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ORIGINAL ARTICLE

Visual Acuity Results in School-Aged Children and Adults: Lea Symbols Chart Versus Bailey-Lovie Chart

VISION IN PRESCHOOLERS (VIP) STUDY GROUP

ABSTRACT: *Purpose.* To compare visual acuity results obtained using the Lea Symbols chart with visual acuity results obtained with the Bailey-Lovie chart in school-aged children and adults using a within-subjects comparison of monocular acuity results. *Methods.* Subjects were 62 individuals between 4.5 and 60 years of age, recruited from patients seen in five optometry clinics. Each subject had acuity of the right eye and the left eye tested with the Lea Symbols chart and the Bailey-Lovie chart, with order of testing varied across subjects. Outcome measures were monocular logarithm of the minimum angle of resolution (logMAR) visual acuity and inter-eye acuity difference in logMAR units for each test. *Results.* Correlation between acuity results obtained with the two charts was high. There was no difference in absolute inter-eye acuity difference measured with the two acuity charts. However, on average, Lea Symbols acuity scores were one logMAR line better than Bailey-Lovie acuity scores, and this difference increased with worse visual acuity. *Conclusions.* The Lea Symbols chart provides a measure of inter-eye difference that is similar to that obtained with the Bailey-Lovie chart. However, the monocular acuity results obtained with the Lea Symbols chart differ from those obtained with the Bailey-Lovie chart, and the difference is dependent on the individual's absolute level of visual acuity. (Optom Vis Sci 2003;80:650–654)

Key Words: visual acuity, interocular acuity difference, Lea Symbols distance acuity chart, Bailey-Lovie distance acuity chart, method comparison

In adults, recognition visual acuity is measured with charts composed of Landolt C or letter optotypes. In 1980, the Committee on Vision recommended that optotypes on visual acuity charts should be arrayed in lines containing equal numbers of proportionally-spaced optotypes and that the size of the optotypes should decrease logarithmically from line to line.[1] The Committee on Vision also designated the Landolt C as the preferred optotype, but indicated that letter optotypes that are approximately equal in difficulty to the Landolt C, such as the group of 10 Sloan letters, were acceptable.[1] Two examples of charts that are constructed with proportional spacing of optotypes and lines of optotypes are the Bailey-Lovie chart,[2] which uses as optotypes the series of 10 letters adopted in 1968 by the British Standards Institution for measurement of visual acuity, and the Early Treatment Diabetic Retinopathy Study (ETDRS) chart,[3] which uses the 10 Sloan letters as optotypes. Letters in the Bailey-Lovie chart have a height-to-width ratio of 5:4, whereas the height-to-width ratio for letters in the ETDRS chart is 1:1.

Three- and 4-year-old children are often able to provide recognition acuity results using tests that employ symbols or a small number of letters as optotypes.[4] However, until recently, there have been no recognition acuity tests for young children that conform to the standards recommended by the Committee on Vision.[1] In 1980, Hyvärinen et al.[5] introduced the Lea Symbols recognition acuity chart, which has equal numbers of optotypes per line, proportional spacing of optotypes, and logarithmic spacing of lines. Instead of 10 letters, as in charts designed for adults, optotypes in the Lea Symbols chart are four shapes familiar to the young child: circle, heart, house, and square. These symbols were designed, based on empirical testing, to blur equally and to be of a size to provide scores equivalent to Snellen E optotypes of the same acuity value.[5] The Lea Symbols optotypes were later recalibrated to provide acuity scores equivalent to Landolt C optotypes of the same acuity value (L. Hyvärinen, personal communication, 1999). To date, there have been no large-scale normative studies of Lea Symbols acuity. In addition, only two published studies have provided data comparing Lea Symbols acuity results with acuity results obtained with standard adult tests in the same clinical patients.[6, 7] In both studies, the standard adult test was a Landolt C chart in which optotypes were not proportionally spaced. In addition, only one of the studies reported results from linearly-arrayed, crowded Lea Symbols optotypes (as opposed to singly-presented optotypes).[6]

The purpose of the present study was to compare monocular visual acuity results obtained with the Lea Symbols chart and the Bailey-Lovie adult recognition acuity chart in a study population that was old enough to complete testing with both charts. The study population was recruited from a patient-based population to ensure inclusion of subjects with a wide range of acuity values, which is necessary to allow evaluation of the correlation between the results of the two acuity tests.

