Objective: To recognize the most common procedures used in pediatrics for Sensory Screening (hearing and vision), as part of the 2017 AAP Periodicity Schedule.

Pre-Meeting Preparation:
Please read the following enclosures, corresponding to the screening procedures:
1) Sensory Screening:
   b. Hearing: “Pediatric Hearing Screening”
2) Bring a hand-held ophthalmoscope or penlight to clinic, if you have one.

Conference Agenda:
• Review “Health-Maintenance III Quiz”
• Complete the following group activities for each screening procedure:
  1) Vision Screening: Encourage residents to do the maneuvers on each other, before completing the picture-examples.
     a. Snellen Eye-Chart
     b. Corneal light reflex
     c. Cover-Uncover
     d. SpotVision Conversion Charts (Faculty—review interpretation with residents)
  2) Hearing Screening:
     a. Conventional audiometer: May not be available for practice this year
     b. Tympanometry: Test each other with clinic tympanometer!

Extra-Credit: ✨ Encouraged for PGY2 & 3 ✨
• Vision: Red Reflex Testing; Vision Screening (AAP Clinical Practice Guidelines)
  ➢ “Pediatric Vision Screening” (ppt by Dr. Erika Beard-Irvine)
  ➢ “Instrument Based Vision Screening: Update and Review” (Contemp Peds, 2014)
• Hearing: Hearing Screening Clinical Report; Hearing Screening Policy Statement (AAP)
  ➢ “Pediatric Hearing Screening” (ppt by Candice Ortiz Au.D.; play as slide-show)
Educational Gap

Although early detection of visual disorders can lead to therapy that will prevent permanent blindness, compliance with screening guidelines of the American Academy of Pediatrics is low.

Objectives  After completing this article, readers should be able to:

1. Be aware of common vision-threatening conditions that can be detected by using basic screening examinations.
2. Become familiar with techniques and findings used in vision screening examinations.
3. Understand the role of commercial screening tools.

Introduction

Early detection of ocular conditions can allow for assessment and treatment of a vision-threatening or life-threatening condition. Amblyopia, or “lazy eye,” can develop if a clear visual image is not projected onto the retina. Amblyopia can be caused by deprivation, strabismus, high refractive error (hyperopia, myopia, or astigmatism), or anisometropia (significant difference in the refractive error between eyes) and can be unilateral or bilateral. The prevalence of amblyopia is estimated to be 1% to 4%. (1)

Many factors may prevent the achievement of universal vision screening, including lack of education of families; language, financial, and state legislative barriers; and a lack of available providers. (2) Primary care physicians are crucial providers for detecting and referring vision-threatening ocular conditions. From the newborn examination, through subsequent health supervision visits, and throughout a child’s life, the pediatrician and family physician can perform effective examinations to screen for common and uncommon conditions that may be vision-threatening or even potentially life-threatening. (3) However, vision screening in the primary care office should not take the place of a full eye examination. If a patient cannot be screened effectively after two attempts, a referral should be made to an eye care professional who is comfortable examining children.

Pediatricians and family physicians should have the ability to perform a thorough ocular examination. According to the US Preventive Services Task Force, children under age 5 years should be screened to detect amblyopia, strabismus, and defects in visual acuity. The American Academy of Pediatrics (AAP) guidelines include screening at all health supervision visits, from the newborn period to age 3 years, by using the following components: ocular history, vision assessment, external examination, ocular motility, pupil examination, and red reflex examination. For children ages 3 to 5 years, the AAP recommends age-appropriate visual acuity measurements and direct ophthalmoscopy. (4) Sensitivity of screening examinations increases with age, while specificity remains unchanged. (5)

However, screening is not universal, and compliance with AAP guideline visual acuity screening is low. (6) In addition, there is controversy over who should provide the screening examinations. In 2000, Kentucky passed legislation mandating diagnostic eye examinations by optometrists or ophthalmologists. (7) A survey of primary care physicians found that the percentage of pediatricians who expected to perform screening examinations dropped from 86% to 71% after the mandate, and the percentage of family physicians who expected to screen dropped from 79% to 50%. The concern with this switch to mandated eye examinations is that children may get overlooked by one of the screening programs. In
addition, we must consider the increased cost of diagnostic eye examinations compared with vision screening programs, given the current health-care crisis.

As discussed, screening from an early age can identify patients who have poor vision. Whether potentially treatable or not, low vision or blindness from amblyopia, nystagmus, or structural abnormalities certainly can affect a patient’s reading ability and educational progress. Getting parents and schools involved early and working with low-vision specialists and visual aids can help patients adjust their needs appropriately. Although low-vision services can provide essential educational tools, primary prevention and treatment of potentially vision-threatening conditions is the better goal.

**Common Vision Conditions**
The age of the patient is an essential consideration in determining a differential diagnosis. From birth to age 1 year, concerning conditions include corneal opacities, cataracts, glaucoma, persistent fetal vasculature, and retinoblastoma. All of these conditions have the potential to cause deprivation amblyopia if not detected and treated at an early age (sometimes within the first weeks after birth).

Early detection of retinoblastoma could mean saving a patient’s eye or eyes and possibly some vision, along with treating a potentially fatal condition. Other conditions that may be present from birth, such as congenital ptosis or capillary hemangiomas causing mechanical ptosis or unilateral astigmatism, are also risk factors for amblyopia.

