Occupational Therapy for Children- Module 3: Motor Control & Learning/Sensory Integration/Visual Perception

Course Description:
This course is derived from the textbook Occupational Therapy for Children by Jane Case-Smith, EdD, OTR/L, FAOTA and Jane Clifford O'Brien, PhD, OTR/L. Occupational Therapy for Children focuses on children from infancy to adolescence and gives comprehensive coverage of both conditions and treatment techniques in all settings. The course includes author contributions, new research and theories, new techniques, and current trends to keep the therapist in step with the changes in pediatric OT practice. The text provides a strong focus on evidence-based practice with the addition of key research notes and explanations of the evidentiary basis for specific interventions.

This course covers chapters 9, 11, and 12
Chapter 9: Application of Motor Control/Motor Learning to Practice
Chapter 11: Sensory Integration
Chapter 12: Visual Perception

Methods of Instruction:
Online course available via internet

Target Audience:
Occupational Therapists and Occupational Therapy Assistants

Educational Level:
Intermediate

Prerequisites:
None

Course Goals and Objectives:
At the completion of this course, participants should be able to:
1. Identify the components of the dynamical systems theory
2. Recognize factors that affect motor performance
3. Recognize the contributions of the visual system
4. Identify the motor control components of posture/balance control
5. Differentiate between the Williams' Motor Learning Principles
6. Identify goals of motor performance intervention
7. Recognize the roles of sensory integration
8. Recognize the sensory challenges of the prenatal period
9. Identify childhood occupation landmarks
10. Differentiate between sensory integration problems
11. Identify commonly used clinical observations
12. Recognize key characteristics of SI intervention
13. Recognize the expected outcomes of occupational therapy
14. Identify the visual-receptive components
15. Differentiate between commonly used Visual-Perceptual tests
16. Recognize intervention strategies for visual attention
17. Differentiate between appropriate reading methods based on reading style

Criteria for Obtaining Continuing Education Credits:
A score of 70% or greater on the written post-test
DIRECTIONS FOR COMPLETING THE COURSE:

1. This course is offered in conjunction with and with written permission of Elsevier Science Publishing.
2. Review the goals and objectives for the module.
3. Review the course material.
4. We strongly suggest printing out a hard copy of the test. Mark your answers as you go along and then transfer them to the actual test. A printable test can be found when clicking on “View/Take Test” in your “My Account”.
5. After reading the course material, when you are ready to take the test, go back to your “My Account” and click on “View/Take Test”.
6. A grade of 70% or higher on the test is considered passing. If you have not scored 70% or higher, this indicates that the material was not fully comprehended. To obtain your completion certificate, please re-read the material and take the test again.
7. After passing the test, you will be required to fill out a short survey. After the survey, your certificate of completion will immediately appear. We suggest that you save a copy of your certificate to your computer and print a hard copy for your records.
8. You have up to one year to complete this course from the date of purchase.
9. If you have a question about the material, please email it to: info@advantageceus.com and we will forward it on to the author. For all other questions, or if we can help in any way, please don’t hesitate to contact us at info@advantageceus.com or 405-974-0164.
Application of Motor Control/Motor Learning to Practice

Jane O’Brien  •  Harriet Williams

KEY TERMS

- Dynamical systems
- Postural control
- Motor control
- Motor learning
- Vestibular
- Balance
- Visual perception
- Feedback
- Transfer of learning

OBJECTIVES

1. Understand the concepts of motor control and motor learning theories.
2. Develop interventions for children with motor control deficits based on current motor control/motor learning research.
4. Describe components of motor control that influence movement, including postural control, balance, visual perception, and body awareness.
5. Define concepts of motor learning including transfer of learning, feedback, practice, sequencing and adapting tasks, modeling or demonstration, and mental rehearsal.

Typically-developing children move into and out of positions fluidly and with ease, exploring their worlds, learning about their bodies, and developing motor, cognitive, sensory, and social skills. They use their hands for feeding, dressing, bathing, play, and academics (Figure 9-1). They practice sitting, walking, jumping, and crawling. They play in a variety of positions and show variability in their movements. Conversely, children with motor control deficits have difficulty in such activities and may not have the same opportunities to explore their surroundings; they may take longer and often do not master movements. Because motor control is central to participation, occupational therapists are concerned with how to help children control movements so that they may engage in their occupations.

This chapter presents case examples to illustrate the principles of motor control and motor learning related to occupational therapy practice, beginning with a definition of motor control and an overview of past motor approaches. Next, dynamical systems theory and the components of movement, including postural control, balance, visual perception, and body awareness are explained to help readers understand the complexity of movement. A definition of related motor learning and a review of related key concepts, including practice, feedback, modeling or demonstration, and mental rehearsal, also are provided.

Case Studies 9-1 through 9-3 illustrate the diversity of motor control deficits found in children. Motor control deficits interfere with activities of daily living, self-care, social participation,
Motor control is defined as the “ability to regulate or direct the mechanisms essential to movement” (p. 4). Motor control refers to how the central nervous system organizes movement, how we quantify movement, and the nature of movement. Researchers interested in motor control examine the mechanisms, strategies, and development of movement, as well as causes of motor dysfunction. Occupational therapy practitioners use this knowledge to design effective intervention so that children with motor control deficits may participate in their desired occupations.

Movement deficits occur in numerous conditions including cerebral palsy, developmental coordination disorder (DCD), pervasive developmental disorder, Down syndrome, sensory integration disorders, and acquired brain injury. Historically, intervention strategies used by practitioners varied according to the etiology and nature of motor impairments. Traditionally, therapists have used bottom-up approaches, hypothesizing that if they treat the underlying causes of motor dysfunction, the child’s function will improve. Therefore, the

CASE STUDY 9-1  Teagan

Teagan is a 4-year-old boy who loves to play tee-ball and especially run the bases. He loves getting ready (like the pros) for the swing. Teagan has Down syndrome. His gross motor skills are awkward and he must take breaks when running around the bases. However, he is able to play tee-ball for long periods of time and enjoys pushing his tricycle, sliding down the slide, and swinging (see the Evolve website for accompanying video). Closer analysis of Teagan’s gross motor skills shows that he has low muscle tone throughout, as is characteristic of Down syndrome. He runs with a wide-based gait, and holds his arms close to his body for balance. His posture is asymmetrical (he elevates his shoulders and leans) when he runs. He holds objects in a palmar grasp and exhibits delayed visual-perceptual skills, interfering with his fine-motor performance. Teagan’s speech is delayed, he mumbles words, he attempts to communicate, and is able to express simple needs through signs (e.g., I want). Teagan engages in parallel play with other children at his day care center, not really interacting with them. When he does interact with his peers, he engages at a much younger level and frequently interferes in their play.

CASE STUDY 9-2  Georgia

Georgia is a 2-year-old girl who has difficulty playing on the playground. She is diagnosed with cerebral palsy, right hemiplegia. She walks but her movements are awkward and slow. She leans to the left and drags her right toe on the ground. Her right leg is positioned in the “typical” hemiplegic pattern (internally rotated, foot pronated, ankle extended). She does not use her right hand when playing with her toys and has difficulty manipulating objects. The other children run quickly past her. Georgia falls frequently. She looks frustrated at times that her body will not cooperate with her intentions.

CASE STUDY 9-3  Devin

Devin is a 10-year-old boy who has difficulty with fine-motor tasks, such as tying his shoes, buttoning, and, especially, writing. He takes longer than his peers to get ready for recess. Devin is awkward in his movements, falls frequently, and experiences difficulty with balance and coordination skills. He cannot skip, hop, or ride a bicycle. Eye-hand coordination is poor as shown in his inability to catch a ball or play games such as baseball or Frisbee. Devin has been diagnosed with developmental coordination disorder (DCD) (Box 9-1). He has above average intelligence and enjoys playing with other children, although he tends to stay on the “fringes” of the activity.

BOX 9-1  Description of Developmental Coordination Disorder

Developmental coordination disorder (DCD) refers to children who exhibit motor coordination markedly less effective than expected for their chronological age and intellectual ability. The motor coordination impairments must significantly interfere with activities of daily living and cannot be a result of physical, sensory, or neurological impairments.

goals of intervention included improving abnormal muscle tone, sensory dysfunction, weakness, and poor endurance. Bottom-up approaches include sensory integration intervention, neurodevelopmental treatment, strength training, and perceptual motor training. These interventions focus on decreasing the underlying deficit and improving performance. These motor control approaches support a hierarchical model of control—that is, the brain (central nervous system) controls movements. Case Study 9-4 illustrates a bottom-up approach.

Overall, bottom-up approaches have not been found to be effective in improving the occupations of children. These motor control approaches support a hierarchical model of control—that is, the brain (central nervous system) controls movements. Case Study 9-4 illustrates a bottom-up approach.

