Validation of the Acuity Card Procedure for Assessment of Infants with Ocular Disorders

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Abstract: The acuity card procedure has been shown to be a rapid method for the assessment of monocular and binocular grating acuity in normal infants from birth through 36 months of age. The current study seeks to validate the procedure further by using the acuity cards to assess 20 2- to 8-month-old infant patients with ocular disorders, including aphakia, strabismus, ptosis, and orbital hemangioma. Assessments were made with the acuity cards by two different observers, both blind to the infant's diagnosis, and by a third observer using a traditional forced-choice preferential looking (FPL) procedure. One hundred percent of the infant patients completed both binocular and monocular acuity card testing in an average time of 8 minutes per test. Interobserver agreement between acuity card observers and inter-technique agreement were high, and were sustained in individual cases in which the infant's acuity was not predictable from its visible signs. These results help to establish the potential clinical utility of the acuity card procedure for the assessment of infant patients. [Key words: acuity cards, grating acuity, infants, ocular disorders, preferential looking.] Ophthalmology 94:644–653, 1987

The acuity card procedure[1–6] has been developed to provide a simplified and efficient method for the assessment of visual acuity in infants, young children, and nonverbal patients in clinical settings. The procedure is a variant of preferential looking (PL)[7] and operant preferential looking (OPL)[8] techniques, and involves the use of a series of cards that contain grating targets which vary in spatial frequency (stripe width) from card to card. During an acuity test, the observer presents the cards sequentially to the infant or child, and makes an integrated decision as to which card contains the highest spatial frequency that is just detectable by the child.

To date, laboratory studies of normal infants and children have shown that the procedure has several practical advantages. The percentage of normal children who can be tested with the acuity cards approaches 100% across a broad range of ages (1–36 months) for both binocular and monocular testing. An acuity estimate can be obtained rapidly, with average test durations of 2 to 6 minutes. Intra- and interobserver reliability are relatively high. The acuity cards yield age norms and population standard deviations similar to those previously reported wth PL techniques, and preliminary, empirically based age norms are available.[9,10] In addition, the cards and testing screen are relatively compact and portable, and testing and scoring techniques are simple and readily learned. Thus, the acuity card technique works well in tests of normal infants and children in laboratory settings.

However, any assessment technique intended for clinical use must prove itself on populations of infants and children of diverse ages and clinical disorders. Ocular disorders such as nystagmus, ptosis, and strabismus may interfere with the quality of responses elicited on a PL task, and reduce the percentage of infants testable or

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the speed or accuracy with which the acuity estimates can be made. In addition, the presence of visual defects, multiple handicaps, neurologic abnormalities, or retardation may result in reduced cooperation with the test procedure.

A second problem is that of potential observer bias. Forced-choice preferential looking (FPL) techniques, carried out with an observer who is blind to grating location and spatial frequency, were developed for the specific purpose of minimizing observer bias.[7] In contrast, the subjective nature of the observer's judgments in the acuity card procedure opens the possibility that a priori knowledge of the infant's age or clinical condition, or preconceptions about the infant's probable visual abilities, might influence the estimated acuity values. If acuity card estimates were more susceptible than FPL estimates to such biases, then such biases would act to reduce the agreement between acuity card and FPL results. On the other hand, the staring behavior on which PL techniques depend is an extremely robust phenomenon; and it may be that most observers, even when they are not blind to the infant's clinical condition or to test parameters, can base their acuity card estimates largely or entirely on the infant's visual behavior. If so, then one would expect that even under conditions in which observer bias can operate in principle, good agreement between FPL and acuity card estimates of an infant's acuity could be maintained.

Mohn and van Hof-van Duin[11] have carried out a direct comparison of the acuity card procedure with traditional FPL and OPL techniques. The subjects were 20 visually impaired, developmentally delayed, or normal infants and children, age 6 to 32 months. Subjects were tested binocularly and/or monocularly by a single experimenter with the FPL or OPL procedure and the acuity card procedure. An additional five subjects were tested with the acuity cards, but could not complete traditional PL testing. There was close agreement in measured acuity values between the two procedures in individual patients, with acuity card estimates falling within ±1 octave of FPL/OPL results in 100% of the tests. These results begin the demonstration of the feasibility and validity of the acuity card procedure in testing patients with visual disorders.

The purpose of the current study is twofold. First, we wish to assess the testability rates, test times, and interobserver reliability of the acuity card procedure on a second clinical sample: infants in the 2- to 8-month age range with visual disorders. Second, we wish to continue to validate the acuity cards against traditional FPL techniques through direct comparison of data obtained with both procedures, using an experimental design in which clinically naive observers made the acuity card judgments, and in which all observers were blind to each others' results. We are especially interested both in infants with and in those without visible ophthalmic disorders which might be expected to produce observer bias. Sustained agreement within and across measurement techniques under these conditions would provide added support for the conclusion that the acuity cards can be used in an unbiased way, at least in circumstances and patients like those in the current study.

