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Correlation of Optotypes with the Landolt Ring—A Fresh Look at the Comparability of Optotypes

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ABSTRACT

The legibility of three selected sets of optotypes: (1) letters; (2) Snellen E; and (3) KOLT test have been compared to the Landolt ring in a study based on the German Standard DIN 58220, Part 2 and the International Standard ISO 8597. The letters were printed in the standard typeface used on German street signs (sans serif Linear-Antiqua, Typeface B). The main results are: 1. A set of letters can be selected in such a way that the differences in legibility displayed between different letters in the set are smaller than the ISO/DIN allowance of 0.05 logarithmic units of the visual angle, although the letters are not constructed according to the traditional 5 by 5 or 5 by 4 construction principles. 2. The eight letters C, D, E, K, N, P, U, Z are proposed for standardized visual acuity tests because of their almost equal legibility. 3. The height of the typeface used for this selected set of letters should be 5% less than the diameter of the Landolt ring in order to achieve the same legibility as the latter. 4. Both shape optotypes (Snellen E and KOLT test) must be approximately 15% smaller than the diameter of the Landolt ring in order to obtain comparable visual acuity scores.

Key Words: visual acuity, correlation of optotypes, Landolt ring, letter optotypes, shape optotypes

The following article pursues two goals: It tries to demonstrate the applicability of the new ISO correlation procedure[1] and it shows that modern typefaces that are not constructed according to the classical 5 by 5 or 5 by 4 construction principles can be used for accurate and reliable visual acuity tests. The results of two study groups (School of Optometry, Aalen; Medical Optics Laboratory, University Eye Clinic, Hamburg) are described which independently used the ISO correlation procedure to compare three sets of optotypes with the Landolt ring, namely: Roman letters, Snellen E optotypes, and Lithander's optotypes for children (KOLT test).

Visual acuity tests for official purposes require standardized optotypes and test procedures in order to assure the comparability of the results obtained. Standardized optotypes and test procedures should also be used for the clinical testing of visual function because the course of an ocular disease is often monitored at various locations and with different equipment. During the process of subjective refraction, the absolute value of visual acuity plays only a subordinate role. The optotypes are used mainly as a tool to determine the power of the optimum corrective lens. It should be kept in mind, however, that results obtained with different subjective refraction techniques can only be compared if the visual acuity scores are finally measured with standardized optotypes and procedures.

Initial attempts to standardize the determination of visual acuity date back to Snellen's[2] work in 1862. Subsequently, Green[3] (1868) and Monoyer[4] (1875) examined letters of different typefaces to evaluate their suitability for visual acuity estimation. Landolt[5] recognized the necessity of a standard optotype that displays smaller differences in legibility than the different letters of the alphabet. His "cercle interrompu" was accepted 21 years later

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as a standard optotype at the International Ophthalmological Congress in Naples.[6]

The current international standard and national regulations[7–9] stipulate the Landolt ring, presented in eight positions, as the standard optotype. Furthermore, conditions for presentation (test distance, distance between optotypes, size of surrounding field, luminance) and criteria for the measurement procedure are also stipulated for the standard determination of visual acuity in distant vision.

The advantages of the Landolt ring are: (1) a single characteristic feature in all eight directions of presentation; (2) low directional dependency in fully corrected patients; and (3) the negligible influence of shape recognition compared with letters or numerals. These advantages must be weighed against the considerable communication problems which can arise. When used in the optometric practice, for example, the Landolt ring test is often not understood without a time-consuming explanation. In addition, a number of patients, e.g., children or mentally retarded patients, often confuse the terms right and left and have problems denoting the oblique orientations. These factors reduce the usefulness of the Landolt ring test with inexperienced observers.

The communication problems with the Landolt ring led to the demand for additional sets of standardized optotypes. These additional optotypes have to be correlated according to the standard ISO 8597[1] with the legibility of the Landolt ring. This comparison procedure requires the determination of visual acuity with at least 10 subjects under exactly defined conditions. If the acuity value obtained with the new set of optotypes differs from the Landolt ring acuity by not more than 0.05 log units, then the new set of optotypes can be regarded as equivalent to the Landolt ring. If the acuity difference is greater, the set of optotypes can be magnified or minified in order to achieve equivalence with the Landolt ring.

