death was bilious remittent fever, which usually terminated fatally on the third, fifth, or seventh day. Many of the cases were as "yellow as an orange." Boyle also mentions that an epidemic occurred in 1824, similar to that which took place in Freetown in 1823.

In 1824, out of a third detachment of 131 men disembarked in March, 1824, the majority had died, after a few months, from "remittent fever and dysentery," and the same occurred with numerous subsequent detachments. Then comes the usual pause, commencing from the middle of the nineteenth century, probably due to the withdrawal of the garrison, and therefore of large bodies of non-immune new arrivals.

At a later date, following on the commercial development of the colony and the growth of the coast towns, yellow fever again began to attract attention.

As had happened, however, in other British West African colonies, the disease was very frequently not recognized, and so far as Europe was concerned, was ignored.

Examination of the case-books of the European hospitals in the principal seaports are of very great interest, for they show, in the first place, the difficulties which medical officers experienced in making a diagnosis; and, secondly, the unwillingness, as in Sierra Leone, on the part of the medical authority of the colony, to admit that yellow fever existed, in spite of the fact, as the careful records amply testify, of the patients presenting all the classical symptoms of fatal yellow fever. The stumbling-block here, as in numerous other instances, being occasioned by the confusion brought about by the use of the word "conflagrations," as applied to yellow fever.

Examination of the medical reports of the colony show that cases of yellow fever were recorded in the following years: 1885, several cases; 1897, 4 cases; 1902, 2 cases.

Whilst on the Gold Coast I examined the hospital casebooks of Cape Coast, Saltpond, Elmina, Axim, and Accra, and I find that yellow fever was diagnosed as such, and entered in the hospital casebooks, during the years 1897, 1902, and 1903; at Saltpond in 1897 and 1902; at Elmina in 1895; and at Accra in 1899.

In 1899 Dr. Elliott, who had had four years' experience in the Gold Coast, published in detail 3 cases of yellow fever which he attended at Saltpond.

He alludes to the reluctance prevalent against the diagnosis of yellow fever and the tendency to regard all fevers as malarial.

In 1901 Dr. S. O. Browne published a case of yellow fever which he attended at Saltpond.

In addition to these well-marked cases which were diagnosed at the time by the physicians in charge as