

THE PERIPHERAL VISUAL ACUITY OF 100 SUBJECTS¹

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Acuity curves for peripheral vision are well known, those of Wertheim (3) and Koester (1) being frequently reproduced. Since their findings nearly fifty years ago the subject has been investigated by numerous workers whose results have been reviewed by Traquair (2) who lists the data of some 28 investigations by 11 workers. Although their methods were essentially the same the results differed considerably. Not a great many subjects were examined. This suggested a more or less wide variation of peripheral visual acuity under normal conditions. Therefore this investigation undertook the development of a suitable test for peripheral visual acuity and the testing of a sufficient number of individuals to determine the extent of the suspected variation.

APPARATUS. Tests were run on a 25 cm. perimeter (American Optical Company—AO 460). The following apparatus was built:

1. *Illuminator.* A 60 w. Mazda daylight lamp was fixed on the locus of all points equidistant from points along the perimeter arms, 25 cm. from the subject's eye. The light turned with the perimeter arms. The subject's eye was protected from glare by a shade. A 75 mm. square of white bristol board was attached to the rod supporting the lamp, near the bulb, placed so as to throw diffused light toward the eye being tested.

2. *Target carrier.* A carrier for the targets was made of 3 thicknesses of bristol board with the following dimensions: (a) front card; 75 mm. sq., 55 mm. cutout in center; faced with photographic paper; (b) middle card; 75 mm. sq., on three sides; all sides 5 mm. wide; built up with photographic paper for thickness; (c) back card; 75 mm. sq.; screw head in center flush with card; semicircular cutout of 10 mm. radius in middle of top edge. The carrier was fastened to the test object carriage so that it would revolve freely around its center.

3. *Targets and test objects.* The targets of bristol board and photographic paper were cut 64 by 69 mm. to fit in the carrier. The test objects were Landolt Broken Circles (diameter equals five times width of line equals width of break) photographed and printed on the targets in the following sizes: width of break in mm. $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, 4, 5, 6, 7, 8, 9, 10. The center of the test object coincided with the center of the carrier.

4. *Identification button.* A circle (10 mm. radius) of white bristol board with a hole in the center was fitted on the button on which the subject fixed his eye. The numbers I, II, III, IIII were marked on this circle in positions corresponding

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to the points of the compass. The subject referred these numbers to the four possible positions of the break in the test object, signaling with a buzzer.

5. *Booth.* Black, non-reflecting cloth was draped wherever the subject's visual field extended. All visible apparatus except the carrier, target, and identification button were black.

6. *Blindfold.* A one-eye blindfold was used to cover the eye not being tested.

7. *Operator.* The operator wore a black robe and black gloves. He was equipped with a black paddle large enough to conceal the carrier during changes.

PROCEDURE. Nine points on the temporal periphery of each eye were tested on meridians 45 degrees apart. The following points were tested on the meridians and angular deviations indicated: out 30°, 60°, 90°; down and out 30°, 60°, 90°; down 30°, up 30°, and up and out 30°, in the order mentioned. With the room blacked out except for the illuminator on the instrument, the subject was seated at the perimeter and a large size target was inserted in the carrier set at the first point to be tested. It was adjusted in one of the four possible positions while covered with a black paddle and then revealed to the subject who signalled an answer. If the subject could not tell he was made to guess. The target was covered again and the position of the break changed. This procedure was repeated until the subject got four consecutive correct answers, or two misses (not necessarily consecutive). When the subject succeeded the next smallest size test object was used. This was continued until the subject failed. The smallest test object successfully identified was scored, using the width of the break of the test object in millimeters to denote the score. During identification the eye not being tested was blacked out. Fixation was checked by watching the subject's eye.

For purposes of correlation the peripheral test was preceded by a standard test for central acuity (Snellen illuminated chart—metric measurement) and the Ishihara color test. The wheel test for astigmatism was given on the uncorrected eye. Age and sex were recorded.

One hundred subjects selected at random were tested as described above. The peripheral test took from 40–60 minutes. The left eye was always tested first, the subject resting about 5 minutes between eyes. Twenty of the original group were retested under identical conditions after a lapse of about 2 to 3 months.