METHODS

Subjects

A total of 62 subjects were recruited at the five clinical centers that are part of the Vision in Preschoolers (VIP) Study Group: New England College of Optometry, Northeastern State University College of Optometry, Pennsylvania College of Optometry, The Ohio State College of Optometry, and the University of California School of Optometry. Subjects were recruited from patients seen in routine optometry clinics and had ocular disorders that included primarily amblyopia, but also aphakia, strabismus, toxoplasmosis, and various refractive errors. The median age of subjects was 11 years (interquartile range, 7 to 26 years), with a range from 4.5 to 60.4 years. All had received a full eye examination within the past 3 months, and all were able to complete monocular assessment of visual acuity in both eyes with the Lea Symbols logarithm of the minimum angle of resolution (logMAR) chart and the Bailey-Lovie logMAR chart.

This research followed the tenets of the Declaration of Helsinki, the protocol was approved by the institutional review board of each participating institution, and written informed consent was obtained from each subject and, in the case of minors, from the parents of the subject.

Apparatus

The Lea Symbols logMAR test (Precision Vision, La Salle, IL) has four symbols on the top line (20/200 at a test distance of 3 m) and five symbols on each subsequent line down to the 20/8 line. There are four symbols used in this chart (house, heart, apple, and circle), and the ratio of the height to width of the symbols is approximately 1:1. The Bailey-Lovie logMAR letter chart (I. Bailey, University of California, Berkeley, CA) has five symbols per line, progressing from 20/250 equivalent for the largest line to 20/12 for the smallest line. There are 10 letters used in this chart, and the ratio of the height to width of the letters is 5:4. Routine clinical office lighting was used to illuminate each chart

Procedure

Each subject's distance visual acuity was assessed monocularly using both the Lea Symbols logMAR chart and the Bailey-Lovie logMAR letter chart, with the order in which tests were administered varied nonsystematically across subjects. The examiner who conducted the second test was not masked to the results of the first test. For each test, acuity of the right eye was measured first, followed by measurement of acuity in the left eye. Subjects who routinely wore spectacles were tested with spectacles. At the beginning of testing, the subject was seated at a distance of 3 m (10 ft) from the acuity chart, and the left eye was occluded with micropore tape or an adhesive patch. The tester asked the subject to identify the optotypes on the top line of the chart, from left to right. If none could be read, the viewing distance was decreased to 1.5 m (5 ft), and the subject was again asked to identify the optotypes on the top line of the chart. If all optotypes on the top line of the chart were identified correctly, the subject was asked to identify two optotypes on the next line and on each subsequent line until one of the optotypes was named incorrectly. After an incorrect response, the examiner retreated one line and asked the subject to identify the three previously untested optotypes on that line. If fewer than three of five optotypes were correct, the examiner retreated another line and tested the subject with the previously untested optotypes until a line was identified on which at least three of five optotypes were identified. When three or more of the five optotypes were identified correctly, the examiner proceeded to the next line and completed testing of all optotypes on that line, continuing line by line until the subject could identify none of the optotypes on a line.

Data Analysis

For each eye, acuity was scored as a logMAR value. The score was calculated as the log of the minimum angle of resolution for the last line on which the subject identified at least three of the five optotypes, plus a value of -0.02 log unit for each optotype that was identified correctly beyond that acuity level. For example, if the subject identified three optotypes on the 20/40 line plus one optotype on the next line, then the logMAR value was calculated as the log of 2 min of visual angle (the minimum angle of resolution for 20/40) plus -0.02 log unit for the additional optotype identified correctly, or $0.30 - 0.02 = 0.28$. The comparison of visual acuity from Lea Symbols vs. Bailey-Lovie charts followed the Bland and Altman[8] guidelines of measuring agreement in method comparison studies. The mean difference in scores was evaluated with the paired t-test, with adjustment for the correlation of eyes from the same subject.[9] The relation between difference in scores and level of visual acuity was examined by a regression model using a robust variance estimator to accommodate the correlation between eyes.[9] The absolute inter-eye difference of visual acuity from the two methods was also examined, and the difference between the results of the two charts was tested by the Wilcoxon signed rank test because of the skewed distribution of absolute inter-eye difference. All data analyses were performed with SAS 8.0 (SAS Institute, Cary, NC).

