Pediatric eye exam for the primary care practitioner

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Pediatric Eye Exam for the Primary Care Practitioner

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Pediatric Eye Exam for the Primary Care Practitioner

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Biographies

Steven Odland grew up in small-town North Dakota and graduated from Minot High School in 1985. He earned a Bachelor’s of Science degree in Communications from Ohio University, Athens in 1989. Upon graduation, he spent four years hiking and working in western Washington State before returning to school in 1995 to begin pre-requisite courses for optometry at the University of Minnesota, Twin Cities. In 1998, he moved to New Mexico to resume backpacking and continue pre-requisite coursework at the University of New Mexico. He entered the Doctor of Optometry program at Pacific University in 2003 where he continues his coursework.

Linsey Olivier received her high school diploma from Hemet High School in California. There she was part of the National Honor Society and graduated with honors. She then received a Bachelor of Vision Science through the combined degree from Pacific University and University of California, San Diego in 2003. She is currently working on her final year at Pacific University College of Optometry for her Doctorate of Optometry.

Brock Wren graduated from Blackfoot High School in Blackfoot, Idaho. There he was a member of the National Honor Society. He then received a Bachelor of Science in Biology from Idaho State University where he was also a member of Mortar Board national honor society. Currently, he is working on his Doctorate of Optometry at Pacific University College of Optometry and is a member of Beta Sigma Kappa International Optometric Honor Society.
Pediatric Eye Exam for the Primary Care Practitioner

Pediatric Case History

A comprehensive case history is important for infants and toddlers as it can isolate a problem even before any testing is completed.

Chief complaint: is a statement from the patient or parent describing the symptom, problem, condition, diagnosis or other reason for the encounter. Location, quality, severity, duration, timing, context, modifying factors and associated signs and symptoms are all important elements.

Developmental history: Developmental history, which is not typically included in an adult history, is very important for an infant and toddler case history.

The first area the examiner should ask questions about is the mother’s pregnancy. Several questions to ask are:

- Did the mother have prenatal care?
- Did she have any illness with associated fever, infection, or bleeding?
- Did she suffer any physical trauma?
- Was the mother taking any drugs, alcohol or medication?
- Did the mother have high blood pressure or pre-eclampsia?
- Did she have any weight loss or excessive weight gain?
- Were there RH factor differences?
- Was the gestation period longer or shorter than expected?
- Was this the mother’s first pregnancy? If not how many other children does she have?
- Has she had any miscarriages in the past?

Labor and delivery: Several key areas to ask questions about:

- Was the birth natural? If not what type of anesthetics were used? Was the delivery done by caesarian and why?
- Was the labor difficult and how long did labor last?
- Did her membrane rupture spontaneously or was it done by physician?
- Were forceps used?
- Were there any other complications?

Newborn’s health after birth: This area can give insight into the child’s overall health, future problems, and developmental progress.

- What was the child’s weight and length at birth?
- Does the mother remember the child’s APGAR score (Activity, Pulse, Grimace, Appearance, and Respiration)? A score of 7-10 is considered normal, while 4-7 might require some resuscitative measures, and a baby with 3 and below requires immediate response.
- Did the child require oxygen, resuscitation, or an incubator?
- Was the child given any special drugs or medication?
- Did the child have jaundice?
- Were there any congenital defects?
- Was the child able to go home with the mother? If not, why?

**Infancy:**
- Is the baby under the care of a pediatrician?
- Was the child breast fed or bottle fed?
- Did the child have a normal sucking and swallowing reflex?
- Did the child sleep well?
- Did the child have normal bowel movements?
- It is also important to ask about overall health and if the child suffered from any illnesses noting age, severity, and treatment.

**Gross motor development:**
- When did the child roll over?
- When did the child crawl and how long?
- When did the child start to walk and at what age was the child able to walk alone?
- Did the child have any difficulty with crawling or walking?
- Does the child have a hand preference? Has it changed?
- A good way to gauge development is to ask parent if they feel their child's development was/is similar to other healthy siblings. If they have no siblings ask the parent if the child does motor activities that other similar age children can do (i.e. tie shoes).

**Speech and hearing:**
- When were the child’s first words?
- Can the child speak two-word sentences?
- Three-word sentences?
- Does the child have speech problems?
- Does the child understand verbal commands?
- Does the child have reversals of spoken words, syllables or words in a sentence?
- Did the child have chronic ear infections, sinus infections, or tubes put in ears?

**Social and Emotional Questions:**
- Does the child have any habits such as thumb sucking, temper tantrums, rubbing eyes, grinding teeth, banging head, etc.?
- Is the child shy or hyperactive?
- A developmental delay may be present if the child cannot: walk by 18 months, does not speak 15 words or more by 18 months, does not use two-word sentences by age 2, or can't follow simple instructions by age two.1

**Family medical history:** Gathering a complete and accurate family medical history is becoming more important as genetic medicine explains more diseases. Conditions that are important to note in an infant/toddler exam are family history of cerebral palsy, reading problems, mental retardation, epilepsy, seizures, birth defects, and allergies.
Personal ocular history: To evaluate the visual system, there are several questions you should ask the parent:

- Has the child ever had an eye infection, injury, or surgery?
- Does the parent notice an eye turn? If so, what direction?
- Does the child get “fussy” when one eye is covered but not the other?
- Does the child recognize you when you enter the room?

Neurological health and gross anatomical features: Practitioners should also make general observations about the child’s neurological health as well as their gross anatomical features.

- Does the child’s head look symmetrical; is the child’s head circumference within normal range?
- Are the orbits round and equal in size?
- Do the eyes look normal in size or do you suspect macro- or micro-opthalmia?
- Does the child have normal epicanthal folds, eye lids, and eyelashes? Do the tears appear to be draining?
- Does the tear layer look normal?
- Is any discharge present?
- Do the irises look equal in color and texture?
- Do the eyelids open and close normally, indicating that cranial nerves 3, 7 and levator are working properly?
- Do the eyes fixate and follow light, indicating that cranial nerves 2, 3, 4, and 6 are working properly?
- When air is puffed onto cornea does child have appropriate blink response (CN 5)?

Family ocular history: Many childhood eye conditions run in families thus it is important to ask about any family history of strabismus, amblyopia, high refractive errors, or learning disabilities.

While there is seemingly more information to be gathered during an infant/toddler exam compared with an adult exam, it must be noted that this information is very valuable. Considering the fact that much of the infant/toddler exam is objective, a comprehensive case history can allude to or reveal your diagnosis.