RESULTS. It was found that the peripheral acuity was so weak at the 90° points that from 89–94 of the 100 subjects could not identify the largest target used (10 mm.). These points were discarded in calculation of the total score of each individual, regardless of performance. Since the score recorded was the size of the break of the smallest test object correctly identified, the actual acuity lay somewhere between that value and the next smallest size. The midpoint between the two was chosen as being presumably more accurate. The sum of the individual scores for 14 points was chosen as the total score for that individual. The smaller the value the better was the acuity. Therefore the reciprocal of this figure was chosen as the value from which percentages were calculated.

The means and standard deviations for the group of 100 are shown in the black boxes of figure 1. Among the 100 subjects there were 30 who would have qualified as aviation cadets on the basis of age, sex, and visual requirements. They were males 18 to 27 years of age inclusive, with normal or better central vision, normal color vision, and no astigmatism. Their means and standard deviations are shown in the white boxes in figure 1. As a whole their scores were better but the degree of variation among individuals, which the height of the standard deviation box indicates in contracted form, is nearly as great as that of the whole group. On the basis of total scores the 2nd and 99th in degree

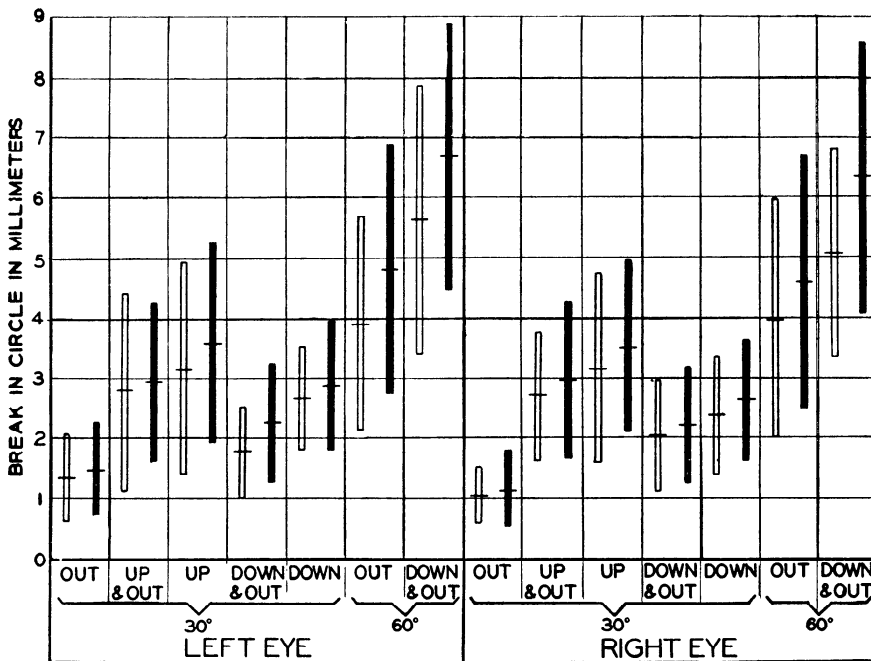


Fig. 1. Graphical representation of means (averages) and standard deviations of peripheral visual acuity. Boxes show limits of standard deviations, cross bars are means. Black boxes are total group of 100. White boxes are selected group of 30 (males 18-27 incl., normal or better central acuity, normal color vision, no astigmatism).

of peripheral acuity were members of this selected group of 30. The actual spread of the total scores of both groups is recorded in table 1. In the group of 100 the reciprocal of the average score was arbitrarily chosen to represent 100 per cent and the value for each individual or group expressed by a comparative percentage. In the test-retest group of 20 individuals the original score, individual or group average, was regarded as 100 per cent and the second score expressed in comparative percentage. Of this group the best subject improved about 50 per cent and the worst declined 8 per cent.

Table 2 shows the relationship of peripheral visual acuity to other measured data. Men scored 11 per cent better than women. The varying average scores

for the different age groups show that there is not necessarily a diminution with advancing years. The eight color blind individuals were 8 per cent below par. The deficiency is somewhat minimized because the best subject, scoring 364 per cent, was a member of this group.

TABLE 1
Averages and actual limits; test-retest scores

GROUP	100	BEST	WORST	SELECTED 30*	BEST	WORST	20 TEST-RETEST	
							First	Second
Score.....	47.90	13.16	110.90	41.66	22.81	92.20	50.07	42.17
Reciprocal.....	0.02088	0.07599	0.00902	0.02400	0.04384	0.01085	0.01997	0.02371
Percentage.....	100	364	43	115	210	52	100	116

* Males 18-27 yrs. old inclusive, normal or better central vision, normal color vision, no astigmatism.

