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Testing visual acuity

(1) A legible four-position test object for standardization of measurement

(2) A new approach to the design of test letters for clinical examinations

L. CASELLATO

Milano, Italy

Measuring visual acuity in practical fields is far from satisfactory. Test types are of major importance and in this field there is need for research. I have developed a legible four-position test type, for measurements where standardization is most important, and a principle for the design of test letters, for examination and measurement. The four-position test type is derived from the clear preference for legible test types in practical work, searching for a compromise between letters and the classical Landolt ring, or the Snellen illiterate E. This may be considered for standardization in the field of official measurements. From these rotating test types I then developed the idea of a new approach to letter design for clinical testing (that is, for more rapid non-official examinations) based on square two-position patterns. These two proposals have different purposes and are dealt with separately below.

(1) Legible four-position test object

An operative decision of the International Civil Aviation Organization (1962), an inter-governmental institution, administering international law, recommends: "... optotypes of Landolt, or similar optotypes ..." for assessing visual requirements for personnel licensing. When the civil aviation standards were already official, the International Federation of Ophthalmological Societies decided in relation to other transport workers: "As optotypes shall be used letters". These two decisions are not standardizations, being limited to these words.

Two important national decisions were successively reached on the selection of letters for visual acuity measurements. In 1959 a Subcommittee of the A.M.A. Committee on Optics and Visual Physiology (Sloan, 1959) approved the charts developed at the Wilmer Institute in Boston. Test types of these charts are:

5 × 5 non-serif letters **C D H K N O R S V Z**

In 1968 a British Standard on Specifications for Test Charts was approved by the Ophthalmic Standards Committee. For this the style and selection of letters are:

5 × 4 non-serif letters **D E F H N P R U V Z**

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Address for reprints: Luciano Casellato, Via Mameli, 31, 20129 Milano, Italy

The difference between these two resolutions presents another obstacle to an international standard based on letters. A choice of letters based on statistics of legibility or on previously-existing charts is subject to differences which may be marked in different peoples or countries.

It may thus be possible to create a standard of official measurements by a compromise between letters and rotating test objects, i.e. a four-position test type legible as four letters. A single test object has many practical advantages in standardization, apart from the theoretical advantage that it is a better unit of measurement than a group of letters with casually different patterns (selected on statistics of legibility). The rotating test type I propose is shown in the four positions in Fig. 1.

This test type can be described as a half-ring measuring one-fifth of the outer diameter in thickness, continued by two parallel bars, as thick as the ring and half as long as the diameter; these parallel bars embrace a perpendicular bar, equal in thickness, and separated from them by two spaces one-third of its thickness; the distance of this bar from the line determined by the ends of the two outer bars is equal to its own thickness.

The relative dimensions of this pattern are clear, except for those separating the inner bar. This separation is not intended to be a critical detail: it is necessary for the sign to be accepted as C and U, at the beginning of the examination, and it must be small for the readings of A and D. The dimension I have adopted is enough for the purpose and is compatible with typographical reproduction.

In my experience, subjects of the age and education of transport operators immediately recognize the four letters in this pattern, after they are shown and named at the beginning of the examination, well above the threshold of recognition. This is a practical advantage over the Landolt ring; another advantage that assists standardization, is that there are clearly four positions, and not four or eight or more. In the theoretical field it has to be noted that the minimum separability is not emphasized by this pattern on the overall design and dimensions, which are the characteristics of test objects which must be known to be recognized.

A four-position test type has many advantages for standardization over a group of test letters. It is easier to reach agreement on a single pattern than on eight or ten; there is no alternative between the 5×5 or 5×4 dimensions; the possibilities of selection from among similarly-designed test types are very few; such tests measure retinal factors of resolution much better than a group of letters necessarily selected for their relative legibility.

The pattern I propose has, moreover, some advantages over illiterate E's: there are more clues for recognition, so that the effect of astigmatism is less marked; and there is just one pattern against the four E's which have historical importance (Snellen's 4/5 inner bar; Pfluger's 3·5/5; Pergens' 5/5; Ammon's 5/5 and truncated corners).

When the visual acuity is examined with the customary charts, with many rows of test types, four possible answers only are not enough to permit recognition at a glance when the subject is reading. But for official examinations such charts are not to be recommended, because they can be memorized. For official assessment of public law requirements, the time factor in giving the test must not be a decisive one.

