Visual Acuity Screening of Children 6 Months to 3 Years of Age

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The operant preferential looking (OPL) procedure allows a behavioral estimate of visual acuity to be obtained from children 6 mo to 3 yr of age. In clinical settings, there is often too little time available to obtain an acuity estimate with the standard OPL procedure. The goal of this study was to identify specific spatial frequencies, termed *diagnostic grating frequencies,* that could enable the OPL technique to be used as a screening procedure under conditions where completion of acuity estimation was not possible. One hundred eighty presumptively normal children, 6, 12, 18, 24, 30, and 36 mo of age, were each tested with up to 20 trials of a potential diagnostic grating frequency to determine the highest spatial frequency grating that could be resolved by 90% of children at each age. For all ages except 18 mo, there existed a spatial frequency that produced uniformly high OPL performance within the age group; this spatial frequency was separated by one-half to one octave from a higher spatial frequency that more than 30% of children at that age failed to detect. These results suggest that at all ages except 18 mo, it should be possible to use the OPL procedure as a vision screening tool by testing individual children with the diagnostic grating frequency appropriate for their age.
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The course of visual acuity development in normal infants less than 6 mo of age has been well described with preferential looking (PL) and forced-choice preferential looking (FPL) procedures (reviewed by Dobson and Teller[1]). With the addition of operant reinforcement to the preferential looking procedure, data on the acuity development of normal children in the 6-mo to 3-yr age range have also become available.[2–4] Thus, normative preferential looking acuity data are available over a wide age range and can be used for comparison with preferential looking acuity data from infants and young children who have suspected vision problems. Unfortunately, however, the binomial variability inherent in these discrete-trial procedures produces acuity estimates that are severely limited in accuracy unless the child is tested with a large number of trials.[5] Because the constraints present in many clinical situations do not allow time for a large number of trials, the use of standard PL procedures for acuity estimation may be restricted to the research laboratory.

Several years ago we developed a modified PL procedure, the FPL diagnostic grating procedure, for acuity screening of infants between 1 and 4 mo of age.[6] In this procedure, each infant is tested with enough trials to give a statistically meaningful result, but the trials are concentrated at one spatial frequency, that which has been empirically determined to be the highest spatial frequency that can be resolved by nearly all normal infants of a given age in a PL test. The procedure does not produce an actual acuity estimate, but it does provide a rapid screening method to determine whether or not an infant's acuity is within the normal range.

To determine the diagnostic grating frequencies for young infants, we tested 1-, 2-, 3-, and 4-month-old infants with several potential diagnostic grating frequencies.[6] Based on sequential binomial probabilities, we concluded ($P \leq 0.05$) that an infant could see a grating if the observer in the FPL procedure made a correct judgment on five of the first five, nine of the first 10, 13 of the first 15, or 15 of 20 trials with that grating. For all ages, there existed one spatial frequency that could be resolved by at least 90% of infants and an adjacent spatial frequency, one-half to one octave higher, that could be resolved by less than 70% of infants tested. Based on these results, we selected gratings of 0.75, 1.1, 1.5, and 1.5 cycles/deg as the

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diagnostic grating frequencies for 1-, 2-, 3-, and 4-month-olds, respectively.

The purpose of the present study was to extend the diagnostic grating acuity screening procedure by determining the diagnostic grating frequencies appropriate for children in the 6-mo to 3-yr age range. The PL procedure used was operant preferential looking (OPL), which has been shown to be an effective method for acuity estimation in this age range.[2,3]