Vision Testing

Measuring visual acuity can help to direct your exam and insure the child is seeing at an age-appropriate level. A major difficulty when doing visual acuities with infants or any pre-verbal child is their inability to recognize symbols and respond appropriately. There are many ways around this problem, including preferential looking, fixation preference, visually-evoked response (VER), and many others. All tests are easier to perform at near than at distance.

Preferential looking tests

Testing is based on evidence that infants will prefer to look at high contrast black and white patterns rather than non-visually stimulating gray targets. Preferential looking tends to overestimate Snellen acuity by a magnitude of 2–3, because the child is not required to identify target but instead just to detect its presence. Preferential looking acuity can be converted to a
Snellen value; however, this does not mean the same child would be expected to achieve an identical value on a letter reading test.

**Preferential looking tests (Ages 0–2)**

Teller acuity card testing: This preferential-looking procedure works by presenting a card, half of which has a set of vertical black-and-white high contrast gratings of varying spatial frequencies and the other half that has a uniform gray luminance-matched background (fig. 1). In the center of the card is a hole through which the examiner can observe the child's fixation.

Teller cards measure grating acuity from 1 cyc/deg (20/2300) to 30 cyc/deg (20/20). Visual acuity for a newborn should be approximately 1 cyc/deg, 3 cyc/deg at 3 months, 6 cyc/deg at 6 months, 12 cyc/deg at 12 months, and should reach 30 cyc/deg by 3–5 years of age. The test can be performed at 38cm, 55cm, and 84cm. The graph shows typical visual acuity (near) for infants and toddlers using Teller PL cards:

![Figure 1. Teller acuity cards](image)

**Graph 1. Age norms for teller acuity cards**
LEA Gratings are another very popular preferential looking test. This grating acuity test is presented using two paddles. A paddle with a striped pattern is held up simultaneously with another paddle with a uniform gray background of the same size and luminance (fig. 2). The examiner observes child's fixation and determines the acuity level.

The test is normally performed at 2 ft (57 cm); however, the paddles can be moved to different distances. On each grating paddle the frequency of the grating is given as cycles per centimeter (cpcm). At 57 cm, 1 centimeter equals 1 degree of visual angle. Thus, at 57 cm the cpcm printed on the paddle is equal to the cyc/deg. For example, at 57 cm, the 0.5 cpcm paddle is equal to 0.5cyc/deg. The number of cycles per degree decreases when the paddle is brought closer. The following table has cyc/deg values calculated for common distances.

![Figure 2. Lea Gratings](image)

**Grating Acuity Reported in Cycles Per Degree**

<table>
<thead>
<tr>
<th>DISTANCE IN CM (INCHES)</th>
<th>CYCLES PER CENTIMETER (cpcm): PRINTED ON PADDLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 cm (7.8”)</td>
<td>1.0 cpcm</td>
</tr>
<tr>
<td>25 cm (9.8”)</td>
<td>0.8 cpcm</td>
</tr>
<tr>
<td>30 cm (11.8”)</td>
<td>0.6 cpcm</td>
</tr>
<tr>
<td>35 cm (13.8”)</td>
<td>0.5 cpcm</td>
</tr>
<tr>
<td>40 cm (15.8”)</td>
<td>0.4 cpcm</td>
</tr>
<tr>
<td>45 cm (17.8”)</td>
<td>0.3 cpcm</td>
</tr>
<tr>
<td>50 cm (19.7”)</td>
<td>0.2 cpcm</td>
</tr>
<tr>
<td>55 cm (21.7”)</td>
<td>0.1 cpcm</td>
</tr>
</tbody>
</table>

![Table 1](image)

**Preferential looking tests (Age 1-3):**

The Cardiff acuity test is a type of preferential looking that uses "disappearing" optotypes such as a dog, fish, train that are vertically displaced on cards (fig. 3). The targets are presented on a gray background and are drawn using a white line bordered by two black lines. The targets are all the same overall size but the size of the white and black lines decrease with increasing acuity.

The examiner presents the cards at 50 cm or 1 m (although it can be recalculated for any distance) and watches the eye movements of the child to determine whether the child can see the target. Final acuity level (endpoint) is taken when at

![Figure 3. Cardiff cards](image)
least two out of three responses are correct. The standard deviation is one octave above or below expected value. Norms for Cardiff Acuity cards are as follows:

<table>
<thead>
<tr>
<th>Age</th>
<th>Acuity (min of arc)</th>
<th>Snellen (meters)</th>
<th>Snellen (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12–17 months</td>
<td>8–2</td>
<td>6/48–6/12</td>
<td>20/160–20/40</td>
</tr>
<tr>
<td>18–23 months</td>
<td>4–1.25</td>
<td>6/24–6/7.5</td>
<td>20/80–20/25</td>
</tr>
<tr>
<td>24–29 months</td>
<td>2.5–1.25</td>
<td>6/15–6/7.5</td>
<td>20/50–20/25</td>
</tr>
<tr>
<td>30–36 months</td>
<td>2–1</td>
<td>6/12–6/6</td>
<td>20/40–20/20</td>
</tr>
</tbody>
</table>

Table 2. Norms for Cardiff Acuity cards

VER Acuity test (Age 0–adult): Evaluates the function of the neural visual pathways from the retina, along the optic nerve and optic tract, to the visual centers of the brain. EEG electrodes are placed on the head and the patient is shown a flashing light and an alternating pattern on a screen. It should be noted that is an objective test and only gives information about the input path. This is a test is rarely used by the private practitioner because it is expensive, is time consuming, and has limited availability.

Typical visual acuity for different age groups using VER:

1 month ~20/540
2 months ~ 20/150 to 20/300
3 months ~ 20/80 to 20/100
4 months ~20/40 to 20/80
5 months ~ 20/30 to 20/50
6 months ~ 20/20

LEA Symbols (18 months and up): This test is based on the principle that a visual acuity test should include symbols that blur equally, are equivalently spaced, and have the same number of test items per acuity level. The Lea symbols are designed so that when the child can no longer recognize the symbols, they all begin to look like circles or rings. The symbols require limited language skills and have kid-friendly shapes (fig. 4).