From ages 1 to 3 years, more common eye conditions with amblyogenic risk factors include strabismus and refractive errors such as high hyperopia (farsightedness), high myopia (nearsightedness), astigmatism, and anisometropia (significant difference between the refractive errors between the eyes). These disorders can be subtle. Preverbal patients are more difficult to examine, but early detection will have a substantial impact on a patient’s future education and life if treatment is initiated promptly.

From ages 3 to 8 years, strabismus and refractive errors continue to be significant amblyopic risk factors. As patients age and grow more cooperative, testing for visual acuity becomes more feasible.

**Strabismus**

**Early Detection**

Early detection of strabismus or ocular misalignment is essential for the prevention or treatment of amblyopia and allows the possibility of saving binocular vision. If the misalignment is constant, a child’s developing brain will ignore the visual input from the misaligned eye to avoid diplopia. If this situation persists, the eye will become “lazy” or amblyopic. If detected and referred early enough, treatment of the amblyopia by using penalization techniques such as patching may improve or resolve the difference in vision between the two eyes. As children get older, treatment is not as effective.

Between the ages of 8 and 10 years, the visual system has developed fully, and therefore decreased vision in one or both eyes cannot be improved, further emphasizing the importance of early intervention. Treatment of the misalignment itself depends on the type of strabismus and can include either using glasses (Fig 1) or performing eye muscle surgery. Surgery may restore binocularity, but it will not treat amblyopia; therefore, amblyopia is treated first with patching or other penalization techniques.

**Figure 1. Accommodative esotropia:** A. The patient is esotropic without glasses. B. The eyes are straight with hyperopic correction.

**Figure 2. Pseudoesotropia.** This patient appears to be turning his right eye in. This is an optical illusion created by wide nasal bridge and epicanthal folds that cover the nasal “white part of the right eye” when the patient turns his head slightly to his right. The symmetric corneal light reflex indicates good alignment.
Pseudostrabismus Versus True Strabismus

Pseudostrabismus occurs when one eye appears to turn in but is straight on cover/uncover testing. This appearance occurs most commonly in patients with wide nasal bridges and epicanthal folds, giving the child the appearance of esotropia. A true esotropia can be ruled out by using an equal corneal light reflex and normal cover testing (Fig 2).

Examination Techniques

Red Reflex

The red reflex test is the single most important screening tool for infants and young children. Using the direct ophthalmoscope to view both eyes simultaneously is the best way to evaluate the red reflex. The patient’s eyes should be viewed through the direct ophthalmoscope from approximately 2 feet away, with a broad beam directed so that both eyes are illuminated at the same time. The patient should be focused on the ophthalmoscope light. Starting with low illumination and increasing the brightness allows the patient to become comfortable with the bright light.

The red reflex will fill the pupil, and the corneal light reflex will also be centered on the pupil (Brückner reflex) if the patient’s alignment is correct. The red reflex represents the reflection of the light from the retina. Therefore, abnormalities of the red reflex can be caused by a physical blockage of the normal clarity of the visual axis, such as tear film mucus, corneal opacity, cataract, vitreous hemorrhage or retinal detachment, retinoblastoma, or persistent fetal vasculature. The red reflex also can appear dull in both eyes from a high refractive error (high myopia or hyperopia) or unequal due to anisometropia (high refractive error in only one eye) (Fig 3) or strabismus.

Differences in pigmentation among racial or ethnic groups also may be responsible for variation in the red reflex. Darker pigmented patients will appear to have a darker red reflex. The AAP policy states that all neonates should have a red reflex examination before discharge from the newborn nursery. Urgent referral and direct communication with the accepting ophthalmologist are essential when abnormalities are detected. High-risk patients who have a family history of retinoblastoma, infantile cataracts, glaucoma, or any other ocular disorders that presented early in life should be referred but also should have a red reflex examination before leaving the newborn nursery. Any parental concern raised by suspicion of a white pupil reflex should be referred urgently. (8) If there is ever any concern regarding a child’s red reflex

Figure 3. Asymmetric red reflex. This 7-year-old boy was found to be severely hyperopic in the left eye with no need for glasses in the right eye. This is an excellent example of a patient who might have passed vision screens but should have been referred much earlier for an abnormal red reflex.

Figure 4. Leukocoria.

Figure 5. Partial leukocoria. The patient had a congenital cataract viewed through a surgical microscope just before surgery.
status, the most prudent action is to refer the patient for a complete ocular examination.

**Leukocoria**

Leukocoria, or a white pupil, occurs when the red reflex appears white rather than the typical red (Fig 4). The most concerning diagnosis on the differential is retinoblastoma. Toxocariasis, Coats disease, persistent fetal vasculature, or a chronic retinal detachment will also appear white and therefore create a white reflex. Cataracts also can cause leukocoria or just an asymmetric red reflex (Fig 5). Because retinoblastoma is potentially fatal, all cases of leukocoria require an urgent referral to determine the cause of the condition.

**External Examination (Inspection)**

The external eye examination can be performed with a penlight to look for any external structural abnormality of the eyelids and adnexa. Paying attention to the eyelids and the vertical and horizontal fissures can reveal ptosis, capillary hemangiomas, and eyelid colobomas, which are important findings in detecting possible risk factors for obstructive amblyopia and systemic diseases. The sclera also can be evaluated easily by using a penlight. Corneal clarity can be evaluated simply by determining if there is a clear view of the iris and pupil. If there is not a good view of the iris or pupil, there may be a corneal opacity or haze. In newborns and infants up to age 2 months, asymmetry of the eyes or face should be noted. From 3 months on, any face turn or head tilt should be noted, especially if mentioned by the parents.