METHODS

SUBJECTS

Subjects were 20 infants with known or suspected visual disorders including strabismus, ptosis, hemangioma, and aphakia (Table 1). The infants ranged in age from 8 to 31 weeks corrected age (age from due date) at the start of testing. The range of infants' birthweights was from 2268 to 4621 g and their due dates ranged from −30 to +20 days from birthdate. Nine of the infants were boys and 11 were girls. All infants had known or suspected visual disorders and were referred to the study by pediatric ophthalmologists. The subjects included in the study were screened through the referring physician to exclude infants with gross neurologic disorders.

After informed consent had been obtained from a parent, the infants participated in five to eight 45-minute test sessions which were completed within a 2-week time period. The parents were paid $5.00 for each test session.

EXPERIMENTERS

Three experimenters with extensive PL experience each carried out two monocular and one binocular test on each infant. (Due to scheduling difficulties one set of acuity card data [infant initials, case 9] was collected by a fourth experimenter with extensive acuity card experience.) Two experimenters with no clinical ophthalmic training tested the subjects with the acuity card procedure. These two observers knew the infants' ages, but were blind to the infants' diagnoses except for information unavoidably obtained by direct observation of the infant during testing. The third experimenter tested the infants with the FPL technique. This experimenter coordinated the study and was clinically trained and fully informed as to the age and diagnostic status of the infants. Each observer was blind to the results of the other two observers until all tests were completed.

EXPERIMENTAL DESIGN

Three acuity estimates (binocular, monocular right and monocular left) were attempted by each observer. Testing sequences were counterbalanced for order of acuity card versus FPL testing and order of the acuity card tests. In all instances, binocular estimates were performed first. Monocular right and monocular left testing were then performed, counterbalanced across infants and test conditions.

ACUITY CARD PROCEDURE

The acuity card apparatus[1] consisted of a grey screen and side panels that shielded the infant from room dis-

Table 1. Patients and Median Acuity Values

Case No.	Age* (mo/days)	Days From Due Date	Ophthalmic Condition	Refraction (OD/OS)	Median Acuity in cy/deg (Snellen equivalent)		
					OU	OD	OS
1	2/29	+7	Aphakia, microphthalmia, OS	+2.25/+30.00 (contact lens correction)†	1.0 (20/600)‡	1.0 (20/600)‡	0.4 (20/1500)‡§
2	2/7	+6	Bilateral aphakia, microphthalmia	+24.00/+24.00 (spectacle correction)†	1.0 (20/600)	1.0 (20/600)	0.5 (20/1200)‡§
3	4/13	−1	30–35$^{\Delta}$ right esotropia	+0.25 +2.00 × 10/+1.75 +1.00 × 155	3.0 (20/200)	1.5 (20/400)	3.0 (20/200)
4	4/10	+4	30$^{\Delta}$ left esotropia	+1.00 +2.00 × 40/−0.50 +2.50 × 150	3.2 (20/187)	3.0 (20/200)	2.4 (20/250)
5	5/20	−30	30–50$^{\Delta}$ alternating esotropia and abnormal VOR	+2.50 +2.00 × 50/+2.50 +1.50 × 140	3.0 (20/200)	3.0 (20/200)	3.0 (20/200)
6	6/29	−25	20–25$^{\Delta}$ left esotropia; optic nerve pallor OU; moderate bilateral ptosis; visual fixation delay	+0.50 +2.00 × 15/+0.25 +1.00 × 180	1.0 (20/600)‡	0.5 (20/1200)‡	0.8 (20/800)‡
7	5/14	−20	Visual fixation delay; moderate bilateral ptosis	N/A / N/A	1.5 (20/400)‡	1.2 (20/500)‡	0.9 (20/667)‡
8	2/13	0	Visual fixation delay	+2.00/+2.50	3.0 (20/200)	1.5 (20/400)	1.6 (20/375)
9	4/3	+2	Visual fixation delay; optic nerve pallor OU; pupillary responses absent	−1.50 +0.50 × 90/−2.00 +0.50 × 90	1.5 (20/400)‡	1.1 (20/545)‡	1.0 (20/600)‡
10	4/7	−6	Hemangioma involving right orbit and palpebrae	+5.50/+6.00	3.0 (20/200)	2.3 (20/260)	2.0 (20/300)
11	6/17	−14	Hemangioma involving left orbit and palpebrae	+2.50 +0.50 × 35/+3.00	4.0 (20/150)	4.0 (20/150)	2.0 (20/300)§
12	7/23	+20	Iris coloboma, OS	N/A / N/A	4.0 (20/150)	3.0 (20/200)	3.0 (20/200)