METHODS

Selection of Optotypes

Letters. The central problem of using letters as standardized optotypes lies in their widely varying legibility, even if they display the same construction, size, and line width. Numerous authors have dealt with the problems involved here.

Hartridge and Owen[10] classified capital letters according to their relative legibility. They used capital letters with the dimensions 5 by 4 (height by width). According to their study, the nine letters D, F, H, N, P, T, U, X, Z are of medium difficulty and approximately the same relative legibility. Coates[11] and Woodruff[12] recommended the letters D, E, H, N, P, T, V, Z with the dimensions 5 by 4 (height by width) as having approximately the same difficulty of recognition.

Sloan et al.[13] selected 10 capital letters with the dimensions 5 by 5 (height by width). They came to the conclusion that the letters C, D, H, K, N, O, R, S, V, Z and the Landolt ring (four directions) exhibit about the same legibility.

Aulhorn et al.[7] recommended a set of 13 letters of a typeface used on European street signs in accordance with DIN 1451, Part 2. They proposed that the letters D, E, F, H, K, N, O, P, R, T, U, X, Z should be approximately 6% higher than the diameter of the Landolt ring to achieve the same legibility. To our knowledge, no experimental verification of the proposed size correction has been described in the relevant literature.

Hedin and Olsson[14] determined the order of legibility for capital letters written in a typeface similar to the middle typeface described by DIN 1451, Part 2.[15] Their results show that the capital letters C, D, E, F, K, M, N, U, V, X, Y exhibit the best possible correspondence with regard to legibility.

If the letters proposed by the authors mentioned above are entered in a table and if the table is then completed by adding the letters recommended by the British Standards Institution (BSI)[16] and the National Academy of Sciences-National Research Council Committee on Vision (NAS-NAC),[17] we see that international preference is obviously being given to certain letters for visual acuity testing.

The main selection criterion of the research mentioned above was the relative legibility. A further aspect determining which letters can be chosen for visual acuity testing is the frequency with which the letters are confused with each other. This parameter is known as the relative confusion frequency. In a very comprehensive study on various optotypes, von Benda[18] established that the relative confusion frequency has a major influence on the resulting visual acuity. With letters resembling each other, a lower acuity score is obtained than with dissimilar letters. Krüger[19] and Roloff[20] made a detailed investigation of the relation between the legibility and the frequencies of confusion exhibited by capital letters. Roloff also determined the order of legibility in the case of unsharpness, which is of importance for subjective refraction.

In the present study, we use letters printed in the typeface sans serif Linear-Antiqua, Typeface B[15] as proposed by Aulhorn et al.[7] It seems important to mention that these letters are not constructed according to the traditional 5 by 5 or 5 by 4 construction principles. As illustrated in Fig. 1, the stroke width is 1/7 of the letter height and the format of the letters varies from 7 by 4.5 to 7 by 5.5. Thus, the reader may think that these unconventional letters may not be particularly useful for visual acuity tests. Our rationale for the use of the typeface mentioned above is based on the following two arguments.

1. The 5 by 5 or 5 by 4 construction principles are no laws per se, but have been used in the past because it was assumed that 5 by 5 or 5 by 4 letters do have a similar legibility. A number of other investigators,[10–13] however, have shown that iden-

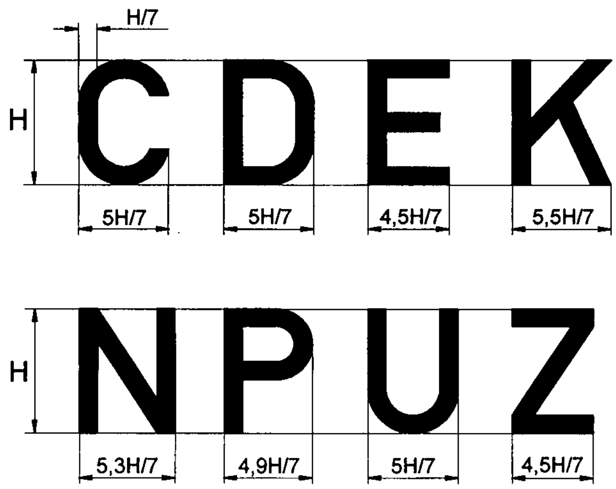

Figure 1. Letter optotypes "linear Linear-Antiqua Typeface B."

tical legibility cannot be obtained with these typefaces. The results presented below will demonstrate that almost equal legibility can be obtained with selected letter sets of other typefaces.