**Visual Acuity**

Visual acuity improves with age as does the ability to recognize letters or shapes. At age 0 to 2 months, patients should manifest a blink response to bright light, equal pupillary response, sporadic fixation, and following that becomes more consistent with age. The neonate can have intermittent strabismus with either an eso- or exodeviation of the eyes (eyes turned in or out), which should resolve by 2 to 4 months, after which the deviation is considered pathologic. If the infant has a constant strabismus, he or she should be referred for evaluation.

At age 2 to 6 months, infants should be able to fix and follow an object, such as a light or mother’s face, and the eye alignment should be straight. From age 6 months to 2 years, children should have central fixation, reach for toys, and demonstrate good alignment.

From age 3 to 5 years, subjective vision can be obtained. Children should test to 20/40, or better, on age-appropriate charts with one eye occluded (Allen or LEA pictures, tumbling Es, or HOTV letters). There should be no more than two lines of difference between the eyes. Patients become more cooperative after age 5 years. These children should test to at least 20/30 vision with a regular Snellen chart, with no more than two lines of difference between the eyes.

**Cover Test and Hirschberg Test**

The cover test (Fig 6) and Hirschberg test are used to examine ocular misalignment. The cover test reveals a manifest deviation (tropia). If a patient is fixating on a target with the right eye and the left eye appears to be turned in or turned out when the right eye is covered, there will be a shifting movement of the left eye in the opposite direction from its deviated position as the left eye picks up fixation. This finding is diagnostic of a manifest deviation because the misalignment is constant. When the cover is removed from the right eye, the right eye will either continue to be deviated or it will re-fixate if there is a right eye preference, indicating a possible amblyopia.

![Figure 6. Alternating cover test.](http://pedsinreview.aappublications.org/Downloaded from http://pedsinreview.aappublications.org/
A latent deviation can be induced by using alternate cover testing (Fig 7). This test is performed by moving the occluder directly from one eye to the other without allowing binocular viewing. This maneuver can bring out a phoria (latent deviation) or intermittent tropia (manifest but controlled at times). A manifest deviation is more worrisome due to the higher risk of amblyopia developing. The general pediatrician who is unsure about the proper performance of these tests should ask a local ophthalmologist to demonstrate the appropriate technique.

When there is a constant deviation, the Hirschberg test can be used to estimate the amount of deviation. Using a penlight directed on both eyes, the light reflex is examined to determine if there is an asymmetry. The light reflex should be approximately in the center of the pupil in both eyes when the child is fixating on the light, or in the same spot in both eyes if the patient is fixating on a different target. If the light reflex is displaced nasally, this finding indicates an exotropia (the eye is turned out) (Fig 8). When the light reflex is displaced temporally, this finding indicates an esotropia (the eye is turned in) (Fig 9). This test can be helpful in determining a true deviation versus pseudostrabismus (discussed earlier).

Ocular Motility and Nystagmus

The patient’s ocular motility should be evaluated as soon as the child is old enough to fixate and follow an interesting target. Eye movements become smoother as infants get older. Parents may report “funny eye movements,” which could indicate a more complex strabismus such as congenital fourth nerve palsy, Brown syndrome, or Duane syndrome.

Figure 7. Alternating exotropia induced by cover testing.

Figure 8. Exotropia. Corneal light reflex in the left eye is nasal compared with the light reflex on the right eye, which is central.

Figure 9. Esotropia. Corneal light reflex is not as apparent in this photograph, but the room light reflected off the cornea is temporal in the right eye compared with the central position in the left eye.

Observing for nystagmus is also important. There are many types and causes of nystagmus, but all children who manifest symptoms should be referred for evaluation of low vision as a cause. If an obstruction to clear visual development, such as a congenital cataract, has not been corrected at an early age, the presence of nystagmus could be a sign of poor vision. Other types of abnormal eye movements, such as opsoclonus, warrant an urgent referral. Opsoclonus can be a presenting sign of neuroblastoma. This condition appears as rapid, involuntary eye movements in all vectors of gaze.

Pupil Examination

Patients should have equal and reactive pupils from birth. It is more difficult to elicit this response in newborns but having the room dark and using a bright penlight often are helpful in distinguishing a pupillary response. The older a patient gets, the more important it is to have him or her focus at a distant target, dim the lights, and check the pupils while standing to the side so the patient does not focus on the examiner and induce accommodation. Any evidence of congenital anisocoria, or pupils of different sizes, also should be referred to evaluate for possible Horner disorders of the eye

vision screening

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Horner syndrome in children is neuroblastoma. In addition to the screening examination, taking a complete medical and family history is vital. At birth, it is important to ask about a family history of any congenital eye conditions or blindness from birth. This inquiry is imperative in evaluating for possible heritable eye diseases such as retinoblastoma, congenital cataracts, congenital glaucoma, and aniridia.

### Commercial Screening Tools

There has been growing interest in using commercial screening tools in schools and primary care offices. Standard techniques of visual acuity tests measure visual function directly. Patient cooperation, understanding, age, and attention, as well as the skill and patience of the examiner, play a role in the success of testing visual acuity. There are a variety of photoscreeners and autorefractors that objectively detect amblyopia or amblyogenic risk factors and require little patient cooperation.

