The purpose of neurologic examination of a child is to assess development and integrity of the nervous system and to determine location and cause of suspected dysfunction. Achieving these goals is often complicated by three impediments: (1) the patient's age and willingness to cooperate, (2) the complexity of the complete neurologic examination, and (3) the fluctuating nature of neurologic function. Many patients would prefer to play than be examined and often fear the examiner. To win cooperation, it is important to establish a comfortable rapport with young patients by engaging them in play as they sit on the exam room floor or in a parent's lap. An examiner who feels competent in assessing neurologic function in a child searches first for the most relevant findings while the child is cooperative and begins with the least-threatening maneuvers. Compared with examination of an adult, neurologic examination of a child requires more observation, considerable flexibility, greater patience, and less reliance on instructions that children might easily misunderstand. Not only is repeated examination helpful, because cooperation can change as a function of mood, energy, or familiarity with surroundings, but a complete neurologic examination also may require more than one session. In addition, neurologic function often fluctuates. Children with tic disorders, seizures, complicated migraines, sleep disorders, dystonias, or stereotypes can appear completely normal during examination at one time while manifesting neurologic dysfunction if examined at another. Thoughtful examination, therefore, requires looking for signs associated with presenting symptoms or for subtle abnormalities that suggest an associated or predisposing condition.

Neurologic impairment is not merely the sum of abnormal neurologic findings. A child typically manifests patterns of impairment, and the goal of examination is to discern coherent patterns amid abnormal findings. For example, a decrease in the width of one thumbnail, together with slightly greater floppiness of the ipsilateral foot and slight external rotation of that leg, can provide the only evidence of a subtle hemiparesis. Although it is important to be familiar with classic presentations of neurologic dysfunction, a good examiner must also be able to discern subtle presentations of hemiparesis, paraparesis, brainstem abnormality, or autonomic dysfunction. Although the neurologic examination is formally divided into several sections to help us remember the complete exam and to facilitate analysis of our findings, it should be tailored in response to the specific symptoms and needs of the child being evaluated. Highlighted below are approaches that are commonly useful; more detailed examinations are described elsewhere.

Examination of the Older Child

Observation

Valuable information can be obtained when a child feels free of the physician's focused attention. Watching a child come into the exam room, interact with parents, play, or dress and undress provides information about neurologic function that obviates the need for portions of the “adult” neurologic examination. Observation of drooling, respiratory irregularities, pain-related behavior,
hyperactivity, tics, confusion, willful defiance, or unexpected urinary incontinence provides important clues to underlying problems. It is helpful to observe the quality of eye contact and social interaction of a child with parents and with the examiner. It is often possible to observe a child during a nap for the presence of periodic movements, sleep-related seizures, or hypopneic episodes.

**Mental Status**

In many circumstances, cognitive performance is not central to the reason for neurologic evaluation. It could be sufficient to demonstrate that a child has good language, memory, and intellectual skills through conversation. However, without a methodologic approach to thinking about a child’s mental status, we lose an opportunity to identify relevant but overlooked cognitive weaknesses. Responses to “who,” “what,” “when,” and “where” questions should be judged for comprehension. Asking a child to tell a story about something that happened provides a friendly way to assess memory, organization, and expressive language skills. Identifying colors or handy objects is helpful to assess naming in young children, whereas spelling the same colors or objects is helpful in assessing older children. Asking a child to read or write age-appropriate information provides an opportunity to assess cognitive and motor function. If needed, a more detailed approach is described below.

**Cranial Nerve Testing**

Although comprehensive cranial nerve examination is ideal, several aspects of the exam often are more useful than others in children.

**Cranial Nerve II**

Visual acuity of a child older than 4 years can typically be assessed by asking a child to point in the direction of lines on an E chart. Older children can use a Snellen’s chart; each eye should be tested independently. Visual field examination is challenging, but finger counting by confrontation is typically effective. The examinee’s hands midway between him and the child and stretched to the limits of his own visual field, the examinee flashes between 0 and 5 fingers in each quadrant. Offering a visual stimulus in a left and right quadrant simultaneously (and asking the child to add up the fingers) keeps the child from turning his gaze away from the examiner’s eye.

