TEST TYPES*

BY

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INTRODUCTION

At the present time Snellen's test type is the one most often used in ophthalmic practice. Recently, however, it has been proposed to substitute the alternate type devised by Green. It appeared to us desirable, before any definite recommendations had been carried out in practice, to examine the basic principles on which test types depend, in order that the greatest efficiency might be obtained in any type that was substituted for Snellen's.

SECTION I**The resolving power of the eye**

It is well known that there are two factors which set a minimum limit to the distances between two bright objects in order that they may be seen as two by the eye. The one factor concerns the structure of the retina, the other the optical properties of the lens system of the eye.

In order that the two bright objects may be seen as two by the eye, it is necessary that their geometrical images formed on the retina should be separated by at least one cone. Further, the two geometrical images must be such a distance apart that when blurring occurs, owing to diffraction and aberrations, the overlapping should not be so great that the intensity of illumination of the area between these images is not appreciably less than that corresponding to the centres of the geometrical images themselves.

The histological limit set by the diameter of the foveal cones is found to be approximately 46 seconds of arc, the optical limit with a pupil of 3 mm. diameter and white light having an approximately identical value. Experimentally, the limit is found to be 58 seconds of arc. For example, in the case of a grating consisting of alternate white and black bars, the centres of the black bars must subtend an angle of nearly 1 minute of arc in order that resolution should take place.

In both Snellen's and Green's test types normal visual acuity is said to be obtained when letters are visible, the separate black components of which subtend an angle at the eye of 1 minute of arc, and the distances between the centres of the separate black bars subtend 2 minutes of arc. This, as Parsons points out, is approximately one half the highest visual acuity shown by experiment for a grating test object.

If a test object be employed different from the grating type, e.g.,

* This research was carried out at the request of the Secretary to the Committee appointed by the Council of British Ophthalmologists to consider test types.

a single black line on a wide white field, altogether different values are obtained. The values ascertained by experiment by a number of different observers are given in the table below.

TABLE I

Acuity of Vision for black bar on bright ground.

Aubert	.../	...	...	6"	
Smith Kastner	...	...	...	3.5"	Spider's web
Hartridge	...	...	...	3.6"	Bright brass wire*
Hartridge and Owen	...	...	...	3.1"	Black brass wire*
Mean	...	...	...	4.0"	

It will be seen that the value obtained by ourselves is approximately 3.1 seconds of arc, that is, that the width of the black line must subtend this angle at the eye in order that it should be visible. This will be found to be about $1/9$ the width subtended by the black bars in a grating in which the alternate black and white bars are presumed to be of equal width, and this value is, moreover, approximately $1/18$ the width of the separate black components of the lines in Green's and Snellen's types. Taking for example the letters L and J which approximate to single black lines on a white ground, it would be expected that such letters would be appreciated at very much greater distances than would letters such as S, R, O, or B, which approximate much more closely to the grating in form, in that overlapping of the aberration images of the different components takes place to a considerable extent.

SECTION II

Experimental results with test type

So important did these theoretical considerations appear to us, that we put the matter to test in the following manner.

A series of letters was prepared, conforming to Green's type. The letters were 5 mm. high, 4 mm. wide, and each black component had a width of 1 mm. From this series certain letters were excluded, e.g., W, Q, M, and G. The remaining letters were fixed to slips of wood so that they could be presented in turn to the observer by the examiner. The latter presented the letters in an irregular order and recorded the answer given by the observer. For example, if V was presented and Y given as the answer, Y was recorded in the column under V. In this way not only was it possible to ascertain the number of mistakes that had been made in the case of any one letter, but also what that letter had been mistaken for. We carried out the tests at a number of different distances, and the results obtained are given in the following table:—

* Both mounted such a distance in front of white paper that no shadow was cast.

GREEN'S TYPE.