The risk factors that should be identified by screening instrumentation include significant anisometropia (>1.50 diopter difference in prescription between the two eyes), manifest strabismus, hyperopia greater than 3.50 diopters, myopia greater than 3.00 diopters, any visually significant media opacity (>1 mm and in the visual axis), astigmatism >1.50 diopters in the regular meridians or >1.00 in oblique axis, and ptosis. (9)

Not all patients who have these risk factors will develop amblyopia. For instance, many infants have a high degree of clinically significant astigmatism that is either eliminated or greatly reduced by age 4 years. (10) Therefore, systems with higher sensitivity but lower specificity will over-refer due to false-positive results. (9)

### Table. Vision Screening Recommendations

<table>
<thead>
<tr>
<th>Age</th>
<th>Evaluation</th>
<th>Indications for Referral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn (0–1 mo)</td>
<td>Examine outer structures of the eye and red reflex before the neonate leaves the newborn nursery</td>
<td>Abnormal red reflex requires urgent consultation</td>
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<tr>
<td></td>
<td></td>
<td>History of retinoblastoma in parent or sibling</td>
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<tr>
<td>1 mo–3 y</td>
<td>History</td>
<td>Poor tracking by 3 months</td>
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<tr>
<td></td>
<td>Vision assessment; fix and follow</td>
<td>Abnormal red reflex</td>
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<tr>
<td></td>
<td>External examination</td>
<td>Chronic tearing or discharge</td>
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<td></td>
<td>Ocular motility</td>
<td></td>
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<td></td>
<td>Pupil examination</td>
<td></td>
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<tr>
<td></td>
<td>Red reflex evaluation</td>
<td></td>
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<tr>
<td>3–5 y</td>
<td>History</td>
<td>Strabismus</td>
</tr>
<tr>
<td></td>
<td>Vision assessment: LEA and Allen figures, HOTV letters, tumbling Es, Snellen chart</td>
<td>Chronic tearing or discharge</td>
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<tr>
<td></td>
<td>External examination</td>
<td>Fail vision screen (cannot read 20/40 with one or both eyes or two-line difference between eyes) or photoscreening</td>
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<td></td>
<td>Ocular motility</td>
<td>Uncooperative after two attempts</td>
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<td></td>
<td>Pupil examination</td>
<td></td>
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<tr>
<td></td>
<td>Red reflex evaluation (photoscreening)</td>
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<tr>
<td></td>
<td>Ophthalmoscopy</td>
<td></td>
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<tr>
<td>≥5 y</td>
<td>History</td>
<td>Strabismus</td>
</tr>
<tr>
<td></td>
<td>Visual acuity</td>
<td>Cannot read at least 20/30 with one or both eyes or two-line difference between eyes</td>
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<tr>
<td></td>
<td>External examination</td>
<td>Fail photoscreening</td>
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<tr>
<td></td>
<td>Ocular motility</td>
<td>Not reading at grade level</td>
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<td></td>
<td>Pupil examination</td>
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<tr>
<td></td>
<td>Red reflex evaluation (photoscreening)</td>
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<tr>
<td></td>
<td>Ophthalmoscopy</td>
<td></td>
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<tr>
<td>At-risk children of any age</td>
<td>History</td>
<td>Retinopathy of prematurity</td>
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<tr>
<td></td>
<td>Visual acuity</td>
<td>Family history of retinoblastoma, congenital glaucoma or congenital cataracts</td>
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<td></td>
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<td></td>
<td>Ophthalmoscopy</td>
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Many studies have compared the different screening tools. The two most common methods are photoscreening, which involves taking pictures of the red reflex of both eyes simultaneously, and autorefractors, which can estimate the child’s refractive error. Photoscreening was shown to be more time-efficient and had a higher positive predictive value than traditional screening techniques in 3- to 4-year-olds. (11) A study of vision in preschool-aged children found autorefractors detected 15% more amblyogenic risk factors than photoscreeners. In addition, depending on the criteria used in the various screening techniques, referral rates can be different. There have been no studies or consensus as to which method should be standard of care. Ease of referral and compliance of parents to keep the referral appointment are obstacles regardless of which method is used. (12)

There is no mechanical substitute at present for an adequate physical examination conducted by an educated primary care physician. Screening programs should be designed to easily identify individuals who have amblyopia or those at risk for developing amblyopia, with the additional concern of keeping the screening inexpensive.

Recommendations

The table highlights the recommendations made by the American Association for Pediatric Ophthalmology and Strabismus for which examinations should be conducted at different ages and also lists guidelines for referral to an ophthalmologist.

Summary

- Pediatricians and family physicians are essential in assessing the health of the eye and in vision screening.
- Newborns should be evaluated before leaving the nursery and referred urgently for abnormal findings on external examination or abnormalities of the red reflex.
- Vision assessment should begin at age 3 years by physicians, nurses, or technicians trained in vision evaluation. Children should be referred to licensed eye care professionals for abnormal findings or poor cooperation after two attempts.
- Photoscreeners can be a valuable addition to routine vision screening, especially in preverbal children.

References

3. Committee on Practice and Ambulatory Medicine Section on Ophthalmology; American Association of Certified Orthoptists; American Association for Pediatric Ophthalmology and Strabismus; American Academy of Ophthalmology. Eye examination in infants, children, and young adults by pediatricians: organizational principles to guide and define the child health care system and/or improve the health of all children. *Ophthalmology.* 2003;110(4):860–865
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Pediatrics in Review 2013;34;126
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Pediatric Hearing Screening
(Adapted from http://www.entcolumbia.org/childscrn.html)

I. Newborns and Infants

Hearing screening for newborns before they leave the hospital or maternity center is now becoming a common practice. Without such programs, the average age of hearing loss identification is between 12-25 months. When hearing loss is detected late, language development is already delayed.

Screening Techniques for Newborns and Infants
The screening of newborns and infants involves use of non-invasive, objective physiologic measures that include otoacoustic emissions (OAEs) and/or auditory brainstem response (ABR). Both procedures can be done painlessly while the infant is resting quietly.