13	2/12	−1	Family history of retinal coloboma; results of subsequent ophthalmic examination were normal	+0.50 +0.25 × 180/+0.75 +0.25 × 180	1.5 (20/400)	0.8 (20/800)	1.0 (20/600)
14	3/8	−9	Family history of optic nerve coloboma; results of subsequent ophthalmic examination were normal	N/A / N/A	3.0 (20/200)	2.0 (20/300)	2.0 (20/300)
15	2/16	−29	Asymmetrical ptosis; severe OS, moderate OD	+4.50/+4.00 +0.75 × 90	2.0 (20/300)	2.0 (20/300)	2.0 (20/300)
16	3/13	+4	Horner's syndrome and astigmatism OS	+0.75 +0.50 × 180/−1.50 +2.25 × 150	4.0 (20/150)	3.8 (20/158)	2.0 (20/300)
17	7/13	+11	Asymmetrical oblique corneal astigmatism	pl +3.50 × 35/+0.75 +1.50 × 85	4.0 (20/150)	2.0 (20/300)	4.0 (20/150)§
18	3/29	−4	Asymmetrical oblique astigmatism	−0.25 +2.50 × 30/pl +0.75 × 155	3.0 (20/200)	3.0 (20/200)	1.5 (20/400)§
19	6/8	+6	Astigmatism; history of small angle left esotropia and asymmetry of astigmatism worse OD	6 mo −1.25 +3.00 × 175/ −0.25 +3.00 × 165 2 mo −2.00 +4.75 × 170/ pl +3.50 × 15	3.0 (20/200)	1.6 (20/375)‡	2.0 (20/300)
20	2/10	−20	Keratoplasty, OS; Moderate corneal opacity, OD	N/A / N/A	2.0 (20/300)	2.0 (20/300)	1.5 (20/400)

OD = right eye; OS = left eye; OU = binocular; VOR = vestibular-ocular reflex; NA = not available.
* Corrected age (age from due date) on median test day.
† Correction in place during testing.
‡ Acuity below age norm.[9,10]
§ Interocular difference ≥1.0 octave.

tractions. The screen contained a rectangular opening behind which the acuity cards were presented. A shield located 33 cm in front of the screen assisted the infant's holder in maintaining a constant test distance and prevented the holder from seeing the location and spatial frequency of the gratings on the test cards.

The acuity cards were 16, 28 × 60-cm grey cards, containing vertical square-wave gratings of spatial frequencies that ranged from 0.2 to 20 cy/deg in approximately half-octave steps. (An octave is a halving or doubling of spatial frequency [e.g., from 30 cy/deg (Snellen equivalent 20/200) to 6 cy/deg (Snellen equivalent 20/100)].) Each card contained two 9° apertures, centered 12° to the left and right of a centrally located 4-mm peephole. The target grating was located behind one of the apertures and a very high spatial frequency grating ("blank," 63 cy/deg) was located behind the other. A seventeenth blank card contained 63 cy/deg gratings on both sides. The space-average luminance of the gratings closely matched the surrounding grey of the cards, and the luminance of the cards and screen was 1.3 log cd/m^2. The cards were labeled on the back with grating location and spatial frequency, and the observers could refer to this information during testing.

During the testing, the infant was held 33 ± 3 cm in front of the screen. The observer stood behind the screen, held the acuity cards up to the opening, and viewed the infant's face through the peephole. Guided by instructions from the observer, the holder rotated the infant slowly from side to side in front of the acuity card. The cards could be presented in any order, but the observer generally started with a very low spatial frequency card (0.4 cy/deg) in order to gain the infant's interest and assess the quality of the looking responses in the presence of a highly visible stimulus. Cards with progressively higher spatial frequencies were then presented to the infant until preferential fixation of the grating was no longer elicited. Presentation of individual cards was repeated as necessary. The highest spatial frequency that the observer judged the infant to be able to see was scored as the estimate of acuity. After all three estimates (binocular, left eye, and right eye) were obtained, the observer had the option of repeating any of the three tests; this option was exercised on 8% of binocular and 8% of monocular tests.

Each acuity estimate was timed beginning with the first card presentation and ending when the observer recorded a final acuity estimate. In instances in which a test was repeated, test time for that estimate was the sum of both attempts, and the acuity estimate was determined by the observer's judgment after the second test. A total test time was also recorded which included all three acuity estimates and all breaks necessitated by the infant and/or experimenter.

FPL PROCEDURE

The FPL test apparatus, described more fully elsewhere,[7] consisted of a large grey screen with side panels. Two 9° apertures were located 18° to the right and left of a centrally located peephole. A large wheel, located behind the screen, allowed one of five acuity gratings to be positioned behind one aperture, whereas a 63-cy/deg blank was positioned behind the other aperture. A shield suspended 30.5 cm in front of the screen assisted in setting the test distance and prevented the experimenter from seeing the location of the grating. The luminance of the stimuli and screen was 1.2 log cd/m^2. A TV camera, located behind the peephole, allowed a view of the infant's head and eyes on a video monitor. The randomization and presentation of stimuli and recording of data were accomplished under computer control.