Distance LEA charts are calibrated for 10 feet and the near charts are 40 cm. The charts use a logMAR scale. The cards should be presented one by one in order of decreasing symbol size. The child responds by naming or matching. The next step is to present two cards to the child and perform the "two alternative forced choice" technique. Use one of the following pairs of cards: circle/apple, house/square, circle/house. The child is then asked to indicate the location of the specified card (i.e. house). This test is often used at a distance other than 3 meters (10 feet). Measure and record the viewing distance and the symbol size (the M value) or the visual acuity value printed on the card with the smallest symbols identified correctly.

Figure 4. Lea Symbols
To determine the visual acuity use one of the following formulas:

\[
1. \quad VA = \frac{\text{Viewing Distance Used (meters)}}{\text{M-value}}
\]

OR

\[
2. \quad VA = \frac{\text{Viewing Distance Used (meters or feet)}}{3 \text{ meters (10 feet)}} \times \text{VA value for 3 meters (10 feet)}
\]

Formula 1. Visual acuity formula

If you do not want to do the calculations simply record the acuity as the M value at the viewing distance.

**Bock candy bead test (ages 10–24 months; near only):** Candy beads (cookie/ cake decorations) are used to estimate near visual acuity (fig. 5). The test is performed by presenting a small candy bead in one hand while leaving the other empty. The patient is then persuaded to pick up the candy. Operant conditioning can be used by giving the child candy for each correct response.

**Bailey-Hall cereal test (ages 2–4):** Bailey-Hall cereal test is performed by showing the child two cards one with a picture of a Cheerio-like cereal and the other a square (fig. 5)

![Figure 5. Bailey-Hall Cereal Test (left) and Candy Bead Acuity Test](image)

There are several sets of cards at different acuity levels. The test is forced choice and the child must indicate which card is the cereal card by looking, touching, or naming. Operant conditioning can be used by giving the child some cereal for each correct response.
Lighthouse symbol cards (ages 2–3): During the test, the child is asked to name, touch, or match the picture on the card (i.e. house) to the one which the doctor holds up. The smallest figure identified or matched indicates level of acuity.

The visual acuity range is 20/10 to 20/100 and the distance chart is calibrated for 10 feet, however a near card is also available. A good tip for doing distance acuity with the lighthouse cards is to first do them at near to confirm the child knows how the test works. It should be noted that the acuity found with this test may overestimate true acuity due to blur interpretation.

Broken wheel (age 3–up): This is a forced choice test that uses the Landolt C in its design. The child is asked to look at the two cards at a distance of ten feet. One card has a picture of a car with full rings for wheels and the other has a picture of the car with “broken” wheels (fig.7).

The child is then asked to point out the car with the “broken wheel” (recognition of the gap in the ring). Responses can be made by pointing or simply in the direction the child's eyes are looking. The smallest wheel in which a gap can be identified or matched indicates the level of acuity.

Tumbling E and Hand Charts (ages 4–5, 50% respond at 48 months): The Tumbling E chart features a capital E facing up, down, left, and right. The child is asked to indicate the direction the legs of the E by pointing in the same direction with their own fingers. The hand chart shows a hand facing up, down, left, and right. The test is performed by asking the child to indicate the direction of the hand. The tests should be performed at distance and at near. The acuity level found is comparable to Snellen acuity.

Snellen (age 6 and above): Visual acuity can be assessed with Snellen if the child is able to recognize letters which typically occurs at the age of 6. For children between the ages of six and eight, the Snellen card can be modified by isolating single letters rather than the entire line. Some practitioners find it quicker to have the child call out only the letters on the left of the chart and if the child correctly identifies those, then move down the chart to a lower line. Continue in this fashion until the child incorrectly identifies a letter. Once a letter is missed the practitioner should stop, move up one line, and take line acuity. Some find this technique to be faster because children have a tendency to call out all of the letters not just the lowest line they can see. Visual
acuity improves with age. All children over age six should be able to achieve 20/20 best corrected acuity using this technique.

Entrance Skills

Pupil response: The pupil response test is performed in the same manner as an adult test. Direct, consensual, and accommodative responses should be seen in a normal newborn at birth. If the unilateral response is absent this suggests an optic nerve or visual pathway abnormality. It should be noted that in some cases an unequal pupillary reaction has been seen in absence of disease. Twenty percent of infants free of disease have anisocoria of 2 mm or more.  

Pupillary distance: Near pupillary distance for infants zero to twelve months should be approximately 40.5 mm (standard deviation of 2.4mm). At the age two to three, the approximate pupillary distance should be 43.5 (standard deviation 2.4mm). By the age five and six it should be 46.5 (standard deviation 2.7mm).

Orientation to sound: A newborn infant should move their eyes in the direction of sound when presented with a loud noise. A loud sound like a squeak from a toy should be presented at different positions.

Confrontation fields: Infant confrontation fields are done in a similar fashion to adult fields except instead of a fixation target, a light is used. A penlight or transilluminator stimulus is presented in all fields if gaze. The child should visually orient to the light in all fields of gaze if visual field loss is not present. The Nef perimeter, a simple opaque funnel, can be used to test infants and young children. The test is performed by having the child look down the funnel at a small hole where the examiner is looking to ensure fixation while a light stimulus is brought to different areas of the funnel. The child should orient to spots of light if visualized. The Nef perimeter can be used on young infants by laying them on their back and placing the funnel above them.

You can find the Nef perimeter at: http://www.lea-test.fi/en/vistests/pediatric/vftests/visfield.html

Ocular Reflexes

- Blink reflex: An infant should have a blink reflex when presented with a close, bright light. It can vary in appearance but should be evident by six months. Some studies, however, have shown a blink reflex as early as 12 hours after birth.

- McCarthy Reflex: Tapping of the supra-orbital area on one side of face produces a blink on the same side. At the age of 2 to 4 months the McCarthy reflex should discontinue.

- Ciliary Reflex: Touching the eyelashes of an infant should produce a bilateral blink. If the ciliary reflex is absent a lesion in the fifth cranial nerve is suspected.

- Nasopalpebral reflex: Tapping the bridge of the nose of an infant should cause bilateral blinking in both eyes.
• Cochleopalpebral reflex: An infant should blink bilaterally when presented with a loud noise. It is found in all newborn infants assuming they have a normal auditory conduction and neurological system.

• Doll's eye(s) sign: This phenomenon is a dissociation between the movement of the eyes and of the head. A positive response is when the head moves but eyes stay stationary. An example is when child is lying supine, the head is turned; the eyes do not follow, but remain staring upward. This is usually present in the first ten days of life and ceases after good visual fixation is developed. Asymmetry in eye movements could be from abducens nerve damage.

