BINOCULAR DIAPHRAGM*

BY

R. H. P. FERNANDEZ, O. P. EDMONDS, AND T. A. HUNT

East Midlands Division, National Coal Board

IN the act of seeing, normally both eyes are kept open, yet the visual acuity is invariably tested with one eye occluded. Occasionally, the distant visual acuity of each eye tested separately is not the same as may be elicited under binocular conditions.

One method of testing the distant visual acuity under binocular conditions is the infinity balance of Turville (1946). Here, the septum is situated midway between the patient and a modified Snellen's test type. The common area of binocularity in this test is around the Snellen's test type. Wilmut (1951) uses polarized glass instead of the septum. Because both methods lack a central binocular area, we utilized the principle of the Bishop Harman diaphragm (Duke-Elder, 1954 a, b), though we wish to acknowledge Turville's infinity balance which gave us the idea of incorporating the Snellen's test type and thus evolving the binocular diaphragm.

Method

Fig. 1 shows the result when a patient over the age of 15 years, who uses both eyes, looks through an aperture $4\frac{1}{2}$ cm. wide in a diaphragm situated midway between his eyes and a Snellen's test type 6 m. distant. All the visual acuity lines on the test type are of the same width (14 cm. approx.) except the 6/60 letter. Fig. 2 shows the chart. Area C_1C_2 , seen by both eyes, is the central area of the test type. Area RC_1 is seen only by the right eye, and the left eye sees only area LC_2 . The vision is, therefore, crossed.

The uniocular patient (Fig. 1), sees area V_1V_2 (9 cm.), which is smaller than area R_1L_1 .

FIG. 1.—Optical diagram of binocular diaphragm test.

*Received for publication December 12, 1954.

The patient's head has to be in the correct position; two red reflectors of approximately $3\frac{1}{2}$ cm. in diameter are placed $9\frac{1}{2}$ cm. apart as in Figs 1 and 2, so that the uniocular subject cannot see both red reflectors at the same time.

Fig. 2 shews five thick black lines 1.5 cm. wide and 1 cm. apart, at the bottom of the test type. The outer lines are 5 cm. high and the three middle ones are 4 cm. high.

In testing, the examiner ensures that the patient's head is in the correct position by giving the following three definite instructions:

- (1) Look through the hole in the diaphragm and position the head so that the same amount of each red reflector is seen,
- (2) Keep the head still when in position,
- (3) State how many black lines are seen at the same time.

Results

Unioocular Candidates.—The individual who only uses one eye cannot see two red reflectors at the same time and often openly admits this to the examiner, who suspects his unioocularly from the frequent side-to-side movements of his head. When the head is still, the candidate either sees the three small central black lines or one of the outer large black lines, together with two or three small black lines according to the position of his head. He does not, however, see the two outer black lines at the same time. Unioocularly for distant vision is presumed when the patient cannot see the two red reflectors at the same time. For these cases the visual acuity has to be tested in the normal manner, each eye being occluded in turn.

Binocular Candidates.—The patient who has good distant binocular vision easily positions himself. He sees two red reflectors at the same time, together with the two outer black lines. The letters of the visual lines above and beside the two outer black lines represent the vision seen solely by one eye when the patient is correctly positioned. In Fig. 2 on the 6/6 line, AEL is seen only by the right eye, the central O by both eyes, and HCT only by the left eye. On the 6/36 line in Fig. 2, A is seen only by the right eye and L by the left eye.

The visual acuity of each eye tested separately, as compared with the acuity tested under binocular conditions, need not be the same. Therefore, where the vision is defective on the diaphragm, the other eye should be occluded to see if the visual acuity is altered.

Certain patients with binocular vision see only four black lines, two large and two small. These patients find that the central letters of the chart on all the visual lines converge on one another, making the differentiation of the smaller letters difficult. The examiner recognizes this because the patient states that he only sees four black lines, and uses the outer letters of the chart as a guide to visual acuity.

This phenomenon is seen in esophorias of 3 to $3\frac{1}{2}$ dioptres and in patients who are excessively accommodating. Fig. 3 shews a chart where the central letters seen by both eyes have been removed; when this is used the above disadvantage is avoided. Our own results, however, were based on the chart shewn in Fig. 2.

FIG. 2.—A standard distant visual test type seen through the diaphragm by a patient, over the age of 15 years, with good binocular vision.

FIG. 3.—Apart from the 6/60 letter, the central letters seen by both eyes by the patient in Fig. 2 have been removed.