Funduscopically is also difficult in children without dilation of pupils, but it is commonly possible to ascertain more than the presence of a red reflex. Keeping the room light on or slightly dimmed helps the child maintain focus on a distant visual target, as the examiner explains that the child needs to “look through” his head should it get in the way. Training the light of the ophthalmoscope on the eye while the examiner is still 18 inches away and 10° from the child’s midline allows the examiner to descend toward the eye while staying focused on the region of the retina where the optic disk is found. Whiteness of the normally salmon-pink optic disk suggests optic atrophy. Elevation of the disk head, seen best by noting the curvature of distended veins as they drape over the elevated disk onto the retina, suggests early papilledema. An experienced examiner with a cooperative child also can confirm the absence of pulsations in veins that issue from the center of the disk. Before this stage of papilledema, the only findings will be hyperemia of the optic nerve and apparent loss of constricted small vessels as they cross the disk head. Blurring of the temporal boundary between the optic nerve head and the surrounding retina is a later finding. Presence of a crescent of dark pigmentation on the temporal side of the optic disk is not abnormal.

**Cranial Nerves III, IV, and VI**

Abnormal eye movements at rest or during visual fixation should be noted. Nystagmus is an involuntary rapid jerk of the eyes back to the point of fixation, correcting for the slow drift away from the target. While vertical nystagmus suggests brainstem dysfunction, horizontal or rotary nystagmus reflects congenital abnormality or vestibular or medication effects. Assessment of the symmetry and reactivity of the pupils is important, although 10% of children have subtle baseline asymmetry in pupil size. During migraine, one pupil can be less reactive than the other. There can also be constriction of one pupil with mild eyelid drooping and ipsilateral anhidrosis with Horner’s syndrome. In general, however, significant asymmetry of pupil size or reactivity suggests intracranial mass effect, midbrain dysfunction, optic nerve problems, or medication effect.

It is important to assess the width of the palpebral fissures—the vertical opening for the eyes. Decreased palpebral width on one side suggests ptosis, which can be seen with impaired sympathetic innervation, myasthenia gravis, or cranial nerve III dysfunction. Complete loss of cranial nerve III function is characterized by dilation of the pupil, ptosis, and rotation of the eye downward and outward, with impairment of up-gaze and adduction. Increased width of the palpebral fissure on one side suggests facial weakness on that side, caused by either upper motor neuron or cranial nerve VII dysfunction. Cranial nerve VI dysfunction is seen with increased intracranial pressure or focal problems that compromise the transit along this long cranial nerve. It is characterized by
in-turning of the eye on the affected side or impairment of lateral gaze (abduction) beyond the midline. Finally, as a screening test, it is helpful to perform an eye-to-eye cover-uncover test while the child’s gaze is fixed on the examiner’s nose. This will unmask an eso- or exophoria, which is diagnosed if a “lazy eye” jumps back to fixate on the visual target as it is uncovered while the opposite eye is covered.

**Cranial Nerves V and VII**

Isolated abnormalities of facial sensation or musculature are uncommon. Nevertheless, perception of light touch of the face in the three distributions of cranial nerve V branches (forehead, maxilla, and jaw) should be symmetric.

Weakness associated with cranial nerve VII can appear as widening of the ipsilateral palpebral fissure, flattening of the nasolabial fold, drooping of facial muscles, or “pulling” of the mouth to the contralateral side with a smile. Facial weakness caused by dysfunction of cranial nerve VII itself involves both lower and upper (forehead) musculature, whereas weakness caused centrally (eg, by a stroke) involves only lower facial muscles. Decreased lacrimation or salivation can suggest a problem with cranial nerve VII rather than with the central nervous system.