• Rotational Eye Movement and Nystagmus: An infant should demonstrate nystagmus after several rotations in a clockwise or counterclockwise direction. The nystagmus should be in the same direction as the infant was rotated. The reflex is present at birth but should stop within a few days. Asymmetry in eye movements could be from abducens nerve paralysis, 8th nerve damage, or irregularities in the labyrinthine region of the ear.

Ishihara color plates: At two months of age most infants are dichromats while some may be trichromats. However, by the age of three months most infants are trichromats. Infants have a spectral sensitivity that is more sensitive to shorter wavelengths such as blue and green. Ishihara color plates can be used to assess color vision as early as three years of age. While most 3 year olds do not know their numbers, you can modify the test by having the child trace the number with their finger rather than call out the number or shape.

Motor Alignment and Ocular Motilities

Direct observation and appearance of face
The exam should always begin by observing the child’s appearance and facial features. In some cases of strabismus, the child may develop a head tilt, turn, or tip their chin up or down. Facial features such as epicanthal folds, interpupillary distance (PD), and size of the face should be observed due to the impact they have on appearance of eye alignment. Epicanthal folds, which are common in infants, can cause the appearance of esotropia in a non-strabismic child (fig.8) or can exaggerate the appearance of an esotropia. Epicanthal folds can also mask the appearance of

Figure 8. Pseudoesotropia in a child with epicanthal folds. 

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exotropia. A narrow PD can cause an esotropia to appear larger, while a wide PD can cause an esotropia to appear smaller than it actually is. The effects of PD on exotropia are just the opposite.

Cover Test
The cover test is the most accurate method for assessing ocular alignment and therefore should be used in place of other methods if the child is capable of understanding and following your instructions. The typical age at which the cover test becomes useful is during the preschool years (3–5 years old).

The cover test is usually performed with the child fixating an object at 40 cm or their working distance, and at 6m while wearing the habitual Rx, if any. For children, it is very important to use targets that will keep their attention rather than the standard targets used with older patients. It is also important to have a variety of targets to help prevent the child from becoming bored and losing attention. Appropriate targets include finger puppets, toys that make noise, and stickers.

The cover test is usually performed in 3 parts. First, the unilateral cover test (UCT) is used to determine if there is a tropia. Next, the alternating cover test (ACT) is used to determine the magnitude and direction of any misalignment due to a phoria or tropia. Following the ACT the UCT is repeated to see if a tropia exists after fatigue. Intermittent tropias may only be seen after fatigue from the first UCT and ACT. Finally, any misalignment is neutralized with prism during the ACT. In cases of unilateral tropias, the neutralizing prism is placed over the strabismic eye.

In children it may be useful to perform the cover test by resting your hand on the child’s head and using your thumb as a swinging occluder. When a tropia is found, comitance should be assessed by repeating the cover test in the nine cardinal positions of gaze and versions should be tested in each of the diagnostic action fields. If a limitation is noticed, ductions should be performed. A comitant deviation is a deviation that is the same in all positions of gaze.

As with any part of the pediatric exam, it is important to perform each test as quickly as possible while keeping the child entertained in order to obtain reliable data. Some useful variations of the cover test for young children that aim to do this include:

- Using your hand and thumb as an occluder to reduce distracting the child
- Use objects that make sound and change the target frequently to maintain the child’s interest and fixation
- Move the target periodically during testing and observe the child’s response to ensure proper fixation
- Using a small block with stickers on each face attached to a handle can be quickly rotated to provide new targets quickly.
- Asking questions about the target helps keep the child focused and lets you know if they are maintaining fixation
- Placing a sticker on your nose for the near cover test will free both hands

Equipment
All that is needed is an assortment of toys, stickers, etc. for near and far fixation and a prism bar or loose prisms to accurately quantify any misalignment. A hand or thumb can be used as an occluder.

**Monocular Light Fixation (MLF)**

Monocular light fixation is a gross measure of angle lambda (the angle between the line of sight and the pupillary axis). It is used in conjunction with the *Hirschberg* to assess ocular alignment and as a gross measure for eccentric fixation.

The procedure involves aligning yourself on eye level with the child at a distance of 30–50 cm. If using a transilluminator, hold it below your eye and close your other eye. The examiner’s left eye should be aligned with the child’s right eye. Shine the transilluminator toward the child’s eye and ensure they are fixating the light by observing their eye movements or by making noises. Once you are confident they are attending to your light, cover one of the child’s eyes and assess where the light reflex is positioned. Repeat for the other eye.

Record the position of each light reflex in mm. The sign convention is (+) for nasal displacement, (−) for temporal displacement, (↑) for vertical up and (↓) for vertical down. Also record whether or not a correction was worn.

The most common position of the corneal light reflex is 0.5 mm nasal to the center of the pupil. The estimated amount of eccentric fixation is calculated using the conversion 1 mm = 22°. Note: most eccentric fixation is less than 3° which is not detectable by most observers using this procedure.

**Equipment**

Light Source (penlight, transilluminator, or direct ophthalmoscope)

**Hirschberg**

The Hirschberg test provides an estimate of ocular alignment in young children that can not be evaluated with the cover test. It is most useful with children from birth to around 3 or 4 years old because very little patient cooperation is needed.

To perform Hirschberg, position yourself 50 cm to 1 m in front of and on eye level with the child. Using your direct ophthalmoscope set to +1.00 D, direct the light between the child’s eyes. If the child can follow instructions ask them to look at your light. If not, making noises will usually attract the infant to look towards the light. Finally, observe the corneal light reflex in each eye and estimate its position relative to the center of the pupil. A penlight or transilluminator can also be used in place of a direct ophthalmoscope.

An assessment of the position of the corneal light reflex is made by using the same sign convention as with MLF. MLF can quickly be performed after Hirschberg by covering one of the child’s eyes and observing any change in the position of the corneal light reflex.

A 0.5 mm deviation of the light reflex in each eye toward the nose is most common although there are normal variations. Angle lambda, also known as monocular light fixation (MLF),
should be measured following Hirschberg to identify the fixating eye or eyes. Using the MLF results and a conversion of 1 mm = 22', the angle of deviation can be determined. For example, with an MLF of +0.5 mm OU and Hirschberg of +0.5 mm OD and +1.00 mm OS would suggest 11' left exotropia. If Hirschberg was +0.5 mm OD and -1.00 mm OS it would suggest 33' left esotropia. If the corneal light reflexes are in the same position under monocular (MLF) and binocular (Hirschberg) conditions there is no strabismus.