Materials and Methods

Overall Strategy

The goal of the study was to determine for each age group the highest spatial frequency grating that could be resolved binocularly by at least 90% of children (i.e., the diagnostic grating for each age). Based on previous research,[3] a potential diagnostic grating frequency (the target grating frequency) was selected for each age group. The target grating frequencies were 4.6, 4.6, 9.1, 9.1, 18.7, and 18.7 cycles/deg for children aged 6, 12, 18, 24, 30, and 36 mo, respectively. Our strategy was to find the appropriate diagnostic grating frequency by a process of approximation. Initially, five children in each age group were tested with the target grating frequency. Based on these results, a second grating frequency was added for each age group, and children tested subsequently in each age group were assigned randomly to be tested with one of the two grating frequencies. The second frequency was one-half octave higher in spatial frequency if at least four of the five children tested at that age had performed significantly above chance on the target frequency, and one-half octave lower in spatial frequency if fewer than four of the five children had performed significantly above chance on the target frequency. For two age groups, 18 and 24 mo, a third spatial frequency had to be added because on neither of the first two spatial frequencies tested at those ages did nine of 10 children perform significantly above chance on the test grating.

Subjects

Subjects were solicited by letters sent to parents listed in the birth announcements section of local newspapers. Parents were paid $5 per session and reimbursed for parking or bus fare.

Subjects were 180 children who were born within ±10 days of their due date, and were tested within ±9 days of 6, 12, 18, 24, 30 or 36 mo postnatal. According to their parents' reports, they had no developmental abnormalities and no known visual defects. The refractive error of each subject was screened with isotropic photorefraction.[7] None of the subjects showed more than 2 diopters (D) of myopia on the horizontal meridian (the relevant meridian for the focus of vertical gratings). Ten subjects showed more than 1 D of oblique-axis astigmatism, and, therefore, their data were not included in the present report.

Apparatus

The OPL apparatus has been described previously.[2,3] It consisted of a gray cardboard screen (Crescent #651) with a 4-mm central peephole. Two 9-deg stimulus holes were located with their centers 18 deg to the right and to the left of the center of the peephole. Stimulus gratings were inserted in a masonite wheel attached to the back of the screen. By rotating the wheel, the spatial frequency and left–right position of the grating could be changed quickly between trials. A rectangular cardboard shutter, 15 × 36 cm with an opening in front of the peephole, covered the stimulus positions between trials. A series of light emitting diodes (LEDs) attached to the shutter was used to center the child's gaze at the beginning of each trial. A cardboard shield suspended 30.5 cm in front of the screen prevented the person holding the child from seeing the position of the grating. Two smoked plexiglas reinforcement boxes were located approximately 80 cm from the subject's eyes, one to the left and one to the right of the screen. Each box contained an animated toy that was activated when the observer correctly indicated the location of the grating, and at the observer's discretion during the training phase of the OPL procedure.

The stimuli were vertical black-and-white square-wave gratings printed on high contrast photographic paper (Intergraphics Precision Phototooling Services; Kirkland, WA). On each trial, one test grating and one control grating were presented. The control grating was subthreshold for adults (81.1 cycles/deg). The contrast of the gratings ranged from 82% to 84%, and they differed in space-average luminance by no more than 0.023 log unit from one another and by no more than 0.07 log unit from the luminance of the screen (1.2 log cd/m^2).[3]

Procedure

After the procedure was explained, informed consent was obtained from the parent. Then the child was seated alone or on the parent's lap with his or her eyes 54 ± 3 cm from the peephole. An adult observer was seated behind the screen and viewed the child's face through the peephole. An adult experimenter, seated beside the observer, rotated the stimulus wheel to position the stimuli, set the reinforcement device so that a correct judgment by the observer

would activate the appropriate reinforcer, and recorded the observer's judgments.

The procedure consisted of three phases: training, criterion, and the diagnostic grating test phase. Initially, the observer attempted to train the child to look at or point to a low spatial frequency grating to activate the reinforcer. The specific low frequency gratings for each age were 1.1, 1.1, 2.2, 2.2, 4.6, and 4.6 cycles/deg for 6-, 12-, 18-, 24-, 30-, and 36-month-olds, respectively. During training the shield was raised to allow the parent to see the stimulus positions and help the child learn the task. The observer was also aware of the position of the grating and told the experimenter where to place the grating on each trial. Training trials were repeated on each side and alternated from side to side, as appropriate, to counteract the individual child's natural response tendencies (alternation, side preference, etc). Training continued until the observer judged that the child was showing a consistent response (looking, head-turning, or pointing) to the grating from trial to trial.