Two reflexes are associated with these cranial nerves. The corneal reflex, which is seldom required in ambulatory settings, tests the sensory arc of cranial nerve V and the motor arc (blink) of cranial nerve VII mediated at the level of the pons. The jaw jerk tests the afferent and efferent motor arcs of cranial nerve VII, also mediated at the same level. The reflex is abnormally brisk with upper motor neuron lesions above the pons; with lesions of the same level. The jaw jerk tests the afferent and efferent motor arc (blink) of cranial nerve VII mediated at the level of the pons. The jaw jerk tests the afferent and efferent motor arcs of cranial nerve VII, also mediated at the same level. The reflex is abnormally brisk with upper motor neuron lesions above the pons; with lesions of the same level. The reflex is abnormally brisk with upper motor neuron lesions above the pons; with lesions of the same level.

**Cranial Nerve VIII**

Hearing should be assessed behaviorally or in a standardized manner as clinically indicated. Each ear should be tested individually. The examiner should use a low threshold for obtaining audiometry.

**Cranial Nerves IX, X, and XII**

If there is no abnormality of phonation or articulation, functional assessment of swallowing is often an adequate screen. Liquids are typically more difficult to swallow without choking than are solids for children with upper motor neuron dysfunction, which is generally associated with an exaggerated gag reflex. Quality of speech is important to assess, with attention to nasality, dysarthria, or stuttering. Respiratory function and cough should be assessed, with attention to power and timing.

**Motor Function and Strength**

**General**

Identification of handedness or dominance is always important and can be checked by observing with which hand a child writes his name on a piece of paper, with which eye the child looks through a pinhole in the paper, and with which arm or leg the child throws or kicks a wadded piece of paper. Posture should be evaluated, looking especially for a protuberant belly and exaggerated lumbar lordosis suggestive of weak truncal musculature. Abnormal movements, such as chorea, stereotypies, and motor tics should be described. (Tics can include sniffing, throat clearing, or squeaks, as well as complex, ritualistic behaviors.)

**Development**

Muscle bulk should be observed when the child is undressed, with careful search for muscle atrophy or underdevelopment. Increased muscle bulk, as in the case of Duchenne’s muscular dystrophy, does not necessarily indicate good strength. The circumference of asymmetric calf or bicep muscles should be measured. Fasciculation of muscles at rest should be noted, although these are difficult to see in the chubby child. Limitations in range of motion should be noted. Assessment of neck rotation and lateral bending should not be overlooked in children with head or neck pain.

**Tone**

Passive resistance to movement of a child’s muscle by the examiner is a valuable tool in motor assessment. Shaking a leg or arm to evaluate the “flappiness” of the foot or hand easily separates the hypotonic or hypertonic child from the normal child.

**Strength**

Observing for drift and pronation of one arm while both are outstretched “to catch raindrops” is a helpful screen for mild weakness. Testing against resistance should focus on muscles that are more sensitive indicators of weakness, particularly with the older or stronger child. These muscles include deltoids (“hold your arms out like wings”), wrist extensors (“hold your hands up like a policeman stopping traffic”), hamstrings (“pull your foot back toward your bottom”), and ankle dorsiflexors (“cock your feet up toward your head”). Handgrip, biceps, quadriceps, and gastrocnemius muscles are comparatively stronger, and they are noticeably weak only when symptoms are advanced. (Isolated weakness of the sternomastoid and trapezius muscles, with diminished ability to turn the head away from the involved side and drooping of the ipsilateral shoulder, is caused by cranial nerve XI weakness.)
If weakness is detected, strength should be quantified on a 5-point scale (ie, 1 = visible or palpable muscle contraction, 2 = movement without gravity, 3 = movement against gravity, 4 = movement against resistance, 5 = normal strength). Asking the child to rise from a squatting, sitting, or supine position is a good screen for lower extremity weakness. Gowers' sign is present if the child rises by pushing hands against the legs. Standing or hopping on one foot is a measure of strength and coordination. Observing a child walk or run is an opportunity to identify ataxia or significant asymmetry of posture, arm swing, or foot orientation.

**Coordination**

Asymmetry of rapid alternating movements reveals abnormal motor function. Comparing rapid left and right pincer movement of thumb and finger (“chomping alligator”) or rapid toe-tapping is a good screen, with slowness suggesting upper motor neuron dysfunction and irregularity suggesting cerebellar dysfunction. Finger-to-nose testing can unmask tremor or dysmetria.