FIG. 4.—Patients with esophoria of 3 to 3.5 D and those accommodating when viewing the Fig. 3 test type. Note closeness of central letters and four instead of five black vertical lines.

Accommodation.—The effect of accommodation on the distant visual acuity can be demonstrated in the normal patient when he views the black lines on the chart through concave spherical lenses, the strength depending on the individual. These lenses make the individual accommodate and he will see four black lines, two large and two small, instead of five (Fig. 4). Patients who normally do not wear glasses but have defective visual acuity sometimes shew this when correcting lenses are used. The effect is temporary, and five black lines are seen if such patients wear glasses constantly.

Patients with excessive accommodation also see only four black lines. If hypermetropia is also present it will not be revealed by the binocular emmetropia test where the test type is viewed through 2-dioptre convex lenses. In such cases even a small convex lens makes the vision blurred (Case 9 in the Table). Excessive accommodation is not present, however, in our experience, if the 6/60 letter is identified on the binocular emmetropia test, and this rule eliminates the majority of esophorias, who are hypermetropes, and also see four instead of five black lines.

FIG. 5.—Patient with hyperphoria of 0·75 D or more when viewing Fig. 3 test type. The letters on the right-hand side of the chart are higher than those on the left.

FIG. 6.—Patient with exophoria and divergence excess when viewing Fig. 3 test type. Note six black lines and central bar running down chart.

The degree of accommodation required to give the best visual acuity in each eye need not be the same. This can be demonstrated in the normal patient when he views the letters through the diaphragm with a convex lens placed in front of one eye. The uniocular area seen by this eye is blurred but immediately becomes clear when the other eye is occluded (Case 3, Table).

Hyperphoria.—When the uniocular area of one eye on the chart is higher than the other (Fig. 5), hyperphoria of 0·75 D or more is present.

Exophoria.—The test does not reveal small or moderate degrees of exophoria, but it does detect those cases of exophoria with divergence excess. Here, six black lines are seen, two large and four small, and the central area viewed by both eyes is seen twice. Such patients also see a bar running down the centre of the hole in the diaphragm (Fig. 6). Thus one patient with 6/6 vision in each eye saw the following letters of the 6/6 line on the chart used in Fig. 2, AELO, then the bar running down the centre of the hole in the

diaphragm, then the letters OHCT.

Construction of the Diaphragm

The chart used is a standard one* which can be obtained in card form or fitted to the usual type of vision box. The diaphragm is approximately the same size as the vision card and is held in position by means of a stand or wall bracket. The width of the aperture in the diaphragm is 4.5 cm.

The test was constructed for patients with an inter-pupillary distance of 5.5 to 7.5 cm. In over 800 patients, many of them school-leavers, we found that the inter-pupillary distance was within these limits.

The central area is smallest (1.5 cm.) and RL in Fig. 1 the largest (16.5 cm.) when the inter-pupillary distance is 7.5 cm. RL is smallest (14.5 cm.) and the central binocular area largest (3.5 cm.) when the inter-pupillary distance is 5.5 cm. Hence, all letters lateral to the 3.5 cm. central area can be regarded as being seen only by one eye.

Trial Tests

(1) Eight-hundred consecutive new entrants to the coal mining industry were subjected to the Maddox rod test; 400 were boys, mainly school-leavers, all under the age of 21 years, and the remaining 400 were men. 7.25 per cent. of the boys and 6 per cent. of the men used only one eye. An incidental finding was that 1 per cent. of the boys were so illiterate that they could not read the letters on the Snellen's test type, even though they had just left school.

(2) A further one hundred consecutive cases of new entrants to the coal mining industry had the vision of each eye tested separately. They were subjected to the Maddox rod test and refracted, and were also tested on the binocular diaphragm. The binocular emmetropia test was also used to test for excessive hypermetropia. None of these candidates complained of any ocular symptoms. One could not read the letters because of illiteracy; 93 had binocular vision; six were uniocular. The Maddox rod and the binocular diaphragm both confirmed these findings.

The visual acuity tested under binocular conditions differed from that of each eye tested separately in twelve out of 99 subjects; six of these used only one eye; the other six, who were binocular, are listed in the Table.

Visual acuity of 6/6 was found in both eyes in 66 subjects, who also shewed no abnormality on the binocular diaphragm. One of these had 4 dioptres exophoria which the diaphragm did not detect, and another had 2 dioptres of correctable hypermetropia detected by the binocular emmetropia test but no excessive accommodation.