2. We believe that letters used for visual acuity tests should be presented in typefaces which are well-known to the public. The typeface sans serif Linear-Antiqua, Typeface B[15] fulfills this requirement because the letters are currently being used on most street signs in our country.

The two study groups formed by the authors of the present paper used different criteria to select their sets of letters and shapes to be correlated with the Landolt ring.

Study Group I[21, 22]*: School of Optometry, Aalen.* The relative legibility and the frequency of confusion served as decision criteria used to select eight letters. Very similar letters with a high frequency of confusion were excluded. On the basis of these requirements, the eight letters D, F, K, N, R, T, U, Z were selected (Table 1, column 9). The selection was based on the results of Krüger[19] and Roloff,[20] who found that these letters have approximately the same relative legibility and that the selected group does not contain those letters which are most frequently confused with each other.

Study Group II[23, 24]*: Medical Optics Laboratory, University Eye Clinic, Hamburg.* Study Group II based their selection of the letters solely on the criterion of approximately identical legibility. In a pilot study, 14 letters were selected on the basis of the existing literature and tested to establish their relative legibility. The result of these measurements led to the 10 letters C, D, E, F, K, N, P, U, V, Z (Table 1, column 10).

Shape Optotypes

Snellen E. From the large number of shape optotypes proposed in the relevant literature the Snellen E was chosen by Study Group I. It was presented in the four positions: up, down, right, left. The rationale for the selection was as follows.

The Snellen E can be used with infants and illiterate patients (known as tumbling E test or E-game). The subjects are required to point out the direction of the E on the test chart with their hands or a model E.

The visual properties of the Snellen E are similar to those of the Landolt ring: (1) the main task demanded of the subject's visual system is to identify a direction and (2) the influence of shape recognition is small compared to letters and numerals. As the Snellen E displays two gaps, it can be recognized more easily than the Landolt ring.

Table 1. Proposal of various authors and national committees regarding the use of letters for visual acuity charts; the letters used in the present paper by Study Group I (SG I) and Study Group II (SG II) are indicated in the two rightmost columns.

Hartridge and Owen[10]	Coates[11]	Sloan et al.[13]	DOG[7]	Hedin and Olsson[14]	BSI[16]	NAS-NAC[17]	No.	SG I 1987	SG II 1989
—	—	C	—	C	—	C	3	—	C
D	D	D	D	D	D	D	7	D	D
—	E	—	E	E	—	—	3	—	E
F	—	—	F	F	F	—	4	F	F
H	H	H	H	—	H	H	6	—	—
—	—	K	K	K	K	K	5	K	K
—	—	—	—	M	—	—	1	—	—
N	N	N	N	N	N	N	7	N	N
—	—	O	O	—	O	O	4	—	—
P	P	—	P	—	P	P	5	—	P
	—	R	R	—	R	R	4	R	—
—	—	S	—	—		S	2	—	—
T	T	—	T	—	T	—	4	T	—
U	—	—	U	U	U	—	4	U	U
—	V	V	—	V	—	V	4	—	V
X	—	—	X	X	—	—	3	—	—
—	—	—	—	Y	—	—	1	—	—
Z	Z	Z	Z	—	—	Z	5	Z	Z
Σ 9	8	10	13	11	10	11	72	8	10

KOLT Test

For a long time it was standard practice to use pictorial symbols for the testing of preschoolers' visual acuity. However, these symbols differ to such an extent in their critical details and in their distribution of bright and dark components that they cannot fulfill the requirements concerning identical recognizability and identical frequency of confusion. Modern alternatives are simple shape optotypes such as the KOLT test described by Lithander,[25] which have been used successfully for testing visual acuity of infants over 2 years of age. The KOLT test consists of four geometrical shapes (triangle, square, cross, circle) in the ratio 1:5:5 (Fig. 2). Because of their simple and well defined geometric construction, these optotypes were chosen by Study Group II and correlated with the Landolt ring according to the ISO/DIN procedure.

