

ORIGINAL ARTICLE

# The Berkeley Rudimentary Vision Test

Ian L. Bailey\*, A. Jonathan Jackson<sup>†</sup>, Hasan Minto<sup>‡</sup>, Robert B. Greer<sup>‡</sup>, and Marlena A. Chu<sup>§</sup>

## ABSTRACT

**Purpose.** Very poor visual acuity often cannot be measured with letter charts even at close viewing distances. The Berkeley Rudimentary Vision Test (BRVT) was developed as a simple test to extend the range of visual acuity measurement beyond the limits of letter charts by systematically simplifying the visual task and using close viewing distances to achieve large angular sizes. The test has three pairs of hinged cards, 25 cm square. One card-pair has four Single Tumbling E (STE) optotypes at sizes 100 M, 63 M, 40 M, and 25 M. Another card-pair has four Grating Acuity (GA) targets at sizes 200 M, 125 M, 80 M, and 50 M. The third card-pair has a test of White Field Projection (WFP) and a test of Black White Discrimination (BWD). As a demonstration of feasibility, a population of subjects with severe visual impairment was tested with the BRVT.

**Methods.** Adults with severe visual impairments from a wide variety of causes were recruited from three different rehabilitation programs. Vision measurements were made on 54 eyes from 37 subjects; test administration times were measured.

**Results.** For this population, letter chart visual acuity could be measured on 24 eyes. Measurements of visual acuity for STE targets were made for 18 eyes and with GA targets, for two eyes. Five eyes had WFP, and one had BWD. Four had light perception only. The median testing time with the BRVT was 2.5 min.

**Discussion.** The BRVT extends the range of visual acuity up to logMAR = 2.60 (20/8000) for STEs, to logMAR = 2.90 (20/16,000) for gratings and includes the WFP and BWD tests.

**Conclusions.** The BRVT is a simple and efficient test of spatial vision that, with 13 increments, extends the range of measurement from the limits of the letter chart up to light perception.

(Optom Vis Sci 2012;89:1257-1264)

Key Words: visual acuity, low vision, severe visual impairment, clinical tests, visual task complexity

The clinical measurement of visual acuity has been made traditionally with a “Snellen chart”<sup>1</sup> of optotypes, usually letters, presented at a standard distance (commonly 6 meters or 20 feet) with the patient’s task being to recognize the letters as they read down the chart from large letters to small. When the visual acuity is so poor that the largest optotypes cannot be named, generally the clinician brings the chart closer to the patient, but rarely closer than 1 meter. If the largest optotype cannot be read at the close distance, testing visual acuity with optotypes is abandoned and the usual practice is for the clinician to next ask the patient to count the fingers on a hand held at a close distance. If the fingers cannot be counted, the next step is to determine whether

the patient can identify when the clinician’s hand is moving. The procedures for the “Count Fingers” (CF), and “Hand Motion” (HM) vision tests are not standardized.<sup>2</sup> Viewing distances, the magnitude of HM, and the size of the target hand and its contrast with respect to the background are rarely mentioned or specified by clinicians. There is no well-organized or widely accepted process for extending the range of visual acuity measurement beyond the limit imposed by the size of the chart’s largest optotypes at the standard viewing distance. There is no “standard” closest distance for viewing the “Snellen Chart.” The Berkeley Rudimentary Vision Test was designed to provide a rational system for quantifying very poor levels of visual acuity (i.e., spatial vision) with methods that are simple and easy to apply in any clinical environment, using reasonably fine systematic increments down to the practical limits of spatial vision.

Traditionally “Snellen Charts” have one or, sometimes, two optotypes of the largest size at the top of the charts, and as the optotypes progressively become smaller from one row to the next, there are more optotypes per row. The size progression sequence

\*OD, MS, FAAO

<sup>†</sup>PhD, MCOptom, FAAO

<sup>‡</sup>OD, FAAO

<sup>§</sup>OD

School of Optometry, University of California, Berkeley, Berkeley, California, (ILB, RBG, MAC), Australian College of Optometrists, Melbourne, Victoria, Australia (AJJ), Royal Victoria Hospital, Belfast, Northern Ireland (AJJ), and International Center for Eyecare Education, Islamabad, Pakistan (HM).

and the spacing between adjacent optotypes can vary significantly between charts. Bailey and Lovie (1976)<sup>3</sup> introduced a set of principles for chart design that ensure that the visual task remains the same at each size level. This means that size remains the only significant variable from one size level to the next. Achieving this standardization of task requires a certain combination of chart design features. At each size level there must be the same number of optotypes; the spacings between optotypes and between rows are proportional to the size of the optotype; and the progression of size must follow a constant ratio. Care should be taken to ensure that there are no significant variations in the difficulty of the optotype sets at the different size levels. Also introduced with these chart design principles was the method of designating visual acuity scores in terms of logMAR, the common logarithm of the Minimum Angle of Resolution (MAR). Landolt rings, Tumbling Es, and most sets of letters that are used as optotypes are constructed so that the width of the stroke and the spacings between strokes is one-fifth of the letter height. The MAR is commonly taken to be the angular size of one-fifth of the height of the optotype and it is specified in minutes of arc. When the size progression proceeds in 0.10 log unit steps (ratio = 1.26x) and there are 5 optotypes per row, then each letter can be assigned a value of 0.02 log units. This facilitates scoring methods that give extra credit for each additional optotype<sup>3-6</sup> that is recognized correctly.