Three further subjects had 6/6 vision in each eye when tested separately, but shewed an abnormality on the binocular diaphragm (Cases 1, 2, and 3 in the Table); twenty-eight had defective visual acuity when each eye was tested separately, and eighteen of these shewed no defect on the binocular diaphragm, apart from defective visual acuity; the ten shewing a defect on the binocular diaphragm are listed in the Table (Cases 4-13).

Case 9 (Table) shewed excessive hypermetropia together with excessive accommodation on the binocular diaphragm test, and would have been missed if the binocular emmetropia test had been relied upon.

Three subjects saw four black lines but could not identify the 6/60 letter viewed

* Obtained from Messrs. Allied Instrument Manufacturers, Ltd.

TABLE
RESULTS IN THIRTEEN CASES

Case No.	Age (yrs)	Visual Acuity				Maddox Rod without Glasses	No. of Black Lines Seen	Optical Error of Each Eye Tested Separately	
		Each eye tested separately		Each eye tested binocularly				R	L
		R	L	R	L				
1	15	6/6	6/6	6/6	6/6	3.5 eso	4	emmetropia	emmetropia
2	15	6/6	6/6	6/6	6/6	2 eso	4	+1.5 = 6/6	+1.5 = 6/6
3	15	6/6	6/6	6/12	6/6	ortho	5	+1.5 = 6/6	+0.5 = 6/6
4	32	6/6	6/7.5	6/6	6/36	3.5 eso	4	+0.5 = 6/6	+0.75 = 6/7.5
5	39	6/18	6/12	6/18	6/36	3.5 eso	4	+1.75 = 6/6	+1.75 = 6/6
6	15	6/12	6/12	6/12	6/12	4 eso	4	-4.5 × 20 = 6/6	-4.5 × 160 = 6/6
7	15	6/12	6/9	6/24	6/9	8 eso, 1.5 left hyper	4	+0.75/ +2 × 90 = 6/6 ptly	+0.75/ +2 × 90 = 6/6 ptly
8	16	6/12	6/12	6/12	6/12	1 exo	4	-0.75/ -0.5 × 90 = 6/6	-0.75/ -0.5 × 90 = 6/6
9	15	6/7.5	6/12	6/7.5	6/12	13 eso	4	No lens improved +5.0	No lens improved +5.0
10	41	6/9	6/24	6/9	6/36	8 eso	4	+1 = 6/6 part	+1.5/ +1.5 × 110 = 6/12
11	16	6/24	6/9	red reflector	6/9	4 eso	4	-0.5/ +4 × 105 = 6/12	+1 × 75 = 6/6
12	53	6/6	6/36	6/6	6/36	2 eso, 0.75 left hyper	4	+0.5 = 6/6	+1.5 = 6/6
13	15	6/9	6/9	6/9	6/9	ortho	5	+0.5/ +1.5 × 105 = 6/6 With glasses four instead of five black lines	+2.0 × 75 = 6/6

through 2-dioptre convex lenses (Cases 6, 8, and 9 in the Table; only Case 9 had hypermetropia).

Summary

A test is described in which the distant visual acuity is tested under binocular conditions. The test detects hyperphorias of 0·75 dioptres or more, and esophorias of 3 to 3·5 dioptres, and shows up cases in which the binocular vision differs from the vision of each eye tested separately. The test also reveals cases of exophoria with divergence excess. Subjects who accommodate or have excessive accommodation due to hypermetropia undetected by the binocular emmetropia test are also detected. For those who are prescribing lenses the trial test is made easier for the patient, if binocular, in that he can compare the vision of one eye with the other.

We should like to thank Mr. E. C. Pemberton, chief orthoptist, Leeds General Infirmary, for his valuable advice and criticism; the Chief Medical Officer of the National Coal Board, Dr. J. Rogan; and our Divisional Medical Officer, East Midlands Division, National Coal Board, Dr. J. Trefor Watkins, for his encouragement and advice. We are especially grateful to Mr. W. Morley and Mr. J. J. Phillips, Survey Department, No. 4 Area, East Midlands Division, National Coal Board, who drew the diagrams.

REFERENCES

- DUKE-ELDER, S. (1954a). "Parsons' Diseases of the Eye", 12th ed. Churchill, London.
 — (1954b). "Practice of Refraction", 6th ed., Appendix 6, p. 319. Churchill, London.
 TURVILLE, A. E. (1946). "Outline of Infinity Balance". Raphael, London.
 WILMUT, E. B. (1951). *Optician*, 122, No. 3148.