Distance.		5 Metres.		7.5 Metres.		8.5 Metres.		10 Metres.		12 Metres.		Mistakes.	Chosen Letters.
Observer.	H.	O.	H.	O.	H.	O.	H.	O.	H.	O.			
		Dull Daylight.		Bright Daylight.		Bright Daylight.		Bright Daylight.		Bright daylight.			
No. of Tests.	10	10	5	5	5	5	5	5	5	5	5	60	
Letter.	Total.												
S	**	**	XXBB	BBXR	RBKL	XXYE	KKLA	AKXXB	VVZX	KKLYN	36	D T U Z F P X H N	
R	**	**	KKA	KK	KKS	KKKK	KKXXW	BKKK	KKZZ*	XXXNK	32		
O	**	*C	D	*	EEDX	C	JAZE	AACAD	PPFU	EEELC	30		
B	DCCD	**	SSB	DD	AXRS	PDE	KKRA	*	XXXK	XXENS	29		
C	*DD	**	*	*	EEEE	*	EEAAL	HBR	LLOUJ	AALED	22		
K	*R	*R	RRSA	R	XXR	*	J	SV	NXZ	LZANR	22		
V	XY	*Y	*	*	TT	YY	TTYV	SV	TTYB	YNK	22		
Y	VT	—	VV	V	TTV	TT	VVVT	—	VVEAX	TKN	21		
D	C*	**	*	*	N	*	AAAA	CE	AAAA	EP	15		
T	**	**	*	*	V	*	VYV	Y	VVVE	YYNV	15		
U	**	**	*	*	*	*	ZVXJ	PV	EJFCP	AAVC	15		
Z	**	**	*	*	XT	*	XVA	*	YYXBB	XXXY	15		
F	**	**	*	*	F	*	ZJ	JP	JJJJ	JJJJ	14		
P	**	**	*	*	F	*	FF	F	FFFFF	JJFY	14		
X	**	**	*	*	TA	*	YVTV	*	YYTV	TTY	14		
H	NN*	**	*	*	*	*	NNN	*	FFFC	PPPX	13		
N	**	**	*	*	*	*	XXXZV	*	KKZ	RRPJB	13		
E	**	**	*	*	NX	*	X	A	AF	TTX	9		
J	**	**	*	*	*	*	X	*	FLTC	CCF	8		
A	**	**	*	*	*	*	XL	*	*	TTP	5		
L	**	**	*	*	*	*	V	*	U	T	3		
G	—	—	—	—	—	—	—	—	—	—	—	—	
I	—	—	—	—	—	—	—	—	—	—	—	—	
M	—	—	—	—	—	—	—	—	—	—	—	—	
Q	—	—	—	—	—	—	—	—	—	—	—	—	
W	—	—	—	—	—	—	—	—	—	—	—	—	
Mistakes Vision	17	30	53	101	166								
	6/4.2	6/2.75	6/2.45	6/2.05	6/1.7								

The type was 4mm. X 5 mm. (black = 1 mm). This equals Snellen's standard (6/6) at 3.44 metres.
H's total mistakes, 217.
O's total mistakes, 150.

The preceding table shows in the first place that, as would be expected, the number of mistakes increased as the distance between observer and test letter increased. Thus at 7.5 metres the total number of mistakes was 30, at 8.5 metres it was 53, at 10 metres 107, and at 12 metres 165.

Further, the total column giving the number of mistakes made in 60 presentations of each letter, shows that whereas letters like L and J have a very high accuracy, other letters such as R, O, B, and S have a very low accuracy. The experimental results fit in almost exactly with the theoretical conclusions drawn in the previous section, namely, that letters which consist of one or two components only are much more readily recognized than are letters in which there is considerable overlapping of the aberration discs formed by the different component parts. In fact, it may be stated that the only letter with which unexpected results were obtained was E. Few mistakes were made, whereas many were expected. It is possible that the frequent use of this letter causes it to present itself more readily to the mind. But the experimental tests show that midway between these two extremes there are a number of letters which have very nearly the same experimental error. For example, the following nine letters were recognised correctly almost the same number of times:—D, F, H, N, P, T, U, X, Z.

Now Snellen's type, *e.g.*, as produced by Curry and Paxton, contains letters differing greatly in difficulty as the following table shows:—

TABLE III

Letter.	Number of Appearances.	Relative Acuity*
E	14 per cent.	0.85
T	13 per cent.	0.74
L	11 per cent.	0.71
Z	8 per cent.	0.84
D	6 per cent.	0.82
A	5 per cent.	—
B	5 per cent.	1.00
F	5 per cent.	0.81
O	5 per cent.	0.80
V	5 per cent.	0.78
G	3 per cent.	0.92
N	3 per cent.	0.85
P	3 per cent.	0.81
R	3 per cent.	0.88
C	2 per cent.	0.79
M	2 per cent.	—
H	1 per cent.	0.92
K	1 per cent.	—
Y	1 per cent.	0.81
I	0	—
J	0	—
Q	0	—
S	0	0.89
U	0	0.79
W	0	—
X	0	—

* Values given by Sheard in *American Jl. Physiol. Optics*, 1921, II., p. 168.

It will be noted that difficult and easy letters both appear, and that the number of appearances bears no relationship to the difficulty of recognition.

SECTION III

Practical conclusions

If the proposal to select Green's test types in preference to Snellen's be adopted, and with this proposal we agree, the practical conclusion that we can draw from the results of the above experiments is that the nine letters which we have selected should alone be used; because otherwise letters of very different difficulty will be employed, which will inevitably lead to ambiguous results.