The gratings available for FPL testing ranged in spatial frequency from 0.2 to 12 cy/deg. Each acuity estimate was conducted using a subset of five consecutive octave-step gratings. The selection of the five gratings was based on prior knowledge of the infant's age so as to include gratings which would be both above and below threshold for a visually normal infant of that age. Each of the five gratings was presented for 20 trials, for a total of 100 trials per acuity estimate. The option of retesting with a new set of gratings, should the infant's acuity fall outside this range, was specifically available in the experimental design, but was never needed. On each trial, the observer watched the infant's head and eye movements on the monitor, and made a forced choice judgment as to the left–right location of the grating. Trial-by-trial feedback was provided.

FPL THRESHOLD ESTIMATION

Cumulative normal curves were fitted to the data by probit analysis.[12,13] The spatial frequencies corresponding to the 65, 70, and 75% correct points, and standard errors of each estimated threshold, were calculated for each data set.

RESULTS

ACUITY VALUES

Overall acuity estimates for each test condition (both eyes, right eye, and left eye) were made by taking the median values for the three observers. These acuity values ranged from 1.0 to 4.0 cy/deg on binocular tests and from 0.4 to 4.0 cy/deg on monocular tests (Table 1).

An infant's monocular or binocular acuity was considered subnormal when the median of the three acuity values fell outside the normal range described in the provisional age norms for the acuity cards.[9,10] Median interocular differences of at least 1.0 octave were also considered abnormal. Based on these criteria, 10 of the 20 subjects were identified as having subnormal acuity on at least one test (binocular, left eye, or right eye), or as having an abnormal acuity difference between the two eyes.

PERCENT TESTABLE

The percentage of infants successfully tested with the acuity card procedure was 100% both monocularly and

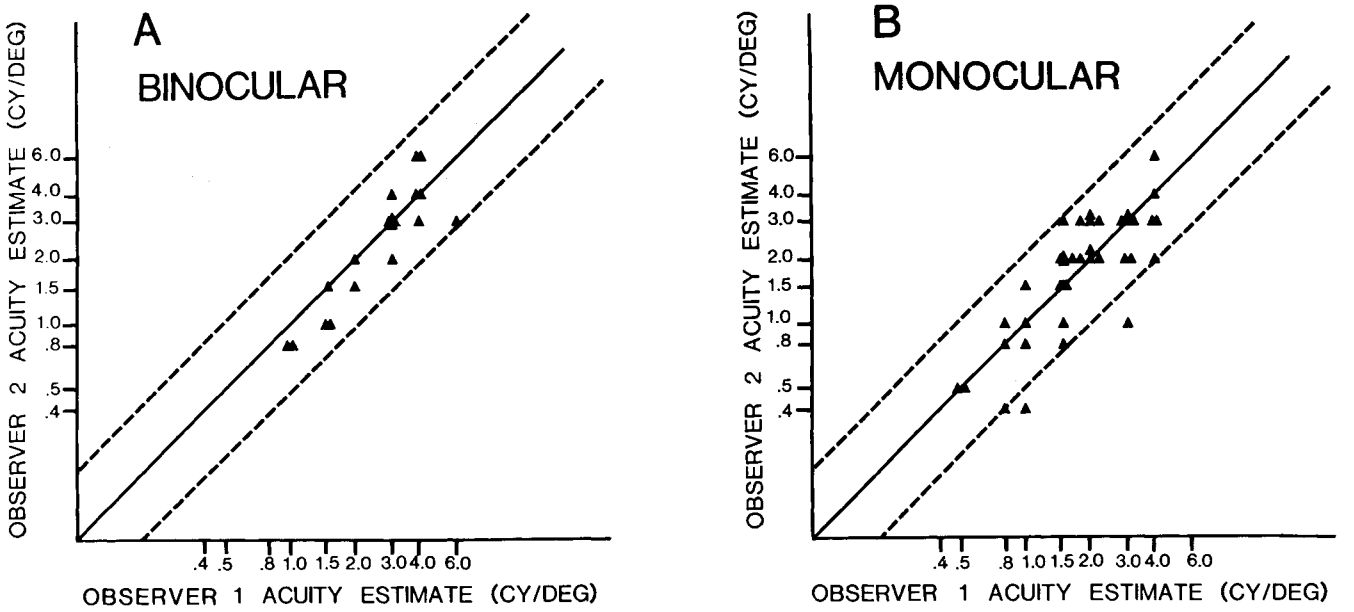

Fig 1. The interobserver agreement of acuity card estimates. **A,** binocular; **B,** monocular. The solid line represents perfect agreement and the dashed line represents agreement of the two estimates to within ±1.0 octave.

binocularly. For the FPL procedure, 100% of the subjects were successfully tested binocularly. The monocular FPL success rate was 83% (33/40). Six of the seven incomplete tests were from three infants, two of whom did not complete the required number of trials within the 2-week time limit and one of whom was untestable due to illness. The final unsuccessful monocular FPL test, the monocular right test from one infant (infant initials, case 9), was unscorable because the slope of the psychometric function after the completion of 100 trials was zero.