RESULTS

Comparison of Lea Symbols vs. Bailey-Lovie Monocular Acuity Results

Fig. 1 provides a comparison of the monocular visual acuity results obtained with the Lea Symbols and Bailey-Lovie charts. Included in the plot are results of the right eye and the left eye of each subject. Mean ($\pm$SD) visual acuity obtained with the Lea Symbols chart (0.17 ± 0.34, equivalent to 20/30) was significantly better than that obtained with the Bailey-Lovie chart (0.26 ± 0.36, equivalent to 20/36). The mean difference between tests was -0.09 ± 0.11 ($p < 0.0001$).

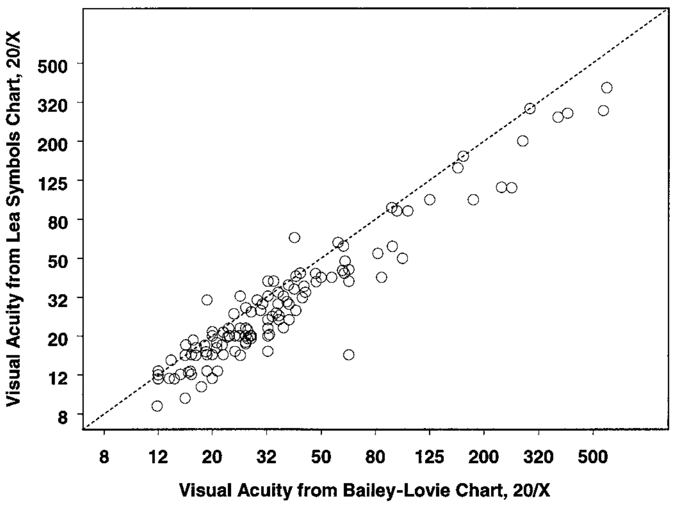

FIGURE 1.
Comparison of monocular visual acuity assessed using the Lea Symbols chart with monocular visual acuity assessed using the Bailey-Lovie chart. Results from the right eye and the left eye of each study participant are shown. Most data points fall below the line of equality, indicating that acuity measured with the Lea Symbols chart was better than acuity measured with the Bailey-Lovie chart.

Fig. 2 shows the difference between Lea Symbols and Bailey-Lovie monocular acuity results plotted as a function of the mean of the Lea Symbols acuity level and the Bailey-Lovie acuity level for each eye of each subject. As shown by the regression line, the difference between Lea Symbols and Bailey-Lovie acuity scores increases by 0.006 logMAR with each single line (0.1 logMAR) decrease in acuity ($p = 0.01$).

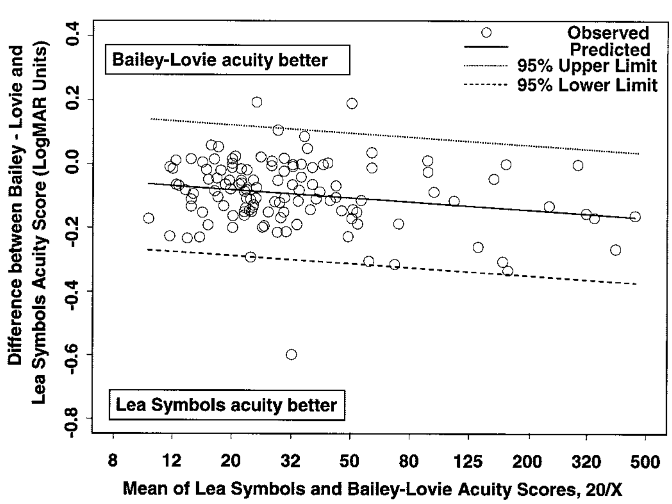

FIGURE 2.
Difference in log units between Lea Symbols and Bailey-Lovie acuity scores plotted as a function of the mean of the two scores in log units. Lines show the estimated regression line with the associated upper and lower 95% confidence limits. Difference between Lea Symbols and Bailey-Lovie acuity scores increased with decreasing mean visual acuity ($p = 0.01$). LogMAR, logarithm of the minimum angle of resolution.