• **Otoacoustic emissions** (OAEs) are inaudible sounds from the cochlea when audible sound stimulates the cochlea. The outer hair cells of the cochlea vibrate, and the vibration produces an inaudible sound that echoes back into the middle ear. This sound can be measured with a small probe inserted into the ear canal. Persons with normal hearing produce emissions. Those with hearing loss greater than 25-30 dB do not. OAEs can detect blockage in the outer ear canal, middle ear fluid, and damage to the outer hair cells in the cochlea.

• **Auditory brainstem response** (ABRs) is an auditory evoked potential that originates from the auditory nerve. It is often used with babies. Electrodes are placed on the head, and brain wave activity in response to sound is recorded. ABR can detect damage to the cochlea, the auditory nerve and the auditory pathways in the stem of the brain.

What happens if an infant does not pass the screening?
Infants who do not pass a screening are often given a second screening to confirm findings and then referred for follow-up audiological and medical evaluations that should occur no later than 3 months of age. These evaluations confirm the presence of hearing loss; determine the type, nature, and (whenever possible) the cause of the hearing loss; and help identify options for treatment. Even if the infant passes screening, certain conditions do not produce immediate hearing loss. Rather, the hearing loss occurs later in the child's development.

II. Older Infants and Toddlers

Infants and toddlers (7 months through 2 years) should be screened for hearing loss as needed, requested, mandated, or when conditions place them at risk for hearing disability. Infants not tested as newborns should be screened before three months of age. Other infants should be screened who received neonatal intensive care or special care, or who display other indicators that place them at risk for hearing loss.

Screening Techniques for Infants, Toddlers and Children
Two screening methods are suggested as the most appropriate tools for children who are functioning at a development age of 7 months to 3 years, visual reinforcement audiometry (VRA) and conditioned play audiometry (CPA). Both of these methods are behavioral techniques that require involvement and cooperation of the child.

• **Visual reinforcement audiometry** (VRA) is the method of choice for children between 6 months and 2 years of age. The child is trained to look toward (localize) a sound source. When the child gives a
correct response, e.g., looking to a source of sound when it is presented, the child is "rewarded" through a visual reinforcement such as a toy that moves or a flashing light.

- **Conditioned play audiometry (CPA)** can be used as the child matures. It is widely used between 2 and 3 years of age. The child is trained to perform an activity each time a sound is heard. The activity may be putting a block in a box, placing pegs in a hole, putting a ring on a cone, etc. The child is taught to wait, listen, and respond.

With both of these methods, sounds of different frequencies are presented at a sound level that children with normal hearing can hear. It is ideal if the child will allow earphones to be placed on his or her head so that independent information can be obtained for each ear. If the child refuses earphone placement or earphone placement is otherwise not possible, sounds are presented through speakers inside a sound booth. Since sound field screening does not give ear specific information, a unilateral hearing loss (hearing loss in only one ear) may be missed.

Alternative procedures, such as otoacoustic emissions (OAEs) or auditory brainstem response (ABR) may be used if the child is unable to be conditioned.

**What happens if a toddler does not pass the screening?**
A toddler who does not pass the screening should be rescreened or referred for audiologic evaluation. Confirmation of hearing status should be obtained within 1 month, but no later than 3 months, after the initial screening.

**III. Hearing Screening in Preschoolers**

The goal of screening for hearing loss in preschoolers (ages 3-5 years) is to identify children most likely to have hearing loss that may interfere with communication, development, health, or future school performance. In addition, because hearing loss in this age range is so often associated with middle ear disease, it is also recommended that children in this age group be screened for outer and middle ear disorders (acoustic emittance screening).

**Screening Techniques for Preschoolers**

- **Conditioned play audiometry (CPA)** is the most commonly employed procedure.
- **Acoustic emittance screening** includes tympanometry, acoustic reflex, & static acoustic impedance:
  - **Tympanometry** introduces air pressure into the ear canal making the eardrum move back and forth. A special machine then measures the mobility of the eardrum. Tympanograms, or graphs, are produced which show stiffness, floppiness, or normal eardrum movement. They are classified as **type A** (normal), **type B** (flat, clearly abnormal), and **type C** (indicating a significantly negative pressure in the middle ear, possibly indicative of pathology).
  - **Acoustic reflex testing** measures the response of a tiny ear muscle that contracts when a loud sound occurs. The loudness level at which the acoustic reflex occurs and/or the absence of the acoustic reflex give important diagnostic information.
  - **Static acoustic impedance testing** measures estimate the physical volume of air in the ear canal. This test is useful in identifying a perforated eardrum or whether ear ventilation tubes are still open.

**What happens if a preschooler does not pass the screening?**

- If the child cannot be conditioned to the play audiometry, the child will be screened using infant-toddler procedures or will be recommended for a more in-depth audiologic assessment.
• If the child did condition and did not pass the screening, then referral for audiological assessment will be made. Hearing status of children referred after screening should be confirmed within 1 month, but no later than 3 months, after the initial screening.

IV. Hearing Screening for School Age Children and Adolescents (5-18 years)

School-age children should be screened for hearing loss as needed, requested, mandated, or when conditions place them at risk for hearing disability. Screening for hearing loss identifies the school-age children most likely to have hearing impairment that may interfere with development, communication, health, and education. School age children with even minimal hearing loss are at risk for academic and communication difficulties.