Early Treatment of Diabetic Retinopathy (ETDRS) charts<sup>7</sup> follow the Bailey-Lovie design principles, and today, most research studies involving the measurement of visual acuity use the ETDRS chart. Following the recommendations of the NAS/NRC Committee on Vision, Working group 39,<sup>8</sup> the ETDRS chart chose the family of 10 Sloan letters as its optotype and 4 meters as its standard testing distance. The Sloan letters are C, D, H, K, N, O, R, S, V, and Z drawn to specific dimensions.<sup>8,9</sup> The ETDRS chart has rows of 5 letters, the spacing of letters within a row is equal to one letter height, the spacing between one row and the next is equal to the height of the letters in the smaller row, and the size progression ratio is equal to 0.1 log unit (= 1.26x). The layout is center-justified. There are 14 different sizes ranging from the largest size of 40 M-units (58.2 mm) at the top of the chart down to the smallest size of 2.0 M-units (2.9 mm). At the recommended viewing distance of 4 meters, the visual acuity range is from logMAR 1.00 to -0.30 (20/200 to 20/10, 6/60 to 6/3, 4/40 to 4/2, 0.1 to 2.0). There are many different visual acuity charts that follow the same chart design principles but use different optotypes such as Landolt Rings, Tumbling Es, numbers, pictorial symbols, and characters and letters from different alphabets.

The ETDRS chart has become the “gold standard.” The recommended protocol provides for shortening the viewing distance to 1 meter when the largest row cannot be read at 4 meters.<sup>10</sup> This extends the range of angular size by a factor of four-fold to logMAR = 1.60. The visual task on the ETDRS chart is to read across each row. The largest row and the smallest row on the chart differ from the other 12 rows in that they have only one neighboring row, and this makes the visual task easier. Thus, if an acuity score is to represent performance at a task that is the same at each size level, the patient should be able to read the top row on the chart and unable to read the bottom row, and then the visual acuity limit will lie within the embrace of the chart’s range of sizes.

There are practical upper limits to the angular sizes of individual optotypes and rows of optotypes. Very large angular sizes require very large letters and/or very close viewing distances. At close viewing distances, positioning large charts is difficult, and the process can be claustrophobic and intimidating to the patient. At extremely large angular sizes, head movements or even changes in body posture can be required to shift attention from one end of the row to the other, or from one part of a target letter to another. To extend the range of visual acuity measurement beyond the limits of the letter chart, it becomes necessary to simplify the visual task, and to achieve very large angular sizes, very close viewing distances may be required.

Several automated computer-based tests have been developed for the purpose of measuring acuity in patients with very low vision. Bach and his colleagues developed the Freiburg Visual Acuity and Contrast Test (FrACT),<sup>11</sup> which is an efficient automated procedure using single optotypes and selectable psychophysical protocols for determining visual acuity thresholds. In its original form, the Landolt Ring was the optotype and subsequent versions of the test provide the option of using Tumbling Es or letters. The test also allows the determination of contrast sensitivity. Bittner and colleagues recently developed a Grating Acuity Test (GAT) and a Grating Contrast Sensitivity Test,<sup>12</sup> with square wave gratings in a 37-cm circular field, with 4 orientation options. To test other functions of vision, Bach’s group developed the “Basic Assessment of Light and Motion test” (BaLM).<sup>13</sup> The BaLM battery includes a test of basic light perception, requiring identification of whether the light display is turned on; a test of temporal resolution, requiring discrimination of double flash from a single flash; a location test, requiring the identification of the location of a large area of light; and a motion test, requiring identification of the direction of motion of a large structured pattern. These various automated tests have been developed for use in clinical trials, and they have important applications in studies involving prosthetic vision devices or in other studies concerned with changes in visual abilities in persons with severe visual impairment.

## THE BERKELEY RUDIMENTARY VISION TEST

Our goal was to develop a simple method for testing visual resolution in patients with very poor vision. We wanted a test that could quickly provide reasonably precise measures of vision, and which could easily be used by non-technical support personnel in almost any setting without requiring power or technological display systems. The test should be an attractive and more quantitative alternative to the counting fingers and hand motion methods of categorizing visual ability once the clinician has abandoned the use of the letter chart. For such a test, it is necessary to systematically simplify the visual task and to use very close viewing distances when the visual resolution abilities become very poor. After considerable experimentation, the Berkeley Rudimentary Vision Test (BRVT) was developed.

Within the BRVT, there is a three-level hierarchy of task complexity.<sup>14</sup> Recognition of a single isolated optotype is a less complex visual task than reading across rows of letters on an ETDRS or similar chart.<sup>15,16</sup> The Single Tumbling E (STE) was chosen as the single optotype for the BRVT because it is easy to administer regardless of the patient’s language or literacy skills. Only one

target is needed at each size and its orientation can easily be changed. The patient identifies whether the legs of the E point up, down, right, or left. Compared with the Landolt ring optotype, the Tumbling E presents a slightly more complex visual task, and it seems a more natural intermediate step between the letter chart task and a grating acuity (GA) task. For the recognition of a STE, localization of visual attention is required and the patient needs to identify both the orientation of the 3-bar grating component of the E as well as the location of the cross bar.

The second step in the BRVT sequence of task simplification is to measure GA. Recognition of grating orientation is a simpler visual task than recognizing the orientation of a STE. For the grating task, fixation control and localization of the point of attention are relatively unimportant. The patient simply has to recognize that, somewhere within the display field, there is a periodic pattern with a discernible orientation. When the coarsest grating patterns cannot be recognized, even more basic tests of spatial vision are required.

The third level of task complexity in the BRVT battery is a test of basic spatial vision function. It tests whether the patient can detect and localize large white fields and also determines whether the patient can tell whether a large display field is black or white.