Dynamical systems theorists propose that movement derives from a variety of sources and takes place within a variety of contexts. This contemporary motor control theory assists therapists in framing evaluation and subsequent intervention to promote movement in children and youth with motor dysfunction. Dynamical systems theory suggests that movement is dependent on task characteristics and an interaction among cognitive, neuromusculoskeletal, sensory, perceptual, socio-emotional, and environmental systems (Figure 9-3). The interaction among systems is essential to predictive and adaptive control of movement; motor performance results from an interaction between adaptable and flexible systems. Dysfunction occurs when there is a lack of flexibility or adaptability of movements to accommodate task demands and environmental constraints.

This lack of adaptability or flexibility is observed in children with motor impairments, who frequently move in limited or stereotypical ways—that is, they have a small repertoire of movements. For example, 3-year-old Sakina, who experienced motor planning deficits, had only one motor pattern for climbing onto a tricycle and could not get on the tricycle when it was turned at a different angle. Case Study 9-5 illustrates the complexity and dynamical nature of movement.

As depicted in this case, Teagan’s movement arises from interactions and organization among many systems and is not simply a matter of muscle tone and central nervous system functioning (as bottom-up approaches suggest). The occupational therapy practitioner simplified the task by using a tee-stand, instead of requesting that Teagan hit a moving target.
Stationary tasks (e.g., ball placed on tee-stand) are more easily accomplished than dynamic tasks (e.g., hitting a moving target). The difficulty of planning and executing movement may also be changed by altering the degrees of freedom required to accomplish a movement. Degrees of freedom are defined as possible planes of motion in the joints controlled by the musculoskeletal and central nervous system. Decreasing the degrees of freedom required for movement may result in more functional movement. Holding the bat close to the ball and hitting it while it is on the tee-stand require that Teagan control fewer planes of motion, thereby limiting the degrees of freedom for the movement when compared with hitting a moving ball.

Teagan may also learn to contract movements together (i.e., synergistically) to decrease the degrees of freedom. For example, synergistic movements (or coupling) occur when children reach for objects, because the elbow, wrist, and fingers tend to extend toward the object. Other synergistic patterns have been found with walking, tapping tasks, and throwing.

Teagan may adopt movement tendencies or patterns in which he is comfortable, such as running with his arms close to his body. Dynamical systems theorists use the term attractor state to describe the tendency to stay in the patterns of the status quo. For example, a child may have the tendency to sit in a posterior pelvic tilt. This pattern may not be the most efficient and may even prevent the child from achieving other milestones (e.g., such as reaching with ease). The therapist’s role is to identify the attractor state and help facilitate movement away from this state (i.e., perturbation), if it is not functional for the client. W-sitting (Figure 9-4) is a common attractor state children use to maintain stable sitting but is not recommended because it may dislocate hips and limit trunk strengthening. Facilitating a child away from an attractor state is often referred to as a perturbation—a force that alters the movement pattern. Perturbations can be used to help children move in different ways.

Dynamical systems theory integrates well with occupational therapy principles and can be used to facilitate intervention. Specifically, a child learns movement more easily and effectively if (1) the movement is taught as a whole (versus part); (2) the movement is performed in variable situations; (3) the child is allowed to actively problem-solve the actions required; and (4) the activity is meaningful to the child. Summarized next are findings from motor control literature on the non-linear dynamical systems concepts of whole learning, variability, problem-solving, and meaning, and their influence on occupational therapy practice.

### Whole Learning

According to dynamical systems theory, many systems are involved and interact with each other to plan and execute movement. Therefore, engaging in the whole activity
(occupation) targets and facilitates multiple systems and the interactions required for effective movement. Overall, learning the whole motor task is more effective and motivating than learning only a part of the movement. 

Children perform whole tasks more efficiently and with better coordination than when they are asked to perform only a part or component of the movement. Van der Weel and colleagues found that children with cerebral palsy used more supination when banging a drum than when simply exercising. Not only did children perform the task more efficiently, but they also engaged in the task for longer periods of time and activated more areas of the brain during the activity. In addition, functional magnetic resonance imaging (fMRI) studies indicate that more areas of the brain are activated when subjects engage in meaningful whole tasks versus parts of the tasks.

Engaging in the whole activity or occupation requires children to use multiple systems and to respond to changes within and between systems. The ability to respond to this variability within systems is a hallmark of functional movement. Typically developing children, for example, use multiple strategies when moving, as opposed to children with DCD who have been found to exhibit limited variability and adaptability in their movement. Therefore, one goal of occupational therapy intervention is to promote variability and flexibility in movements.

Variability

Dynamical systems theorists propose that movement requires an ability to adapt to changes within and between systems; in other words, variability is central to functional movement. Variability is inherent in activity (e.g., reaching for different objects, environmental stimuli) as well as within and between systems (e.g., interactions between visual and sensory systems).

Movement occurs in a variety of settings and requires that children adapt to environmental changes (using visual and auditory systems) or internal changes (perceived through vestibular and proprioceptive systems) changes. For example, children may need to adjust movements in response to interpretations of visual input (e.g., the ball is coming fast versus slow); children may experience physiological changes (e.g., low energy) affecting movement patterns. The environment may pose changes (e.g., weather, terrain, other children). Functional movement, the goal of motor control intervention, requires that children possess a variety of motor skills.

Because variability is essential to functional movement, occupational therapists teach children to move in variable ways while engaging in occupations. Thus, the expectation of intervention is that the child perform movements in a variety of ways versus repeating and learning one pattern of movement. For example, requesting a child sit in a corner seat to repeatedly pick up a block and drop it into a stationary container requires no adaptability on the child’s part. The child is repeating the same motion. A better intervention session would include placing the blocks scattered on the floor and requiring the child reach in different directions (for different sized blocks) (Figure 9-5).

Performing movements in multiple ways requires that children problem-solve and self-correct. For example, to learn to build a sand castle, the child problem-solves his or her position in the sand and how to scoop and place the sand. Learning a new motor task is more likely to occur if this is a meaningful, socially engaging activity for the child. The child must position his or her body away from the structure and use adequate timing and force to make the castle of his choice. All children use problem-solving to develop and refine movement; therefore, problem-solving is an important part of motor control.

Problem-solving

Improved retention of motor skills occurs when children problem-solve and self-correct for motor errors. Children learn and retain motor skills more from intrinsically problem-solving a motor action than from receiving external feedback during an action (such as hand-over-hand assistance). Self-correcting enables children to rely on internal cues that indicate the effectiveness of movement and thereby help them adapt and modify movements in a variety of contexts.

Therefore, therapists working to improve a child’s motor performance provide many opportunities for the child to actively solve motor problems by doing, rather than repetitive practicing of a part of the movement. Setting up the environment to facilitate physical, social, and cognitive tasks encourages the child to discover how to move, explore options, and self-correct movement errors beneficial to motor learning.
Not only do children benefit from problem-solving how to move, they also benefit from engaging in activities that they find meaningful. Participation in meaningful activities is central to occupational therapy practice and also improves the child’s motor control.

**Meaning**

Dynamical systems theory proposes that the interactions between systems (including the emotional system) influence movements. Occupational therapists have historically viewed the meaningfulness of activities as essential to practice and acknowledge the benefits of purposeful activity in motivating clients to perform. Kielhofner uses the term *volition* to describe one’s motivations, goals, desires, and belief in skill. A child’s participation in motor tasks is influenced by the extent to which he can identify his own interests and goals and believes he will be effective in those motor tasks. Illustrative of these concepts is that children are more motivated to engage in difficult motor skills if they find the activity important and fun and if they believe they can be successful.

In addition, subjects participate for longer periods of time and perform more repetitions when activities are meaningful. Not only do subjects perform longer, but, in addition, the quality of movement improves when the activity has meaning to the child. Meaning may be determined by asking children directly using semi-structured interviews. Cohn, Miller, and Tickle-Degnen and O’Brien et al. found that children with motor deficits wanted to participate in “regular” activities with friends. These expressed interests suggest that practitioners promote meaningful physical activity (such as skiing, swimming, cycling, running, and skating) for children who have motor impairments.

To design effective motor control intervention, occupational therapists must acknowledge the meaning a child attaches to the activity by learning the child’s goals and desires. Meaning is derived from an individual’s experience and viewpoint; thus therapists involve the child in selecting and designing the activity.

**DEVELOPMENT OF MOTOR CONTROL**

The development of motor skills occurs in three stages—cognitive, associative, and autonomous—and involves an interaction among three processes (i.e., cognition, perception, and action). These stages and processes are considered dynamic in that they are constantly changing and interacting with each other in relation to the motor skill or performance requirements.

