THRESHOLD TESTS*

(Concluded)

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PART TWO

THE subject of my paper ends with part one. I am conscious of digressing, but the reader may stop here, as the rest of the article contains little bearing on the threshold test.

At the present stage of our knowledge of colour vision, a flawless test of this sense cannot be expected. The arbitrary nature of pigments alone precludes this. The ideal test would be with the colours of the spectrum. But whether attenuating these up to their threshold is achievable, is a question which takes me beyond my depth. I think this test should suffice to get at some clinical facts which might benefit the early diagnosis of disease. The test of the form sense is far from perfect. Yet who would dispute the value it has proved to humanity? Neither the real nature of colour nor the understanding of colour vision is a fact to-day. Individuals have put forward theories and others have refuted them.

Revolving discs lend themselves to an infinite variety of very interesting and, for the present, unexplained phenomena. On that very account there must be knowledge to be gained from them. It strikes me they form a large unexplored territory for practical investigation of the physiology of human colour vision. Much that I have noticed while experimenting with all sorts of discs and colours is startling. In my humble sphere as a clinician, I can only draw attention to a few strange features. The test I suggest above, is merely the A of a new alphabet. It may or may not suffice for the clinician to distinguish the sound from the defective eye in a more or less large number of cases. Other colours, or combinations may prove useful. It is easy to add them. Who, for instance, has never been struck, on a country walk or such like occasion, by some member of the party utterly failing to distinguish violet tints in nature, which to you and all others are obvious? Who knows whether this is a symptom, or an anomaly?

I pointed out at the Oxford Congress that I had some reason to believe that human colour sensations are sometimes the product of a succession of retinal stimuli of various degrees of light intensity, differing in principle from the unequal refrangibility of light, and I showed that the disc, Fig. 5, composed of black, grey, and white, when revolved, creates colour instantly. Other

* Read at the Oxford Ophthalmological Congress, 1917.

proportions and successions yield different colours, as can easily be ascertained experimentally. To my own eyes and those of others I have examined, Fig. 5, if slowly rotated clockwise, produces the sensation of yellow in some cases (myself included), and if rotated anti-clockwise it produces the sensation of purple in all cases. This is particularly marked in artificial light, but quite plain in daylight as well. The effect cannot be one of after-images, being instantaneous, no period of fixation or retinal fatigue being required. Analyzing the clockwise action, a certain portion of the retina is successively stimulated by black, grey, and white. Yellow appears to some. Anti-clockwise the succession becomes black, white, and grey. Purple appears. Assuming black to equal absence of light stimulus or 0, grey partial or $1/2$, white full or 1, formulae suggest themselves, as in this case :

(1). The succession 0, $1/2$, 1 = yellow.

(2). " " " 0, 1, $1/2$ = purple.

whether one begins with (1) or (2) makes no difference, in other words (1) does not elicit (2) or vice-versâ. Neither does the direction of movement matter. Reversed test objects and such as produce the same succession if revolved one way or the other, show this.

The phenomenon of Fig. 5 may be the principle underlying the colour top of Mr. Chas. E. Benham of this city, of which illustrations are to be found in *Scientific American*, May 18, 1895, *Cassell's Family Magazine*, January, 1895, *Science*, July, 1895, *Engineering*, March 22, 1895, and others.

FIG. 5.

FIG. 6.

And, indeed, I find by modifying it in the manner of Fig. 6, in which form each of the four circles produces a succession of stimuli somewhat similar to Fig. 5, that it evokes a play of colours quite as pronounced. Probably still greater intensity could be attained if the physical laws governing these phenomena were not wrapped in mystery.

If the whole sector within the angle subtended by the black bands be given a wash of gray, the colours appear more diluted and

are more easily distinguished from one another. As figured the four colours are very deeply saturated, but can soon be differentiated. If the whole sector be painted black, the delicate variations are perhaps most pronounced. These colours resemble the subdued tints of sunset clouds much more than the luminous ones of the rainbow, and verge on neutral tints. Some find it difficult to name them, but everyone recognizes them.