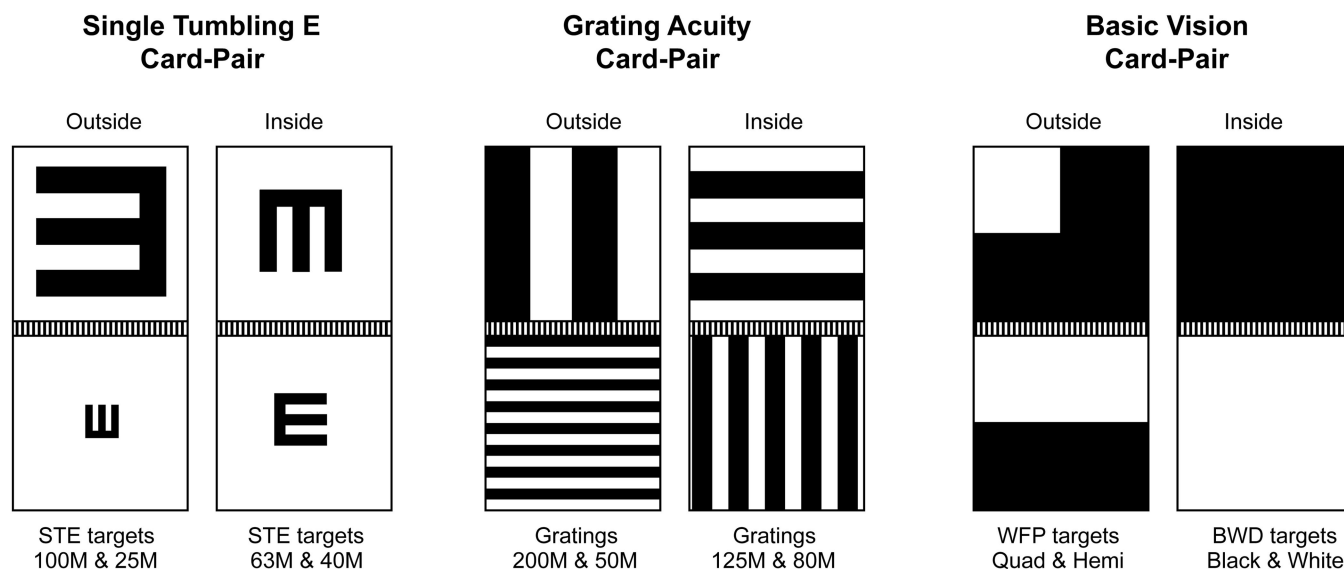
The Berkeley Rudimentary Vision Test consists of three card pairs. Each card-pair has two 25-cm square cards hinged together so that there are four panel faces for each of the three card-pairs. These are shown in Fig. 1.

The STE card pair is used for measuring visual acuity with single optotypes. Each STE card-pair has 4 STEs whose sizes in M-units are 100 M, 63 M, 40 M and 25 M. (in millimeters, 145mm, 92 mm, 58 mm, and 36 mm). The visual task is to identify the direction to which the legs of the E are pointing: up, down, right, or left. The STE cards are hinged so that when the 100 M and 25 M Es are on the outside faces, the intermediate 63 M and 40 M Es are on the inside faces. For these STE targets, the visual acuity demand, the MAR, is determined by the stroke widths (or the spacing between parallel strokes) in arc-minutes. For a viewing distance of 100 cm, the visual acuity demands for these 4 optotypes are, in logMAR terms, logMAR = 2.00, 1.80, 1.60, and 1.40 (equivalent to 20/

2000, 20/1250, 20/800, and 20/500). For a viewing distance of 25 cm, the angular sizes increase by 0.6 log units to become logMAR = 2.60, 2.40, 2.20, and 2.00 (equivalent to 20/8000, 20/5000, 20/3200, and 20/2000).

The GA card-pair is used for measuring visual acuity with grating targets. The GA card-pair has 4 square-wave gratings of different spatial frequencies, and the gratings fill the area of the 25-cm square panels. The widths of the black and white stripes on the 4 different gratings are 60, 38, 24, and 15 mm. Similar to the Tumbling E targets, the stripe widths of the gratings have been taken to represent the visual acuity demand. For a viewing distance of 25 cm, the visual acuity values of the four grating targets are logMAR = 2.90, 2.70, 2.50 and 2.30 (equivalent to 20/16,000, 20/10,000, 20/6,300, and 20/4,000) The M-unit values given to the gratings are the distances in meters at which the stripe widths subtend 1 min of arc, and for these 4 gratings these are 200 M, 125 M, 80 M, and 50 M. For a 25 cm viewing distance, the 25 cm square test cards subtend an angle of 53°. The patient's task is to identify whether the stripes are oriented horizontally or vertically. The GA cards are hinged so that when the 200 M and 50 M gratings are on the outside faces, the intermediate 125 M and 80 M gratings are on the inside.

The Basic Vision card-pair tests two different aspects of basic spatial vision. There is a test of spatial localization called White Field Projection (WFP). Two card faces are used for this test. One card is black with a white quadrant. The other card is divided into a black half and a white half. The visual task is to identify the location of the large white area. When presented at 25 cm, the quad-field subtends 26° × 26° and the hemi-field area is 26° × 53°. The other test of basic vision function is called Black White Discrimination (BWD). One of the two card faces is all black, the other all white. The patient's task is to tell whether the card being presented is black or white. With the cards at 25 cm from the eye, the black and white fields of the BWD test subtend 53° × 53°. The Basic Vision card-pair is hinged so that when the quad-field and hemi-field panels for the WFP test are on the outside, the black and white panels for the BWD test are on the inside. The WFP and the



**FIGURE 1.** The BRVT has three pairs of hinged cards that are 25 cm square.



BWD tests of the Basic Vision card-pair are similar to the basic light perception test and the location test components of the computer-based BaLM test.<sup>13</sup>

### BRVT Testing Sequence

The testing sequence with the BRVT is simple and intuitive. The sequence is shown in Fig. 2.