**Reflexes and Sensory Examination**

Muscle stretch reflexes demonstrate the integrity of the reflex arc that occurs at several levels of the spinal cord. An approximate but easy way to remember these is as follows:

- (Sacral) 1, 2 ankle jerk
- (Lumbar) 3, 4 knee jerk
- (Cervical) 5, 6 biceps reflex
- (Cervical) 7 triceps reflex

Significantly decreased reflexes suggest a muscle, peripheral nerve, or cerebellar problem. Acutely, an upper motor neuron lesion also causes decreased reflexes. Significantly increased reflexes suggest a brain or spinal cord problem. This is typically found in conjunction with absent abdominal reflexes and a positive Babinski’s reflex (ie, dorsiflexion of the big toe). Doing this test properly requires stroking the plantar surface of the foot, beginning near the heel and progressing along the lateral side of the sole—not the central region—to the base of the toes and then medially toward the big toe. The initial movement, not the greatest movement, of the big toe is recorded. Abdominal reflexes extinguish quickly but are properly done by stroking from lateral to medial in each quadrant above and below the umbilicus.

Sensory examination is more difficult and often less revealing in children than in adults. However, it is essential to identify an early, distal neuropathy. In addition to causing decreased ankle reflexes relative to more proximal reflexes, distal neuropathy is characterized by diminished sharpness to sharp sensation (produced with a splintered, sterile, disposable tongue depressor). Older children with distal neuropathy can also report earlier extinction of vibratory sensation at the nail of the big toe compared with the ankle (medial malleolus) or the knee (patella). Global assessment of proprioceptive pathways is invaluable. The examiner should ask a child to stand with feet together, first with eyes open and then with eyes closed. An abnormal response, positive for Romberg’s sign, is an inability for the child to maintain balance when eyes are closed. In most circumstances, limited reliability makes detailed assessment of other primary modalities (ie, touch, temperature, and position sense) or cortical modalities (ie, graphesthesia or extinction on double simultaneous stimulation) an unrewarding investment of the examiner’s time.

**Other Parts of the Examination**

Every child should be examined for possible neurocutaneous findings, as both skin and nervous system derive from ectoderm. The examiner should search for hypopigmented spots (seen best with ultraviolet light), café-au-lait spots, and angiomas. The dorsal midline from the base of the skull to the sacrum should be examined for defects such as a dimple, angioma, or tuft of hair. The child’s nutritional status should be evaluated, including subcutaneous tissue as well as distribution and quality of hair. Autonomic abnormalities, manifest by postural instability of blood pressure and pulse or by changes in skin temperature, color, sweating, capillary refill, or hair loss, should be noted. The head should be examined carefully, with special attention to features of the face, palate, or skull that might suggest a known syndrome. With a child referred for headache or pain, the examiner should search for focal tenderness (eg, temporomandibular joint, gingiva, sinuses, trigger points) and impaired range of motion (eg, scoliosis, contractures, cervical strain, paraspinal muscle spasm). The abdomen should be examined for hepatosplenomegaly when there is concern about metabolic disorders, storage diseases, or human immunodeficiency virus; the heart should be examined carefully as part of evaluation for stroke. The examiner should request old photographs whenever changes in appearance or habitus are reported and home videotapes when there are concerns about paroxysmal events or movement disorders.

**Special Considerations for the Infant and Younger Child**

**Head Growth**

Head circumference is a tremendously important measurement to be taken at every visit; it should be double-checked.
by the examiner after initially being measured by staff. Up to age 6 years, there is a linear relationship between head circumference and brain volume. Head circumference measurements should be plotted on a standardized growth chart for boys or girls. Head circumference increases approximately 0.5 cm each week in term infants; during the first 2 months it can increase 1.0 cm per week in preterm infants. Average head circumference is about 40 cm at age 3 months, 45 cm at age 9 months, and 50 cm at age 3 years.