The cognitive stage refers to the skill acquisition stage. In this stage, the learner practices new movements, errors are common, and movements are inefficient and inconsistent. During this stage, learners need frequent repetition and feedback. Children learning to hold a spoon, for example, may need reminders to take little scoops of food, and to move the spoon to the mouth slowly.

The associative stage involves skill refinement, increased performance, decreased errors, and increased consistency and efficiency. During this stage the learner relates past experiences to the present, thereby “associating” movements (e.g., the child may realize that the last time he moved his hand too quickly, the food dropped off the spoon, so he reminds himself to slow down).

During the autonomous stage, the learner retains the skills and can perform the movement functionally. During this stage, skills are transferred easily to different settings and refined. For example, during this stage a child can feed himself or herself a variety of foods using a spoon and simultaneously carry on a conversation at the table.

Each stage of movement involves interactions among the processes of cognition, perception, and action. Cognition refers to intent or the child’s motivation to move, and also to the ability to plan the movement. Cognitive processes are used in decisions about how to use an object (e.g., throw versus catch).

Perception refers to how the individual receives and makes sense of a stimulus (visual, auditory, tactile, kinesthetic, vestibular, olfactory). Perception involves attributing meaning to sensory input. Perception refers to both peripheral sensory mechanisms and higher level processing that add interpretation and meaning to stimuli. For example, the child must be able to identify the object coming toward him or her or “feel” balance.

The process of action includes muscle contractions, patterns, and precision and nature of the movement (dynamic versus static). Research devoted to the action stage explores factors such as strength, ability to co-activate muscles groups, reaction time, and timing and sequencing, all contributors to movement.

Each stage and process of movement involves a variety of factors that contribute to the motor performance. The following section provides an overview of factors that contribute to motor performance.

**FACTORS AFFECTING MOTOR PERFORMANCE**

A variety of factors are involved in producing motor skills and participation in occupations. After identifying the child’s desires and occupational goals, occupational therapists examine factors within a variety of systems (e.g., social-emotional, physical, sensory) to determine what may be interfering with or facilitating optimal movement.

**Social-Emotional Factors**

Emotion is a psychological state that may affect motor performance. Individuals are able to achieve motor challenges in which they attribute positive feelings. For example, athletes use the “power of positive thinking” to visualize achievement and subsequently exhibit improved motor performance as a result. Conversely, children may experience difficulty performing at their best when they are experiencing negative emotions (such as anxiety or fear). Children may perform less effectively if they are feeling pushed or judged; they may be afraid of failure. Children may want to perform an activity or skill and feel frustrated when they cannot. Watching the child’s expressions during therapy can provide cues to therapists about the degree of difficulty (Figure 9-6).

The practitioner’s therapeutic use of self can facilitate the child’s motor control. Pushing children too hard (e.g., to the point of tears) produces chaos versus self-organization and is not conducive to motor learning. A child who is crying
not actively problem-solving or ready to learn a new motor skill. Children learn movement best when they are challenged at a level at which success is achievable and they are emotionally ready to engage in problem-solving.

Physical Factors

While social-emotional factors are important for movement, physical limitations (and/or strengths) must be equally considered. Occupational therapy practitioners examine physical client factors using knowledge of biomechanics and kinesiology. The following section provides a brief overview of these client factors.

Range of motion is necessary for movement to occur. Impairments in range of motion may require children learn how to move differently (to compensate) or make adaptations in how activities are performed. Interventions are developed to help children increase range of motion to improve function. When examining range of motion, therapists also observe the physical appearance of the structures such as symmetry, physical anomalies, scar tissue, and stature. Not only is it important to evaluate these things, but also to consider how these areas affect movement. Occupational therapy intervention for physical anomalies often includes teaching children to compensate by performing activities in a different manner or providing adaptive equipment to help children perform occupations.

Muscle tone affects movement patterns and is considered in evaluation of motor performance. Muscle tone is defined as the resting state of the muscle. Typical muscle tone allows movement into and out of positions with ease. Children with hypertonicity exhibit increased muscle tone, resulting in limited movements; those with hypotonicity exhibit low muscle tone, which results in excessive range of movement but limited control over movement.

The goal of occupational therapy intervention is not to change the muscle tone, but rather to improve the child’s ability to perform occupations. This may be accomplished by providing children with assistive support, such as a supportive seat or an alternative tabletop (Figure 9-7). Case Study 9-6 illustrates how engaging the child in play and supporting an upright posture may improve muscle tone or, conversely, how despite abnormal muscle tone, a child can learn to move.

Strength limitations may interfere with motor performance. Strength is defined as the voluntary recruitment of muscle fibers. In strength training, the child repeats movements, often with added resistance or weight. Although it is possible to increase a child’s strength through exercise routines, engaging the child in play is more suitable to occupational therapy. Kaufman and Schilling reported changes in muscle strength, motor function and proprioceptive position in space in a young child with DCD after a strength training program. However, the

**FIGURE 9-6** Children can become frustrated when learning new motor skills or tasks.

**FIGURE 9-7** Sitting in an adapted seat with tabletop helps postural control.

**CASE STUDY 9-6** Kiera

Kiera is a 4-year-old girl with spastic quadriplegia who has difficulty sitting independently and playing. Kiera is unable to reach accurately for objects. Rather than working to decrease Kiera’s muscle tone, the occupational therapist provided Kiera with an adaptive seat, which supported her trunk and allowed her to sit upright. Kiera was able to sit upright and interact with others, play, and work her trunk muscles in this seated position. As a consequence of engaging in play in supported sitting, her muscle tone improved and she was able to play with improved physical coordination.
authors did not examine how the program affected the child’s occupational performance.

### RELATING DYNAMICAL SYSTEMS THEORY TO BALANCE

Because balance is an integral part of movement, occupational therapy practitioners frequently address balance issues in children. For example, children must possess adequate standing balance to dress and play. Children require adequate sitting balance for handwriting, feeding, and academic tasks. Balance involves the interaction of multiple systems (e.g., sensory, neuromuscular, skeletal, cognition, and environmental). How dynamical systems theory relates to balance is discussed next.

**Balance: An Overview**

For children to carry out skillful, coordinated, and effective movements, whether they are fine motor or gross motor actions, they must have an adequate foundation of balance and postural control. Children with poor posture and/or balance often exhibit limited motor skills, in part because the foundation for carrying out skillful movements is not well developed (e.g., posture is inappropriate and/or control of balance is poor or inconsistent). Frequently, it is the core muscles of the trunk and muscles of the lower extremity, along with the timing of activity in the muscles of the trunk and lower extremities, that contribute to the motor control issues observed in children who have difficulty carrying out both fine and gross motor tasks. Thus, it is important to have a rich understanding of the nature of the processes and developmental milestones associated with developing and maintaining balance.

To understand posture and balance and their intricate interrelationships, it is important to define and describe these terms. **Posture** is defined as the alignment of body parts and involves the relationships among various segments of the body. The optimal alignment of body parts (e.g., posture) for standing is close to a straight line from the ankles through the hips, shoulders, and ears. In contrast with posture, **balance** has to do with overall body equilibrium or stability. Biomechanically, it is described as the maintenance of the center of mass over the base of support. Maintaining the center of mass over the base of support requires that the child equalize differences between two opposing forces: gravity, which is constantly pulling on the body and moving it out of alignment, and the internal force of muscular activity, which acts against gravity to maintain the body in its appropriate or desired alignment.

Stability is required for movement and functional activities such as hand skills, feeding, dressing, bathing, and play. Stability and balance change as children modify their posture (e.g., the alignment of body parts). For example, if a child raises the arms over the head (as when reaching for a toy), the center of mass increases and stability diminishes, whereas if a child bends the knees, the center of mass decreases and stability increases. Generally, the higher the center of mass, the less stable balance is, and the lower the center of mass, the more stable the balance. Assuming different foot positions add to the effect by changing the child’s posture on the base of support. Standing with the feet in a tandem position narrows the base of support and thus decreases stability whereas standing with the feet shoulder width apart provides a wider base of support and increases stability in relation to standing with feet in tandem. Thus, when planning intervention, occupational therapy practitioners should keep in mind that it is more difficult for children to perform activities standing with one foot forward than with feet shoulder width apart. If a child then stands on the balls of the feet, this both raises the center of mass and reduces the base of support and decreases stability. These examples illustrate the subtle and intricate relationship between posture and balance. Both are controlled by the part of the sensory-motor systems referred to as the *postural control system*. The postural system maintains the body’s stability by maintaining (1) the body in a stationary position when necessary (e.g., static balance); (2) balance when changing from one discrete position to another (e.g., moving from supine to sitting or from sitting to standing); and (3) equilibrium while the body is in continuous motion (e.g., walking, running). Multiple physiological systems are involved in carrying out these highly interrelated functions and include the musculoskeletal, neuromuscular, and sensory systems (i.e., visual, vestibular, and proprioceptive or somatosensory).

