Threshold Visual Acuity Testing of Preschool Children Using the Crowded HOTV and Lea Symbols Acuity Tests

Vision in Preschoolers (VIP) Study Group*

Purpose: To compare the testability and threshold acuity levels for very young children on the crowded HOTV logMAR distance visual acuity test presented on the BVAT apparatus and the Lea Symbols logMAR distance visual acuity chart. ***Methods:*** Subjects were 87 Head Start children from age 3 to 3.5 years. Testing consisted of binocular pretraining at near using a lap card as needed, binocular pretraining at 3 m, and threshold testing for each eye. The testing procedure, adapted from the Amblyopia Treatment Study, presented optotypes until the child was unable to correctly name or match three of three or three of four optotypes of a given size. Threshold acuity was the smallest size for which at least three optotypes were correctly identified. ***Results:*** Both near and distance pretraining were completed by 71% of children for HOTV and by 75% for Lea Symbols ($P = .39$). The distribution of threshold acuities differed between the two tests. For the 69 eyes of 53 children who were successfully tested with both optotypes, results from the crowded HOTV acuity test were on average 0.25 logMar (2.5 lines) better than those from the Lea Symbols acuity test ($P < .001$). ***Conclusions:*** The proportion of children between 3 and 3.5 years of age whose monocular visual acuity could be assessed was high and was similar for the two charts tested. Crowded HOTV acuity results were better on average than results using Lea symbols. The different formats of the two tests may explain the observed differences in threshold acuity level. (J AAPOS 2003;7:396-9)

Many professional organizations concerned with the ocular health of children recommend vision screening and/or comprehensive eye examinations for preschool children age 3 and older.[1] Measurement of visual acuity is central to determining whether amblyopia or other conditions affecting vision are present. An important issue in testing the visual acuity of preschool children is the selection of a test requiring cognitive skills appropriate to the child's age as indicated in the extensive review of visual acuity assessment in preschool children that was recently published by the Preschool Vision Screening Task Force.[2] Tests that are appropriate for children age 4 years may require cognitive skills that many 3-year-olds do not possess.[2]

The present study compared the ability of children between the ages of 3 and 3.5 years to complete two distance visual acuity tests. The two tests evaluated—the crowded HOTV acuity test using the BVAT apparatus (Medtronic Solan, Jacksonville, FL) and the Lea Symbols chart (Precision Vision, La Salle, IL) were especially designed for testing young children. Each test provides a method for obtaining threshold visual acuity in preschool children using crowded optotypes in a logMAR progression as is recommended for visual acuity tests used with adults.[3] In addition, both tests allow children who cannot name the optotypes to respond by matching using large optotypes on a lap card. Single noncrowded optotype visual acuity tests have high testability in young children

*Vision in Preschoolers Study Group Executive Committee: Elise Ciner, OD, Pennsylvania College of Optometry, Philadelphia, PA; Lynn Cyert, PhD, OD, Northeastern State University, College of Optometry, Tahlequah, OK; Velma Dobson, PhD, Department of Ophthalmology, University of Arizona, Tucson, AZ; Marjean Taylor Kulp, OD, MS, The Ohio State University, College of Optometry, Columbus, OH; Maureen Maguire, PhD, Department of Ophthalmology, University of Pennsylvania, Philadelphia, PA; Bruce Moore, OD, The New England College of Optometry, Boston, MA; Deborah Orel-Bixler, PhD, OD, University of California Berkeley, School of Optometry, Berkeley, CA; Ellen Peskin, MA, Department of Ophthalmology, University of Pennsylvania, Philadelphia, PA; Graham Quinn, MD, MSCE, Division of Pediatric Ophthalmology, The Children's Hospital of Philadelphia, Philadelphia, PA; Maryann Redford, DDS, MPH, National Eye Institute, Bethesda, MD; Paulette Schmidt, OD, MS; The Ohio State University, College of Optometry, Columbus, OH (Chair); Janet Schultz, RN, MA, CPNP, University of Maryland University College, Early Head Start, Adelphi, MD.

This study was supported by funds from the institution of each VIP Study Group Executive Committee member and by Grant Nos. EY12644 (PS), EY12550 (LC), EY12534 (BM), EY12547 (MM), and EY05804 (VD) from the National Eye Institute, National Institutes of Health, Department of Health and Human Services, Bethesda, MD; Cherokee Nation Head Start, Tahlequah, OK (LC); Research to Prevent Blindness, New York, NY (University of Pennsylvania); Paul and Evanina Bell Mackall Foundation Trust (MM); and Morris Funds (PS).