The next phase of testing, the criterion phase, was an objective test of whether or not the child was responding reliably to the low frequency grating used during training. During this phase the observer was unaware of the position of the grating on each trial and the shield was lowered so that the parent could not see the stimulus positions. The right–left position of the grating was varied according to a pseudorandom order from trial to trial and the observer pressed a button to indicate whether she judged the stimulus to be on the left or right on each trial. If the observer pressed the correct button, the animated toy on the same side as the grating was activated. Testing continued until one of the following criteria was met: six of the first six trials, eight of the first nine trials, 10 of the first 12 trials, or seven in a row correct. The cumulative probability of meeting one of the first three criteria by chance is less than 0.05. The criterion of seven in a row correct was included to allow for additional training to occur in those cases where the observer had misjudged the timing of the move from training to the criterion phase.

When the observer met one of the four criteria described above, the test phase began. As in the criterion phase, both observer and parent were unaware of the left–right position of the grating, the location of the grating was varied from trial to trial according to a predetermined pseudorandom order, and the observer's task was to use the child's response as an indicator of grating location. In this phase, however, a potential diagnostic grating was used as the test grating. Testing continued until the observer judged the location of the potential diagnostic grating correctly on six of the first six, nine of the first 10, 13 of the first 15, or 15 of 20 trials, or until the child became uncooperative. The probability of meeting one of the four cutoff criteria is less than 0.05 (sequential binomial probabilities).

After each incorrect response, a trial with the low frequency grating used during the training and criterion phases was inserted. If an incorrect response was given to the low frequency grating, one to two more trials with that grating were presented, and the observer was required to get at least one of these trials correct to allow testing to continue. Also, if the total number of incorrect responses to the low frequency grating reached three at any time during the test phase, testing was discontinued. Thus, the ability of the observer to judge the location of the grating on trials with the low frequency grating was used to indicate whether poor performance on the potential diagnostic grating was due to the inability of the child to see the grating or to a general decline in the child's performance in the test situation.

Results

Diagnostic Gratings

For each child the percents correct scored by the observer on the potential diagnostic grating and on the low spatial frequency grating are shown in Figure 1. Percent correct on the low frequency grating was calculated by combining the observer's percent correct during the criterion phase and the observer's percent correct on trials in which the low frequency grating was presented during the test phase. The one 18-month-old and two 24-month-olds who showed performance below 75% on the low spatial frequency grating all showed performance above 75% on the potential diagnostic gratings with which they were tested.

In our previous study,[6] we found that for all ages tested there existed one spatial frequency that (1) could be resolved by at least 90% of infants tested; and (2) was separated by one-half to one octave from another higher spatial frequency that could be resolved by less than 70% of infants tested. Examination of Figure 1 shows that this was also true for all but one of the ages tested in the present study. For 6-, 12-, 30-, and 36-month-olds, the spatial frequency resolved by 90% of children tested was separated by one-half octave from the spatial frequency resolved by less than 70% of children tested, while for 24-month-olds, the two spatial frequencies that met these criteria were separated by one octave. For 18-month-olds, there was no spatial frequency resolved by 90% of children tested, not even the 4.6 cycles/deg grating that was resolved by 95% of the 6- and 12-month-olds tested with that spatial frequency.