To carry out these functions, the child must first detect the presence of instability—that is, any perturbation or disturbance to balance, must be detected and evaluated with regard to its potential for leading to a loss of balance (Figure 9-8) (Case Study 9-7). This is the job of the visual, vestibular, and proprioceptive systems. Generally, input from these systems is transmitted through the primary motor systems to the periphery to appropriate musculature. These muscle groups contract, moving the skeleton as dictated by the muscular activity, and balance is maintained or recovered.

**Sensory Organization and Control of Balance/Posture**

To maintain balance, the child must be able to detect when balance has been challenged and equilibrium or stability is changing. The vestibular, proprioceptive, and visual systems work together to provide information to detect changes in postural stability, as discussed next.

**Vestibular System**

The vestibular system is a powerful source of information about orientation of the body, position of the head, and movement of the head. Children use vestibular information to understand where their head and body are in space. One set of sensory receptors in the inner ear signals the position of the head in relation to gravity (otoliths); another set helps to detect the speed and direction of body movement based in part on what is happening to the head (semicircular canals). The vestibular system provides critical input regarding head position, body orientation, balance, and equilibrium. It helps to detect and interpret the following:

- Is the head up in upright, midline alignment?
- If not, is it forward, backward, to the side?
- Is the head moving?
- How fast is the head moving and in what direction?
Proprioceptive/Somatosensory Systems

The proprioceptive system contributes information critical to maintaining posture and balance. It provides information from the sensory receptors in the muscles (muscle spindle), tendons (Golgi tendon organs), and joints (joint receptors) throughout the body to the brain. Children use this proprioceptive information to detect body position, determine stability, and maintain posture and balance. The proprioceptive system conveys critical information about the position of the joints of the body and their relationship or alignment with each other, and gives children a sense of overall position of the body. The proprioceptive system also provides information about joint movement (e.g., changes in joint position), along with speed and direction of those changes/movements. Thus, the proprioceptive system helps children detect:

- What is the position of the body?
- How are body parts aligned?
- Which joints are stationary/which are moving?
- If joint positions are changing, how fast and in what direction (e.g., flexion, extension, rotation) are they moving?

Visual System

The visual system also contributes to posture and balance control. Briefly, the visual system may be thought of as a monitoring system that tracks a variety of aspects of information integral to maintaining balance and postural control. For example, the visual system:

- Monitors the environment and provides information that addresses:
  - What are the primary features of the environment?
  - What is present in the environment (objects, people)?
  - Are these objects/people moving or stationary?
  - Where are the objects/people in the environment in relation to each other?
  - Where are the objects in relation to the child?

- Monitors the body and its movement in the environment and transmits information about:
  - Self-motion: is the body stationary or moving?
  - Speed and direction of body movement
  - Verticality of the body: where is the head/body in relation to gravity?
  - Is this changing or constant?
- Monitors vestibular and proprioceptive input and indicates:
  - Is this information consistent with the current and continuing visual input?
Intersensory Function

Many of the foregoing functions are intersensory functions because they involve synthesizing and integrating visual, proprioceptive and/or vestibular information in making decisions related to the stability of the body. It is well known that the sensory systems do not work in isolation of each other; rather they work in tandem and share information that is needed to detect instability and help correct that instability. Three conditions reveal how intersensory functions contribute to balance control: (1) redundancy of information, a condition in which all three sources of sensory information (visual, proprioceptive, and vestibular) are present and accurate; (2) removal or substitution of sensory information, a condition in which one or more of the three inputs is missing or degraded; and (3) sensory conflict, a condition in which input from any one of the three sensory systems is in conflict with other inputs (e.g., visual input may indicate that balance is unstable, whereas proprioceptive or vestibular information indicates that balance is stable).107,133,139

The redundancy condition is the most common condition in which children maintain balance; balance is generally well controlled in conditions where all three sources of sensory information are present and accurate. In many instances, one or more of these primary sensory inputs is not available or is inadequate, and in this case (removal or substitution of sensory information) the child must rely on other inputs to determine the nature or status of the equilibrium of the body. For example, children with visual impairments maintain balance based solely on inputs from the vestibular and proprioceptive systems. The third condition, sensory conflict, creates the greatest challenge to balance because the brain must determine which input is conflicting or erroneous and which is accurate, and then ignore or suppress the conflicting information. In this case, the child uses the remaining sources to judge the nature and degree of instability.133

Intersensory function and the effect of different sensory inputs on balance control can be measured by the amount of postural sway a child exhibits under different sensory conditions. To examine this, a child stands upright on a force platform and attempts to maintain balance under different combinations of sensory conditions (Figure 9-9): 1. Redundant information 2. No vision (proprioceptive/vestibular information present) 3. Conflicting visual information (proprioceptive/vestibular information present) 4. Conflicting/degraded proprioceptive information (visual/vestibular information present and accurate) 5. No vision and conflicting/degraded proprioceptive information (vestibular information accurate) 6. Conflicting visual information and conflicting/degraded proprioceptive information (vestibular information present and accurate)

In each of these conditions, changes in the amount of sway and/or in sway patterns can indicate deficits in a particular sensory system.107,133,139

When all three sensory inputs are available (Condition 1), sway is minimal; when visual input is removed (Condition 2), sway increases slightly suggesting that visual input is important in maintaining balance. It is interesting that in any condition when ankle proprioception is conflicting or degraded (e.g., Conditions 4, 5, 6) sway increases dramatically compared with when it is not degraded (e.g., Conditions 1, 2, 3). Sway is greatest when only vestibular information is present and “accurate” (Conditions 5, 6). The most difficult condition for maintaining balance is when ankle proprioception is degraded and visual input is conflicting and has to be suppressed. This type of condition may occur in children with hemiplegia who have limited sensation in the affected extremity (e.g., decreased ankle proprioception) and poor visual perceptual skills.

Motor Coordination Aspects of Posture/Balance Control

Once a child becomes posturally unstable, some correction for the disturbance to balance must take place quickly to avoid loss of balance. The response to instability and recovery of balance is a function of the motor control system and is referred to as the Motor Coordination component of balance control. Corrective responses to disturbances of stability involve different levels of the motor control system. Some responses are “wired-in,” that is, they are reflexive or automatic and may involve lower levels of the nervous system (e.g., the stretch reflex, postural reflexes). Other responses may require higher-order analysis of visual, proprioceptive, and vestibular information and have been shown to involve supraspinal mechanisms, including the cortical regions. These latter responses include the postural synergies and integrative responses, both of which are adaptable or modifiable and are affected by practice and experience. These supraspinal responses or types of postural control include reactive responses (responses that occur after an instability or disturbance to balance have occurred), anticipatory responses (responses planned before the occurrence of instability and designed to avoid instability). Presented next is a brief review of the postural reflexes, postural synergies, and integrative responses.16,17,82,83,122,136,140

![Sway and sensory conditions](image-url)
Postural Reflexes

Children tend to develop postural reflexes in a predictable sequence: prone and supine positions to quadruped to standing. Postural reflexes act primarily to align the head with the body, keep the head in an upright position, and maintain equilibrium. There are three major categories of postural reflexes: attitudinal (also known as primitive), righting, and equilibrium and protective reflexes (Table 9-1). Attitudinal reflexes appear within the first year and are designed to align the head with the body (limbs) and the upper body with lower body. For example, when an infant changes his head position, the position of his limbs automatically shift (e.g., the symmetrical tonic neck and asymmetrical tonic neck reflexes). Most attitudinal reflexes are suppressed early in infancy but may reappear after injury or trauma to the brain.

Righting reflexes are typically observed at about 3 months of age and persist to 6 months of age. When rotation is imposed on the body, the righting reflexes realign the segments of the body and bring the body into appropriate alignment. They are designed to align the head with gravity (keep the child’s head upright) and include, among others, the optical righting and labyrinthine righting reflexes. These two reflexes realign the head vertically when the body is displaced and are mediated, respectively, by the visual and vestibular systems.

The third category, equilibrium and protective reflexes, are present at about 6 months of age and persist throughout life to help the child remain upright. Equilibrium and protective reflexes are whole-body responses to instability. Shoves or pushes to the body or tilting of surfaces on which the child is standing or sitting will elicit these responses. These reflexes help children protect the body from injury during loss of balance; if some instability occurs that could lead to a fall, the child extends the appropriate set of limbs to protect the body. Children develop equilibrium reactions in supine and prone positions between 5 and 8 months of age and continue to develop equilibrium in more upright positions throughout early childhood.

Occupational therapy practitioners evaluate reflexes and reactions as an indication of the child’s neuromotor status, and the intervention emphasis is on improving postural stability and equilibrium to enhance the child’s occupational performance. Thus, therapists help children improve balance and equilibrium reactions for play, mobility, feeding, dressing, self-care, and school functions.