Comparison of Inter-Eye Acuity Difference as Measured with the Lea Symbols vs. Bailey-Lovie Charts

Fig. 3 provides a comparison of the inter-eye acuity difference (right eye − left eye) obtained with the Lea Symbols and Bailey-Lovie charts. As shown by the clustering of points along the diagonal line, there was good agreement between inter-eye difference scores obtained with the two acuity charts. In addition, there was no systematic difference between the absolute value of the inter-eye differences (ignoring whether the right eye or the left eye was the better-seeing eye) obtained with the two acuity charts ($p = 0.11$, Wilcoxon signed rank test).

Fig. 4 shows the difference between Lea Symbols and Bailey-Lovie inter-eye difference results plotted as a function of the mean inter-eye difference score for each subject. As shown by the regression line, the difference between Lea Symbols and Bailey-Lovie inter-eye difference scores did not change with the mean inter-eye difference score ($p = 0.28$).

DISCUSSION

One of the primary goals of measuring visual acuity in young children is to detect amblyopia at an early enough age that it can be treated successfully. This means that there is a need for a test that can measure inter-eye differences reliably in a young child. The results of the present study support the validity of the Lea Symbols acuity chart as a measure of inter-eye recognition acuity differences, with the amount of inter-eye difference detected by the two acuity tests being virtually the same (Fig. 3) and independent of the magnitude of the mean inter-eye difference (Fig. 4). These results are consistent with previous reports indicating similarity in the ability of the Lea Symbols test (in either the single symbol or line format) and a Landolt C chart with a constant (rather than proportional) interoptotype distance in detecting interocular acuity differences in amblyopic patients.[6,7]

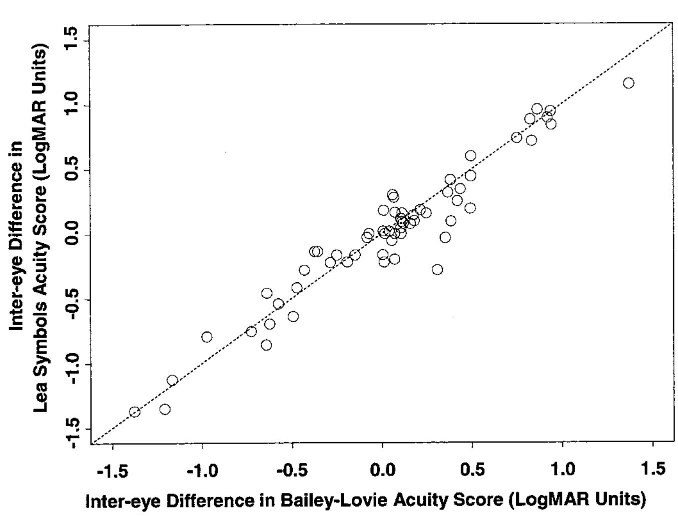

FIGURE 3.
Comparison in log units of the difference in acuity scores between eyes obtained using the Lea Symbols chart with the inter-eye difference obtained using the Bailey-Lovie chart. LogMAR, logarithm of the minimum angle of resolution.

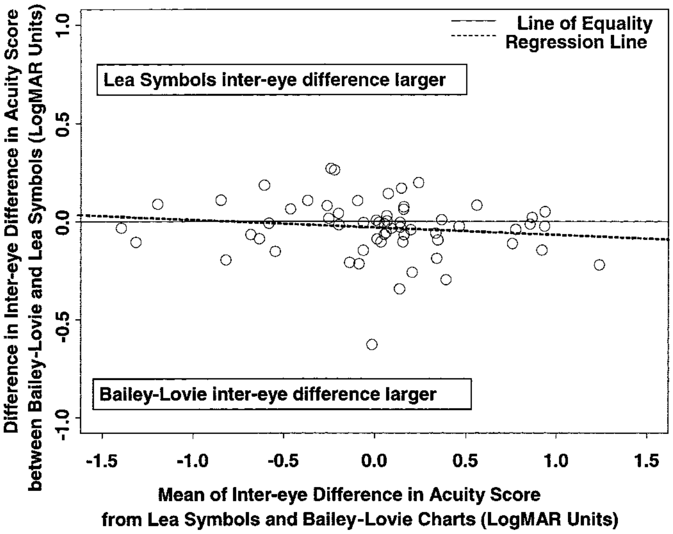

FIGURE 4.