Testing with the BRVT standard protocol begins with the STE card-pair at a viewing distance of 100 cm. The smallest STE (25 M) is presented first.

If the orientation of the 25 M STE can be readily recognized at 100 cm, then it is likely that visual acuity will be measurable with an ETDRS chart or similar at 100 cm, given that the largest optotype size on the ETDRS chart (40 M) is larger than the 25 M STE.

If the 25 M STE cannot be recognized at 100 cm, then the 100 M STE is presented at 100 cm. If the 100 M STE can be recognized at 100 cm, then the visual acuity measurement can be completed at 100 cm with the STE card-pair. If the 100 M STE cannot be recognized at 100 cm, the visual acuity for STEs is less than logMAR = 2.0 (equivalent to 20/2000), then the viewing distance should be reduced to 25 cm. Because the cards are 25 cm square, it is convenient to use the card itself as a measuring stick to check that the eye-to-card distance is 25 cm. If the 100 M STE can be recognized at 25 cm, the visual acuity for STEs is at least logMAR = 2.60, (equivalent to 20/8,000), and the visual acuity determination can be completed with STEs. While the 25 cm viewing distance does create a +4.00 D accommodation demand, it is not important that adjustments be made to the refractive correction. The visual acuity demand for the smallest STE target at 25 cm is logMAR = 2.0. Smith's analyses<sup>17</sup> of defocus and visual acuity indicate that +4.00 D of error reduces visual acuity only to about logMAR = 1.20. If the 100 M STEs cannot be recognized at 25 cm, then testing with STEs is abandoned, and the GA card-pair is used next.

The GA test begins with the largest grating (200 M) being presented at 25 cm. If the grating orientation can be recognized

then the GA is at least logMAR = 2.90 (equivalent to 20/16,000), and GA can be measured using the finer grating targets. If the orientation of coarsest grating target (200 M) cannot be recognized at 25 cm, then visual acuity measurement is abandoned, and then the Basic Vision tests card-pair is used.

The Basic Vision Tests are presented at a viewing distance of 25 cm. For the WFP test, the quad-field card and the hemi-field card should each be shown at least once in each of the 4 card orientations. If the location of the white quad-field or hemi-field cannot be reliably identified, then the BWD test is administered. If the patient is unable to discriminate black from white with the BWD test, then a test of "Light Perception" is conducted using a penlight shone at the eye from a close distance.

### Number of Target Presentations

Initially, there is a screening process in which the clinician makes a preliminary estimate of the patient's spatial vision abilities. Following the sequence described earlier, two presentations are made with each acuity target (STE or Grating) that is used. Usually some targets will be very easy to see, and the patient gives quick and confident correct responses. Other targets may be far too difficult to see, and then the patient is likely to give a prompt response indicating that they think this task is impossible. This screening process provides a quick estimate of the visual threshold and indicates whether testing should proceed with the letter chart, the STE card-pair, the GA card-pair or the Basic Vision card-pair.

Once an initial estimate has been made through the screening process, more target presentations are made with the target sizes concentrated in the region of the patient's threshold. For the STE targets, at least four target presentations should be made at each size level, jumbling the order of the different target orientations. For four presentations, all four being correctly identified indicates that the target size is at, or larger than, the visual acuity threshold. For six or more presentations, a success rate >50% meets this criterion. For the GA task, at least 6 target presentations should be

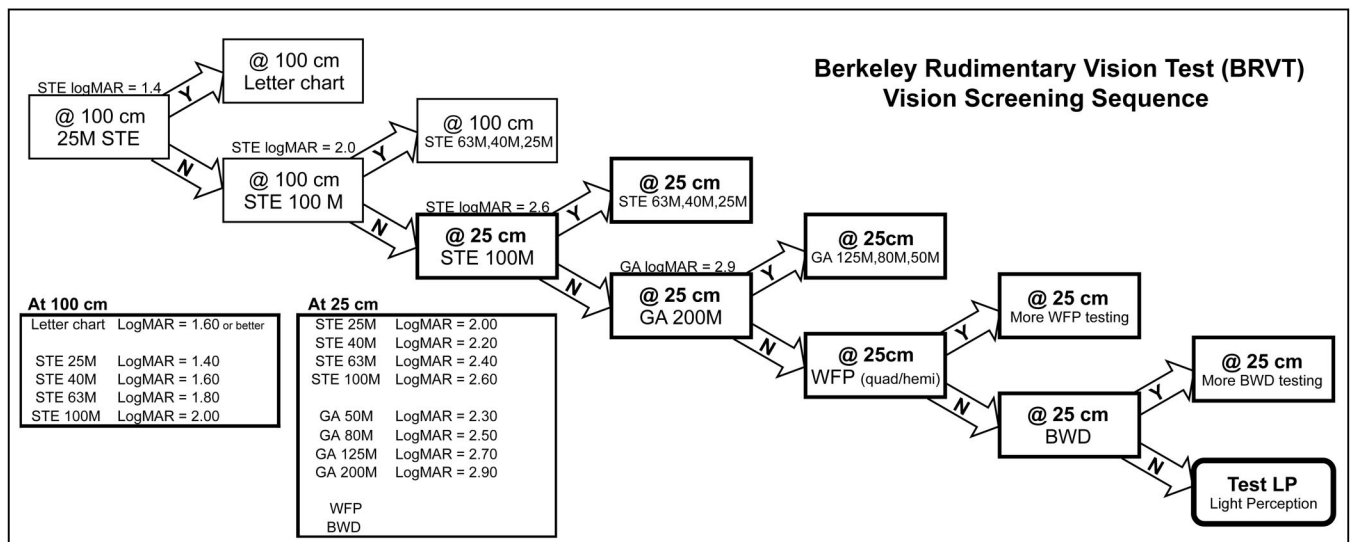


FIGURE 2.