Macrocephaly refers to a head circumference above the 98th percentile. It can be familial in origin (underscoring the importance of measuring head circumference in both parents); however, it can reflect abnormal brain growth (eg, megencephaly) or increased cerebrospinal fluid spaces (ie, hydrocephalus). Microcephaly refers to a head circumference below the 2nd percentile. It commonly reflects a perinatal insult to the brain, intrauterine growth retardation, or a genetic syndrome; it is rarely caused by fusion of the sutures (ie, craniosynostosis). Special attention should be given to a child whose head circumference crosses percentile lines after serial measurements. Increases can be suggestive of autism or elevated intracranial pressure; decreases can be suggestive of progressive cerebral atrophy or growth problems. Craniosynostosis is most commonly manifest as altered head shape rather than altered head size. The most common form is fusion of the midline sagittal suture; this results in a long, thin (ie, dolichocephalic) head.

Neurodevelopment

Identifying finger-pointing as a preverbal skill is often helpful in distinguishing aberrant development (eg, with autism) from delayed but otherwise normal development. It is necessary to confirm developmental milestones. When lying prone, a 3-month-old should be able to lift his head off the table, a 4-month-old should be able to support his torso on both hands, and a 5-month-old should be able to balance on one hand and reach with the other. A 6-month-old should be able to roll from supine to prone, an 8-month-old should be able to sit unsupported, and a 10-month-old should be able to crawl and to pull up to a standing position. By 12 months a child should be able to walk with support and by 14 months without help.

Developmental reflexes appear at birth and normally disappear at specific ages. Truncal incurvature should disappear by 2 months, the rooting reflex by 3 months, and Moro’s reflex by 4 months. Persistence or exaggeration of reflexes is abnormal. The asymmetric tonic neck reflex (“fencer posture”), which typically disappears at 4 to 6 months, must dissipate before the infant can roll over. Side-to-side differences in muscle tone occur with changes in head position because of this reflex, emphasizing the importance of keeping the head midline during examination of posture and tone. The tonic labyrinthine reflex, which typically disappears around 6 months, accounts for differences in muscle tone depending on the position in which a child is examined. When supine (with head extended), muscle tone is greater than when sitting in the examiner’s lap (with head flexed).

Cranial Nerves

Funduscopic examination is possible if the ophthalmoscope can be used in a game of “peek-a-boo.” Sometimes toys can be used to help a child fixate, and the child will be more comfortable in a parent’s lap than on the examining table. The tongue should be examined carefully for fasciculations, which can be subtle but are a valuable sign of motor neuron disease.

Motor Function

Handedness appears around 1 year of age; earlier manifestations of preference suggest unilateral weakness. The grasp reflex in the hand disappears before normal handdness develops; persistence beyond 6 months of age suggests upper motor neuron dysfunction. A functional grasp in the normal child involves the thumb and two fingers by 8 to 10 months of age and a thumb–index finger pincer movement by 12 months of age. Persistent fisting of the hand, adduction of the thumb against the palm of the hand, and increased flexion of the wrist are signs of upper motor neuron dysfunction.

In the legs, persistent toe walking or shortening of the Achilles tendon are upper motor neuron signs. Plantar grasp reflex is abnormal beyond 10 months of age. Decreased strength with motor neuron disease, peripheral nerve dysfunction, or a muscle problem is suggested by a frog-leg posture when the child is supine; decreased flexion at the hips and knees is abnormal. A child with significant weakness who is suspended upright slides through the examiner’s hands because of decreased shoulder muscle strength. In the normal infant, spontaneous movements should be symmetric or reciprocating but equal. In the toddler, functional assessment is helpful; examples are observing the child get up from a supine position on the floor without using the arms, climbing steps if they are available, hopping, or repeatedly stepping up onto a low stool.

Special Considerations in the Newborn

Cranial Nerves

Cranial Nerve II

Full-term infants will typically blink in response to bright light and turn toward and fixate on a light of moderate intensity.
intensity. The blink response appears at around 26 weeks of gestation and sustained eye closure appears around 32 weeks; turning toward a light develops at around 37 weeks. The optic disk of a newborn is gray-white in color rather than yellow-pink, particularly in blond, fair-skinned children, so the examiner should be careful in diagnosing optic atrophy. Papilledema is rarely seen in infants because fontanelles and sutures typically remain open and can separate with increased intracranial pressure. (However, the ability to palpate the squamosal suture, which runs in a frontal–occipital direction above the ear, is highly suggestive of increased intracranial pressure.)