**TABLE 9-1 Age of Postural Reactions Acquisition**

<table>
<thead>
<tr>
<th>Balance Reactions</th>
<th>Age (mos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RIGHTING REACTIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Neck on body</td>
<td></td>
</tr>
<tr>
<td>Immature</td>
<td>Birth</td>
</tr>
<tr>
<td>Mature</td>
<td>4–5</td>
</tr>
<tr>
<td>Body on body</td>
<td></td>
</tr>
<tr>
<td>Immature</td>
<td>Birth</td>
</tr>
<tr>
<td>Mature</td>
<td>4–5</td>
</tr>
<tr>
<td><strong>Body on head</strong></td>
<td></td>
</tr>
<tr>
<td>Prone (partial)</td>
<td>1–2</td>
</tr>
<tr>
<td>Mature</td>
<td>4–5</td>
</tr>
<tr>
<td>Supine</td>
<td>5–6</td>
</tr>
<tr>
<td><strong>Landau</strong></td>
<td></td>
</tr>
<tr>
<td>Immature</td>
<td>3</td>
</tr>
<tr>
<td>Mature</td>
<td>6–10</td>
</tr>
<tr>
<td><strong>Flexion</strong></td>
<td></td>
</tr>
<tr>
<td>Partial (head in line)</td>
<td>3–4</td>
</tr>
<tr>
<td>Mature (head forward)</td>
<td>6–7</td>
</tr>
<tr>
<td><strong>Vertical</strong></td>
<td></td>
</tr>
<tr>
<td>Partial (head in line)</td>
<td>2</td>
</tr>
<tr>
<td>Mature (head to vertical)</td>
<td>6</td>
</tr>
<tr>
<td><strong>PROTECTIVE REACTIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Forward</td>
<td>6–7</td>
</tr>
<tr>
<td>Lateral</td>
<td>6–11</td>
</tr>
<tr>
<td>Backward</td>
<td>9–12</td>
</tr>
<tr>
<td><strong>EQUILIBRIUM REACTIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Prone</td>
<td>5–6</td>
</tr>
<tr>
<td>Supine</td>
<td>7–8</td>
</tr>
<tr>
<td>Sitting</td>
<td>7–10</td>
</tr>
<tr>
<td>Quadruped</td>
<td>9–12</td>
</tr>
<tr>
<td>Standing</td>
<td>12–21</td>
</tr>
</tbody>
</table>

Postural synergies are an important part of posture and balance development. A synergy consists of a group of muscles acting as a single unit; it involves the “coupling” of muscle activation in a particular set of muscles. Postural synergies act to help correct for disturbances to balance or equilibrium, and although they are believed to be an inherent part of the motor system, they appear to be regulated at supraspinal levels. For this reason, postural synergies are often referred to as “long-loop” reflexes, indicating that they can be modified through practice and experience. Three major postural synergies—ankle, hip, and step—react to disturbances to equilibrium when the individual is in an upright stance. These are present as early as 2 years but continue to develop and undergo refinement until 7 to 10 years of age.

The ankle strategy involves the sequential contraction of the lower extremities in a disto-proximal direction (i.e., from the ankles up). The ankle strategy is usually activated when/if the child is standing on a firm surface that is wider than a foot (e.g., a large platform or a beam 6” or wider). Typically it is elicited when the child’s center of mass is displaced by a small amount (see Figure 9-9).

The hip strategy involves the sequential contraction of the muscles of the lower body in a proximo-distal direction (from the hips downward). The hip strategy is typically activated when/if the child is standing on a narrow or unstable/compliant surface. The strategy is elicited primarily with a fast, large perturbation to body stability (a quick but substantial jerk). This often occurs in young children when they attempt to walk a narrow (2”) beam or stand on a balance board. When standing balance is perturbed in a backward direction, muscles on the anterior of the body contract in a consistent sequence (see Figure 9-9).
The third postural synergy is the step strategy; although this is elicited easily, the muscle activity involved is not well documented because this is a more complex strategy for regaining equilibrium. The step strategy typically occurs when or if the perturbation to balance is great enough to cause the center of mass to fall outside the base of support. This can be elicited under a variety of conditions, depending on the level of control of the child. In these instances, the response is a step/hop that serves to restore equilibrium. Children may use a variety of different combinations of strategies, depending on the task, individual, or circumstance.

Integrative Responses

Another set of responses often involved in responding to perturbations to balance are those referred to as integrative responses. These fall into the category of higher-order, conscious or voluntary responses that are thought to be anticipatory in nature. Integrative responses are preplanned and are designed to accommodate known or anticipated disturbances to balance. Integrative responses by definition involve intersensory functions, where the brain must either substitute one source of sensory information for another (e.g., when visual input is not available) or if there is a need to suppress erroneous incoming sensory information. Postural synergies can and do occur under such conditions as well. A common example of the use of integrative, anticipatory responses may be seen in the form of preplanning for possible changes in equilibrium when a child is asked to move through an obstacle course. In this case, the system must plan for maintaining balance as the child moves through a series of obstacles that require the body move in a variety of positions and on, over, and/or around a number of stable and unstable objects.

Balance Control Issues in Children with Developmental Coordination Disorder

Children with DCD exhibit a variety of motor control disorders that include deficits in balance and postural control and other gross motor and fine motor eye-hand coordination skills that interfere with activities of daily living, school, feeding, and social participation. Examining the differences in balance and sensory processing between children with and without DCD may provide some insight into the motor coordination difficulties of children with DCD.

Vision and Proprioception

Children integrate and use information from visual, proprioceptive, and vestibular systems to control balance. Several studies indicate that children with DCD rely more heavily on visual input in controlling balance than typical children. It is possible that children with DCD who rely on vision to regulate balance may do so in part because of the inability to process and use proprioceptive input effectively.

Proprioceptive feedback is believed to play an important role in correcting for externally or internally induced errors in balance, as well as in modifying the speed and force of corrective actions. Effective processing of proprioceptive input is especially important in recognizing when one is becoming or close to becoming unstable. Children with DCD have more difficulty with this than typical children and thus lose control of balance more often. They also have difficulty in recovering balance after onset of instability. That is, when balance is lost or they become unstable, they cannot easily regain a stable state. Recovery of stability is also thought to be in large part a proprioceptive-related function.

The brain may place greater weight on proprioceptive, visual, or vestibular inputs in regulating static balance. Based on performances on the Test of Visual-Perceptual Skills, it is clear that many children with DCD have less well-developed visual perception skills than typical children. Young children with DCD (4 to 6 years of age) have more difficulty regulating balance (e.g., they exhibit more sway) when proprioceptive input is degraded than when it is not. Children with DCD may rely more on proprioceptive input for balance control than typical children because of visual perception deficits. However, such deficits are not present in all of these children. They often have difficulty effectively integrating visual and proprioceptive information, a process important to maintaining and recovering control of balance.

Overall evidence suggests that many children, including those with DCD, have deficits not in any one sensory system but in sensory organization (i.e., integration of visual, proprioceptive and/or vestibular inputs). For that reason, many young children, in particular children with DCD, tend to rely more on vision than proprioception for balance control. The child’s age certainly plays an important role in this integrative process because younger children do appear to have less well-developed integrative capacities than older children (10 years and older).

Improving Balance: Intervention

Planning for and organizing a program of intervention activities to promote balance control is of critical importance to occupational therapists. Such planning and organization requires that therapists use as much information as possible about various aspects of balance so that tasks can be designed to provide a gradual, orderly, and sequential program of activities to promote and enrich the child’s ability to maintain stability. Therapists design tasks that are both varied and interesting to the child for whom the program is intended.

Occupational therapy practitioners help children perform a variety of daily living activities, play, and academic activities, all of which require balance. One perspective on how to approach analyzing and developing tasks to challenge balance in a systematic way is to consider the major ways in which the body and the environment can be structured to challenge different aspects of balance. These can be thought of as components of balance, which can be varied or combined in different ways to encourage adaptive balance control. By analyzing and facilitating components in an occupation-based intervention, the child can easily generalize new skills to his or her everyday natural environment. Components of balance may be grouped as primary or secondary, as described next.

Primary Components

Primary components involve aspects of balance that are integral to developing efficient balance control and consist of the
following: body movement, use of vision, and external base of support. Therapists address these first in planning balance interventions.

**Body Movement**

An important component in any balance activity or task is whether the child is maintaining balance in a stationary position (static) or maintaining balance while the body is moving (dynamic). Because static and dynamic balance skills are important for effective stability in a wide variety of situations, and because they tend to be somewhat independent of each other, it is important to provide opportunities to develop control under conditions where the body remains stationary and where the body is moving or changing positions. Therefore, occupational therapy intervention to improve sitting balance may include sitting in one position and coloring (static) and sitting on an unstable surface (e.g., therapy ball) and playing catch (dynamic).