*School age children should be screened at the following times:* on first entry into school; every year from kindergarten through 3rd grade; in 7th & 11th grade; upon entrance into special education; upon grade repetition; upon entering a new school system without evidence of having passed a previous screening.

**Screening techniques used for school-age students**
- *Conventional audiometry,* in which students are instructed to raise their hand (or point to the appropriate ear) when they hear a tone, is the commonly used procedure. Conditioned play audiometry (CPA) is also used.

**What happens if a school-age student does not pass the screening?**
The student should be re instructed, earphones repositioned, and rescreened in the same session. If the student does not pass the rescreening, he or she should be referred for audiologic assessment. Hearing status of referred students should be confirmed within one month, and no later than 3 months, after initial screening.

V. Risk Factors for Hearing Loss in Children

• Parental, caregiver and/or health care provider concerns regarding hearing, speech, language, and/or developmental delay based on observation and/or standardized developmental screening.
• Family history of permanent childhood hearing loss.
• Infections associated with sensorineural hearing loss including bacterial meningitis, mumps.
• In utero infections such as cytomegalovirus, herpes, rubella, syphilis, and toxoplasmosis.
• Neonatal indicators - specifically hyperbilirubinemia at a serum level requiring exchange transfusion, persistent pulmonary hypertension of the newborn associated with mechanical ventilation, and conditions requiring the use of extracorporeal membrane oxygenation (ECMO)
• Syndromes associated with progressive hearing loss such as neurofibromatosis, osteopetrosis, and Usher’s syndrome.
• Neurodegenerative disorders, such as Hunter syndrome, or sensory motor neuropathies, such as Friedreich's ataxia and Charcot-Marie-Tooth syndrome.
• Head trauma
• Recurrent or persistent otitis media with effusion for at least 3 months.
• Anatomic disorders that affect eustachian tube function
• Reported exposure to potentially damaging noise levels or to drugs that cause hearing loss.
Health Maintenance III Quiz

1. At what ages does the AAP recommend hearing screening? Do we perform hearing screening in our clinic? If so, how? **Newborn testing (e.g. OAE on the MICC), followed by yearly risk assessment until age 4**, at which time audiometry may be started. (Routine screening then occurs at 4-6 yrs, 8 yrs, and 10 yrs). **We do NOT do hearing screening in clinic; refer to audiology (5th floor America Building) for all testing modalities.**

2. At what ages does the AAP recommend vision screening? Do we perform vision screening in the clinic? If so, how? **Risk assessment starting as newborn. Screening to be performed starting at age 3 yrs** (3-6 yrs; 8 yrs; 12 yrs; 15 yrs; 18 yrs). **We use SpotVision Screening at well-baby/well-child visits, starting at 12 months—annually unless some abnormality, then repeated at the next well visit. Snellen Chart used in adolescent clinic and older children in peds clinic on case by case basis.**

3. Please fill in the appropriate sensory screening tests for each of the following age-groups:

<table>
<thead>
<tr>
<th>Age-Group</th>
<th>Hearing Screen</th>
<th>Vision Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate</td>
<td>OAE (otoacoustic emission)</td>
<td>Red reflex</td>
</tr>
<tr>
<td></td>
<td>ABR (auditory brainstem response)</td>
<td>Inspection</td>
</tr>
<tr>
<td></td>
<td>Fix &amp; follow with each eye</td>
<td>Corneal light reflex</td>
</tr>
<tr>
<td>Toddler</td>
<td>VRA (visual reinforcement audiometry)</td>
<td>Visual acuity (figures)</td>
</tr>
<tr>
<td></td>
<td>CPA (conditioned play audiometry)</td>
<td>Corneal light reflex</td>
</tr>
<tr>
<td></td>
<td>Cover-Uncover</td>
<td>Red reflex/inspection</td>
</tr>
<tr>
<td>Preschool</td>
<td>CPA</td>
<td>Visual acuity (Tumbling E)</td>
</tr>
<tr>
<td></td>
<td>Tympanometry</td>
<td>Corneal light reflex</td>
</tr>
<tr>
<td></td>
<td>Static acoustic impedance</td>
<td>Stereoacuity (Random Dot E Game)</td>
</tr>
<tr>
<td></td>
<td>Acoustic Reflex</td>
<td>Red reflex/inspection</td>
</tr>
<tr>
<td>School-Age</td>
<td>Conventional audiometry</td>
<td>Visual acuity (Snellen Chart)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corneal light reflex</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cover-uncover</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stereoacuity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red reflex/inspection</td>
</tr>
</tbody>
</table>

4. Please define the following terms:
   a. **Myopia** = “Nearsightedness”. Refractive error where distant objects appear blurred.
   
   b. **Astigmatism** = A type of refractive error where vision is blurred due to either an irregularly shaped cornea or lens which prevents light from focusing properly on the retina. This causes blurred vision at any distance.
   
   c. **Strabismus** = Misalignment of the eyes, including tropias and phorias. Onset is between 18mo and 6yrs. Distinguish from pseudostrabismus, which is the appearance of misalignment, for example due to a broad nasal bridge covering the nasal sclera.
d. **Esotropia** = *Full-time occurrence* of eyes to deviate **inward** (adducting)

e. **Exophoria** = *Tendency* of eyes to deviate **outward** (abducting)

f. **Amblyopia** = **Loss of visual acuity** due to active cortical suppression of the vision of an eye. Can be due to strabismus or deprivation (e.g. congenital cataract).

g. **20/40 OU** = Myopic vision in BOTH eyes. 20/40 means that when you stand 20 ft away from the chart, you can see what a “normal human” can see when standing 40 ft from the chart. 20/200 is the cutoff for legal blindness in the US (i.e. you can see what a normal human can see when standing 200 ft from the chart; your vision is worse).