In the first few months of life, children are at highest risk for non-accidental trauma, and careful observation for retinal hemorrhages is essential. In the young child, hemorrhages resolve quickly; those that occur in one-third of infants following vaginal delivery usually resolve within 72 hours and essentially all resolve within 1 week. “Shaken baby” hemorrhages of different types typically resolve within a week, depending upon the extent of hemorrhage and the likelihood of multiple insults. Flame hemorrhages, which occur in the transverse nerve fiber layer of the retina, have feathered edges. Dot hemor-

CRANIAL NERVES III, IV, AND VI
The pupil typically reacts to light by 30 to 32 weeks gestational age, indicating that term infants should demonstrate the same pupillary symmetry and reactivity as older children. Full eye movements can be demonstrated as early as 25 weeks gestational age. At rest, premature infants have slightly disconjugate gaze, with pupils up to 1 mm lateral of their position during fixation. Disconjugate gaze persists in infants with periventricular leukomalacia. In the normal infant, sudden movement of the head horizontally or vertically should be accompanied by a symmetric movement of the eyes in the opposite direction. (This is a positive doll’s eye maneuver.)

CRANIAL NERVES IX, X, AND XII
Sucking and swallowing, as well as the rooting reflex, develop around 28 weeks gestational age. However, synchronized movements to facilitate feeding occur around 32 to 34 weeks, and coordination of feeding with breathing occurs 4 weeks later. Effective sucking also requires integrity of cranial nerves V and VII. Cough can be triggered by gentle pressure to the trachea at the suprasternal notch.

Motor Function
Observation of tremulousness, exaggerated startle responses, or myoclonus (whether spontaneous or reflexive) suggests central nervous system or metabolic abnormalities. Muscle tone is typically assessed by the range of passive movement around a joint, such as how far the arm can be “stretched” at the shoulder across the chest. In a term infant with normal tone, the elbow does not quite reach the midline chest. This is a function of both gestational age and muscle tone. A normal infant at 28 weeks of gestation has only minimal resistance to movement and the elbow easily stretches beyond midline. Resistance in flexor muscles of the legs increases by 32 weeks and in the arms by 36 weeks.

Another useful measure of tone is the popliteal angle created behind the knee when the foot is stretched toward the abdomen. Contractures from decreased movement in utero can restrict movement and misleadingly simulate increased tone. Central nervous system problems are typically associated with decreased tone initially at birth, which evolves to increased tone by 4 to 6 months. Increased tone during the first few weeks of life is more likely to represent rigidity than spasticity and suggests metabolic disorder, basal ganglia abnormality, or drug withdrawal.

Assessment of Higher Brain Function
Children are increasingly referred for neurologic evaluation of school failure, hyperactivity, learning disability, and autism, necessitating more detailed assessment of cognition. Prior assessments by school psychologists, speech-language pathologists, or developmental pediatricians can help focus this specialized evaluation. Although several acceptable strategies build upon the traditional mental status examination, the following approach, adapted with permission of the surviving authors (Weinberg and colleagues, 2001), is particularly useful:

- **Attention and vigilance.** The examiner should observe behavior that suggests decreased vigilance or attention, such as yawning, stretching, or napping; daydreaming or distractibility from a current activity; poor cooperation on structured or repetitive activities with complaints of boredom; delayed, slow, or incomplete effort on assigned tasks; fidgetiness, motor restlessness, or akathisia; and poorly focused busyness or talkativeness. It is important to distinguish between the child who remains attentive to the conversation while exploring the room’s contents and the child who is not engaged in the process.