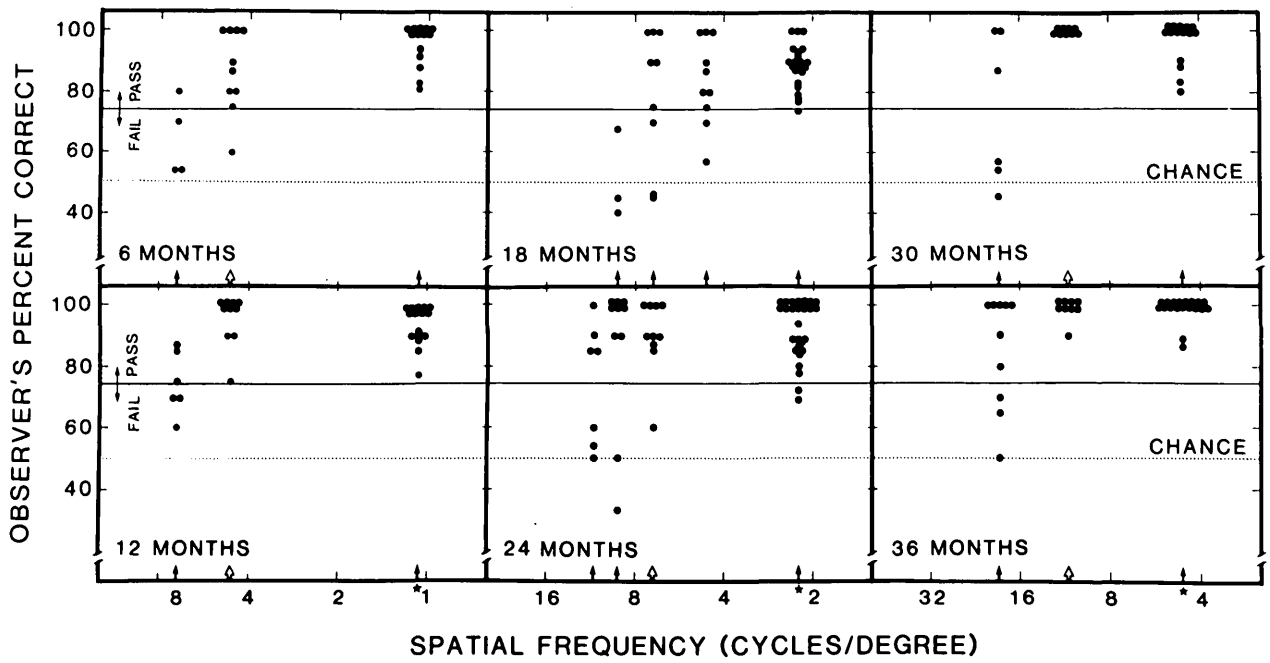

Fig. 1. Observer's percent correct as a function of spatial frequency at 6, 12, 18, 24, 30, and 36 mo. Arrows indicate actual spatial frequencies used. The low spatial frequency gratings used during training, criterion and testing at each age, shown by the starred arrows, were 1.1, 1.1, 2.2, 2.2, 4.6, and 4.6 cycles/deg for 6-, 12-, 18-, 24-, 30-, and 36-month-olds, respectively. At each age, each child contributed two data points to the graph, one point at the lowest (starred) spatial frequency and one point at one of the higher spatial frequencies. Observer's scores of 6/6, 9/10, 13/15, or 15/20 were counted as a "pass." The diagnostic grating frequency (i.e., the highest spatial frequency on which 90% of children obtained a passing score) was estimated to be 4.6, 4.6, 6.9, 11.1, and 11.1 cycles/deg at 6, 12, 24, 30, and 36 mo, respectively, as indicated by the open arrows in the figure. A diagnostic grating frequency could not be defined for 18-month-olds.

Based on these results, we estimated the diagnostic grating frequencies to be 4.6, 4.6, 6.9, 11.1, and 11.1 cycles/deg for 6-, 12-, 24-, 30-, and 36-month-olds, respectively. These values are listed in Table 1, along with the previously established[6] diagnostic grating frequencies for 1- to 4-month-old infants tested with the FPL procedure. We were unable to use the results of the 18-month-olds to estimate a diagnostic grating frequency for that age, according to our criteria for selection of a diagnostic grating frequency.