In order to get accurate data, the child must fixate the light source accurately using central vision. In children that are not interested in viewing the light, a finger puppet with a hole cut in the mouth may be placed over a transilluminator to hold attention better. Making noises while directing the light at the child also may be helpful. Also, reducing the room illumination may help to focus attention on the light source. In those with dark irises, it may be easier to judge the position of the light reflex relative to the pupil border when a direct ophthalmoscope is used. The ratio 22' per mm is considered to be stable throughout development except at ages younger than 5 months which may appear exo due to the anatomy of eye.

Equipment
Light Source (penlight, transilluminator, direct ophthalmoscope)

Krimsky
The Krimsky technique is a method to more accurately quantify the magnitude of a deviation found with Hirschberg.

Perform Hirschberg and MLF to estimate the magnitude and direction of the deviation. Place prism over the non-fixating (strabismic) eye so the corneal light reflex of the deviating eye is equal to the fixating eye. To prevent prism adaptation don’t leave the prism in place more than 2 to 3 seconds.

It may not be possible to perform this technique on children under 6 months because they tend to look at the prism instead of the light source as you place the prism in front of their eye.

Equipment
Light Source (penlight, transilluminator, direct ophthalmoscope), loose prisms or prism bar

Bruckner Test
The Bruckner test is useful in detecting small-angle deviations. It can also be used to detect amblyopia, anisometropia, and anisocoria. The Bruckner test is recommended for strabismus screening in children 8 months and older due to a relatively high rate of false positive (28%) in
children between 2–8 months, and an absence of reflex dimming in children younger than 2 months.32–33

To perform, position yourself about 1 m in front of the child and at eye level. Using a direct ophthalmoscope, direct the light toward the bridge of the child’s nose so both eyes are illuminated equally. Adjust the focus of the ophthalmoscope so the eyes can be clearly seen. If the child can follow instructions ask them to look at your light, if not, then making noise should attract their attention to the light source. The procedure should be performed in dim room illumination to make the fundus reflex easier to observe. Dimming the room lights will also help the young child focus on the examiner’s light source. Once the child is attending to the light, the examiner compares the color and brightness of the fundus reflexes. The examiner should also observe the position of the corneal light reflexes (Hirschberg) and relative pupil size. After observing both eyes, the examiner should evaluate each eye monocularly for changes in corneal light reflex (MLF/Angle lambda), color and brightness of the fundus reflex, and pupil size. If it’s not possible to occlude one eye, the examiner should decrease the ophthalmoscope aperture and illuminate one eye at a time.

The color and brightness of the fundus reflex is expected to be equal. In cases of strabismus, the deviated eye will have a whiter and brighter reflex.34 The dimming of the fixating eye is due to the macular pigments. An estimation of the magnitude of the deviation can be made only if the positions of the corneal light reflexes (Hirschberg) are observed at the same time. In cases of marked anisocoria, the larger pupil will be brighter. When light is directed only to one eye, it may be possible to detect amblyopia. In the case of amblyopia, the pupil in the amblyopic eye will weakly constrict, then dilate immediately if the fovea is not being used. The examiner should compare the pupil reactions of both eyes to determine if there is a difference. Using the Bruckner test to evaluate anisometropia will be discussed in refractive error assessment below.

Pearls

- The examiner can easily and quickly perform Hirschberg and Bruckner tests simultaneously and then cover each eye to obtain MLF results using the direct ophthalmoscope
- The examiner may get unreliable results in children under 8 months
- False positive can occur from pigmentedary differences between the eyes, media opacities, anisocoria, or uncorrected anisometropia
- Dilated pupils may invalidate test

Equipment
Direct ophthalmoscope
Figures 10 and 11. Left: Positive Bruckner test reflex in the right eye
Right: This child has a white pupil (leukocoria) causing positive Bruckner test due to tumor in
the right eye. 35

Near point of convergence (NPC)
Performing NPC on children is largely the same as for adults. It is most useful to rely on the
objective break and recovery points, rather than on the child’s subjective responses. In the older
child (4–5 years) you may be able to get subjective responses by first demonstrating “seeing
double” by placing a large amount of prism over an eye. A small accommodative target such as
a toy or sticker should be used.

According to Griffin, normative data are not established for infants and preschoolers. Moore
suggests NPC should be 2–3 inches at approximately 3 months of age. 36 A reduced NPC in
children may indicate high hyperopia, binocular problems, or lack of cooperation.

Pearls
- Rely on objective test results
- Use targets that interest the child

Equipment
Small toys or stickers; transilluminator may be most easily used for infants but this is a non-
accommodative target

Vergence Ranges
The examiner can quantify fusional vergence ranges using a prism bar or loose prisms when the
child is in the toddler to preschool age range. Of course, the largest factor is the individual’s
ability to understand the test. For infants, motor fusion can be assessed objectively by observing
re-fixation when prism is placed before an eye.

Positive and negative fusional vergence can be measured at distance and near although near
targets are generally easier for the child to maintain attention. The examiner should first
demonstrate what “double” looks like by placing a large amount of prism in front of an eye.
Making the procedure into a game will help the child to cooperate which in turn will provide
more accurate results. One example suggested by Moore is to use a “bubble gum” colored target
and have the child report when they see the double-bubble. After the child understands what to
do instruct him to look at the target while you slowly increase the amount of prism he is looking
through. As you do this you should carefully monitor the child’s responses as well as observe
eye movements to determine the break value. The recovery value is obtained the same way but
start with a large amount of prism and decrease until the child reports seeing one or you observe fixation.

For children 6 to 12 months of age, you can assess gross motor fusion by observing re-fixation through prism as the infant looks at a light or toy. Infants under 6 months will typically try to look at the prism rather than the target as you put the prism close to their eye. First, present a small target at near that the infant will attend to then place BO loose prism over an eye and observe any version and vergence eye movements. You should see a versional movement of the eye looking through the prism and then a vergence movement of the other eye.

For infants, you should see prism refixation through 10 BO by 6 months and re-fixation through 5 BO by 12 months. The ages at which fusional vergence becomes adult-like is not known according to Schor. According to Griffin, in their clinical experience, those as young as 7 years old should have adult-like responses.