TEST DURATION

The average test duration for a monocular or binocular acuity estimate was 8.1 minutes with the acuity cards and between 1 and 2 (1.3) 45- to 60-minute test sessions with FPL testing. The total time from the start of the first acuity estimate until the three final estimates had been completed, including breaks needed for attending to the infant's needs, averaged 36 minutes for acuity card testing and 3.6, 45- to 60-minute test sessions for FPL testing. Thus, the acuity cards produced monocular and binocular estimates in one test session in less time than was required for a single FPL estimate.

INTEROBSERVER COMPARISONS

For the acuity cards, the results of binocular and monocular interobserver comparisons are shown in Fig 1. Ninety-five percent (19/20) of the binocular estimates and 88% (35/40) of the monocular estimates obtained by the two observers agreed to within 0.5 octave, and 100% of the binocular and 95% (38/40) of the monocular estimates agreed to within 1 octave. The correlation between acuity estimates obtained by different observers was r = 0.90 ($P < 0.001$) for the binocular estimates, and r = 0.78 ($P < 0.001$) and r = 0.85 ($P < 0.001$) for the monocular right and monocular left tests, respectively. The two observers also agreed well in the evaluation of interocular acuity differences. The two observers agreed to within 0.5 octave on the magnitude and direction of the interocular difference, if any, in 75% (15/20) of the subjects and to within 1.0 octave in 95% (19/20) of the subjects.

The 75% threshold FPL versus acuity card comparisons for each observer, for both binocular and monocular testing, are shown in Fig 2. Agreement to within 1.0 octave between the two procedures was 75% binocularly (r = 0.60 $P < 0.001$) and 88% (r = 0.68, $P < 0.001$) and 88% (r = 0.75, $P < 0.001$) for the monocular right and monocular left tests, respectively. Wilcoxon signed ranks tests showed a significant ($P < 0.01$) difference between the means of the binocular (but not monocular) FPL estimates and acuity card estimates for both observers, in the direction that the acuity cards yielded slightly (average, 0.55 octave) higher estimated binocular acuity. Mean test–retest differences and mean interobserver differences are summarized in Table 2. (Test–retest difference refers to the mean absolute value of the difference in acuity reported by the two observers on the same infant. Mean interobserver difference refers to the magnitude of the difference in mean acuity values between observers for all infants tested and indicates the magnitude of any consistent difference, or bias, of the estimates of one observer with respect to the other. The distinction is important because test–retest differences can be large even when mean interobserver differences are small.) The most important aspects of this analysis are that mean test–retest differences between the two acuity card observers for an individual infant are less

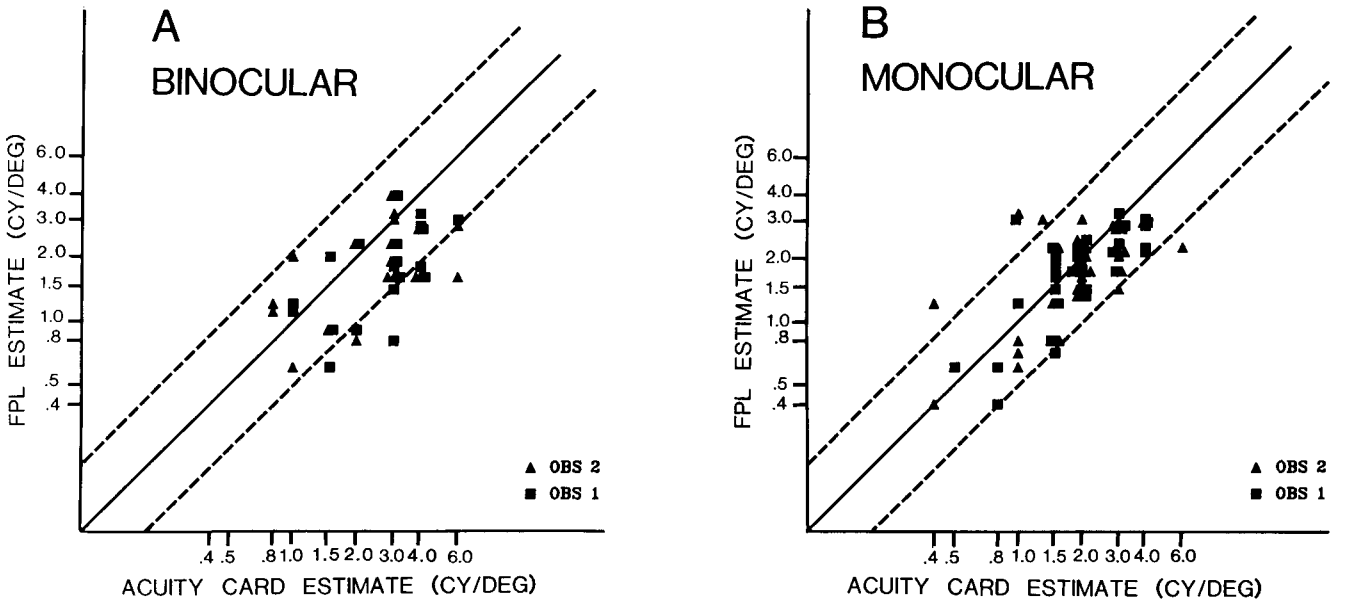

Fig 2. The agreement between FPL and acuity card estimates. **A,** binocular; **B,** monocular. ■: observer 1; ▲: observer 2. The solid line represents perfect agreement and the dashed lines represent agreement of the two estimates to within ±1.0 octave.