In Fig. 6 I should describe the stimuli and colours as follows: (Rotating clockwise, not too rapidly, and counting the circles as 1 to 4 from the inner towards the outer.)

- (1) $\frac{1}{5}$ rest, $\frac{3}{5}$ full, $\frac{1}{5}$ partial stimulus=dark slate-blue.
- (2) $\frac{1}{5}$ rest, $\frac{2}{5}$ full, $\frac{1}{5}$ partial, $\frac{1}{5}$ full=olive-green.
- (3) $\frac{1}{5}$ rest, $\frac{1}{5}$ full, $\frac{1}{5}$ partial, $\frac{2}{5}$ full=olive-brown.
- (4) $\frac{1}{5}$ rest, $\frac{1}{5}$ partial, $\frac{3}{5}$ full stimulus=purple.

When rotated anti-clockwise the same succession of stimuli takes place if one counts from the outer circle towards the inner one. The whole principle is exactly reversed. The colours should therefore also appear reversed. And so they do. There is sufficient analogy between each ring of Fig. 6 and the ring in Fig. 5 to conclude that whatever they do to the human retina is one and the same thing. There is very close similarity between the effect produced on my eyes (and those of others) by Fig. 6 and the effect produced by the Benham top. I take it that Fig. 5 illustrates the principle of the latter in its most primitive form. It hardly explains it, unless the theory I ventured to put forth is tenable, that a succession of stimuli of various intensity is one cause of human colour vision. Even if this were proved, the actual physiological process in the retina would still remain a puzzle.

FIG. 7.

Types of discs like Fig. 7, also with fewer black sectors, yield regular kaleidoscopes, and when rotation ceases appear to move in the reversed sense. Fig. 7 appears to flicker at the centre, like the beginning of an attack of scotoma scintillans, when one fixes a point more or less remote from the centre. This flickering is very

apparent to me, while reading the text in its neighbourhood, and it distinctly evokes colour sensations of purple and yellow. Although the object is not in motion, it seems probable that the minute oscillations of the eye result in the same retinal area being alternately stimulated by a black or white sector. I cannot pretend to place on a solid scientific foundation any of these, or many other such phenomena that all will meet with in experimenting with revolving discs. My knowledge is quite inadequate to such a task. But that there is fruitful soil here I have no doubt.

As a clinician I mean to continue exploring the thresholds for clinical purposes. The question to decide, as far as our work is concerned, is: Does studying the threshold of light and colour lead to diagnostic signs, and what are they? This can be settled empirically. Quantities of tests, quantities of earnest collaborators, will reveal the scope and the limitations of this method.*

ANNOTATIONS ·

A Ministry of Health

Our readers have doubtless followed with interest the discussions which have recently taken place with regard to the establishment of a Ministry of Health. As ophthalmologists, and therefore somewhat wrapt up in our own special affairs, it behoves us to make active efforts to keep in touch with all movements which affect the welfare of the medical profession as a whole. The establishment of a Ministry of Health involves the solution of two great problems. Matters relating to the health of the nation are at present dealt with by a large number of Government Departments, and the first problem, preparatory in its nature, is the correlation of these sectional interests and their co-ordination under a single administration. This is the work of the departments concerned; but the success of the new Ministry will depend largely upon the obliteration of inter-departmental jealousies and the adoption of well-considered plans for the division of the administrative labours. In drawing up such plans the authorities will be well advised to consult those leading members of the profession whose experience and good judgment endow their opinions with peculiar weight on the several questions requiring consideration.

* In a case of Daltonism the palest red and green evoked colour sensations. They were called "brown," but differed from one another. They were pronounced as differing entirely from the neutral page or the grey spots, because "these are not colours and those are." Apparently his colour thresholds for red and green are normal, though he fails in the simplest test for colour blindness.