A behavioral method for efficient screening of visual acuity in young infants

II. Clinical application

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Visual performance in 130 infants was assessed in a clinical setting with the forced-choice preferential looking (FPL) method described by Dobson et al.5 Over 90% of infants completed testing. Testing usually required less than 10 min. One group of infants tested also underwent complete ophthalmic examination. The second, larger group was screened with handlight examinations and FPL testing; any abnormalities detected were evaluated by full ophthalmic examination. Results so far indicate that the FPL test accurately identifies babies with binocular visual problems and that, when coupled with a handlight examination, it provides efficient screening for ocular problems in infants 0 through 16 weeks of age (postten).

Key words: visual acuity, infant, behavioral method, clinical application

The plasticity of the developing visual system is now well recognized, and early attention to visual problems may improve a child’s chance for best possible visual outcome.1-4 A test which would assist personnel of pediatric clinics in identifying abnormal visual performance in infants might aid in appropriate referrals of infants who would benefit from early ophthalmologic attention. The Dobson and Teller behavioral method5 has features especially attractive for a clinical screening test. The apparatus is uncomplicated, compact, and portable; the test itself can be rapidly performed so that interference with established clinical activities is small.

We set out to use the forced-choice preferential looking (FPL) technique of Dobson and Teller to test infants’ vision in a clinical setting. Our experience is reported here. Ages given herein indicate postterm age. For example, an infant born after 36 weeks gestation and seen by us 7 weeks postnatal is considered 3 weeks old for the purposes of the FPL test.5-7

Methods

Patient populations. Two patient populations were tested by the FPL method.

Group A. This group consisted of 30 infants aged 0 through 16 weeks who had been referred directly to ophthalmologists at the Children’s Hospital Medical Center, Boston, because an ophthalmic problem had been identified or systemic findings had raised suspicion of an associated ophthalmic problem. These infants underwent full ophthalmic examination, including evaluation of ocular motility, fixation behavior, pupillary reactions, clarity of ocular media, cycloplegic retinoscopy, and indirect ophthalmoscopy.

Group B. One hundred infants, 0 through 16
FORCED CHOICE PREFERENTIAL LOOKING

NAME ____________________________  Hosp. No. ________  Date ________

AGE
post-natal age__________
post-term age__________  

MEDICAL HISTORY
post-natal age
post-term age

DIAGNOSTIC STRIPES

<table>
<thead>
<tr>
<th>conceptional age</th>
<th>test width stripes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7 wks.</td>
<td>20/800</td>
</tr>
<tr>
<td>8-11 wks.</td>
<td>20/600</td>
</tr>
<tr>
<td>12-16 wks.</td>
<td>20/400</td>
</tr>
</tbody>
</table>

OPHTHAL Fixation

RNS Media

Fundi

POSITION OF STRIPES IN WHEEL:

20/1600 always in position 1
Diagnostic ( ) in position ________

SCORE: + = observer's judgment correct
       o = observer's judgment incorrect

TRIAL  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
GRATING SIZE | 20/1600 | 20/1600 | 20/1600 | 20/1600 | 20/1600 | 20/1600 | 20/1600 | 20/1600 | 20/1600 |
POSITIONS  | R  | R  | L  | R  | L  | R  | L  | L  | R  | R  |
SCORE

TRIAL  | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
GRATING SIZE | D  | D  | 1600 | D  | D  | 1600 | D  | D  | D  | 1600 |
POSITIONS  | R  | L  | L  | R  | R  | L  | L  | L  | R  | R  |
SCORE

TRIAL  | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
GRATING SIZE | D  | 1600 | D  | 1600 | D  | 1600 | D  | D  | D  | 1600 |
POSITIONS  | L  | R  | R  | L  | L  | R  | L  | R  | R  | R  |
SCORE

TRIAL  | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
GRATING SIZE | 1600 | D  | 1600 | D  | 1600 | D  | D  | D  | 1600 | D  |
POSITIONS  | R  | L  | R  | R  | L  | R  | L  | L  | R  | R  |
SCORE

5/5 QUIT
7/8 QUIT
9/11 QUIT
11/14 QUIT

Total Correct: 20/1600

Diagnostic ( )

IMPRESSION:

Fig. 1. Sample scoresheet. Space was allowed to record relevant clinical data, including ophthalmic examination. The sequences of trials of wide 20/1600 control stripes and diagnostic test stripe widths (D) and left (L) and right (R) positions were quasirandom and varied from one infant to the next. The postterm age of the infant to be tested governed the diagnostic stripe width to be used; see text. The cutoff points (5/5, 7/8, 9/11, 11/14, 12/16, and 14/19) are indicated by arrows. For an alternate set of cutoff points, see Dobson et al.5

weeks of age, who were attending the Comprehensive Child Health Program, Children's Hospital, Boston, and who were not acutely ill, participated in the FPL test. In addition, these infants had handlight examination of ocular alignment and motility, pupillary reactions, and clarity of ocular media. A history of family eye problems was taken.