Equipment
Fixation target such as toys, stickers, or transilluminator, and prism bar or loose prisms

Ocular Motilities
Eye movements may provide information as to the integrity of the visual system. Eye movements we would normally expect in infants do not develop in the visually impaired and according to Hyvariaen may be the first symptom of significant visual problems.

Saccades
Horizontal saccadic eye movements are present but not mature at birth. Unlike normal adult saccades with an amplitude equal to the target distance the infant uses a series of smaller saccades to reach the target. Infant saccades that are made across the midline will involve a midline jump, where the eyes stop when looking from side to side.

The speed of the saccade in infants is similar to adults but the latency is greater for infants (500-800 ms vs. 200-250 ms). According to Harris, hypometric saccades are considered part of normal development, become less noticeable by 7 months old, and saccadic hypermetria (a secondary saccade in the opposite direction from the primary saccade) is rare. Frequent hypermetria is considered abnormal and may be associated with cerebellar disease.

Infants also rely more on head movements when changing fixation than do adults. When changing fixation from central to peripheral field it is common for the infant to turn their head toward the object as well as initiate saccades. Vertical saccades develop after horizontal movements and are usually seen by 2-3 months. Accuracy of saccades improve during the first year and are nearly adult-like by 6 years.

Pursuits
Horizontal pursuits develop before vertical pursuits. The ability to make pursuit eye movements is present at birth but only under certain conditions. Pursuits are less mature at birth than saccades so the target velocity must be slow. As the target velocity is increased the infant will use saccades to track the object.
Optokinetic Nystagmus (OKN)
Slow and fast phases of OKN can be seen from birth. It is easier to elicit a response with temporal-to-nasal target movement. It is normal to have an asymmetric OKN response before 3–6 months of age. A persistent asymmetry or loss of symmetry suggests abnormal binocular development and may be due to strabismus, amblyopia, or unilateral congenital cataracts. The OKN response is generally absent in infants with retinal or cortical damage or CNS dysfunction.

Vestibulo-Ocular Reflex (VOR)
The vestibulo-ocular reflex maintains fixation during body or head rotation. The VOR is present from birth and is adult-like by 2–3 months old.

Testing Saccades
Position yourself in front of and on eye level with the child. Hold two targets that interest the child approximately 20 cm apart. If the child can follow directions, ask him/her to look back and forth between the two objects. If not, two penlights or penlights with puppets mounted on them can be alternatively turned on and off to attract attention to each of the lights. You should evaluate the quality of the saccades in terms of speed, latency, accuracy, and any inappropriate saccades.

Testing Pursuits
Pursuits can be evaluated using the same instruments as used for saccades. Move the object in a circular pattern and observe the quality of movement, under- or over-shooting saccadic movements, limitations in gaze, head movement, and the ability to cross the midline. In older children, you may want to evaluate pursuits and saccades while the child is standing.

Testing OKN and Nystagmus
Nystagmus can be observed during any of the other testing, and during direct ophthalmoscopy when the illumination and magnification of the eye is increased. If nystagmus is present you should evaluate amplitude, frequency, type (pendular or jerk), and null position. Recent onset nystagmus requires a review of systemic and neurological disorders, and a referral.

OKN response can be elicited with an OKN drum or by drawing a tape measure in front of the infant’s eye.

Pearls
- Use kid-friendly targets and change targets periodically to maintain fixation
- The examiner may need to hold the child’s head while testing saccades or pursuits to isolate eye movements
Refractive Error

Near retinoscopy (Mohindra)
The Mohindra technique was developed to evaluate refractive error in children from birth to around 3 years. The technique involves performing retinoscopy at a distance of 50 cm in a dark room. The dark room and close working distance draws the child's attention to the plane of the retinoscope. The eye not being tested is occluded while the examiner neutralizes the refractive error with a retinoscopy rack. To calculate the net refractive error a correction factor of 1.25 D is subtracted from the gross sphere measure. This factor was intended to compensate for working distance and residual accommodation, but it has been shown that there is a low correlation between Mohindra results and cycloplegic results. It has been suggested that a correction factor of 0.75 D be used to obtain results closer to a cycloplegic refraction. The Mohindra technique is probably more useful for monitoring astigmatism.

Example: If the horizontal meridian was neutralized with +3.00 D and the vertical meridian was neutralized with +4.00 D the net refractive error would be +2.75 -1.00 x 090 (using 1.25 D correction factor)

Pearls
- Set the illumination of the retinoscope to a low level so the child can comfortably look at the beam
- Making noises or holding colored light sources near the plane of the retinoscope may help hold the child's attention

Equipment
Retinoscope, occluder, retinoscopy rack, and colored lights or toys that make noise

Distance Retinoscopy
Retinoscopy, as performed on adults, may be used when the child is able to accurately attend to a distant target. This technique becomes viable at around age 3 years when accommodation can be

Figure 12. OKN drums
controlled by using fixation targets the child will attend to such as cartoons on a TV, toys that make sound, or kid-friendly pictures placed at 6 m.

A retinoscopy rack rather than a phoropter should be used to further control accommodation as children may lose attention behind the phoropter. If possible, fogging lenses should be placed on the child to help control accommodation. This also simplifies calculating the results if fogging lenses equal to the examiner’s working distance are used.

Pearls
- Using fixation targets such as TV programs and talking toys help control accommodation and prevent boredom. If using toys or other pictures, change the target frequently and ask questions about the target so you know if the child is looking where you want.
- Use retinoscopy rack to allow observation of the child’s eyes and attention

Monocular Estimate Method (MEM)
MEM is used to assess accommodative posture. It is probably most useful for school-age children but can be used with younger kids (2–3 years) if they can maintain fixation of figures at near. Accommodation is nearly adult-like by 3 months. At 1 month, the tendency is to under accommodate at near and over accommodate at distance. MEM is performed under binocular conditions at the child’s habitual working distance. The technique involves neutralizing the motion seen with the retinoscope with loose lenses as the child views a card with age-appropriate pictures or words at the plane of the retinoscope. As the child reads aloud or answers questions about the pictures, the examiner neutralizes the reflex to determine if an accommodative lag or lead is present. The motion seen is estimated and then the appropriate lens is placed before one eye to neutralize the motion. It is important to remove the neutralizing lens within a second because the latency of the accommodative response is very short and leaving the lens in front of the eye will change the accommodative response. Like other retinoscopy techniques, “with” motion is neutralized with plus lenses and “against” motion with minus lenses. The lens power used to neutralize the motion is the estimated accommodative posture. Addition of plus indicates an accommodative lag while addition of minus indicates an accommodative lead.