5. Match the following vision problems in children with the appropriate screening method:

<table>
<thead>
<tr>
<th>Problem</th>
<th>Test(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refractive Error</td>
<td>Visual acuity testing (figures, Tumbling E, Snellen)</td>
</tr>
<tr>
<td>Strabismus</td>
<td>Corneal light reflex, Cover-Uncover test</td>
</tr>
<tr>
<td>Cataract</td>
<td>Red reflex testing (cataract = opacification of the lens)</td>
</tr>
</tbody>
</table>

6. Which of the following patients is at increased risk for hearing loss? All 4 patients—see “Section V: Risk Factors for Hearing Loss”. **Encourage residents to share patient scenarios of their own, in which they recommended close audiology follow-up.**

- a. 8do former 37+4 week infant, readmitted for bilirubin of 28.5
- b. 3yo with Trisomy 21
- c. 18mo female with OME at 12mo, 15mo, and 18mo well-baby visits
- d. 14yo with Neurofibromatosis Type II

7. Please list the visual acuity criteria for optometry referral for the following age groups:

- a. 3 y.o. 20/50 or worse or 2 lines difference between the eyes
- b. 5 y.o. 20/40 or worse or 2 lines difference between the eyes
- c. > 5 y.o. 20/30 or worse or 2 lines difference between the eyes

*Ask residents to reflect upon their own practices: Are you making appropriate referrals? How has SpotVision screening changed your referral practices? (Remember, optometry is a self-referral clinic; patients do not need a consult in AHLTA)*
Sensory Screening Group Activities
(Adapted from http://www.aafp.org/afp/980901ap/broderic.html)
* Remember to add the Snellen chart, audiometer, and tympanometry to your Procedure Log.

Vision Screening

1. Visual acuity (Snellen chart)
   * Ensure that Snellen chart is **10 or 20 ft away** from where the patient stands.
   * Have the patient cover one eye and read aloud every letter in the chart. If the patient misses only one letter, have the patient continue reading the next line.
   * Record the last line the patient reads accurately, and note what the vision is. (Visual acuity measures are marked on the Snellen Chart)
   * Ask the patient to repeat the process with the other eye, and the with both eyes uncovered.
   * Record the visual acuity for each eye and with both eyes uncovered. Remember—**OD** = oculus dexter (R eye); **OS** = oculus sinister (L eye); **OU** = oculus uterque (both eyes)

2. Corneal light reflex (Hirschberg Test)
   * Hold a penlight about 3 ft (1m) from both eyes. Note the position of the corneal reflection.
   * The reflection should fall in the same location in the cornea of each eye, even when the eyes move. Displacement of the corneal light reflection in one eye suggests strabismus.

   How would you interpret these findings?
   A: Normal alignment
   B: L esotropia (the light reflex is outwardly displaced)
   C: L exotropia (the light reflex is inwardly displaced)
   D: L hyperopia (the light reflex is downward displaced)
3. Cover-Uncover test
(For demo, see: http://www.youtube.com/watch?v=TxEQWtlXtrI&feature=related)

Example 1: Unilateral Cover-Uncover Test:
* Direct the patient to focus on an interesting object about 10ft (3m) away.
* For testing of the R eye, cover the L eye and observe the R eye for “fixation” movement.
  - If no movement, the patient does NOT have a R eye tropia.
  - If the R eye moves inward after the left is covered, the patient has a R eye EXOtropia.
  - If the R eye moves outward after the left is covered, the patient has a R eye ESOtropia
* For testing of the L eye, cover the R eye and observe the L eye for “fixation” movements.
* Cover each eye for approximately 3-4 sec, and repeat 3x for each eye.

Example 1: Unilateral Cover-Uncover Test for ‘Tropias’

| A. Observe the corneal light reflex at rest, the L eye shows esotropia (corneal light reflex is outwardly displaced). |
|---|---|
| C. Uncover the L eye. What happens? No movement of either eye (the L eye maintains its esotropic position). |
| D. Cover the R eye. What happens to the L eye? Moves outward. The previously esotropic eye takes up fixation. |
| E. Uncover the R eye. What happens to the L eye? Moves inward, back to its original esotropic position. |
Example 2: Alternating Cover-Uncover Test:
* Direct the patient to focus on an interesting object about 10ft (3m) away.
* For testing of the R eye, cover the R eye for 1-2 sec, then move to cover the L eye for 1-2 sec. Observe the R eye as it is being uncovered to detect “re-fixation” movements.
  - If no movement, the patient does NOT have a R eye phoria.
  - If the R eye moves inward, as it is being uncovered, the patient has a R eye EXOphoria.
  - If the R eye moves outward, as it is being uncovered, the patient has a R eye ESOphoria.
* For testing of the L eye, cover the L eye, then move to cover the R eye. Observe the L eye as it is being uncovered to detect “re-fixation” movements.

Example 2: Alternating Cover-Uncover Test for ‘Phorias’

A. Cover and uncover the L eye. What happens? The L eye moves inward as it is being uncovered, returning to a central position. This patient has a L exophoria.

B. Cover and uncover the L eye. What happens? The L eye moves outward as it is being uncovered, returning to a central position. This patient has a L esophoria.

C. Cover and uncover the L eye. What happens? The L eye moves downward as it is being uncovered, returning to a central position. This patient has a L hyperphoria.