Table 1. Diagnostic grating frequencies

Age (mo)	*Procedure*	*Diagnostic grating (cycles/deg)*
1	FPL	0.75
2	FPL	1.1
3	FPL	1.5
4	FPL	1.5
6	OPL	4.6
12	OPL	4.6
18	OPL	?
24	OPL	6.9
30	OPL	11.1
36	OPL	11.1

Success Rates

Table 2 shows the number and percentage of children who were tested successfully, and the number and percentage of children who failed to complete the test during the initial training period and during the test phase with the potential diagnostic grating. It is clear from the table that the most difficult ages to test were 18 and 24 mo. It is also clear from comparison of the two rightmost columns in Table 2 that the majority of children who did not complete testing at these ages were untestable because they did not learn the task or perform the task well enough to allow the observer to complete the criterion phase of the procedure.

Test Duration

The mean and standard deviation of the time required at each age to complete all phases of testing—training, criterion, and testing with the potential diagnostic grating—are shown in Table 3. At all ages, the mean test time averaged less than 30 min, and those children who passed the test (ie, those children for whom the observer's performance met one of the

Table 2. Success rates

Age (mo)	Total subjects n	Complete tests n	Complete tests (%)	Incomplete during training and criterion n	Incomplete during training and criterion (%)	Incomplete after training and criterion n	Incomplete after training and criterion (%)
6	17	14	(82)	1	(6)	2	(12)
12	16	16	(100)	0	(0)	0	(0)
18	47	22	(47)	15	(32)	10	(21)
24	53	27	(51)	17	(32)	9	(17)
30	17	15	(88)	2	(12)	0	(0)
36	20	19	(95)	1	(5)	0	(0)

criteria of 6/6, 9/10, 13/15, or 15/20 trials correct) required less time than children who failed (six incorrect responses by the observer) or did not complete the test.

Discussion

The results of the present study suggest that it is possible at most ages to define a maximum (diagnostic) spatial frequency that will allow above-chance performance by most children with presumptively normal visual acuity tested in the OPL procedure. For the 6-, 12-, 30-, and 36-month-olds tested in the present study, the spatial frequency designated later as the diagnostic grating frequency produced uniformly high percents correct in the OPL task, while a spatial frequency one-half octave higher produced percents correct no different from chance in many of the presumptively normal infants. Thus, the diagnostic grating frequency was easy to specify for these four ages.

For 24-month-olds, the designated diagnostic grating frequency was separated by one octave from the spatial frequency that produced poor performance by at least 30% of infants at that age, and the spatial frequency midway between these two grating frequencies produced above-chance performance by 80% of the 24-month-olds tested. Thus, the appropriate diagnostic grating frequency at 24 mo was less well defined than at 6, 12, 30, or 36 months. The somewhat ambiguous performance by 24-month-olds is probably due to the frequent lack of cooperation of children in this age group, as is also reflected in the relatively low success rate for 24-month-olds shown in Table 2.

For 18-month-olds, there was no spatial frequency for which at least 90% of the group showed above-chance performance. This is almost certainly due to the lack of cooperation of the 18-month-olds, since only 80% of children at this age showed above-chance performance at the spatial frequency (4.6 cycles/deg) at which 95% of 6- and 12-month-olds produced above-chance performance.

As shown in Table 3, the mean time required to complete the procedure ranged from 29 min for 12-month-olds who failed the potential diagnostic grating to 6 min for 36-month-olds who passed the potential diagnostic grating. Since testing with the potential diagnostic grating required only six to 20 trials, the primary cause of the variation in total test duration was the amount of time required to teach the child the task required for OPL testing. Therefore, the best way to shorten the procedure would be to reduce the number of trials preliminary to testing with the diagnostic grating. One of us (Dr. Mayer), in using OPL for clinical assessment of visual acuity, has found that for most infants and children, only six

Table 3. Total time for testing (training, criterion, and diagnostic grating phases combined)