Test procedures. The same FPL test methods were used for groups A and B. The apparatus was exactly as described in the preceding article.5 It is composed of a gray screen with a small, inconspicuous peephole in the center and apertures to the right and left of the peephole where the stimuli, striped vs. homogeneous, are positioned. A holder keeps the infant approximately 31 cm from the screen (i.e., 36 ± 3 cm from the centers of the grating stimuli) for the trials; a small auxiliary screen positioned at the eye level of the holder.
Table I. Infants tested

<table>
<thead>
<tr>
<th>Diagnostic stripe</th>
<th>Group A: Full ophthalmic exam</th>
<th>Group B: Pediatric clinic</th>
<th>Groups A and B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Completed test</td>
<td>Did not complete test</td>
<td>Completed test</td>
</tr>
<tr>
<td>20/800 0 through 7 weeks</td>
<td>5</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>20/600 8 through 11 weeks</td>
<td>7</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>20/400 12 through 16 weeks</td>
<td>17</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>Totals</td>
<td>29</td>
<td>1</td>
<td>92</td>
</tr>
</tbody>
</table>

Total sample = 130 infants.

Table II. Infants completing test

<table>
<thead>
<tr>
<th>Diagnostic stripe</th>
<th>Group A</th>
<th>Group B</th>
<th>Groups A and B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Passed</td>
<td>Failed</td>
<td>Passed</td>
</tr>
<tr>
<td>20/800 0 through 7 weeks</td>
<td>4</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>20/600 8 through 11 weeks</td>
<td>7</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>20/400 12 through 16 weeks</td>
<td>15</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>Totals</td>
<td>26</td>
<td>3</td>
<td>85</td>
</tr>
</tbody>
</table>

Total sample = 121 infants.

prevents the holder from seeing the position of the grating stimuli. An observer watches the infant through the peephole. The experimenter can quickly rotate the disk in which the gratings and homogeneous fields are mounted to change the stripe width and right-left position of the stimuli presented to the infant.

The observer must judge the right vs. left position of the stripes based on the infant's looking behavior; the observer is provided with trial-by-trial feedback. One to two minutes is allowed for each trial, but it is rare that such long times are necessary to make the judgment. The entire FPL test is usually completed in less than 10 min and often under 5 min. The experimenters and holders were from the staff of the Ophthalmology Department. Observers were staff members or, in 54 out of 121 (45%) FPL tests completed, mothers.

Mothers have proved to be excellent observers because they are attentive and interested in their baby's behavior and naïve to sequence of trials and other test procedures. After a parent was shown the apparatus and the nature of the test was explained, the parent was seated behind the screen and invited to look through the peephole at the infant's eyes. Initially they were asked, "Which side does your baby like to look at more, right or left?" Trial-by-trial feedback was given: correct if the parent named the correct position of the stripes; wrong if the mother named the incorrect position of the stripes.

In practice, "warm-up" trials with wide (20/1600, or 80') control stripes are presented; at least five but up to 10 control trials are given to acquaint all participants with the procedure. Then trials of diagnostic test widths, with control trials interpolated to keep the baby interested, are given. Diagnostic stripe widths for clinical testing of infants were chosen using the normative data of Dobson et al.\(^3\) as guidelines. Stripes of 20/800 (or 40') are used for 0 through 7 weeks of age, ~20/600 (or 27') for 8 through 11 weeks, and 20/400 (or 20') for 12 through 16 weeks.