than 0.5 octave in all cases, and there was no significant tendency for one acuity card observer to estimate higher acuities. The infants showed better acuities when tested binocularly with acuity cards than when tested with the FPL procedure.

The agreement between acuity card and FPL estimates can be improved by shifting the FPL scoring criterion to 70% (Table 2). Agreement of the two procedures to within 1.0 octave or less at this scoring criterion is 97% ($r = 0.72$, $P < 0.001$) binocularly, and 87% ($r = 0.60$, $P < 0.001$) and 94% ($r = 0.73$, $P < 0.001$) for the monocular right and monocular left tests, respectively.

Table 2. Summary of Mean Test-retest and Interobserver Comparisons

	Mean Test-retest Differences (octaves)		Mean Interobserver Difference (octaves)	
	75%*	70%*	75%*	70%*
Binocular				
Acuity card 1/acuity card 2	0.30	—	−0.13	—
Acuity card 1/FPL	0.75	0.56	0.49	0.13
Acuity card 2/FPL	0.75	0.49	0.62	0.26
Monocular—right				
Acuity card 1/acuity card 2	0.40	—	−0.14	—
Acuity card 1/FPL	0.48	0.45	0.04	0.27
Acuity card 2/FPL	0.56	0.51	0.20	0.12
Monocular—left				
Acuity card 1/acuity card 2	0.35	—	−0.02	—
Acuity card 1/FPL	0.58	0.62	0.20	0.18
Acuity card 2/FPL	0.37	0.39	0.24	0.14

FPL = forced-choice preferential looking.
* FPL scoring criterion.

Wilcoxon signed ranks tests showed no significant differences between the means of binocular or monocular acuity card versus FPL results with this scoring criterion.

CASE REPORTS

We return now to the question of potential observer bias in the acuity card procedure. Although the acuity card observers were not clinically trained and were blind to the formal diagnosis and ocular history of the infants, they knew the infant's age, and the general nature of the disorder could, in some cases, be ascertained by direct observation of the infant during testing. The possibility of observer bias is of course impossible to rule out universally, and cannot be fully addressed within any single study. However, four case reports have been selected to illustrate the dissociation that is sometimes found between the infant's visible presentation and the acuity values obtained.

Cases 10 and 11 (unilateral orbital hemangioma). Two infants (ages 16 and 27 weeks) presented on the first day of testing with hemangioma involving the orbit of one eye to approximately the same degree. Infant 10 (Fig 3A) had a history of partial eyelid closure of the right eye due to orbital and palpebral hemangioma since birth (palpebral fissure height average, 3–4 mm). Total eyelid closure at 14 weeks was resolved within 10 days with steroid injection. No other ocular abnormalities were noted. Thus, the duration of eyelid closure was probably too brief to cause any marked interocular acuity differences, but the visible anomaly was dramatic and could have biased the observers toward finding reduced acuity in the left eye.

Acuity card tests by both observers showed equal acuities between the two eyes. The values obtained by the two observers in each condition (right or left eye) differed by 0.5 octave or less and all values were within the normal range for 16 weeks. FPL tests also indicated an interocular difference of less than 0.5 octave, and left and right eye acuities agreed with their respective acuity card estimates to within 1.0 octave in all