A slight lag in the range of +0.25 D to +1.00 D is expected. A high lag suggests that accommodative insufficiency, infacility, or ill-sustained accommodation may be present. Any accommodative lead that is consistently present is considered abnormal and VT should be considered. According to Griffin, VT is indicated for a child with a lag of ≥ +1.00 D. 57

Equipment
Retinoscope, loose lenses
Walk In / Walk Away Retinoscopy

Walk in/walk away retinoscopy can be used to quantify the amount of astigmatism, anisometropia, or myopia and to estimate the amount of hyperopia. It can be used for all ages although it may be difficult to keep an infant’s attention as you move further away. The technique involves scoping the principal meridians while the child is attending to the plane of the retinoscope. For some, the beam from the retinoscope may be enough to hold the child’s attention, but other targets such as stuffed animals or toys that produce flashing colored lights placed near the plane of the retinoscope may help to keep the child interested. Making noises such as barking or meowing may also be helpful.

Comparing the reflexes of the right eye to the left eye can rule out anisometropia while a comparison of the principal meridians in each eye can estimate the amount of astigmatism present. If myopia is present, “against” motion will be seen when the examiner reaches the child’s optical farpoint. The amount can be quantified by moving towards the child and noting where the reflex becomes neutral. For example, if you move in from 3 m and see neutrality at 50 cm, there is 2.0 D of myopia. In those with a large amount of hyperopia, you may observe a change in the reflex to a very slow “with” response as you move close to the child and they release accommodation. Normally, in those with moderate hyperopia, you should be able to get fairly close before noticing a change in the reflex with some release of accommodation. If not, this may indicate a very large amount of hyperopia or attention loss. The walk away portion involves scoping the principal meridians out to about 3 m. This can be used to rule out myopia. If you get plano or with motion at 3 m you have ruled out any significant amount of myopia. If you see with motion at 3 m, you can estimate the magnitude of hyperopia by putting a pair of plus lenses on the child (in a kid’s frame or have parent hold lens flippers). For example, if you put +1.50 D glasses on the child and see with motion at 3 m, you know there is at least +1.50 D of hyperopia. If you get against motion with the lenses in place, you know there is less than +1.50 D of hyperopia or the child may have accommodated with the plus lenses in place. Briefly interposed loose lenses can also be used for neutralization. The key for accurate measurements
is keeping accommodation fixed, which can be difficult with younger children because they tend to look at the lenses as they are placed in front of them.

Since lower amounts of hyperopia is the norm for young children, it is most important to rule out myopia and large amounts of anisometropia or astigmatism. Any child exhibiting myopia, anisometropia, or significant amounts of astigmatism or hyperopia should be cyclopleged to more accurately determine refractive error.

Pearls
- Use of noise, toys, lights helps to keep the child's attention
- Switch targets frequently to hold interest

Equipment
Retinoscope, kid-friendly targets, plus spectacles in a kid's frame, ± lens flippers, or loose lenses

Figures 14 and 15. Toys the flash provide a compelling fixation target

Cycloplegic Retinoscopy
The only way to truly control accommodation and find the full amount of refractive error is with the use of cycloplegic agents. The decision to perform cycloplegic retinoscopy is up to the clinician. Some advocate for its use on every child's first exam, while others perform it only if there is concern that distance or near retinoscopy results are suspect or indicate a high refractive error. Cycloplegic results are helpful in confirming refractive error, determining what to prescribe, or diagnosing other conditions related to accommodation and refractive error such as amblyopia or accommodative esotropia.

Cycloplegic agents include cyclopentolate, atropine, homatropine, and tropicamide. Cyclopentolate is usually the drug of choice because of its time of action and relative lack of side effects. Atropine tends to reveal more plus than cyclopentolate in high hyperopes but is less frequently used because of its slow onset of action (a few days) and side effects in children. Tropicamide does not have a very strong cycloplegic effect in children although some studies suggest a strong correlation between cyclopentolate and tropicamide refractions.
General guidelines for cycloplegic agents

- Premature or low-birth-weight infants: 1 drop Cyclomydrol (0.2% cyclopentolate with 1% phenylephrine)
- Neonate–1 year: 1 drop Cyclomydrol or 0.5% cyclopentolate
- 1–5 years: 1 drop 1% cyclopentolate or 1 drop 1% tropicamide
- A cycloplegic spray may be helpful in uncooperative children. It consists of 3.75 ml 2% cyclopentolate, 7.5 ml of 1% tropicamide, and 3.75 ml of 10% phenylephrine. The spray is applied to the child’s closed eyelids and consists of a final concentration of 0.5% cyclopentolate, 0.5% tropicamide, and 2.5% phenylephrine. A potential problem of using the spray is that the actual amount of drug that reaches the eye is unknown.
- Maximum effect when using cyclopentolate is about 30–40 minutes after instillation.
- Mydriasis not a good indicator of cycloplegia. Observe retinoscope reflex at near
- Use of topical anesthetic prior to other agents may increase absorption

Pearls

- Applying drops in kids can be difficult. Use of an anesthetic prior to other agents will reduce the stinging from the other drops but may cause a child to become even more uncooperative due to the less intense, but considerable discomfort from the anesthetic. For this reason some may choose not to use an anesthetic.
- Placing a drop on the child’s hand to show them what it is may make them less apprehensive.
- Have the child lie down and close their eyes and apply the drop to the margins of the closed eyelids. A problem with this is that you don’t know how much of the drug reaches the ocular surface.
- Anticipate that the child will cry so try to get the drops in as quickly as possible.
- The bottom line is that you need to get the drops in to do your job and trying to reason with a child is not likely to work so some gentle “force” may be required for the difficult cases.

Autorefraction

Use of autorefractors may be helpful in determining refractive error in children as young as 3 years old. Positioning and fixation generally make autorefraction results unreliable for younger kids. Autorefractors that are hand-held may be easier to use with children.

Keratometry

Keratometry may be useful to evaluate the cornea and determine refractive error in kids around the age of 3 years. To obtain reliable results, the child must be able to maintain fixation. Keratometry should be used if there is a large amount of astigmatism and you want to confirm the location of the refractive error, rather than as a primary test for refractive error.