Presentation of Optotypes

The two study groups used different techniques for the presentation of the optotypes. Study Group I projected the optotypes,[22] whereas Study Group II presented the optotypes on charts which were produced photographically.[23]

In both study groups the test conditions complied with the requirements specified in the standard.[1] The distance between the test subject and the test field was fixed by a head rest. From a distance of 5 m, the subject binocularly viewed a homogeneously illuminated wall featuring a round aperture with a diameter of 4° of visual angle. Either the projection microscope for the presentation of the optotypes (Study Group I) or the optotype charts produced photographically (Study Group II) was mounted behind this aperture. Fig. 3 illustrates the visual field seen by the subject. Further details of the test configuration are listed in Table 2. The size of the optotypes was chosen so that the diameter of the Landolt ring equaled the height of the optotype of the same acuity grade (for details see Fig. 1 and Fig. 2).

Measurement Procedure

Both study groups presented only optotypes of the same kind during a single experimental session. The optotypes were presented individually and in random succession with regard to size, shape, or direction. Table 3 shows the number of presentations for the different optotypes. The presentation time totaled 3 s. After the presentation, the optotype was removed from the test field and the subject was given 4 s to answer. The next optotype was not presented until an answer had been given.

The determination of visual acuity was performed with the method of constant stimuli and a multiple-alternative forced-choice procedure. This means (1) all optotypes in the set (alternatives) were known to the subjects; (2) only a single optotype was presented at a time; and (3) the subject had to respond to every trial and, if necessary, had to guess the answer.

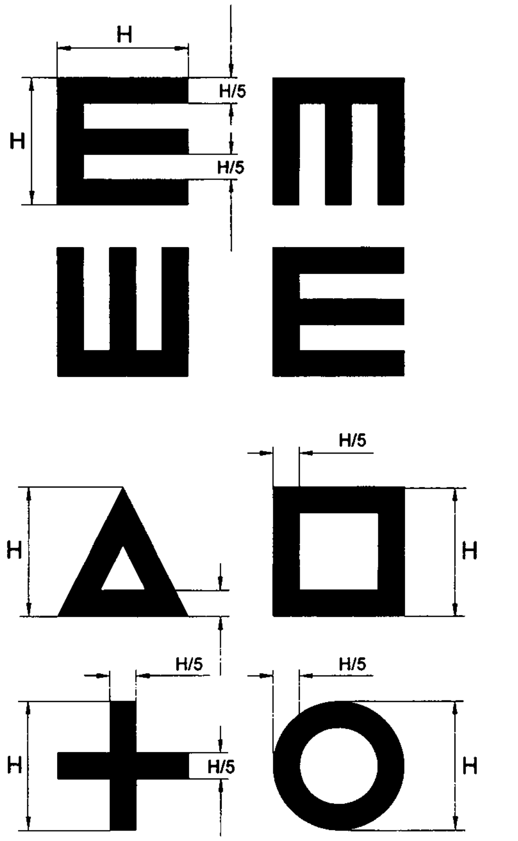

Figure 2. Snellen E and KOLT Test.

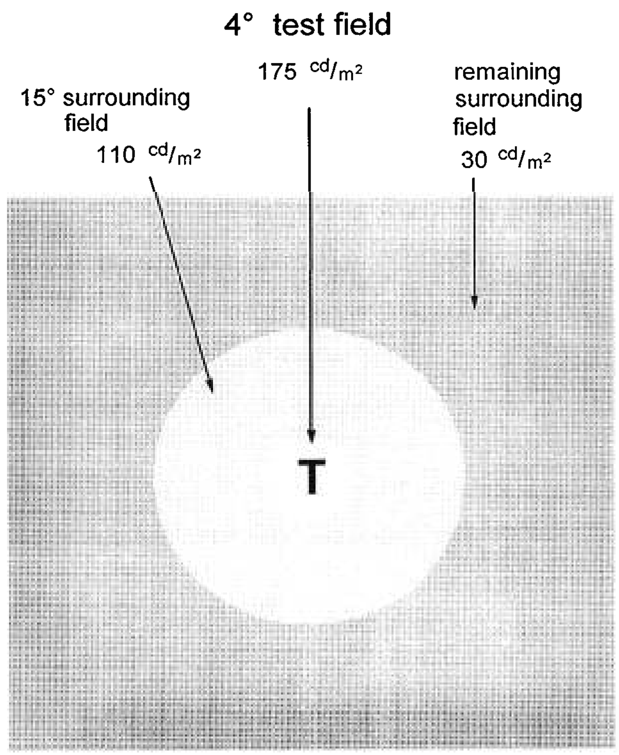

Figure 3. Geometry of optotype presentation.