(2) Design of test letters

The history of the style and selection of letters for testing visual acuity was summarized by Bennett (1965). It may be put in a few words as follows:

Snellen (1862) and Armaignac (1906) using letters with serifs; Monoyer (1875) and Sulzer (1904) using letters without serifs, adopted practically all the alphabet;

In 1868 Snellen limited the letters to fifteen;

A stricter selection was made by Green (11 letters in 1868, but 16 in 1872);

Oliver (1885) and Cowan (1928) used seven and nine letters respectively to conform to the minimum separability principle;

Hay (1919), Blaskovics (1923), and Sloan (1959) used eight to ten letters which they found of equal legibility (many other authors have experimented on legibility but I have not found charts published by them);

Emsley (1933) and Finkel (1963) used letters and groups intended to help with refracting.

In this scheme (very shortly, as the charts published by their authors run into hundreds) three lines of development may be traced:

(1) Design of the letters to be discriminated by clues one-fifth of the overall size;

(2) Selection for equal recognition;

(3) Interest in refracting greater than in measuring.

A new development is possible derived from the rotating test types used to test illiterates and in research.

In visual acuity testing, letters are used for convenience, to save time: visual acuity should not measure the subjects ability to interpret alphabets imperfectly focused or badly transmitted by the retina and nerve fibres: what matters in a visual acuity test object is its ability as a geometrical pattern, to test refractive or retinal functions. The minimum separability requirement as applied by Snellen to letters has failed to ensure sufficient uniformity of response and has now been abandoned. A quotient of legibility within a certain interval is a necessity, but it varies with the individual and is closely related to subjective functions. We could then design letters for their geometrical properties. A few simple patterns would at least give a purer test of retinal resolution. If this lead to a wider range of statistical legibility, it would be an advantage in the clinical evaluation of the functions of the eye and could be overcome in measurements by appropriate methods of scoring.

Interesting geometrical properties can be obtained to extend to letters the principle of rotating patterns, which has a long history in the illiterate E and in Landolt's ring. At least half the alphabet may be so designed that one letter transforms into another by rotation through 90°. Among these letters we can use those whose patterns are most useful for refracting or for clinical measurements. Since the optical system of the eye has directional properties, two-position patterns would be better than the customary letters designed only on the minimum separability principle or selected on statistics of legibility.

The following couples of two-position letters are mostly derived from letters already used as optotypes (some of them are shown in Fig. 2):

A D C U H I N Z

AD, from Snellen's D: many reproductions in Bennett (1965, p. 239) and in Pergens (1906a, b).

CU, from the U of Green (1868) (see Pergens, 1906b, p. 133).

EM, from the E of Snellen or Pergens or Ammon (or EW from Pergens' or Ammon); reproductions in Bennett (1965), Ewing (1928), and Pergens (1907, p. 298).

HI, from Hay's H (see Bennett, 1965); the resulting I has very long serifs, but when well focused it is promptly identifiable.

KY, from a suitable K, designed with symmetrical oblique bars; these letters seem to me sufficently identifiable (though there is no K or Y in the Italian alphabet).

NZ, from a suitable N (Hay's?, style and size in Bennett, 1965, p. 243).

These patterns are sufficiently numerous to permit different selections according to the needs of a particular clinic. There are straight and curved contours and different oblique lines. Some patterns are simpler, others more complicated; the relative proportions of black and white vary. Charts could be developed which are the best for refracting; moreover, since they will contain few patterns, the level of acuity will be more accurately measured. The patterns will be fewer than in any other set of letters numerous enough to be practical, as they contain half the number of letters. In consequence any set selected from them is a more exact unit of measurement. It will also be feasible to develop charts in which a selection of one or two patterns (two or four letters) repeated in each row is conventionally devoted to acuity assessment. In clinical tests a strict standardization would not be so necessary as in official tests, but it is desirable that the premises for it exist. Reducing the number of patterns is the only way to standardize, even in clinical examinations of the visual acuity. Also, for rotating patterns there is no alternative in relative dimensions, for the 5×5 size is enforced.

Summary

1. Official recommendations on visual acuity measurements are conflicting and/or inadequate. For international standardization a four-position test type which can be read as the letters ACDU is described. Its advantages over groups of letters, Landolt's ring, and illiterate E's are set forth.

2. The development of the selection of letters for acuity charts is traced. A new line is suggested, based on the overall geometrical pattern of a few letters, legible in two ways when rotated through 90°. Possible letters are listed. Their advantages for standardization in clinical tests are given.

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