The quasirandom right or left position of the stripes was determined, and score sheets with a variety of sequences were made. An example of a scoresheet is shown in Fig. 1. The number of trials necessary to complete the test depended on how well the infant performs; infants were scored pass if they got 5/5, 7/8, 9/11, 11/14, 12/16, or 14/19 trials correct on the diagnostic stripes.\(^5\)

Results

The infants tested are tabulated in Tables I and II. To date we have used the FPL method to test 130. Nine of these (6.9%) did
Fig. 2. Results of FPL testing. The observer's percent correct is given by the ordinate and the stripe width used by the abscissa. Open circles plot the results of trials with 20/1600 control stripes, and the black circles indicate the results of trials with diagnostic stripe widths. The dotted line defines the lowest passing score, 75%; the dashed line represents the 50% chance level. A, Results of tests using 20/800 diagnostic stripes. Infants tested were 0 through 7 weeks of age. The numbers in brackets next to the points plotting the failing diagnostic scores indicate the individual infant whose failure is detailed in Table III. B, Results of tests using 20/600 diagnostic stripes. Infants tested were 8 through 11 weeks of age. There were no failing scores in this group. C, Results of tests using 20/400 diagnostic stripes. Infants tested were 12 through 16 weeks of age. The bracketed numbers indicate the individual infant listed in Table III.

not complete the test because of fussiness or sleepiness. Of the 121 infants completing the test, 111 passed the FPL test. Twenty-six in group A passed and were judged on the basis of full ophthalmic examination to have no ocular abnormalities that would interfere with vision. This means that no pupillary abnormalities, no opacification of the cornea or ocular media, no significant refractive error, and no abnormality of the fundus or optic nerve were revealed by full ophthalmic examination; also, motility and alignment were normal. Eighty-five from group B passed the test. One of these (tested at the age of 16 weeks) was esotropic but alternated freely and had approximately 23Δ of deviation, a smaller angle than often encountered in congenitally esotropic patients. On subsequent ophthalmologic evaluation, no other abnormalities could be found; history suggested that the esotropic deviation was intermittent. All other group B infants who passed the FPL test were without detectable abnormality of ocular alignment and motility or pupillary reactions, and all had clear red reflexes from both fundi.
Table III. Infants failing FPL vision test

<table>
<thead>
<tr>
<th>Infant No.</th>
<th>Postterm age* when tested (weeks)</th>
<th>Diagnostic stripes used</th>
<th>Correct on diagnostics (%)</th>
<th>Correct on 20/1600 trials (%)</th>
<th>Ophthalmic diagnosis</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>2</td>
<td>20/800</td>
<td>73</td>
<td>100</td>
<td>Disconjugate eye movements at initial FPL test; normal exam and passed</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>4</td>
<td>20/800</td>
<td>45</td>
<td>75</td>
<td>Left lateral rectus palsy</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>4</td>
<td>20/800</td>
<td>53</td>
<td>93</td>
<td>Myopia = –2.00</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>4</td>
<td>20/800</td>
<td>74</td>
<td>100</td>
<td>Exotropia handlight exam; no follow-up</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>5</td>
<td>20/800</td>
<td>70</td>
<td>90</td>
<td>Normal handlight exam; no follow-up</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>5</td>
<td>20/800</td>
<td>65</td>
<td>83</td>
<td>Exotropia</td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>7</td>
<td>20/800</td>
<td>64</td>
<td>82</td>
<td>Exotropia</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>12</td>
<td>20/400</td>
<td>72</td>
<td>100</td>
<td>Central cataracts, O.U.</td>
</tr>
<tr>
<td>9</td>
<td>A</td>
<td>13</td>
<td>20/400</td>
<td>50</td>
<td>38</td>
<td>Dense total cataracts, O.U.</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>16</td>
<td>20/400</td>
<td>70</td>
<td>93</td>
<td>Abnormal macula, R.E.; variant of PHPV, L.E.</td>
</tr>
</tbody>
</table>

*For definition, see text.

The 10 infants, three from group A and seven from group B, who failed the FPL test are listed in Table III. Ophthalmic examination revealed bilateral ocular abnormalities or abnormalities of motility and alignment in nine of these 10 patients. Two (Infants 8 and 9 in Table III) had bilateral cataracts. Five (Infants 1, 2, 4, 6, and 7 in Table III) had abnormalities of binocular cooperation including esotropia, exotropia, lateral rectus palsy, and disconjugate eye movements. One (Infant 3) had an unsuspected refractive error. The 2 D of myopia in Infant 3 seem a surprising cause for failure of the FPL test, since one would suppose the infant's accommodative range would be sufficient to overcome the myopic handicap. Perhaps this failure is explained by the significance of 2 D of myopia in a young infant; the normal infants studied had 1 to 2 D of hyperopia on cycloplegic retinoscopy, so Infant 3 could easily have been 4 D more myopic than the normal infants tested. Perhaps the cause of failure was not an ocular problem at all; Infant 3 had been prematurely born; respiratory and cardiovascular abnormalities had been recognized, and there is the possibility that there were other problems (e.g., involving the central nervous system) not yet identified at this early age. One infant (No. 10) had abnormalities of both globes. Another (Infant 5) had no problem discovered on handlight examination but failed to return for full ophthalmic examination. Thus this behavioral method of vision screening successfully identified patients with abnormalities of both eyes or abnormalities of binocular cooperation (strabismus).