TABLE 2. Test conditions in the correlation procedure.

Optotypes	Letters, Landolt Ring	Snellen E	Letters, KOLT Test, Landolt Ring
Optotype presentation	Back surface projection		Optotype charts
Contrast of optotypes	91%	90%	91%
Test distance	5 m	5 m	5 m
Diameter of test field	4°	4°	4°
Luminance of test field	175 cd/m²	177 cd/m²	170 cd/m²
Size of homogenous surrounding field	15°	15°	15°
Luminance of surrounding field	110 cd/m²	64 cd/m²	110 cd/m²
Remaining surrounding field	30 cd/m²	<30 cd/m²	<30 cd/m²

Before the measurements, the individual visual acuity of every subject was determined with a conventional visual acuity test. Centered around this individual visual acuity, seven acuity grades separated by 0.05 log units were presented in each group of trials. Each group of trials lasted between 10 and 12 min.

The measurements were performed with 10 adult subjects with healthy eyes and a normal binocular status. The refractive errors of all subjects were determined, and the subjects were requested to wear the required corrective lenses/eyewear constantly. All subjects attained a monocular visual acuity of better than 1.25 (6/4.8) and none exhibited anisometropia.

Evaluation of Visual Acuity

The visual acuity values were calculated using the method suggested in the correlation standard.[1] Initially, the number of correct responses R was determined for every subject, each set of optotypes, and each acuity grade. To compensate for the influence of correct guesses, the values were subsequently corrected using the following formula:

$$\frac{E}{N} = \frac{R - N \cdot p}{N(1 - p)}$$

where E = number of correct responses after correction for guessing probability; N = number of presentations; R = measured number of correct responses; and p = guessing probability (p is equal to the reciprocal of the number of different optotypes or directions in the set)

p is

- ⅛ when the Landolt ring or 8 letters in a set are used
- 1/10 when 10 letters are used in a set and
- ¼ for the KOLT test and the Snellen E set if four directions are presented.

The frequency of the corrected right answers E/N is plotted against the logarithm of the size of the critical detail. The resultant psychometric function can be approximated by the cumulative normal distribution to a high degree of accuracy. Thus, it is possible to linearize the psychometric function by means of a z-transformation. The validity of this linearization procedure is substantiated by the results of the linear regression analysis performed on the z-transformed data. The correlation coefficients, both for the group and for the individual optotypes and test subjects, were close to 1. In Study Group II, for example, the mean correlation coefficient for the 10 subjects was 0.993 ± 0.005 for the Landolt ring test and 0.992 ± 0.006 for the set of letters. (Values for E/N which were greater than 94% or smaller than 6% were ignored.)

The visual acuity values were determined from the regression line in a two-step process. First, the size of the critical detail was evaluated (in min arc), at which the ratio of correct responses (E/N) equaled 50%. This value served as a threshold estimate for the resolving power of the eye. Subsequently, the visual acuity was calculated in the customary way as the reciprocal of the resolving power.

The acuity scores determined for the Landolt ring V_L, the sets of letters V_{LeS}, and the shape optotypes V_{ShS} were used to form the pair difference $\Delta_i = \log V_{xS} - \log V_L$ [the index x denotes the letters (Le) or the shape optotypes (Sh)]. The mean of Δ_i across all 10 subjects served as an indicator for discrepancy between the visual acuity values obtained with the optotype set under test and the Landolt ring.

The t-test was performed to verify the significance of the difference between the legibility of the optotype sets and that of the Landolt ring. If a significant difference is found, the size of the optotypes can be corrected to establish the exact equivalence with the Landolt ring.

RESULTS

Correlation of the Letter Sets

Table 4 shows the result of the correlation for the two letter sets consisting of the

8 letters D, F, K, N, R, T, U, Z and the
10 letters C, D, E, F, K, N, P, U, V, Z.

The mean pair difference between the visual acuity with the letter sets and the Landolt ring is entered in the table in logarithmic units. The results of the correlation show that:

1. Both letter sets are equivalent to the Landolt ring because the mean pair difference is smaller than 0.05 logarithmic units.[1]

TABLE 3. Frequency of presentation for letter and shape optotypes.