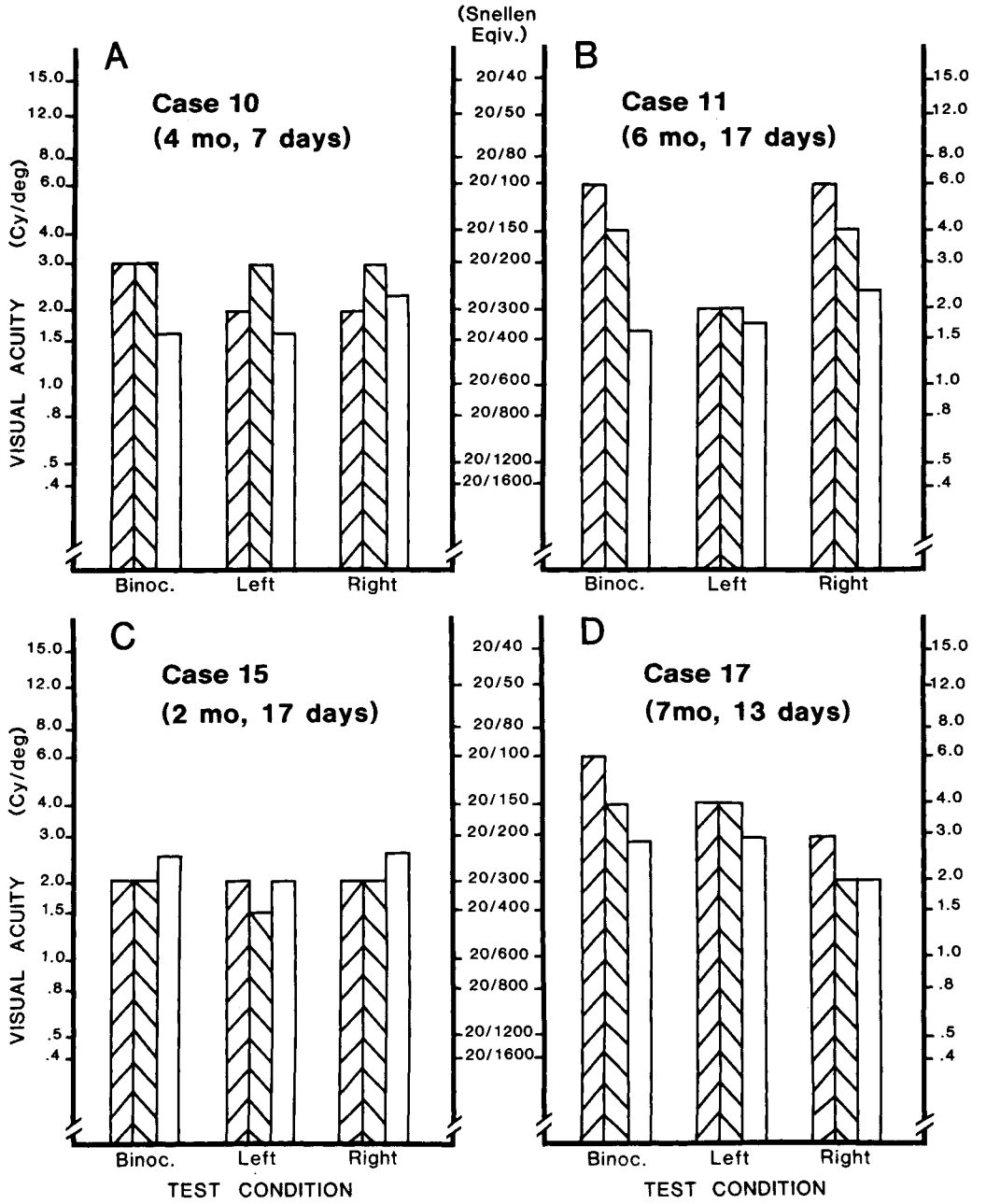

Fig 3. Agreement across observers and techniques in individual infant patients. Right-diagonal shading: Acuity card observer 1; left-diagonal shading: acuity card observer 2; open bars: FPL. **A**, case 10 (orbital hemangioma, right eye); **B**, case 11 (orbital hemangioma, left eye); **C**, case 15 (bilateral congenital ptosis, worse left eye); **D**, case 17 (oblique astigmatism, right eye).

four comparisons. Thus, the acuity values were consistent with the infant's history, but not with the hypothesis of observer bias.

In contrast, infant 11 (Fig 3B) had a history of nearly complete lid closure (palpebral fissure, 1–2 mm) of the left eye between the ages of 4 and 18 weeks. Injection with 1.7 cc triamcinolone and dexamethasone (both 40 mg/cc) at 18 weeks opened the palpebral fissure to approximately 4 mm within 15 days postoperatively. Thus, substantial monocular deprivation had occurred, and amblyopia was suspected from the clinical perspective.

The acuity card estimates for this infant were within the normal range for all conditions. However, judgments of interocular differences of 1.0 to 1.5 octaves, respectively, by the two acuity card observers indicated poorer acuity in the left eye. Poor compliance for FPL testing resulted in estimates with large standard errors (due to low asymptotes of the psychometric functions) and inconsistent results (binocular acuity was found to be poorer than the monocular right acuity by FPL). Therefore, a comparison between FPL and acuity cards was not meaningful in this case.

The results of cases 10 and 11 are consistent with the very different individual case histories of these infant patients despite the similar presentation of the ocular disorder for both infants during the course of the data collection. The acuity card observers were blind to the case histories, and could not have known that one infant would be expected, on the basis of the respective durations of monocular deprivation, to have poorer acuity in the affected eye, whereas the other would not.