Most babies who failed the FPL test scored 75% or better on the 20/1600 control stripes but scored less than 75% for trials with diagnostic stripe widths. The good performance on the 20/1600 trials likely indicated (1) that the baby was alert and otherwise able to do the test and (2) that vision, though diminished, was not severely compromised. An ex-
ception was Infant 9, who performed poorly on 20/1600 (score of 38%) and diagnostic (score of 50%) stripes; this infant had dense white cataracts in each eye; in an adult such opacities could account for "hand motions" or worse vision. With the strabismic infants, we suppose failures are due not to diminished acuity alone but to abnormal fixation patterns which confuse the judgment of the observer who is watching the infant through the peephole. The relatively poor scores on the 20/1600 control stripes achieved by strabismic Infants 2, 6, and 7 are consistent with this idea.

Finally, we note that the FPL screening test is a binocular test. So far it has not been effective as a monocular test, although we have tried patching some normal infants, strabismic infants (i.e., Nos. 7, 4, and 2), and one who had a definite eye preference (No. 10). Patching a preferred eye not surprisingly caused increased fussiness; patching a non-preferred eye or a normal eye appeared to distract these young infants too much for good performance on this behavioral test. But these difficulties were encountered in a clinical setting where our purpose was to screen vision quickly and not interfere with the primary purpose of the young patient's visit. In another situation, a few hours of patching prior to the test session to accustom the infant to the patch might allow monocular testing. Monocular rather than binocular testing would certainly be more helpful in following most ophthalmic treatments.

Discussion

Our observations to date indicate that the FPL screening test effectively identifies infants with binocular visual problems. Non-specialized personnel can use the FPL test to quantitate an infant's vision; this was previously impossible without complex equipment and highly trained personnel. The short time required to complete the test makes it acceptable to clinic personnel and to most infants (less than 7% did not complete the test because of fussiness), and parents enjoy participating as observers. Currently the FPL test complementing a skilled handlight examination would seem reasonable as a vision screening method for large clinic populations of infants. The abnormalities in Infant 3 and 10 would have escaped detection by handlight examination. A screening device which would help personnel of general pediatric clinics accurately identify infants with abnormalities of binocular cooperation would aid greatly in appropriate referral of such patients for ophthalmic care. So it would seem that the FPL screening test could fit usefully into the routine of a general pediatric clinic, perhaps becoming part of the examination of 2- and 3-month-old infants, an age when they are awake at longer intervals than newborns but not yet "bored" with the test.

Further experience with the FPL test in infants available for detailed ophthalmic examination may help us understand something more of what aspect of visual function must be intact for good performance on the present preferential looking task. A prospective study, which would in childhood reassess ophthalmic status and subjective visual acuity of the patients who had had ophthalmic examination and FPL testing in infancy, would be another means of evaluating the efficacy of the FPL method in identifying young patients with abnormal visual performance. Further laboratory developments to extend the clinically testable age beyond 4 months, to devise improved procedures for monocular testing of acuity, and to design clinical tests for other visual functions (e.g., color vision, light and dark adaptation) may lead to new and welcome methods of clinical evaluation of visual function in infants. Extensions to preschool and retarded children would also be most welcome.

We thank Drs. W. P. Boger, B. A. Petersen, and R. M. Bobb, Department of Ophthalmology, Children's Hospital, Boston, for allowing us to test their patients included in group A; and Dr. J. Levy of the Comprehensive Child Health Program, Children's Hospital, Boston, for access to patients included in group B. Gail Sinewitz, Libby Doonan, and Micheline Cignoli assisted in testing the babies.

REFERENCES


Errata

In the September, 1978, issue of the JOURNAL, in the article entitled "Different loci suggested to mediate tilt and spiral motion aftereffects" by Virginia A. Mann, the labels and legends for Figs. 2A and 2B should read STEREOACUITY (seconds of arc) instead of (minutes of arc). In addition, on page 906, right column, criterion for rejecting the Null hypothesis should read $-1.76 > t$ or $+1.76 < t$ instead of $1.76 > t > +1.76$. 