The standard testing sequence for using the BRVT for screening to obtain an initial estimate of the patient's visual abilities. The STE acuity is used at 100 cm for the range STE logMAR = 1.40 to 2.00, and at 25 cm for STE logMAR = 2.00 to 2.60. The GA test is used at 25 cm for grating acuities in the range GA logMAR = 2.30 to 2.90. The WFP and the BWDB tests are presented at 25 cm.

made at each size. A 100% success rate for 6 presentations, or a success rate of 80% or better for 8 or more presentations indicate that the grating is at, or larger than, the visual acuity threshold. The reliability of the patient's responses, the clinician's strategy for determining threshold, and the precision being sought, all influence the number of additional presentations at the different levels of angular size. For the WFP test, at least one new presentation should be made at each of the four orientations for both the quad-field and hemi-field targets. For the BWD test at least 6 presentations should be made.

## TESTING VISUALLY IMPAIRED POPULATIONS WITH THE BRVT METHODS

As a demonstration of the practicality of the BRVT, we tested the vision of 37 severely visually impaired subjects recruited from the California School for the Blind, the Orientation Center for the Blind, and the Lighthouse for the Blind and Visually Impaired in San Francisco. All subjects were adult volunteers who gave informed consent. The protocols for this study followed the tenets of the Declaration of Helsinki and were approved by the Committee for the Protection of Human Subjects of the University of California, Berkeley.

Within their own visually impaired communities, all subjects were considered to have very poor vision. The 18 subjects from the California School for the Blind were all students and the mean age was  $19.8 \pm 1.1$  years. The 9 subjects from the Orientation Center were all enrolled in the OCB's residential rehabilitation program, and the average age was  $41.9 \pm 15.6$  years. The 10 visually impaired subjects from the Lighthouse in San Francisco were either staff members or clients and the mean age was  $40.2 \pm 14.9$  years. Within each of the 3 groups, there was a wide diversity in the causes of low vision. Optic nerve atrophy and congenital disorders were predominant in the CSB group. In the OCB group, the visual impairments were acquired in adult life, and retinitis pigmentosa, glaucoma, and diabetic retinopathy were the most prevalent disorders. Almost half of the Lighthouse group had impaired vision since childhood.

A battery of vision tests was completed for all 37 subjects. This included a brief case history and measurements of visual acuity, contrast sensitivity, and visual fields. Note was made of the time taken to complete the various tests. Only the visual acuity results are reported here. Most subjects within these groups had access to ocular and vision care but their medical records were not readily available. Subjects wore their best available optical distance-vision correction during the testing and no additional lenses were used for testing at 100 cm or 25 cm. For 17 subjects with dissimilar levels of vision loss in the two eyes, the visual acuity measurements for both eyes are reported so that the results come from 54 eyes from 37 subjects.

For most subjects, testing with the BRVT followed the recommended sequence. A few subjects reported that their vision was "light perception" only, and for them testing began with the Basic Vision card-pair. When visual acuity was being measured with the ETDRS letter chart, visual acuity was scored in logMAR units giving 0.02 log units credit for every additional letter read.<sup>3-6</sup> When visual acuity was being measured with the STE card pair, testing began at the size estimated by the screening procedure, and four presentations were made at that size. Subjects were not obliged to guess but they were encouraged to guess if they were not quite certain. Systematically larger and smaller sizes were presented to

establish the range over which the success rate extended from 4 of 4 to 1 of 4. For the GATs, the testing established the range over which the success rate ranged from 6 of 6 to 1 of 6. For the WFP test, first there were 4 different orientations presented for both the quad-field and hemi-field cards, and if there was any success (2 of 8 or better), the process was repeated. For the BWD test, there were at least 4 presentations with both the black and white cards.

## RESULTS

The frequency distribution of the visual acuity scores and the basic vision results are shown in Fig. 3. Visual acuity scores could be obtained with the letter chart for 24 of the eyes tested. Of these 24, 20 measurements were made with 100 cm viewing distance, and 4 were made at 4 meters. For 18 eyes, visual acuity was measured with the STE card-pair, with 16 eyes tested at 100 cm with STE acuities ranging from logMAR = 1.4 to 2.0, and the 2 eyes tested at 25 cm had acuities of logMAR = 2.2 and 2.6. For 12 of the 54 eyes, visual acuity could not be measured with the letter chart or the STEs. Two of these had measurable GA with the logMAR values being 2.3 and 2.7.

Of the 10 eyes for which visual acuity scores could not be obtained, 5 successfully showed WFP, one showed only BWD and 4 eyes had light perception only.

The median time taken to test each eye was 120 s. For letter chart acuities, the median time was 97 s. For eyes tested with the BRVT, the median time was 152 s and the average was 171 s. There was substantial diversity in the testing times. For 12 eyes, the testing time exceeded 3 min, and for 3 of these, the testing time exceeded 5 min. Most of the very slow testing times were a result of impaired motor or communication abilities in some students from the California School for the Blind.