Presented in part at the annual meeting of the Association for Research in Vision and Ophthalmology, Fort Lauderdale, FL, May 2000, and at the annual meeting of the American Academy of Optometry, Orlando, FL, December 2000.

Submitted November 26, 2002.

in revised form July 16, 2003.

Reprint requests: The Vision in Preschoolers Study Center, The Ohio State University, College of Optometry, 320 W Tenth Ave, PO Box 182342, Columbus, OH 43218-2342.

Copyright © 2003 by the American Association for Pediatric Ophthalmology and Strabismus.

1091-8531/2003/$35.00 + 0

doi:10.1016/S1091-8531(03)00211-8

Fig 1. BVAT monitor and remote control used for presentation of the crowded HOTV test.

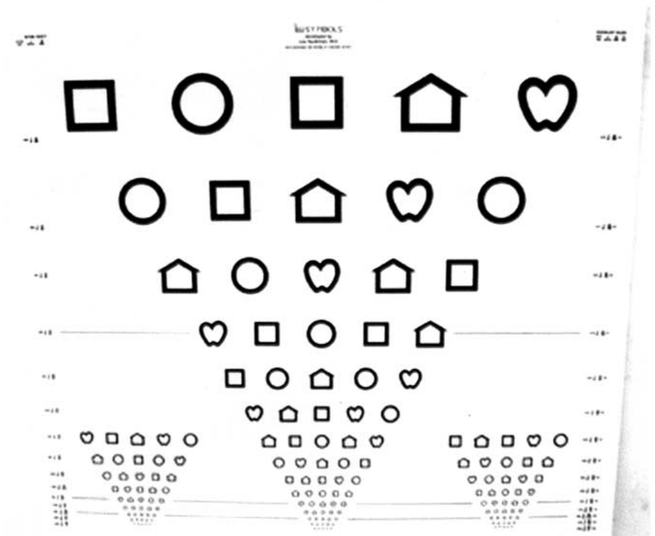

Fig 2. Lea Symbols distance visual acuity chart.

but are undesirable because they indicate better acuity in amblyopes than do linear optotype clinical charts. Allen cards and other single-optotype tests thus lack sensitivity for detecting amblyopia.[4]

SUBJECTS AND METHODS

Subjects

Subjects were 87 Head Start children between 3 and 3.5 years old who were tested in Boston, MA; Columbus, OH; Philadelphia, PA; and Tahlequah, OK. In addition to meeting the age criterion, children were included only if they did not have manifest strabismus on a cover test administered at 40 cm and at 3 m. The cover test was performed immediately before the child's participation in the project. Children were tested in their Head Start classrooms. Although the study protocol indicated that only one eye of each child should be tested, one center elected to test both eyes of each child, and the resulting data were included in the analysis by using statistical techniques that accommodated the correlation between eyes of the same child. The Institutional Review Board of each participating institution and of the Cherokee Nation approved the research protocol. Written informed consent was obtained from each child's parent(s) before the children were tested.

Crowded HOTV Test

The crowded HOTV test was presented on the lighted, nonglare BVAT monitor using normal room lighting (Figure 1). The crowded HOTV acuity test allowed presentation of the single letters "H," "O," "T," or "V" with crowding provided by solid black bars surrounding the single letters. The 20/70 letter size (present in the instrument's letter size sequence) was skipped so that letter size decreased from 20/200 to 20/15 in a logMAR progression. The computer determined the letter presented on each trial, but the examiner determined the size progression of optotypes by using the remote control device. The procedure is similar to that developed for the Amblyopia Treatment Study to provide a standardized crowded HOTV protocol for measuring threshold visual acuity in children.[5,6] During testing, the tester did not point to the optotype on the BVAT monitor.

Lea Symbol Chart

The Lea Symbols chart is a printed chart having four optotypes (circle, square, house, and heart) arranged in lines with each line containing five optotypes and one logMAR progression between the lines. The chart (Figure 2) allows all lines of symbols to be viewed simultaneously, thus making crowding bars unnecessary. Illumination for the Lea Symbols test was provided by a lamp or overhead light fixture that produced uniform lighting across the chart and a minimum luminance of 100 candela/m^2 as measured with a light meter. The tester was permitted to point to an individual symbol with a pencil or finger below the symbol.

Testing Procedure

A 3-meter test distance was used for both tests. The order of testing was balanced between the two tests in a predetermined, variable order. For each test, the right eye was always tested first and the left eye second. If the child came to the test wearing glasses, the child wore the glasses during the test.