**Use of Vision**

Balance is almost always better when visual information is available than when it is not. Most experts agree that it is important to provide opportunities to practice balance under a variety of visual conditions; such practice also has the indirect benefit of providing opportunities to enhance the capacity to use vestibular and proprioceptive input regulating balance. Efforts to improve balance should include tasks where the child balances with vision, with vision occluded, as well as with varying kinds of distortion of visual information (e.g., blocking peripheral vision, wearing goggles, moving in lower levels of illumination). Occupational therapists can incorporate games with children, such as wearing various “funny” glasses.

**External Base of Support**

The nature of the external surface on which the child is asked to balance is an important part of developing effective balance control. Therapists structure the environment to challenge balance in a variety of ways. For example, the external base of support may be selected to include surfaces that range from:

- Wide to narrow
- Rigid to compliant
- Stable to unstable
- Flat to tilted or inclined

Occupational therapy practitioners can use a wide range of combinations of different types of surfaces to provide interesting and relevant challenges that encourage improved balance control.

**Secondary Components**

Secondary components of balance are aspects of balance that can be used to add new and different challenges to balance control and include position of the body, internal base of support, and elevation.

**Position of the Body**

Examining the position of the body and/or the alignment of different parts or segments of the body provides another set of possibilities for challenging balance. Some common positions that challenge balance include upright position, trunk flexed forward, arms extended in front, hands on hips, arms overhead, and/or any combination of the foregoing. All of these have the effect of modifying the location of the center of mass (even though only slightly in many cases). Thus, occupational therapy practitioners modify the position in which the child balances to challenge stability and improve balance control whether the child is stationary or moving through space.

**Internal Base of Support**

The internal base of support is a component of balance that involves varying the nature and number of body parts used to maintain balance. Modifications in the internal base of support are an integral ingredient in challenging balance. Some examples of varying the internal base of support are activities requiring the child to balance on two feet or a single foot, knee and a hand, or one foot and a knee. Changing the internal base of support creates different demands on the balance system and in that way adds to the range of adaptations that the child must make. Occupational therapists can make this fun by incorporating different positions into play sessions or relay races (e.g., walk with right hand on left knee).

**Elevation**

A third and final secondary component important in challenging balance is that of elevation. This has to do with structuring the environment so that the element of height is added. Children tend to perceive a greater risk or challenge to balance with elevation than when they balance on the ground (e.g., non-elevated surface). Typical uses of elevation include balancing on large, very stable boxes of different heights (4", 8", 12" high). Overall, the potential combinations of the foregoing components are almost endless and thus provide a guideline for developing interventions to promote improved balance as well as the child’s confidence in his or her ability to adapt to everyday balance challenges.

Occupational therapists may play climbing games with stacked heights on soft surfaces to promote balance. For example, encouraging children to walk on the blocks without falling into the “water” is a fun game that works on balance.

**Examining Balance: Process Characteristics**

When the goal is to improve balance for occupational performance, it is important to assess the nature and extent of the control exhibited in carrying out various balance tasks. Box 9-3 provides an assessment of balance. Figure 9-10 is a checklist that includes a series of process characteristics occupational therapists can observe as the child balances in various positions. 134

**VISION, VISUAL PERCEPTION, AND MOTOR CONTROL**

Visual perception refers to making sense and attributing meaning to what is seen. Depth perception, for example, refers to the ability to determine distance visually. This section defines the importance of visual perception on controlled movement and balance and explains the theoretical and practical aspects of visual perception related to balance and movement.

Perception and action are coupled in the sense that rapid and accurate perception of the visual components of the environment is intricately linked to the effective planning and execution of associated actions/movements. In general, children rely on vision and the processing of visual information for almost all interactions with the environment. For example the simple acts of reaching for an object on a table, walking down the street, using a computer, and writing a sentence within the boundaries of a defined space all require the ability to perceive and use visual information from the environment. To illustrate, the way a child prepares to reach for and grasp...
an object clearly differs for blind versus sighted children; a child with vision tends to reach directly toward the target object and automatically shapes the hand as it approaches the object to be grasped. This is accomplished by processing visual information that indicates the distance and direction of the object to be grasped (the transport phase) as well as the processing of the size, shape, and orientation of the object (the grasp phase). In contrast, a child without vision reaches less accurately toward the object to be grasped, and only when the object is touched is the hand shaped in an appropriate way for grasping.21,58,107,125,137,143

- **Pivot prone:** a position in which the child lies down with the hands/arms at the sides and the head and shoulders raised. This position provides a broad base of support (nearly the whole body) and requires appropriate head control and back extensor strength.

- **Prone on elbows:** in this position, the head, shoulders, and upper trunk are lifted and the body weight is borne on the forearms and the lower body; this position also involves a broad base of support and requires improved head and upper trunk control.

- **All fours (quadruped):** the body is positioned on the forearms and lower legs (dog position); the base of support is considerably smaller in this position and the demand for efficient head, shoulders, and trunk (horizontal position) strength is increased.

- **Full kneel:** in this position, the body weight is centered on an even smaller base of support, that of the lower legs. Greater control of the head and vertical position trunk is integral to stability in this position; strength of the core muscles also plays an important role.

- **Half kneel:** body weight is centered on the foot (with the leg up and the knee flexed) on one side and on the whole of the lower leg on the other side; the base of support is still smaller than in the full kneel, and appropriate head control and adequate trunk and leg strength are integral to stability in this position.

**STATIONARY AND MOVING UPRIGHT BALANCE**

The suggested sequence of acquisition and/or practice of these skills is as follows:

- **Two-foot stance** with feet in the following sequence of positions: shoulder width apart, standing with feet together, standing with feet in semi-tandem, and, finally, standing with feet in tandem (heel-toe) position; varying arm/hand positions adds an important element here.

- **One-foot stance** (dominant and non-dominant) superimposing a sequence of positions of the hands/arms, (a) standing with the hands/arms free, (b) with hands/arms in other positions (arms overhead, one arm extended in front and one raised over head, etc.), and finally (c) with hands on hips.

- **Walking a single line or between two lines (wide to narrow)** (a) with one foot on/one foot off the line; (b) using a non-alternating forward pattern (inching the feet forward on the line); (c) using a side-stepping (non-alternating sideways gait) in forward and backward directions; (d) using an alternating foot pattern forward and backward; and (e) using a tandem or heel-toe walk forward and backward.

- **Walking on a beam** (wide to narrow raised surface) using the sequence of foot patterns described for walking a line.

**A Theoretical Perspective**

Visual perception may be thought of as a process that involves the pick-up, processing, analysis/interpretation, and/or retrieval of visual information stored in the brain. Visual perception involves the capacity to discriminate among various visual stimuli and interpret or give meaning to those stimuli. In many ways, visual perception is a learned phenomenon; children learn to use the eyes, to attend to and fixate on visual stimuli, and to search these stimuli for information about the nature and meaning of what is being viewed.72,98,123,126,127

> Children use information from the visual system, including visual structures and visual perception to understand the nature of the environment so they can respond to what they perceive and act on it.4,31,63,105,131 These components are described in Chapter 12.

**Eye Movement Control**

Eye movements may be helpful in identifying subgroups of children with movement or motor skill problems, particularly those with eye-hand coordination issues. Eye movements may act as a “window” to understanding general motor control processes; more specifically, they may serve as an early biological marker of motor control problems in children born prematurely and especially those with DCDs.