- **Language comprehension.** The examiner should also evaluate a child’s ability to clearly understand and correctly respond to spoken language. Poor eye contact or inattention to the examiner, irritability or resistance to
listening, and preference for pictures or for a nonverbal environment suggest a problem with language comprehension. Alternatively, a child who maintains an enduring interest in watching the speaker's lips could have difficulty with word reception. Even if hearing has been shown to be normal, this can cause a child to repeatedly say "What?" or "Huh?" when spoken to. A child who provides an inappropriate answer, such as "I'm fine" when asked his name, demonstrates impaired word reception.

• Language production. The ability to retrieve and correctly use words also must be assessed. The examiner should meticulously listen to a child's spontaneous speech to make sure that he can effectively communicate his message and that he uses appropriate words to convey his intended meaning. Not only should the normal child be able to correctly name specific objects that are age-appropriate, he also should be able to define the following words:

  • Age 6 to 8 years: baby, name, green, second
  • Age 8 to 10 years: visit, spring, money, thought
  • Age 10 to 12 years: grasp, moist, browse, stride, coward
  • Age 12 to 14 years: freight, obsolete, drought, absorb, occupation
  • Age 14 to 16 years: fortuitous, vaguely, judicious, vocation, absurd

If the child has difficulty with this task, he should be asked to choose among three definitions, one of which is correct. In addition to knowing words, a child must demonstrate his ability to retrieve them. Asking a child to describe the examining room or his most recent meal offers the examiner an opportunity to evaluate this skill.

• Speech production. Closely related to language production is the ability to produce spoken words. By age 18 months, a child should be able to clearly express single words. By 24 to 30 months, a child should be able to make a statement using a short string of words. Repetition of words spoken by someone else (ie, echolalia) is common among toddlers, but is abnormal in the child of preschool age. Consistent stuttering in a young child more likely suggests a problem with word production than does stuttering in an older child during periods of stress.

• Memory. By age 6 years, a child should be able to state at least part of his birth date. In the examination setting, a child of this age should also be able to remember a person's name. Introducing a one-syllable name for a 6- to 8-year-old, a two-syllable name for an 8- to 10-year-old, a three-syllable name for a 10- to 12-year-old, and a four-syllable name for an older child, the examiner should ask the child to repeat the name five times and then tell the child that he will have to recall the name in 5 to 10 minutes. If he has difficulty recalling all or part of the name, he should be asked to select correctly from three choices. An older child who has difficulty recalling the names of friends, teachers, or coaches should be carefully evaluated, as should one who has more difficulty with fill-in-the-blank than with multiple-choice tests.

• Reading and writing. Effective written communication depends upon recognition of letters and words. By age 5 1/2 years a child should be able to name the capital letters A, B, C, D, and E. By age 6 1/2 years he should be able to name the lowercase letters a, b, c, d, h, j, k, m, n, p, u, w, x, y, and z. Listed below are age-appropriate tasks of spelling that build upon the above elements. Also, the ability to spell the target word below both forward and backward, and know what the reversed word means, correlates with the ability to read and understand age-appropriate material. If a child fails these screening tests, they should be supplemented with sample reading passages at grade level.

<table>
<thead>
<tr>
<th>Spell Forward</th>
<th>Spell Backward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 6 to 7 years</td>
<td>it, cat, look, stop, spot</td>
</tr>
<tr>
<td>Age 7 1/2 to 8 years</td>
<td>work, talk, girl, went</td>
</tr>
<tr>
<td>Age 8 to 9 1/2 years</td>
<td>should, could, phone, house</td>
</tr>
<tr>
<td>Age 9 to 10 years</td>
<td>monkey, elephant, receive, friend</td>
</tr>
<tr>
<td>Age 10 to 11 1/2 years</td>
<td>purchase, ethics, delicate, live, dial, delicious</td>
</tr>
</tbody>
</table>

Like letters and words, numbers and mathematical phrases represent symbolic communication. Similar age-appropriate screens are available to assess skills with numbers and arithmetic (Weinberg and colleagues, 2001). Consideration also should be given to handwriting, which relates to reading and writing as speech articulation relates to receptive and expressive language.