The testing protocol consisted of three steps: (1) binocular pretraining at near, (2) binocular pretraining at 3 m, and (3) threshold testing for each eye. For the pretraining testing, the child was given a lap card with the appropriate group of symbols, either the four crowded letters used in the crowded HOTV test or the four pictures used in the Lea Symbols chart. During the near pretest, the examiner stood approximately 2 feet from the child, held up a card

with a single large symbol, and said to the child "Point to the letter (picture) on YOUR card that looks like this letter (picture)." This procedure was repeated with the remaining three letters or pictures. The child was allowed no more than two chances to respond correctly to each of the cards during the near pretraining. If the child could not respond correctly to all four letters or pictures, the results were scored as "unable." If the child spontaneously named the letters or pictures, verbal responses were accepted.

If the child completed the matching/naming at near, the pretraining continued at the 3-m test distance. For the HOTV test, single 20/125 letters with crowding bars were projected onto the monitor. For the Lea Symbols test, the top line of the chart (10/100) was used. The tester pointed to each optotype and asked the child to find the matching optotype on the lap card. If the child missed one of the optotypes, a second trial of that optotype was permitted. No more than five total trials were administered. If the child could not reliably match or name all of the optotypes at 3 meters, the child was scored as "unable" to perform the task.

Threshold testing was begun by patching the left eye. The child's attention was directed to one large optotype to be matched or identified. On the HOTV test, the starting optotype size was the 20/125 equivalent at 3 meters. On the Lea Symbols test, the picture in the middle of each line of the chart was used, starting with the 10/100 line. If the child matched or named the optotype correctly, one symbol from the next smaller size was presented, continuing on to the next smaller size until the child missed an optotype.

Once the child missed an optotype, the examiner went up two lines in size to larger optotypes and proceeded to determine the threshold visual acuity. If the child did not identify three optotypes correctly at that level out of a maximum of four optotypes presented, testing proceeded to the next larger line until a line was determined for which the child correctly identified three optotypes. If the child identified three of three or three of four optotypes of a given size correctly, testing proceeded to the next smaller size. If the child identified three correctly at that level, testing proceeded to the next smaller size. Testing was stopped when the child missed two optotypes of the same size. Threshold acuity was defined as the smallest size for which at least three optotypes (three of three or three of four) were correctly identified. This criterion was used because it is identical to that used with the crowded HOTV test in the Amblyopia Treatment Study.[5,6] Therefore, the child was never required to identify the fifth symbol on each line of Lea symbols.

Data Analysis

Examiners at each site recorded results on a standard data collection form for each visual acuity test. The proportion of children able to complete the pretraining for each visual acuity test successfully was compared using McNemar's exact test for correlated proportions. The distributions of threshold visual acuity for the two visual acuity tests were compared using a paired Student *t* test on the data from eyes with threshold measurements on both tests. Correlation between the threshold measurements of two eyes of the same child was accommodated in the paired Student *t* test by using the generalized estimating equations approach to correlated data. Calculations were performed using SAS/STAT 8.0 software (SAS, Cary, NC).

Table 1. Testability among children for the crowded HOTV and Lea Symbols acuity tests

		Able to Do Test*	
Test	Children	n	Percent
Crowded HOTV	85	60	(71)
Lea Symbols	85	64	(75)

*No statistically significant difference between tests; $P = 0.39$ (McNemar's test).

Table 2. Threshold visual acuity

Visual Acuity (20/x)	Crowded HOTV*		Lea Symbols*	
	Eyes	Percent	Eyes	Percent
15–25	42	(55)	3	(4)
32–50	28	(37)	46	(58)
62–100	4	(5)	28	(36)
125–200	2	(3)	2	(3)
Total	76	(100)	79	(100)

*Statistically significant difference between tests; $P < .001$ (paired Student *t* test with robust variance estimation on the 69 eyes with measurements on both visual acuity tests).

RESULTS

A total of 85 children underwent visual acuity testing with both methods on the same eye. Sixty of the children were tested on one eye only, and 25 children, all from one center, completed testing on both eyes.

As shown in Table 1, both near and distance pretraining were successfully completed by 71% of children for the HOTV test and by 75% of children for the Lea Symbols test ($P = 0.39$, McNemar's exact test). Among the 29 children who were unable to complete the pretraining tasks on at least one acuity test, 59% (n = 7) were unable to complete the pretraining tasks on both acuity tests.

As shown in Table 2, the distribution of threshold visual acuities differed between the two tests. Among eyes that were tested using the crowded HOTV test, 92% achieved monocular visual acuities of 20/50 or better, whereas only 62% of the eyes tested with the Lea Symbols test reached this level of acuity. For the 69 eyes of 53 children who were successfully tested with both crowded HOTV and Lea Symbols optotypes, the results from the crowded HOTV acuity test were on average 0.25 logMar (2.5 lines) better than the results from the Lea Symbols acuity test ($P < .001$; paired Student *t* test with robust variance estimation to accommodate including 2 eyes of some children).