**Tracking/Pursuit Movements**

In typical development, von Hofsten and Rosander found that smooth pursuit or tracking of predictable targets (0.1-0.3 Hz sinusoidal motion) develops rapidly in the first 3 months of postnatal life.127 The tracking action was carried out predominantly by movement of the eyes, with some head motion.
## Overall Balance Control
1. What are the general characteristics of the balance performance?
   - __easy stability throughout__
   - __stable but with effort throughout__
   - __often unstable but recovers easily__
   - __often unstable often; has difficulty recovering__
   - __unstable more than 50% of time__
   - __other__

## Specific Aspects of Balance Control
1. How are the arms used?
   - __appropriate action (based on task/developmental level)__
   - __out for balance__
   - __at sides__
   - __hands on hips__
   - __other__
   - __inappropriate action__
   - __flail__
   - __held in a contorted position__
   - __other (Please describe)__

2. How are the feet/legs used?
   - __appropriate action (based on task/developmental level)__
   - __heel toe pattern__
   - __alternating pattern__
   - __non-alternating pattern (inching forward)__
   - __feet placed toes pointing straight ahead (on line/beam)__
   - __knees are soft (slightly flexed)__
   - __walks or moves with ease__
   - __other__
   - __inappropriate action__
   - __knees are stiff (extended)__
   - __feet are placed crosswise on line/beam__
   - __steps on toe of trail foot__
   - __executes foot patterns inconsistently/with difficulty/hesitation__
   - __alternating/ side stepping__
   - __heel toe (frequently leaves space between heel/toe of front foot and toe of trail foot)__
   - __other__

3. What is the status of the trunk?
   - __relaxed and upright__
   - __stiff and upright__
   - __flexed forward__
   - __leans to right or left__
   - __slumped__
   - __other__

4. What is the status of the hands/fingers?
   - __relaxed__
   - __extended/tense (fingers)__
   - __spread/tense (fingers)__
   - __contorted (hands/fingers)__
   - __other__

5. What is the status of the face?
   - __relaxed__
   - __tense__
   - __grimace/contorted__
   - __tongue protruding__
   - __other__

### Comments:

**FIGURE 9-10** Williams' checklist of process characteristics of balance performance.¹³⁴
Other data indicate that tracking (pursuit) of slowly moving targets matures by age 7 but continues to improve into adolescence, whereas horizontal tracking of faster moving targets (12°/sec) takes longer to develop. Overall tracking skill appears early in development and continues to improve into adolescence. The long time course in acquiring skillful tracking movements may be due partly to incomplete maturation of the tracking/pursuit system and higher-level cognitive factors. For example, the ability to track a ball through space and judge its speed and direction is not fully developed until after 12 years of age.

Langaas et al. studied differences between the tracking movements in children (5-7 years) with and without DCD. These workers examined (1) how closely the speed of eye movements matched the speed of target movement and (2) whether eye movements lag behind or ahead of target movement. Typical children tracked moving targets well and needed just a few quick saccades to get back on the target. Children with DCD consistently failed to match target velocity with eye movement speed and thus fell behind the target, suggesting that messages to the brain for making sensory decisions were slower or were incomplete. In addition, children with DCD had difficulty catching up to the target and had significantly more shifts away from the target than those noted in typical children. Thus children with DCD received less sensory input to the brain about the moving object and the surrounding environment. Visual acuity was within normal limits for all of the children and therefore did not account for the differences between children with and without DCD.

It is important to consider the effect that reduced ocular-motor control has on children’s perceptual development. For example, in children with DCD, the lack of effective tracking movements makes anticipatory judgments about speed and direction of moving targets difficult (i.e., they have difficulty judging when and where to go to catch an object). Many young children and those with DCD in particular have problems with catching or intercepting moving objects. The association between ocular-motor control and more general motor impairment has not been verified by research.

**Fixation/Search Movements**

Infants develop the capacity to fixate on stationary objects with some degree of control within 4-5 days after birth and during the first two postnatal years. In terms of search processes (e.g., finding information in a picture) and determining the nature of the object or figure being viewed, refinement of this process undergoes important changes between 3 and 6 or 7 years. Whereas young children tend to be unsystematic and spend as much time fixating off target as they do on target (the time and number of fixations also varies widely), older children are more systematic and tend to use more rapid fixations of short duration that are directed to the salient parts of the stimulus being viewed (e.g., they follow the object’s contours). The important difference is that the patterns of fixation of the older child are adapted to fit the characteristics of the object/figure of interest, whereas the young child’s are not.

**Body Awareness and Motor Control**

Several different terms are used in defining and discussing body awareness. Generally the development of the concept of the physical self involves at least three major components: body schema, body image, and body awareness. Figure 9-11 shows a schematic of the components of the concept of the physical self and the behavioral components specific to body awareness.
Body Schema

The body schema is the neural substrate for body awareness. It is present at birth, and as children grow and develop, this so-called diagram of the body (homunculus) in the sensory and motor areas of the brain is modified, in part, through the sensory-motor experiences (active movement, interaction with the environment, and the feedback derived from those interactions) the child undergoes. The child’s own body representations are processed in distinct regions of the intact brain. An example of the manifestation of the body schema may be seen in the phantom limb phenomenon. Children who have had a limb amputated often report that they “feel” both pain and sensation from the missing limb just as if it were physically present. Children who have cerebral palsy (hemiplegia) tend to ignore the affected limbs.

These clinical observations suggest that sensations received when the limb was intact are stored in the brain and when stimulated cause the child to experience feelings and sensations of the missing limbs. The general consensus is that the body schema becomes defined through sensory input from receptors in the skin, muscles, tendons, joints, and the vestibular system, which act to define the boundaries of the limb(s) in the body schema. These receptors are stimulated through body movement and through the actions of the child that are involved in interacting with persons and objects in the environment. The importance of body schema in motor control lies in its relation to motor planning (e.g., the planning of actions). Children develop body schema through active use of the body. Adequate planning of action is based, in part, on the fullness of the body schema. Theoretically, it is proposed that if information children receive and store in the brain in the form of the body schema is incomplete, imprecise, or simply unavailable, children will have difficulty planning or adequately preparing specific plans for action or movement.

Body Image

Body image refers to the image one has of oneself as a physical entity; it includes the perception that one has of the body’s physical or structural characteristics (e.g., am I short, tall, heavy, lean?) and of one’s physical performance abilities. By its nature, body image has an important emotional component; it includes the perception that one has of the body’s physical or structural characteristics (e.g., am I short, tall, heavy, lean?) and of one’s physical performance abilities. Integral to the development of a positive body image is the input from significant others who interact with the child and provide feedback (verbal and nonverbal) about the importance and uniqueness of the child. Clearly, the nature of the interactions between the child and the family, teachers, peers, and others is an important element in the development of a positive self-image.

An interesting aspect of the development of body image is seen in attempts by very young children (e.g., 30 months) to do things that the body size/shape simply will not allow; for example, they often try to fit themselves onto or into miniature toys that are clearly too small for them. This suggests that they are still developing body image in terms of the ability to accurately judge the physical characteristics of the body in relation to objects in the environment. Development of body image continues to evolve and be refined throughout early and later childhood, and into adolescence.

Body Awareness

A second component of the physical self-concept is body awareness; it is closely related to body schema in that it involves the conscious awareness of the location, position, and movement of the body and its parts, as well as the relationship between the body and the external environment. The importance of body awareness to motor control is seen in the many challenges that the young child, typical or atypical, faces in judging the characteristics of the body and of objects, people, and events in the surrounding environment. Children use the capacity to hold information about their own body in relation to other objects in the world as the foundation for developing effective plans for execution of movements necessary to achieve specific end goals. For example, the child uses body awareness when moving through obstacle courses, whether they be of natural origin or structured for specific purposes in a clinical setting or when manipulating objects of different sizes and shapes to learn about concepts such as spatial orientation; relationships among shape, size, and weight; and functional uses of objects.

Body awareness is defined as the ability to visually discriminate, recognize, and identify labels for various aspects of the body’s physical and motor dimensions. Body awareness can be divided into internal (body-related) and external (environmental) aspects. Internal aspects involve the development and refined awareness of the body itself; external aspects are associated with development and awareness of the relationship of the body to the environment (external space), as well as the extension of select internal aspects of body awareness to external space. Internal aspects of body awareness tend to develop slightly in advance of external components. The internal and external aspects of body awareness and the relationships between the two are discussed next (see Figure 9-11).

Internal Aspects

As shown in Figure 9-11, there are five important behavioral indicators of the development of the internal aspects of body awareness.

Reflective self-awareness is manifested, in part, in young children’s ability to recognize themselves in the mirror, to refer to themselves by name, and to point to themselves referentially. Visual self-recognition exemplifies the emergence of the objective self and of body awareness. The development of this aspect of body awareness begins with the toddler’s discrimination of his own real-time limb movements as different from those of other toddlers when viewing paired videos or watching himself and another child in a mirror. Recognition of the movements of the limbs is an early form of the differentiation of the body (self) from the external environment (space). This recognition also serves as the perceptual/perceptual-motor foundation for later development of refined self-awareness and in particular the acquisition of conceptual knowledge about the body. This reflective self and body awareness typically are present in 2-year-olds. The significance of the awareness of the body’s movements is that it involves a kind of visual-kinesthetic-motor matching that is integral to effective planning and execution of actions. For example, children develop self-awareness as they begin to feed themselves and understand where their mouth is in relation to their body.
Laterality refers to the awareness that the body has two sides, that the body is separate from space, and that the limbs on each side of the body can move independently of each other. Initially, the infant has only a crude awareness of the distinctness of the body as separate from space. Early in development, the infant does not distinguish between the two sides and often moves the two arms/hands and two legs together as a single unit. Gradually, the child begins to be “aware” that the limbs on either side of the body can be used independently of one another. Although at this early stage, the infant does not have “verbal labels” for any aspect of the body, he or she “knows” what is and what is not the body. Much of the defining of the body’s dimensions is derived from feedback from the movement of the body itself. Awareness that the body has two sides is an important part of the development of the perception of other internal aspects of the body and provides the foundation for the acquisition of directionality.