And finally, what’s this?

pseudostrabismus
## Conversion Chart: Refractive State to “estimated” Visual Acuity

<table>
<thead>
<tr>
<th>Myopia</th>
<th>Hyperopia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearsighted</td>
<td>Farsighted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minus (-) Sphere</th>
<th>Plus (+) Sphere</th>
<th>Plus (+) Sphere</th>
<th>Plus (+) Sphere</th>
<th>Estimated Visual Acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ages: All</strong></td>
<td><strong>Estimated Visual Acuity</strong></td>
<td><strong>Ages: 5y to 15y</strong></td>
<td><strong>Ages: 25y to 35y</strong></td>
<td><strong>Ages: 45y to 55y</strong></td>
</tr>
<tr>
<td>-0.5</td>
<td>20/30-40</td>
<td>+2.00</td>
<td>+1.25</td>
<td>+1.00</td>
</tr>
<tr>
<td>-0.75</td>
<td>20/50</td>
<td>+3.00</td>
<td>+1.75</td>
<td>+1.25</td>
</tr>
<tr>
<td>-1</td>
<td>20/60</td>
<td>+3.25</td>
<td>+2.50</td>
<td>+1.50</td>
</tr>
<tr>
<td>-1.25</td>
<td>20/70</td>
<td>+3.75</td>
<td>+3.00</td>
<td>+1.75</td>
</tr>
<tr>
<td>-1.5</td>
<td>20/100</td>
<td>+4.25</td>
<td>+3.50</td>
<td>+2.00</td>
</tr>
<tr>
<td>-2.5</td>
<td>20/200</td>
<td>+4.75</td>
<td>+4.00</td>
<td>+2.50</td>
</tr>
</tbody>
</table>

[1] Spherical results are based upon minus (-) cylinder convention.


*Not Recommended for conversion of screening results for children screened for amblyopic risk factors*
Instructions for: Conversion Chart Refractive State to “estimated” Visual Acuity

Example 1
- DS Result in minus (-), use “myopia” columns
- Myopia conversions are for all ages
- Conversion for this example indicates an “estimated” visual acuity of 20/60 (OD) and 20/60 (OS)

Example 2
- DS Result in plus (+), use “hyperopia” columns
- Hyperopia conversions require age selection
- Conversion for this example indicates an “estimated” visual acuity of 20/40 (OD) and 20/40 (OS) for a 25 to 35 years of age subject

Example 3
- Conversion for this example indicates an “estimated” visual acuity of 20/20(OD) and 20/20 (OS) for a 5 to 15 years of age subject
- This example indicates a 2.50 diopter variance in refractive power, identified as “anisometropia.”
- “Complete Eye Exam Recommended” is properly identified for the subject even when the conversion indicates 20/20

Visual Acuity conversions not intended as an alternative to the recommendation presented on Spot.
**Hearing Screening**

1. Conventional Audiometer

Conventional audiometry uses air conduction testing: different sounds go into the ear canal, through the middle ear, to reach the inner ear. **An audiogram is a graph that shows the softest sounds a person can hear at different pitches or frequencies.** An “O” is used to represent the R ear responses and an “X” for the L ear. The closer the marks are to the TOP of the graph, the softer the sounds that can be heard.

![Diagram showing different degrees of hearing loss and range of pitch and loudness for most of the “speech sounds”]

**Label the following audiogram examples:**

- **Severe** hearing loss
- **Moderate** hearing loss
- **Mild** hearing loss

Tympanometry is an examination used to test the condition of the middle ear and mobility of the tympanic membrane and the conduction bones by creating variations of air pressure in the ear canal. A probe is inserted into the canal, permitting a hermetic seal to form. On the probe tip are 3 small holes. Through the 1st hole, we introduce an 85 dB pure-tone sound; through the 2nd hole we measure the sound pressure in the cavity; through the 3rd hole we create and remove pressure in the cavity to get a dynamic measure of the movement of the TM. We can exert positive pressure, pushing the TM away from us, or negative pressure, creating a partial vacuum and pulling the TM toward us. Most testing instruments use +200 mmH2O to -200 mmH2O.

In basic tympanometry, we insert +200 mmH2O pressure against the TM, effectively pushing it away from us (into the middle ear space). When we do that, we make it “stiffer”. As we make it stiffer, it reflects more sound back into the cavity, and this allows less energy (“less sound”) through the TM. Then, we begin to remove the pressure in the cavity, a bit at a time. As we do, the TM becomes more compliant, lets more sound through, and the perception is that the sound gets louder. We make a measurement at +200, +100, +50, 0, -50, -100, and -200 mmH2O. We plot the amount of sound pressure at each of these points to create a tympanogram. The X-axis shows the air pressure, and the Y-axis shows the “static compliance” or mobility of the TM.

There are 5 basic types of tympanograms. **Type A** is normal: there is a normal pressure in the middle ear with normal mobility of the eardrum and the conduction bones. **Type B and C** may reveal fluid in the middle ear, perforation of the TM, scarring of the TM, lack of contact between the conduction bones of the middle ear, or a tumor in the middle ear. **Types AS and AD** represent variations with decreased (s = shallow, stiff) or increased (d = deep, disarticulated) compliance.

Please identify the following tympanometry tracings:

- **Type A**
  - Due to normal middle ear pressure and static compliance

- **Type B**
  - Due to no measurable middle ear pressure or static compliance, consistent with middle ear pathology (e.g. MEE, perforation, cholesteatoma)

- **Type C**
  - Due to significant negative middle ear pressure with normal static compliance, consistent with ET dysfunction/middle ear pathology (e.g. retraction of TM, blockage of ET).