Age (mo)	Passed* Mean (min)	Passed* sd	Passed* n	Failed† Mean (min)	Failed† sd	Failed† n	Incomplete Mean (min)	Incomplete sd	Incomplete n
6	15.1	6.5	10	18.0	2.4	4	21.0	15.6	3
12	14.2	8.2	13	29.0	11.5	3	—	—	0
18	14.9	7.1	14	18.1	3.7	8	17.8	10.5	25
24	11.3	4.8	21	20.8	5.9	6	17.7	5.2	26
30	8.3	4.8	12	12.3	4.0	3	16.0	5.7	2
36	6.0	2.5	16	12.7	5.9	3	10.0	—	1

Sd: standard deviation.
* Observer's correct judgments = 6/6, 9/10, 13/15, or 15/20.
† Observer's incorrect judgments ≥ 6.

to eight training trials and no criterion trials are necessary prior to acuity testing.

Now that we have determined diagnostic grating frequencies for 6-, 12-, 24-, 30- and 36-month-olds we can ask, how would one implement the procedure in a clinical setting? We foresee two types of clinical situations in which the diagnostic grating procedure would be useful. First is the situation in which one is interested in large-scale screening, where the purpose is to identify children with poorer-than-normal visual acuity and to refer them for more extensive testing. We have not yet used the OPL diagnostic grating procedure for mass screening, but preliminary results with the FPL diagnostic grating procedure suggest that the procedure is potentially useful as a screening tool.[8,9] The second situation in which the diagnostic grating procedure could be useful is the situation that exists when one does not know at the outset of testing whether a child will complete enough trials to produce an acuity estimate with one of the standard FPL procedures for estimating acuity threshold. In this case, the diagnostic grating procedure can be used sequentially with gratings of several spatial frequencies to provide, first, an estimate of whether a child is blind, then a decision concerning whether a child's acuity is within the normal range, and, finally, an estimate of acuity that becomes more and more refined the longer the child cooperates.[10]

What is the advantage of the diagnostic grating procedure over other preferential looking procedures that have been used clinically? In addition to the diagnostic grating procedure, three other preferential looking procedures have been used for the assessment of visual acuity in infants and young children with vision disorders.[11-13] Each of the three uses a different staircase procedure to produce an acuity estimate. At first glance, these staircase procedures might seem more attractive than the diagnostic grating procedure to the clinician because, regardless of how many trials are completed, the staircase procedures produce a single number that gives an estimate of the child's acuity threshold. On the other hand, when small numbers of trials are used, the diagnostic grating procedure produces only a statement concerning whether or not the child's acuity is within the normal range. Unfortunately, however, the sense of accuracy produced by the results of staircase procedures when small numbers of trials are used is a false one. Statistically, the standard error of estimation of visual acuity will be larger the smaller the number of trials used. For example, if the standard deviation of the child's psychometric function is one octave, then an acuity estimate resulting from 20 trials, a common occurrence with two of the staircase procedures,[11,12] has a confidence interval of about ±1.5 octaves at best. This means, for example, that although the results of a 20-trial staircase procedure may yield a nominal acuity estimate of 20/140, in fact, all that the staircase procedure has shown is that the child's acuity is between 20/50 and 20/400. On the other hand, 20 trials with the diagnostic grating procedure is often enough to allow one to conclude with certainty that a child's acuity is within the normal range.* Thus, the advantage of the diagnostic grating procedure over staircase procedures is that when it is possible to obtain only a small number of trials from a child (eg, due to constraints on an experimenter's time or lack of cooperation from a child), the diagnostic grating procedure allows one to conclude whether acuity is within the normal range, whereas staircase procedures only allow one to conclude that acuity is somewhere within a several-octave range, which may include values outside the normal acuity limits for the child's age.