Case 15 (ptosis). A 2-month-old infant with severe ptosis of the left eye and moderate ptosis of the right eye presented particular difficulty for acuity assessment, in that even with

maximal chin elevation, the left eye was barely visible through the palpebral fissure. Direct observation of the infant would have led to a biasing of results toward poorer acuity, particularly in the left eye. Despite the extreme difficulty of measurement, all three observers estimated, with close agreement, acuities at the high end of the normal range in both eyes (Fig 3C).

Case 17 (astigmatism). This 7-month-old infant (Fig 3D) was referred to the study after asymmetrical oblique corneal astigmatism was discovered during routine refraction after pediatrician referral for lacrimal obstruction. The remaining results of the ophthalmologic examination were unremarkable except for slight flattening of the right side of the forehead due to in utero compression. The optical defocus of vertical gratings resulting from the 3.50-diopter oblique astigmatism in the right eye would be expected to exceed the depth of focus of a 7-month-old infant,[14] thus influencing visual acuity in the right eye.

The results of the FPL and acuity card tests showed a small (0.5–1.0 octave) but consistent interocular difference with the right eye showing poorer acuity in all cases. This reduction in acuity of the right eye compared to the left eye could not have been predicted from general observation of the infant, yet it was found by all three observers.

In summary, these case histories illustrate the fact that the infant's appearance does not always exert a major controlling influence on the acuity values obtained. They show instances of (1) similar presentations, but different acuity values, where the acuity values are consistent with other aspects of the infant's case history (cases 10 and 11); (2) ocular disorders visible on direct observation, but acuity values within the normal range (cases 10 and 15); and (3) no ocular disorder visible on direct observation, but acuity values that are low and consistent with other aspects of the infant's case history (case 17). The sustained interobserver and cross-technique agreement in these cases may also help to diminish concern about observer bias in using the acuity cards to assess infant ophthalmic patients.

DISCUSSION

These results expand the validation studies of a new infant acuity assessment technique, the acuity cards, to include a sample of 20 infants in the 2- to 8-month-old age range with diagnosed or suspected visual disorders. At issue are questions of test times, testability rates, interobserver agreement, agreement with traditional FPL acuity estimates, and potential observer bias effects.

Average test durations were substantially shorter for a monocular or binocular test with the acuity card procedure than for FPL (8 minutes versus one to two 45- to 60-minute sessions). However, acuity card test times for infants with visual disorders are longer than the 3- to 5-minute averages reported for normal infants tested with the acuity cards.[1,2] These results are in accord with the results of Mohn and van Hof-van Duin, who report longer test times for infants and children with visual and neurologic disorders than for normal infants and children.[11] We are in agreement with their conclusion that the longer test times are a result of increased difficulty in assessing patterns of looking behavior in nonnormal infants. The increased difficulty in testing nonnormal infants reflected by longer test durations does not, however, result in lower testability rates. As was also reported by Mohn and van Hof-van Duin, the testability rates for infants with visual disorders are similar to those found with normal subjects. One hundred percent of the infants in the current study completed two binocular and four monocular tests with the acuity cards.

The results of the current study are also in agreement with prior studies[1–5,11] which indicate that the procedure provides reliable and valid acuity estimates. Acuity card interobserver test–retest reliability was high: only 2 (of 60) monocular or binocular test–retest comparisons differed by more than 1.0 octave, and the estimates made by the two observers were highly correlated. In addition, agreement between acuity card and formal FPL estimates is high.

The remaining issue is that of potential observer bias. Controls against observer bias are built into formal FPL testing, but the subjective nature of the observer's judgments in the acuity card procedure leaves open the possibility that inflated interobserver reliability scores could be obtained if both observers had prior knowledge of the infant's age and clinical history. In the current study, these influences were minimized, in that the acuity card observers were clinically naive and blind to the infant's condition except for the unavoidable direct observation of obvious visual disorders. The sustained high interobserver acuity card agreement, and the agreement between FPL and acuity card estimates found in this study, militate against the argument that observer bias effects had a major influence on the results obtained.

In addition, we present examples of cases in which the patients' acuities were not predictable from direct observation of the patient; yet there was good agreement with predictions from knowledge of case histories. In these cases, good agreement between observers and across techniques was also sustained. Thus, there is evidence that the infant's responses to the acuity cards are robust enough to produce consistent estimates of acuity which are not primarily controlled by the a priori knowledge the observer brings to the test situation. Of course, future studies will be required to evaluate fully the effects of observer bias in diverse patient populations, test personnel, and circumstances.

In summary, the acuities of 20 infants with known or suspected ocular disorders were estimated using both the FPL technique and the acuity card procedure. The acuity cards provided relatively rapid monocular and binocular estimates of acuity in 100% of the patients. Excellent interobserver agreement, and agreement between FPL and acuity card estimates, support the reliability and validity of acuity card estimates in this clinical population. This interobserver and cross-technique agreement was sustained in clinical cases in which the acuity values obtained could not have been guessed a priori on the basis of the infant's visible symptoms. The results of the current study thus support the usefulness of the acuity card procedure for clinical assessment of infants with ocular disorders.

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