Difference in log units between Lea Symbols and Bailey-Lovie inter-eye difference scores plotted as a function of the mean inter-eye difference score. The solid line shows the line of equality, and the dashed line shows the regression line. The difference between the Lea Symbols and Bailey-Lovie inter-eye difference scores did not vary with the mean inter-eye difference score (p = 0.28). LogMAR, logarithm of the minimum angle of resolution.

Although acuity assessment with the Lea Symbols chart and the Bailey-Lovie chart yields nearly identical estimates of inter-eye differences, the two charts do not result in identical absolute monocular acuity scores. As shown in Fig. 1, acuity scores obtained with the Lea Symbols chart tend to be better than those obtained using the Bailey-Lovie chart, and the average difference (0.09 log unit) is approximately one line on a logarithmic acuity chart. In addition, the difference increases as acuity worsens (Fig. 2). Gräf and colleagues[6] also found that acuity measured with Lea Symbols in a line format similar to that used in the present study was better than acuity measured with Landolt C optotypes and that the difference increased as acuity worsened. Gräf et al.[6] suggested that the decrease in Landolt C acuity that occurred at poorer acuity levels was due to the constant spacing (2.6 min arc) between optotypes, which resulted in relatively more crowding between larger optotypes than between smaller optotypes. This factor would not have played a role in the present study because of the proportional interoptotype spacing for all optotype sizes.

A possible explanation for the better acuity scores obtained with the Lea Symbols chart is that this test includes only four optotypes, whereas 10 optotypes are used in the Bailey-Lovie chart. This means that as acuity threshold is approached, the individual has a 25% chance of guessing the correct symbol in the Lea Symbols chart, but only a 10% chance of guessing the correct letter in the Bailey-Lovie chart. Another possible explanation for the better acuity scores obtained with the Lea Symbols chart is that the average height of the optotypes on the Lea Symbols chart is greater than the height of optotypes of the same acuity level on the Landolt C chart.[6] However, this is an unlikely explanation because the Lea Symbols optotype sizes were created to be equivalent, when tested empirically, to optotypes of the same acuity level on the Snellen E chart[5] and, later, to optotypes of the same acuity level on the Landolt C chart (L. Hyvärinen, personal communication, 1999). Recent data have shown that Bailey-Lovie acuity scores are, on average, 0.09 log unit poorer than Landolt C acuity scores,[10] so the fact that Lea Symbols optotypes are calibrated to Landolt C optotypes and not to Bailey-Lovie optotypes could have contributed to the finding that Bailey-Lovie acuity scores were on average 0.09 log unit poorer than Lea Symbols acuity scores in the present study. However, it is also important to note that a constant difference in optotype size between Lea Symbols and Bailey-Lovie letters could not account for the increasing difference between Lea Symbols and Bailey-Lovie acuity that occurred with decreasing visual acuity (Fig. 2).

In conclusion, the purpose of the present study was to compare visual acuity results obtained using the Lea Symbols chart, a visual acuity test designed specifically for use in young children, and the Bailey-Lovie adult recognition acuity chart in a study population that was old enough to complete testing using both charts. The results suggest that the Lea Symbols chart provides an accurate measure of inter-eye acuity difference, but may overestimate the acuity score measured by the Bailey-Lovie letter chart. There is, nevertheless, a high correlation between visual acuity scores obtained with the Lea Symbols and Bailey-Lovie charts, and the two tests rank-ordered study participants similarly from highest to lowest acuity. Thus, testing visual acuity using the Lea Symbols chart may be useful for identifying children with poor acuity as well as children with large inter-eye acuity differences.

CREDIT ROSTER
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