• Sequencing. Being able to recognize, learn, and assemble components of a sequence is an important skill for learning. By age 5 years a child should be able to count to 10; by age 6 years he should be able to do it backward. A 6-year-old also should be able to recite the alphabet. A 7-year-old should be able to say the days of the week, and an 8-year-old should be able to say them backward. By 9 1/2 years a child should be able to say the months of the year, and by 11 years he should be able to say them backward. The child's development of sequencing skills with numbers (eg, in simple calculations), with symbols (eg, drawing clocks), and with body parts (eg, in drawing people) also should be evaluated.

• Prosody. Although difficult to quantify, the emotional quality of communication is important. This ranges from the pitch, intonation, and musicality of speech,
to the appropriateness of gestures and recognition of personal space. It also includes the concept of empathy and the ability to understand the facial expressions, gestures, and feelings of others. The examiner should ask a child to identify feelings expressed by faces (of the examiner or on face cards) that show happiness, sadness, or anger. The child should then be asked to mimic the facial expression. The examiner can dispassionately make a variety of statements, asking the child which of the three emotions best fits the statement. An older child can be asked to repeat the statement, adding the inflection of happiness, sadness, or anger appropriate to the content of the statement. It is important to observe the repertoire and emotional appropriateness of the child’s gestures, as is observing the child’s response to the examiner’s gestures.

• Mood. Depression is often overlooked in children, particularly in those for whom it cycles in minutes or hours to giddiness. The examiner should be alert for signs of sadness, loneliness, frustration, loss of interest, decreased energy, sleep disturbance, or change in appetite. Paroxysms of unprovoked rage or inappropriate hyperactivity should be noted. After winning a child’s agreement to answer serious questions, the examiner can inquire whether the child has mostly good or bad days; whether the bad days are accompanied by good or bad feelings about himself; whether the bad feelings cause him to cry, keep him from having fun, or prevent him doing school work; and whether the bad feelings lead to a wish for death, suicidal thoughts, or suicidal behavior. Depression can significantly interfere with cognitive function. Similarly, obsessive–compulsive or oppositional behavior can compromise performance during examination. Although a better measure of healthy cognition than healthy affect, humor and wit should also be assessed. Like logical thought, humor and wit reflect higher brain processes that help a child to be adaptable, perceptive, and successful in developing social relationships.

Final Notes

The reporting of neurologic examinations is often formulaic or mechanical. However, with children the exam must be descriptive, even if such description implies some lack of sophistication on the part of the examiner. It is more important for the reader to have a vivid mental image of how a child moved, responded, and behaved than to know that the child was “oriented × 3,” had a “red reflex present” or that “DTRs were 2+ throughout.” During this era in which neurologic disorders are reconsidered and reclassified because of advances in molecular genetics, careful recording of clinical phenomenology is essential.

There is professional pride that derives from mastering the neurologic exam. Even if it is done well, however, there can be circumstances in which deficits remain silent or cannot be localized. For example, strokes can occur in children with sickle cell disease and produce no localizing signs. Focal cortical dysplasia can be the cause of localized seizures but manifest no abnormality on exam. Similarly, it can be impossible to quantify or localize global insults, such as those produced by exposure of newborns to bilirubin or of toddlers to lead. This underscores the importance of coordinating the neurologic exam with thoughtful laboratory evaluation when it is likely to expand understanding of the problem. Diagnostic studies cannot replace meticulous examination, however, because of the expansiveness of the nervous system and potential adverse effects of the tests themselves.

Suggested Readings


Practitioner and Patient Resources

Internet Handbook of Neurology
http://www.neuropat.dote.hu/neurology.htm
This page lists neurologic examination guidelines for multiple institutions and includes an online interactive guide with video demonstrations as well as many links to pages containing information on various aspects of neurologic diagnosis and treatment.

NeuroExam.com
www.neuroexam.com
This Web page provides an interactive guide with video demonstrations of all parts of the neurologic examination.

eMedicine: Neurological History and Physical Examination
http://www.emedicine.com/neuro/topic632.htm
eMedicine provides this comprehensive guide to the basic neurologic examination and that aimed at the assessment of more specific problems.