A hand-held keratoscope may be useful in detecting large amounts of astigmatism in infants because little cooperation is needed. The illuminated Placido disc is reflected off the cornea and the examiner observes the appearance of the rings. Usually 1.00 D of corneal astigmatism is needed for the observer to detect elongation of the reflected rings. The pattern becomes elongated along the minus cylinder axis.
Equipment
Keratoscope (placido disc)

Figure 16. Placido discs. Right: elongation along horizontal meridian (axis 180)\textsuperscript{64}

Bruckner Test
The procedure for the Bruckner test was discussed previously in motor alignment. The information the Bruckner test can provide concerning refractive error is discussed here.

When performing the Bruckner test, observe the fundus reflex for any crescents in the 90 and 180 degree meridians by holding the ophthalmoscope vertically and then horizontally. The crescents appear white to gray and larger crescents usually suggest greater refractive error. A crescent that fills half the pupil usually corresponds to approximately $+/-2.00$ D of refractive error. Hyperopic crescents are located toward the head of the ophthalmoscope while myopic crescents are opposite to the orientation of the ophthalmoscope. This technique is useful as a screening tool and other methods should be used to more accurately identify refractive error.

Figure 17. Top: Direct ophthalmoscope held vertically. Position of crescents indicate hyperopia
Bottom: Direct ophthalmoscope held horizontally with o-scope head oriented to the left. Position of crescents indicate hyperopia\textsuperscript{65}

Equipment
Direct Ophthalmoscope
Stereopsis and Sensory Fusion

The first two years of life are the most important development period for stereopsis. Newborns develop binocularity rapidly after a period of three months, during which accommodation and central acuity are primarily developed. Most 3-4 month-olds have a stereoacuity of about 45 minutes of arc, and after 6 months, all infants should demonstrate some degree of stereoacuity. Children have an average of 200 arc seconds of stereoacuity by 3 years of age, and 90 arc seconds by age 4. Development continues until reaching adult levels of 40 arc seconds by five years of age. The following tests may be utilized to screen for and quantify stereopsis.

Randot® Stereo Smile I and II
The Randot® Stereo Smile I and II from Stereo Optical Company is a good test to determine the stereoacuity of young children and as a screening tool for older children. The Stereo Smile I kit includes two cards, one to test 480" and another for 120". Half of each card contains a stereo-encoded smiley-face and half with no figure, to be used in preferential looking for nonverbal patients. The Stereo Smile II kit contains cards to test 480", 240", 120", and 60". Also enclosed is a blank card to be presented simultaneously with one of the four stereo-encoded cards, allowing for preferential looking testing technique. Each kit also contains polarized spectacles and a non-stereo demonstration card printed with the same smile pattern as the stereo cards.

Lang Stereotest I and II
The Lang Stereotests (Richmond Products, Inc.) are based on the principles of random dot stereograms with a Fresnel lens overlay to create a stereo image without having to used polarized or anaglyphic glasses. Lang I contains the following images and stereoacuities on one card: Car 550", Star 600", and Cat 1200". Lang II, also one card, contains: Moon 200", Car 400", Elephant 600", Star is visible monocularly. The tests are able to be used for patients who are at least old enough to point.
**Frisby Near Stereotest**

The Frisby Near Stereotest (Richmond Products, Inc.) also benefits from the viewer not having to wear special glasses to achieve stereo. The test consists of three separate polycarbonate plates of varying thickness. Each plate has arrowhead shapes of varying sizes and orientations printed on each side of the plate. The plate thickness determines the disparity each eye perceives to produce a stereo image. The cards measure stereopsis between 600" and 15" depending on testing distance and plate used.

Figure 21. Frisby Near Stereotest

**Stereo Fly and Stereo Butterfly**

The Stereo Fly and Stereo Butterfly tests, from Stereo Optical Company, are polarized targets that present the patient with stereo images ranging from 2000" (fly) or 2000" to 700" (butterfly). The cards, in booklet format, also contain animal figures representing 400" to 100" stereoacuity, and graded circles to measure 800" to 40" of stereo.

Figure 22 and 23. Stereo Fly (left) and Stereo Butterfly (right)

**Randot®**

The Randot® tests (Stereo Optical Company) are polarized, random-dot stereograms in two configurations: the SO-002 and the SO-007 Preschool model. The SO-002 consists of three geometric forms each in stereoacuities of 500" and 250". It also contains animal figures from 400" to 100" and graded circles from 800" to 40". The SO-007 Preschool is comprised of three booklets, each of which have non-stereo images on the left page to be matched by the patient with stereo figures of varying ranges on the right sided page. Booklet 1 varies between 200" and 100", booklet 2, 60" and 40"; and booklet 3, 800" and 400".

Figure 24. Randot® test
Random Dot E
Stereo Optical Company also manufactures the Random Dot “E” SO-003. The kit contains a card with a large, polarized, random dot “E” printed on it, a blank card for preferential looking and to discourage guessing, and a demonstrator card. The stereo “E” card represents about 500” of stereo disparity at 50 cm.

Figure 25. Random Dot E cards

Worth 4-dot
The Worth 4-dot test is a standard test of secondary fusion and suppression in children able to express themselves verbally. The test consists of four illuminated dots: one white, one red, and two green. The patient, wearing anaglyphic glasses, reports what they see while looking at the illuminated dots. The test is flexible enough to be performed at varying distances to give the clinician insight into the nature and severity of the condition.

Figure 26. Worth 4-Dot

NPC
A quick and easy determination of sensory fusion is the near point of convergence (NPC). The examiner simply moves a fixation bead toward the patient’s nose and notes when the eyes lose fixation. Verbal patients may also report when they see two images of the bead.

Prism Recovery
Another fairly quick way to screen for sensory fusion is the 8\(^\Delta\) base out/base in recovery test. To perform the test, an 8\(^\Delta\) prism, either base-out or base-in, is applied in front of one of the patient’s eyes. Normal motor fusion is exhibited if the eyes are able to refixate with the prism in place.

Ocular Health
The following examination procedures are performed similarly on children as on adults. However, it may be helpful to have an assistant to use techniques to help the patient maintain
fixation using a combination of toys, vocalizations (animal sounds may be particularly effective), and facial expressions. In the absence of an assistant, the examiner may learn to multitask and provide a fixation target while performing the exam.

direct ophthalmoscopy
binocular indirect ophthalmoscopy
monocular indirect ophthalmoscopy
hand-held slit lamp
hand-held fundus camera
limbal glow estimation of anterior chamber angle
Tonopen tonometry
Keeler Pulsair tonometry

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