Optotype Set	Number of Presentations per Acuity Grade	
	Study Group I	Study Group II
Landolt ring	8 * 15	8 * 15
8 Letters	8 * 120	—
10 Letters	—	10 * 12
Snellen E	4 * 15	—
KOLT test	—	4 * 15

TABLE 4. Correlation of letter and shape optotypes with the Landolt ring[a]

Optotype Set	Mean Pair Difference $\bar{\Delta}_i$ and 95% Confidence Interval (log units)	Pair Difference Statistically Significant at the 95% Level? (t-test)	Size Correction Factor
8 letters	0.027 ± 0.019	yes	0.94
10 letters	0.021 ± 0.014	yes	0.95
Snellen E	0.065 ± 0.021	yes	0.86
KOLT test	0.076 ± 0.015	yes	0.84

[a] All pair differences between the visual acuity values are positive numbers, indicating that all optotype sets were easier to recognize than the Landolt ring. The letter sets have to be presented slightly smaller than the Landolt ring in order to obtain the same acuity value. The respective size correction factors are listed in the right column. The factors indicate how much the height of all optotypes in the set has to be reduced.

2. The differences between the legibility of the letter sets and that of the Landolt ring are significant at the 95% confidence level. Both letter sets lead to slightly higher visual acuity scores than would be obtained with Landolt rings of the same size. To achieve complete equivalence between the letter set and the Landolt ring, the size of the letter sets has to be reduced by the size correction factors given in column 4.

Correlation of the Shape Optotypes

The results of the correlation of the Snellen E presented in four directions and of the KOLT test with four shapes (Table 4) show that:

1. Both optotype sets are not equivalent to the Landolt ring. The mean pair differences between each of the two optotype sets and the Landolt ring are larger than 0.05 logarithmic units.[1]

2. The differences between the legibility of the optotype sets and that of the Landolt ring are significant at the 95% level. Both shape optotype sets lead to much higher visual acuity scores than those which would be obtained with Landolt rings of the same size. To achieve equivalence with the Landolt ring, the optotype sets must be reduced by the size correction factors specified in column 4.

Legibility of Individual Optotypes in a Set

The evaluation procedure described above was also used for the analysis of the legibility of individual optotypes in a group. The letter set with the eight letters D, F, K, N, R, T, U, Z was selected for this purpose. Each letter was presented 120 times in every visual acuity grade, thus exceeding the statistical requirements of the correlation procedure.[1] Using the visual acuity scores obtained with each individual letter, V_{Le}, and the Landolt ring, V_L, the mean pair difference was calculated as an average across all 10 subjects.

The results entered in Table 5 for the eight letters D, F, K, N, P, U, V, Z show that:

1. The letters K, U, N, D, F are individually equivalent to the Landolt ring. The mean pair difference is smaller than 0.05 logarithmic units, indicating that the legibility of the letters is not substantially different from the Landolt ring. This small difference in legibility is not significant at the 95% level.

2. The letter "R" is more difficult to recognize, and the letters "T" and "Z" are easier to recognize than the Landolt ring. The mean pair difference is larger than the tolerable difference of 0.05 logarithmic units. The difference in legibility is significant at the 95% level, indicating that these three letters are not individually equivalent to the Landolt ring.

3. If we correct the size of the letters using the set mean (Table 4, column 4), the letters Z, K, U, N, D, F are individually equivalent to the Landolt ring.

The result of a comparable evaluation for the letters C, D, E, F, K, N, P, U, V, Z which were, however, only presented 12 times individually in each acuity grade, also shows that individual letters deviate by more than 0.05 logarithmic units from the set mean despite the successful correlation of the letter set with the Landolt ring. A similar problem was found with the KOLT test. The circle—when considered as a separate entity—also deviates by more than 0.05 logarithmic units from the mean visual acuity obtained with the complete set. Conversely, an evaluation of the eight directions of the Landolt ring showed that none of the eight positions will give rise to visual acuity values

TABLE 5. Legibility of the individual letters in the optotype set used by Study Group I.[a]

Letters	Mean Visual Acuity Difference between Individual Letters and the Landolt Ring (log units)	Pair Difference Statistically Significant at the 95% Level? (t-test)	Visual Acuity Difference after Size Correction Using Set Mean (log units)
T	+0.127	yes	+0.100
Z	+0.061	yes	+0.034
K	+0.049	no	+0.022
U	+0.032	no	+0.005
N	+0.027	no	0
D	+0.026	no	−0.001
F	+0.014	no	−0.013
R	−0.054	yes	−0.081