## DISCUSSION

Our subjects were selected because they had been identified as having substantial vision impairments. For over half of the eyes tested, a visual acuity could not be obtained with a letter chart at 1 meter. In such circumstances, the common clinical practice is to assess vision using "Counting Fingers" or "Hand Motion." The BRVT offers 13 incremental steps for quantifying or characterizing spatial vision abilities when they are beyond the limit of the letter chart but better than "Light Perception" only. For 26 eyes, the BRVT results were scattered broadly across this range. Twenty had visual acuity scores from testing with the STE ( $n = 18$ ) or GA ( $n = 2$ ) targets. It is reasonable to assume that all of these would have had either "Count Fingers" or "Hand Motion" if tested by usual clinical procedures. Because there is no standard way of performing the tests for CF and HM, visual acuity scores cannot be used to predict which eyes would be classified as CF and which would be HM.<sup>18,19</sup> There were 6 eyes that showed either WFP ( $n = 5$ ) or BWD ( $n = 1$ ), and one would expect that these would have been classified as having HM but not CF. Four eyes had light perception only. These results give a practical demonstration that the BRVT readily provides more increments when assessing spatial visual abilities beyond the limits of testing with letter charts. The test is obviously portable, easy to use, and typically it takes <3 min to test an eye. The visually impaired population used for this study was diverse, but unique. The results reported here should not be taken as being

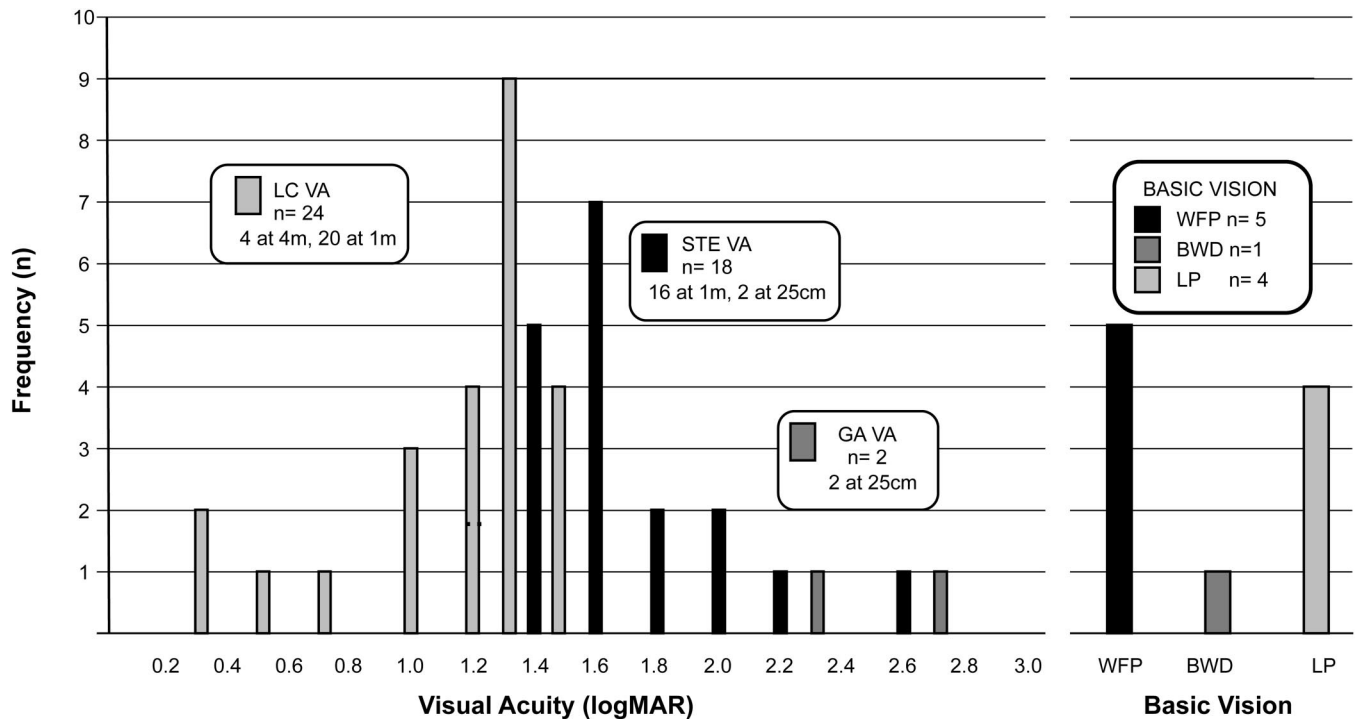


FIGURE 3.

The frequency distribution of the BRVT results from testing 54 eyes in a population of severely visually impaired adult patients recruited from three different agencies that serve the blind and visually impaired. Letter chart acuity could be measured on only 24 eyes. Twenty eyes achieved visual acuity scores with the STE ( $n = 18$ ) or GA ( $n = 2$ ) targets. These would have normally been classified as either "CF" or "HM." For six eyes, the vision was classified as WFP (5) or BWD (1) and these normally would have probably been classified as "HM." Four eyes had light perception only.

representative of results to be expected in other low vision populations or subgroups. There are on-going studies to examine test-retest reliability using the BRVT in selected low vision populations and to compare the results of the BRVT and the FrACT tests.

The sequence of testing at different levels of BRVT is logical and intuitive. However, the number of presentations made at each size in both the screening and the measurement phases can be a matter of choice. For 95% confidence that STE target is recognized, at least 4 correct out of 6 presentations, or 5 of 8 are recommended criteria. Because the GA test is a 2-choice task, more presentations are required and recommended criteria are at least 7 of 8 or 8 of 10. For research studies, testing procedures should be more rigidly specified.