DISCUSSION

The results of the present study indicate that the proportion of children between 3 and 3.5 years of age whose monocular visual acuity can be assessed is high and is similar whether the crowded HOTV distance visual acuity test (71%) or the Lea Symbols distance visual acuity test (75%) is used. Both testing procedures have the advantage that they use a logMAR progression of optotype sizes as recommended by the Committee on Vision in 1980,[3] a format in which crowded rather than isolated optotypes are used. In addition, both have the advantage of having a lap card that allows the child to match rather than verbally identify the shape of the optotypes presented during testing.

Although success rates for pretraining did not differ between the crowded HOTV and the Lea Symbols visual acuity tests in this young age group, the visual acuity results obtained using the crowded HOTV test were on average 2.5 lines better than visual acuity results obtained using the Lea Symbols chart. The different formats of the two tests may explain the observed differences in threshold acuity level. For example, the crowded HOTV test monitor is similar to the television monitor commonly used by the children in their classrooms, and it therefore may provide a more salient stimulus for the children than that provided by the Lea Symbols chart. Also, the BVAT monitor is a self-illuminated screen that may have been more effective than the Lea Symbols chart in drawing the child's attention away from distractions in the classroom testing environment. On the other hand, emphasizing by pointing was used for individual Lea symbols and was not used with the BVAT monitor.

Another possible explanation for differences between the two tests in the acuity results obtained is that the letters, although surrounded by crowding bars, are shown one at a time in the crowded HOTV test. In contrast, when using the Lea Symbols chart, all the lines and symbols on the chart are exposed simultaneously. Therefore, the Lea symbols acuity chart may have been more confusing to the child because all of the symbols were visible at the same time. Furthermore, the HOTV test, which presents the letters sequentially rather than all at one time, may have had a novelty effect that helped to maintain the child's attention. The audible beep produced when the crowded HOTV optotype was changed may also have helped to attract the child's attention.

A final difference between tests is the use of letter optotypes in the crowded HOTV test versus the use of picture optotypes in the Lea Symbols chart. Traditionally, visual acuity tests that use pictures are considered to be easier for a young child and are typically used at younger ages than are acuity tests that have letter optotypes. This difference in optotypes, however, would predict better acuity with the Lea Symbols chart than with the crowded HOTV optotypes. The opposite difference was in fact observed.

The ability to complete threshold visual acuity testing using the crowded HOTV test and the Lea Symbols chart is high among 3-year-old Head Start children, a group comprised largely of children from low-income families who are enrolled in a structured educational setting. Although there was a measured difference in threshold acuity between the two tests, the significance of this difference is difficult to determine in light of several format differences between the two tests. The differences in the optotypes used in the two tests may explain the observed threshold differences. It is also possible that the observed threshold differences may be the result of differences between tests in the mode of presentation of the optotypes. The results suggest that the computer monitor presentation used in the crowded HOTV acuity test shows greater promise for acuity measurements in young children than the fixed symbol full chart because it better facilitates the sustained attention required to determine threshold visual acuity in 3-year-old children.

ACKNOWLEDMENT

The authors thank the Writing Committee: Lynn Cyert, PhD, OD (Chair), Paulette Schmidt, OD, MS, Maureen Maguire, PhD, Bruce Moore, OD, Velma Dobson, PhD, and Graham Quinn, MD, MSCE.

References

1. Schmidt P. Screening for the vision problems of young children. In: Moore BD, editor. Eye Care For Infants and Young Children. Newton (MA): Butterworth-Heinemann; 1997. p. 175-89.
2. Hartmann EE, Dobson V, Hainline L, Marsh-Tootle W, Quinn GE, Ruttum MS, et al. Summary of a task force report. Pediatrics 2000;106:1105-16.
3. Committee on Vision. Recommended standard procedures for the clinical measurement and specification of visual acuity. Adv Ophthalmol 1980;41:103-48.
4. Simons K. Preschool vision screening: rationale, methodology and outcome. Surv Ophthalmol 1996;41:3-30.
5. Holmes JM, Beck RW, Repka MX, et al. The Amblyopia Treatment Study visual acuity testing protocol. Arch Ophthalmol 2001;119:1345-53.
6. Moke PS, Turpin AH, Beck RW, et al. Computerized method of visual acuity testing: Adaptation of the Amblyopia Treatment Study visual acuity testing protocol. Am J Ophthalmol 2001;132:903-9.