[a] When presented at the same height 7 of the 8 letters are easier to recognize than the Landolt ring. When the size of all letters is reduced according to the size correction factor given in Table 4, 6 of the 8 letters deviate by less than 0.05 log units from the legibility of the Landolt ring.

that deviate from the mean by more than 0.035 logarithmic units of visual angle (Table 6). Using the 0.05 equivalence criterion, the eight positions of the Landolt ring can be described as equally legible.

CONCLUSIONS

On the basis of the results presented here, the two study groups jointly compiled one set of letters in such a way that every individual letter and the letter set as a whole fulfill the equivalence criterion of 0.05 logarithmic units. This set comprises the following letters:

C, D, E, K, N, P, U, Z

The size correction factor relative to the Landolt ring for this set of letters is 0.95 (Table 4). Interpreting the correlation standard ISO 8597 strictly, this set of letters should now once again be subjected to the correlation procedure. This will be done after the final publication of ISO 8597.

Looking back at our results of the correlation experiments with letters and shape optotypes, both study groups believe that the current equivalence criteria given in ISO Standard 8597 is not sufficient. According to the ISO equivalence criterion, a set of optotypes is considered to be equivalent to the Landolt ring if the mean value of the visual acuity determined with the complete set of optotypes does not deviate by more than 0.05 logarithmic units from that found with the Landolt ring. The standard does not specify, however, any strict requirements concerning the legibility of the individual optotypes in the set. The standard mentions that the recognizability of the individual letters shall be comparable without actually defining the recognizability itself and the permissible deviations from one optotype to the other.

Our analysis of the recognizability of the individual letters contained in the set (Table 5) showed that, even after a size adjustment using the set mean, the letters T and R still differ by more than 0.05 logarithmic units from the set mean. These substantial differences between the individual members of the optotype set indicate that we cannot assume a similar recognizability of the letters. The same problem appears with shape optotypes. According to our findings, only three symbols of the KOLT test do comply with the requirement for equal recognizability. Conversely, the analysis of the eight directions of the Landolt ring shows that it fulfills the criterion of identical recognizability in its eight directions. None of the eight positions of the Landolt ring deviates by more than 0.035 logarithmic units from the mean value (Table 6). The four directions of the Snellen E have an almost identical recognizability as well (Herzog[21]).

We believe that identical legibility or recognizability of the individual optotypes is of importance for the practical applicability and usefulness of an optotype set that is used for standardized visual acuity measurements. We would, therefore, suggest adding the following sentence to the existing ISO 8597 document in Chapter 6: "If the set of optotypes consists of different sorts of optotypes, e.g., different letters, numerals or shapes, the difference of the threshold values for each individual optotype from the mean threshold of the set must be less than 0.05 logarithmic units."

TABLE 6. Visual acuity of the 8 directions of the Landolt ring in comparison with the set mean.

Orientation of the Gap of the Landolt Ring	Visual Acuity Obtained With Landolt Rings Oriented at 0°/90° (log units)	45°/135° (log units)	Difference from the Mean (log units)
top	0.296		−0.008
top right		0.283	−0.019
right	0.338		+0.034
bottom right		0.303	−0.001
bottom	0.317		+0.013
bottom left		0.283	−0.019
left	0.324		+0.020
top left		0.291	+0.013
mean	0.304		

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NOTICE

The American Academy of Optometry's Research Committee in cooperation with the American Optometric Association's Council on Research announces the 1994 Invitational Optometric Clinical Research Workshop. This will be the fourth workshop co-sponsored by the AOA and the AAO. It will take place August 3 to 7, 1994, on the campus of Indiana University, Bloomington, Indiana.

This workshop is open to all optometrists to apply. Applications will be sent out on January 5, 1994. The deadline for return of the application is March 1, 1994. The Workshop Committee of the American Academy of Optometry and the American Optometric Association will review applications and select the final candidates.

Contact the American Optometric Association's Council on Research, John C. Whitener, O.D., M.P.H. or Jeanne A. Parr, 1505 Prince St., Ste. 300, Alexandria, VA 22314. Telephone (703) 739-9200.