Different approaches can be taken for deciding the value that is taken to be the threshold visual acuity.<sup>6</sup> It can be the smallest target at which the success rate is sufficient to provide a 95% confidence that targets of that angular size can be recognized. A more analytical and mathematical approach would be to record the success rates over different size levels and prepare a plot of the probability of seeing as a function target size. For a 50% probability of seeing, the success rate for the 4-choice STE test should be at 62.5%, and for the 2-choice GA test, the required success rate is 75%. A third alternative is to make the same number of presentations at each size level, and assign a value to each presentation, and the value will be equal to the size of the increments divided by the number of presentations.<sup>5</sup> For the STE test, the size increments are 0.2 log units and if there are 8 presentations, the value for each presentation is 0.025 log units. For example, if the STE card pair was presented at 100 cm, the targets sizes available would be  $\log\text{MAR} = 2.00, 1.80,$

1.60 and 1.40. If the success rates were respectively 8 of 8, 6 of 8, 3 of 8, 0 of 8, then the  $\log\text{MAR}$  score would become 1.775. This gives credit for 9 presentations correctly identified after  $\log\text{MAR} = 2.00$ .

The size increments for the STE and GA card-pairs are in steps of 0.20 log units (size ratio = 6 $\times$ ) and this is a coarser scale than the 0.1 increments (ratio 1.26 $\times$ ) used on the letter charts. Precision can be improved simply by taking more measurements making more presentations at each size in the region of threshold. Modifying the viewing distance changes the angular size, and careful changes in viewing distance can achieve intermediate angular sizes and thereby improve measurement precision. For example, changing the viewing distance from 100 to 80 cm will cause the angular size of the 100 M STE target to change from a  $\log\text{MAR}$  value of 2.00 to 2.10. And for the 100 M STE target at 125 cm,  $\log\text{MAR} = 1.90$ .

The WFP test only produces a qualitative result, and there is not a recommended set of criteria or rules for success at the WFP test. The clinician makes a qualitative judgment as to whether the patient can identify the location of the white areas with reasonable consistency. One impediment to developing a scoring method is that for both the quad-field and hemi-field components of the test, there can be partial successes. For example, if the perfectly correct response for the quad-field test is up and right, two partially correct responses would be up or right. For the hemi-field test, if the perfectly correct response is up, there are 4 partially correct responses, namely, up-right, up-left, left, or right. Fixation is not constrained during this test, and this can contribute to response inconsistencies. The practice we recommend is to make one pre-



sentation at each of the 4 orientations for both the quad-field and the hemi-field targets. A very high success rate would indicate that the patient has very reliable WFP. If there is a moderate success rate, the clinician might gather an impression that the patient has some ability to locate the white field when it is located in a given direction. This hypothesis should then be put to the test by repeating the 8 presentations. The WFP test is passed only when the clinician becomes convinced that the patient can reliably identify the location of the white field consistently, at least in one direction.

With the progressive simplification of the tasks in the acuity tests within the BRVT, it is inevitable that sometimes the logMAR visual acuity score from a simpler test will be significantly better than the logMAR value that was failed on the more complex test. Visual acuity scores should identify the nature of the vision test task. For example, a patient might not be able to read across the largest row of five letters at the top of the ETDRS chart at 100 cm so, on the letter chart, they fail to achieve a Letter Chart logMAR = 2.00. However, the STE presents a much easier task, and the STE acuity in logMAR terms might be found to be 1.80, 1.60, or even 1.40. Patients with central scotomas and patients with amblyopia are very like to have significantly better acuities when the target is an isolated optotype, but how much better is individualistic and difficult to predict. Similarly, GA targets are only used when the patient fails to achieve a STE logMAR of 2.60. Because the GA visual task is much simpler, the acuity with gratings may be significantly better than logMAR = 2.60 value that was failed with the STE targets. Some patients who fail the Single Tumbling E acuity task for STE logMAR = 2.60 will be able to identify the 80M or 50M GA targets at 25 cm giving GA logMAR scores of 2.50 or 2.30. It sometimes occurs that a patient will be unable to see the largest STE target at 25 cm (STE logMAR = 2.60) but able to see the finest of the grating targets at 25cm (GA logMAR = 2.30). In such circumstances, the available range of grating acuities can be extended by increasing the viewing distance in order to reduce the angular size of the grating stripes. The 50 M GA target presented at 25 cm has a logMAR value of 2.3, but changing the viewing distance to 40 cm, 63 cm, or 100 cm, (steps of 0.20 log units) will cause logMAR value for the 50 M GA target to become 2.10, 1.90, or 1.70, respectively.

With the BRVT, the range of visual acuity measurements made with the STE targets presented at either 100 cm or 25 cm extends from STE logMAR = 1.40 to STE logMAR = 2.60 (equivalent to 20/500 to 20/8000) in 7 steps of 0.20 log units. The GA test is presented at 25 cm, and this allows a GA range from GA logMAR = 2.3 (20/4000) up to GA logMAR = 2.90 (20/16,000) in 4 steps separated by 0.20 log units. The WFP test and the BWD add two more qualitative levels of vision between GA logMAR = 2.90 and light perception.

When visual acuity scores are reported, it is important that the visual task be identified. The visual acuity score on one task is not necessarily a reliable predictor of the visual acuity scores that would be obtained on alternative test tasks.<sup>14</sup> The computer-based tests designed to measure very low levels of visual acuity use the one kind of visual task across a very wide range of sizes. Having one task for the widest practical range of sizes is critically important for studies identifying and quantifying changes in acuity, but the task should be specified as an integral part of reporting the visual acuity scores. The FrACT test<sup>11</sup> usually measures visual acuity for single

Landolt Rings, and the GAT test<sup>12</sup> measures visual acuity for gratings. When visual acuity is measured with letter charts, the reports of results should identify which kind of letter chart was used. With the BRVT, any visual acuity scores should specify whether they came from the STE or the GA tests.