TABLE 2
Correlation of peripheral visual acuity scores with other data

GROUP	SEX		AGE				COLOR VISION
	Males No. = 87	Females 13	17-20 13	20-29 67	30-39 13	40-70 7	Color blind g*
Score.....	47.16	52.88	41.58	49.21	48.62	45.82	51.86
Reciprocal.....	0.02120	0.01891	0.02405	0.02032	0.02057	0.02182	0.01928
Percentage.....	102	91	115	97	99	105	92

* All male; 7 red-green type, 1 unclassified (blue green?).

TABLE 3
Correlation of central acuity with peripheral acuity in 200 eyes

GROUP	200	NO. = 92	19	19	10	9	12	12	4	23
		6/5	6/6	6/7.5	6/10	6/12	6/15	6/20	6/30	6/60*
Score.....	23.95	21.58	20.63	26.61	25.53	21.94	26.22	28.98	25.73	29.93
Reciprocal..	0.04175	0.04633	0.04853	0.03757	0.03917	0.04558	0.03822	0.03451	0.03887	0.03341
Percentage..	100	111	116	90	94	109	92	83	93	80

* Some eyes weaker than 6/60.

Table 3 shows the relation of peripheral to central acuity. The same method of comparative percentages has been used but was calculated for each eye separately. The degree of correlation between the two values (Pearson product-moment correlation) was found to be positive at 0.38, a figure too low to yield any practical reciprocal predictive value.

DISCUSSION. The variation of peripheral visual acuity among individuals was found to be even greater than anticipated. Table 1 shows the best subject

to possess peripheral acuity about $3\frac{1}{2}$ times that of normal and about $8\frac{1}{2}$ times that of the weakest subject.

The relative average acuity for each point as noted in figure 1 agrees in the main with the curves of Wertheim (3). The actual variation of acuity for each individual point is of course greater than the limits of the standard deviation boxes. For example, on the up 30° point, the smallest test object identified was size 1, while 2 of the subjects could not identify size 10, the largest used. On each 60° point some individuals failed on size 10.

It is notable that the variation of the acuity for any point increased as the acuity itself decreased. This is illustrated by the fact that the higher the mean in figure 1, the larger the standard deviation box.

The data reported in table 3 indicate that central acuity is not a reliable indicator of peripheral visual acuity. This is in accord with the fact that the focusing power of the lens, which is largely responsible for central acuity, hardly functions at all beyond 30° from the line of vision. Also the failure of peripheral vision to decline regularly with advancing age as indicated in table 2 is understandable, since the decline in central vision is due to lens changes. The lack of high grade positive correlation between peripheral visual acuity and other measured factors seems to justify the statement that peripheral visual acuity is an independent visual function.

Especially interesting is the result of the test-retest experiment on 20 subjects. This technique was intended for use as a check on the reliability of the test, but the subjects, with very few exceptions, did better on the retest. Despite this improvement the scores for the two eyes of any one individual remained very close together. It was decided to check the reliability of the test on the assumption that, for any one subject, the score of one eye ought to be exactly the same as the score of the other. Calculation on this basis (Pearson product-moment correlation, corrected by Spearman-Brown formula) yielded a reliability of 0.91, a figure well within the allowable limits of variation for such a test. The improvement on the test-retest technique was interpreted to be bona fide improvement in peripheral acuity due to the practice afforded during the two tests, each of which lasted 40 to 60 minutes. This interpretation is supported by the fact that the right eye, which was always the second tested, scored better than the left. In a series of tests (not reported here) in which the order of testing the eyes was reversed, the second eye tested (left) showed better scores than the first. These indications that simple practice can train peripheral acuity are the basis of further investigations now in progress.

SUMMARY

1. A new test for peripheral visual acuity is described.
2. One hundred subjects have been tested.
3. Peripheral visual acuity is a very variable value, the total scores running from 43 per cent to 364 per cent of the average for the whole group.
4. Peripheral visual acuity is an independent visual function.

5. The weaker the peripheral visual acuity for any point the greater is the variation for that point.

6. The collected evidence indicates that peripheral visual acuity can be trained.

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