In summary, the goal of the present study was to identify single grating frequencies that could be used as indicators of whether or not a child's performance was within the normal range on an OPL acuity task. For 6-, 12-, 30-, and 36-month-olds, there was a clearly-defined highest spatial frequency that could be detected by at least 90% of infants at each of those ages, and this spatial frequency was designated as the diagnostic grating frequency for each age. For 24-month-olds, the diagnostic grating frequency was less well defined, and for 18-month-olds it was not possible to use our specific criteria to designate a diagnostic grating frequency. Similarly, the percentage of 6-, 12-, 30-, and 36-month-olds who completed testing ranged from 82% to 100%, while the success rates for 18- and 24-month-olds were considerably lower, due primarily to the difficulty of teaching children of this age the response required in OPL testing, and to our inability to maintain their interest in the task.

Although obstacles remain that limit the usefulness of the OPL procedure with 18- and 24-month-olds, it is clear that use of the diagnostic grating procedure should significantly increase the usefulness of OPL testing. For example, in situations where time is too limited to obtain the full number of trials required for acuity estimation, the diagnostic grating procedure allows a statistically meaningful estimate of whether

* To provide an acuity value rather than simply a statement that the child's acuity is within the normal range, the child who passes the diagnostic grating appropriate for his or her age can be assigned the mean acuity value for normal children of that same age. This assigned acuity value will be as accurate an estimate of the child's true acuity as the acuity value obtained from a staircase procedure employing a small number of trials.[5]

or not a child's acuity is within the normal range. In addition, in situations where it is unclear whether a child will remain cooperative through a longer procedure, the diagnostic grating procedure allows the examiner to establish first whether the child's acuity is within the normal range, and then, by testing the child with other spatial frequencies sequentially, according to the criteria for pass and fail used with the diagnostic gratings, to define the child's actual acuity threshold as accurately as time allows.[10]

Key words: acuity screening, infants, children, operant preferential looking, grating acuity

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References

1. Dobson V and Teller DY: Visual acuity in human infants: a review and comparison of behavioral and electrophysiological studies. Vision Res 18:1469, 1978.
2. Mayer DL and Dobson V: Assessment of vision in young children: a new operant approach yields estimates of acuity. Invest Ophthalmol Vis Sci 19:566, 1980.
3. Mayer DL and Dobson V: Visual acuity development in infants and young children as assessed by operant preferential looking. Vision Res 22:1141, 1982.
4. Birch EE, Gwiazda J, Bauer JA Jr, Naegele J, and Held R: Visual acuity and its meridional variations in children aged 7–60 months. Vision Res 23:1019, 1983.
5. Teller DY: Measurement of visual acuity in human and monkey infants: the interface between laboratory and clinic. Behav Brain Res 10:15, 1983.
6. Dobson V, Teller DY, Lee CP, and Wade B: A behavioral method for efficient screening of visual acuity in young infants. I. Preliminary laboratory development. Invest Ophthalmol Vis Sci 17:1142, 1978.
7. Howland HC, Braddick O, Atkinson J, and Howland B: Optics of photorefraction: orthogonal and isotropic methods. J Opt Soc Am 73:1701, 1983.
8. Fulton AB, Manning KA, and Dobson V: Infant vision testing by a behavioral method. Ophthalmology 86:431, 1979.
9. Sebris SL, Dobson V, and Hartmann EE: Assessment and prediction of visual acuity in 3- to 4-year-old children born prior to term. Hum Neurobiol 3:87, 1984.
10. Dobson V: Clinical applications of preferential looking measures of visual acuity. Behav Brain Res 10:25, 1983.
11. Gwiazda J, Wolfe JM, Brill S, Mohindra I, and Held R: Quick assessment of preferential looking acuity in infants. Am J Optom Physiol Opt 57:420, 1980.
12. Mayer DL, Fulton AB, and Hansen RM: Preferential looking acuity obtained with a staircase procedure in pediatric patients. Invest Ophthalmol Vis Sci 23:538, 1982.
13. Atkinson J, Braddick O, and Pimm-Smith E: "Preferential looking" for monocular and binocular acuity testing of infants. Br J Ophthalmol 66:264, 1982.