We are also of the opinion that test type for near vision should be similar to that used for testing at a distance, the size of the type being proportionately reduced.

Reference to the following table will show the number of mistakes made by us at different distances using the nine letters of Green's test type that we have selected:—

Distance in metres	Snellen's fraction	Relative acuity	No. of mistakes in 90 tests
3.44	6/6	1.0	0
5	6/4.2	1.45	0
7.5	6/2.75	2.18	1
8.5	6/2.45	2.47	7
10	6/2.08	2.91	38
12	6/1.7	3.5	78

It will be seen that errors increased rapidly when the distance exceeded 7.5 metres, that is when Snellen's fraction was less than roughly 6/3. Since neither experimenter was selected on account of exceptional visual acuity, it seems to us that 6/6, or even 6/5 is far too easy a test for normal visual acuity. We, therefore, recommend that lines of 6/4 and 6/3 be added to the test card for use if required.

We should perhaps point out that we are well aware that the recognition of a letter involves mental processes with a strong personal factor. It is quite possible that if as the result of experiment another pair of observers drew up a selection of letters of medium difficulty their list and ours would not agree. In fact, we would go so far as to say that it is probable that even a selection made by 100 individuals would not exactly tally with that made by a different set of 100 individuals. It appears to us that this is a difficulty which is inseparably connected with the use of any kind of figure, letter, or pattern for the purposes of test type. Yet the advantages of letters are manifest, and the additional advantage of

using a few letters instead of a complete alphabet is also clearly marked.

Since the above was written we have found a paper by Dr. P. J. Hay (*Trans. Ophthal. Soc.*, XXXIX, 1919) bearing on this question. Hay states that he has selected the easiest letters. Unfortunately the experimental evidence on which his selection is made is not given. His selected list contains the following letters:—A, C, E, H, L, N, O, T. The letters X and Z, he says, are left out because they are not so “familiar” as the others. If Hay’s list and our own be compared it will be observed that the only letters common to them both are H, N, and T. The fact that so few letters appear in common is readily explained as follows:—

1. Hay chose the easiest letters, whereas we selected those of medium difficulty.

2. Hay’s selection was for a type of his own; our selection, on the other hand, was for standard Green’s type. If X and Z be excluded as Hay would suggest, we think that two letters valuable for testing cases of astigmatism will be omitted.

Summary

1. Experimental results with grating test objects show that the optical limit imposed by the lens system of the eye, and the histological limit imposed by the finite diameter of the cones hold good for the fovea; the limiting value being 58 seconds of arc.

2. Experimental results with single isolated contours show, on the other hand, that the fovea has a much higher acuity for this type of object, the limiting value being approximately 4.0 seconds of arc.

3. Certain letters of the alphabet can be selected as approximating to the grating type of test object, in that considerable overlapping of the aberration images of the different components occurs: for example, in the case of Green’s type the letters S, R, O, and B. Other letters, on the other hand, can be selected as approximating to the isolated contour type of test object: for example, in the case of Green’s type L and J. The expectation that the latter would be recognized at much greater distances than the former was justified by experiment. Thus one mistake was made out of 10 tests at 10 metres in the case of L and J, whereas, at the same distance 10 mistakes out of 10 tests were made in the case of R, 9 mistakes in the cases of S and O, and 5 in the case of B. In order to reduce the number of mistakes to one, a distance not greater than 5 metres would have to be used in the cases of S, R, O, and B.

4. Experiment showed between these two groups, L and J, on the one hand, and S, R, O, and B on the other, a group of

letters of medium difficulty, the number of mistakes made in their recognition being approximately equal. The letters in the case of Green's type were D, F, H, N, P, T, U, X, and Z. We recommend that these letters be alone used on the test card.

5. These letters of medium difficulty were recognized, without any mistakes, when they were placed at such a distance that they corresponded to Snellen's fraction of $6/3$. We, therefore, recommend further that lines of type corresponding to $6/4$ and $6/3$ be incorporated on the test card.

PRELIMINARY COMMUNICATION ON INJURY AS A CAUSE OF DIABETES INSIPIDUS WITH BITEMPORAL HEMIANOPIA

BY

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SOFIA

DURING the late war four cases of wounds involving the chiasma have come under my observation, one of which is worth recording

FIG. 1. CASE I.

on account of the accompanying symptoms, especially the occurrence of diabetes insipidus.

This case was that of an officer wounded on March 22, 1917, by a bomb explosion. He was unconscious for 20 days following the injury, which was over the right eyebrow. At the end of a month the following symptoms were observed: bitemporal hemianopia (Fig. 1), diplopia, polydipsia, polyuria (from 4.5 to