## CONCLUSIONS

The BRVT is a simple, low-tech, and efficient test for measuring visual acuities and basic spatial vision in very low vision. It provides a large number of reasonably fine increments ( $n = 13$ ) to cover the range between the limits of letter chart visual acuity and light perception. The BRVT should be most valuable for low vision clinicians, but it could be useful for all optometrists and ophthalmologists who sometimes encounter patients who would otherwise have their vision recorded as “CF” or “HM.” Recent developments in prosthetic vision devices and biological interventions<sup>20,21</sup> to restore or enhance vision in persons with profound vision loss have raised the clinical community’s awareness of the need for better methods for testing vision at the very poor vision end of the scale. The BRVT has already found application in the measurement and classification of vision in athletes participating in sports for the blind and visually impaired.

## ACKNOWLEDGMENTS

*The Regents of the University of California holds the copyright for the Berkeley Rudimentary Vision Test. Any royalties will be used to support research in low vision in the School of Optometry at the University of California, Berkeley. During this project AJJ was supported by a Northern Ireland Research & Development Office Sabbatical Grant. MAC received support from a grant to the School of Optometry from the Bernard A. Newcombe Foundation.*

*Received February 8, 2012; accepted May 14, 2012.*

## REFERENCES

1. Snellen H. Letterproeven tot Bepaling der Gezichtsscherpte 1862. (van der Weijer PW, Utrecht), cited by Bennett AG. Ophthalmic test types. A review of previous work and discussions on some controversial questions. *Br J Physiol Opt* 1965;22:238–71.
2. Lim LT, Frazer DG, Jackson AJ. Clinical studies: visual acuities beyond Snellen. *Br J Ophthalmol* 2008;92:153.
3. Bailey IL, Lovie JE. New design principles for visual acuity letter charts. *Am J Optom Physiol Opt* 1976;53:740–5.
4. Bailey IL. Designation of visual acuity in logarithmic units. *Optom Monthly* 1980;71:80–5.
5. Bailey IL. Measurement of visual acuity: towards standardization. In: Baldwin WR, ed. *Vision Science Symposium: a Tribute to Gordon G. Heath*. Bloomington, IN: Indiana University, 1988:215–30.
6. Carkeet A, Lee L, Kerr JR, Keung MM. The slope of the psychometric function for Bailey-Lovie letter charts: defocus effects and implications for modeling letter-by-letter scores. *Optom Vis Sci* 2001;78:113–21.
7. Ferris FL, 3rd, Kassoff A, Bresnick GH, Bailey I. New visual acuity charts for clinical research. *Am J Ophthalmol* 1982;94:91–6.
8. National Academy of Sciences/National Research Council (NAS-NRC), Committee on Vision. Recommended standard procedures for the clinical measurement and specification of visual acuity: Report of Working Group 39: 1979. *Adv Ophthalmol* 1980;41:103–48.
9. Sloan LL. New test charts for the measurement of visual acuity at far and near distances. *Am J Ophthalmol* 1959;48:807–13.
10. Age-related Eye Disease Study (AREDS). Manual of Operations:

2000. Chapter 7: Examination procedures. Available at: [https://web.emmes.com/study/areds/mopfiles/chp7\\_mop.pdf](https://web.emmes.com/study/areds/mopfiles/chp7_mop.pdf). Accessed June 14, 2012.
11. Bach M. The Freiburg Visual Acuity test—automatic measurement of visual acuity. *Optom Vis Sci* 1996;73:49–53.
  12. Bittner AK, Jeter P, Dagnelie G. Grating acuity and contrast tests for clinical trials of severe vision loss. *Optom Vis Sci* 2011;88:1153–63.
  13. Bach M, Wilke M, Wilhelm B, Zrenner E, Wilke R. Basic quantitative assessment of visual performance in patients with very low vision. *Invest Ophthalmol Vis Sci* 2009;51:1255–60.
  14. Kitchin JE, Bailey IL. Task complexity and visual acuity in senile macular degeneration. *Aust J Optom* 1981;63:235–42.
  15. Flom MC, Weymouth FW, Kahneman D. Visual resolution and contour interaction. *J Opt Soc Am* 1963;53:1026–32.
  16. Flom MC. Contour interaction and the crowding effect. *Prob Optom* 1991;3:237–57.
  17. Smith G. Relation between spherical refractive error and visual acuity. *Optom Vis Sci* 1991;68:591–8.
  18. Schulze-Bonsel K, Feltgen N, Burau H, Hansen L, Bach M. Visual acuities “hand motion” and “counting fingers” can be quantified with the Freiburg visual acuity test. *Invest Ophthalmol Vis Sci* 2006;47:1236–40.
  19. Lange C, Feltgen N, Junker B, Schulze-Bonsel K, Bach M. Resolving the clinical acuity categories “hand motion” and “counting fingers” using the Freiburg Visual Acuity Test (FrACT). *Graefes Arch Clin Exp Ophthalmol* 2009;247:137–42.
  20. Chader GJ, Weiland J, Humayun MS. Artificial vision: needs, functioning, and testing of a retinal electronic prosthesis. *Prog Brain Res* 2009;175:317–32.
  21. Schwartz SD, Hubschman JP, Heilwell G, Franco-Cardenas V, Pan CK, Ostrick RM, Mickunas E, Gay R, Klimanskaya I, Lanza R. Embryonic stem cell trials for macular degeneration: a preliminary report. *Lancet* 2012;379:713–20.

**Ian L. Bailey**

*University of California, Berkeley*

*School of Optometry*

*415 Minor Hall*

*Berkeley, California 94720-2020*

*e-mail: ibailey@berkeley.edu*