Therapists assess laterality clinically, using a series of both individual and coupled arm and leg movements (child lies in supine and moves various individual and combinations of arm and leg movements as requested by the clinician). The coupled arm/leg movements include both ipsilateral and contralateral (e.g., right arm/right leg versus right arm/left leg). Laterality is established when the child can discriminate and coordinate various individual and combinations of movements of the ipsilateral and contralateral sides of the body. Clearly, then, laterality involves both sensory (awareness of limbs) and motor (coordination/control of movements) systems. Children need to develop a sense of laterality (i.e., understand the body has two sides) to move in a coordinated fashion. Awareness of both sides of the body is observed in movements required for feeding, dressing, bathing, play, and academics. Therefore, occupational therapy practitioners facilitate mastery of laterality to help children function in a variety of daily life skills (Figure 9-12).

Sensory dominance develops as the child becomes aware of his or her body and its parts and its separateness from space. Sensory dominance helps to further define the body, especially the two sides of the body. It manifests in the development of the preferential use of one side of the body. Most children have a well-defined preferred hand and foot by the age of 6 years. Occasionally, children as young as 4 years of age have established a hand preference; however most do not. The two categories of sensory dominance are mixed and pure. Pure dominance refers to the preferential use of the eye, hand, and foot on the same side of the body; mixed dominance involves the situation in which the preferred limbs and eye are on opposite sides of the body—that is the child may be right-handed, right-eyed, and left-footed. A large percentage of the adult population has mixed dominance (about 95%).

Hand dominance appears to be associated with cerebral dominance; approximately 90% of the population is right-handed and left cerebral dominant. The left cerebral hemisphere houses the major motor and speech control centers and regulates the actions of the right side of the body. The remaining 10% of the population has been reported to be either right cerebral dominant or have dual dominance. Interestingly, some of these individuals are right-handed, whereas others are left-handed. Handedness also appears to have a familial component. Clearly, mechanisms underlying sensory dominance, in particular handedness, are complex and not well understood.

The period from 4 to 8 years is an important period in the development of hand, eye, and foot preference. By 6 years of age, 81% of children have established a preferred hand, 73% have a preferred eye, and 94% have a preferred foot. Eye preference appears, in general, to be more variable than hand or foot preference. Foot preference is interesting in that there may be two types of foot preference: a preferred balance/strength foot and a preferred skill foot (Figure 9-13). This is most evident in comparing balance times on the right and left feet and examining the skill in kicking a ball. For example, balance is typically better on the side of the preferred foot. Although many children kick using the right foot, these children often have better balance on the left foot. In this case the left foot is considered the “balance foot” and the right foot, the “skill foot.” This makes sense in terms of differentiating the role of each foot in skills such as kicking.

Body part identification develops at different rates in children and depends, in part, on the experiences of the child and the emphasis placed on language and the learning of the names of body parts. Knowing verbal labels for different body parts further solidifies the distinctness of the body and its parts. At 2 years, children can often identify some major body parts (e.g., nose, eyes, ears); by 3 years, they are aware of such parts as head, hand, and foot. By 5 years, a majority of children (55%) know more remote body parts (e.g., thumb, eyebrows) and at 6 to 7 years, 70% to 88% of children can name both major and minor parts of the body consistently (e.g., elbows, wrists, heels, shoulders, hips). At 8 or 9 years, it is rare that a
awareness, including reflective self-awareness, laterality, sensory dominance, body part identification, and right-left discrimination to be aware of their body to effectively move throughout the environment. For example, children with DCD frequently have difficulty “sensing” or “feeling” where their limbs are without looking at them. They may not possess an internal awareness of their body. This interferes with smooth and coordinated movement.

### External Aspects

Children must also develop external awareness, including directionality and spatial awareness, to move their body through the environment. External aspects of body awareness are an extension or outgrowth of internal aspects and involve relating the body to space and to objects and other people in space.

Directionality refers to the child’s ability to identify right/left and other dimensions (e.g., top/bottom, front/back, beside) on objects or other persons. Some hypothesize that children project or extend the concepts of right/left and other spatial dimensions of the body onto objects in space. Because the environment has variant spatial references, children appear to use their reflection in the mirror, to refer to themselves by name, and to point to themselves or their own bodies to reference directionality. Thus, knowledge about the body is expanded to objects and persons in space. Most work has focused on directionality defined as identifying right/left on objects and other people. Mastery of directionality, in this case, is described as the ability to consistently and accurately identify right and left on another person and to understand the tenuousness of right and left on objects and how this varies with regard to their position (in relation to the object). Identification of other dimensions of objects is thought to be based on knowledge gained via experiences the child has had using language to describe dimensions of the body. Developmentally, with regard to right-left identification, approximately half of 6-to 7-year-olds have mastered directionality (50-52%); not until 9 years of age do a majority of children consistently and spontaneously identify right and left on another person.

Spatial awareness is the other major component of the external aspects of body awareness. This discussion focuses on two aspects of spatial awareness: awareness of the body in relation to objects in space and awareness of relationships between or among objects. These aspects of body awareness rely heavily on language and the conceptual meaning of the so-called “spatial” words. The former involves relating objects to the body and the body to objects using language. A sample activity might involve the child holding an object (e.g., a doll) and the clinician asking the child to “put the doll behind you,” “put the doll in front of you,” “put the doll on your right side,” “place the doll on your right foot.” Object-to-child relationships involve the child’s identifying where the object is in relation to himself or herself. By placing a red ball to the right of the child and a blue balloon to the left of the child, and asking the child “where is the red ball/where is the blue balloon,” one can examine the child’s understanding of this relationship.

Object-to-object relationships are more complex and involve identifying where one object is in relation to (an)other object(s). Children 9 to 10 years of age are able to spontaneously identify relationships among objects. For example, place two objects (e.g., a key and a coin) on a table, one in front of the other and one to the right of the other and ask the child...

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**FIGURE 9-13** Playing hopscotch requires balance.
the following: “Which object is in front?” “Which object is to the right?” Development of body-object and object-object relationships overlap. Children typically develop these two aspects of spatial awareness as follows: placement of objects in front or back of self; identification of front and back of objects; placement of a standard object in front and back of an object with distinct features (e.g., a doll); placement of an object to one’s own side and to the side of an object with distinct features (e.g., a doll). Development of optimal spatial awareness (including awareness of relationships between or among objects, as well as the relationship between the body and objects in the environment) is integral to adequate planning and carrying out skillful movements. If spatial awareness is lacking or underdeveloped, the child often has difficulty moving and interacting skillfully with the surrounding environment because the child cannot accurately judge these subtle but important relationships between the body and the environment. Spatial awareness is a critical aspect of the movement planning and execution process.

**INFLUENCE OF NON-MOTOR FACTORS**

Dynamical systems theory suggests that motor control is the result of interactions between many systems, including the environment. These factors include the physical, social, psychological, institutional, and societal influences that may affect occupational performance.

The physical environment consists of the surroundings, surface (e.g., flat, inclined, smooth, rough, hilly), and setting (inside, outside, city, country) and influences motor demands. Playing tee-ball on a competitive team differs from playing at home with parents. Playing on a rocky surface versus soft grass changes movement and balance requirements. Therapists examine the physical environment to determine the movement required.

The social system is part of the environment and influences movement requirements as well. For example, different motor skill requirements exist for a 10-year-old boy who is eating at home with one parent on a quiet afternoon and for another boy who must feed himself in the busy cafeteria at school with three friends. While the child is in the cafeteria, he wants to interact with his peers, increasing the motor demands for self-feeding. Now the child must try to socialize and feed himself (quickly so he can get to recess), realizing his friends will notice if he spills. Social participation is important to children, and, consequently, the influence of this system must be considered. For example, some children may not want adaptive equipment or special considerations in the classroom that make them “look different” than their peers.

The effect of psychological factors on movement must also be considered.4,8 Attention, concentration, and motivation to perform movements are necessary for motor learning.20,32 The ability to imagine or think through movement (e.g., mental practice) increases motor performance. Children who are motivated to perform or succeed in motor challenges are able to achieve skills more quickly and with better quality than those who do not.31,54,124

Institutional factors include those aspects of the institution or setting that hinder or facilitate movement. For example, institutions may have policies requiring children participate in physical activity. These institutional policies make it possible for children to participate. Requiring children to go outside for recess, for example, is an institutional policy that promotes activity.

Finally, societal influences may influence movement. For example, in the United States, active children are viewed as healthy and thus activities in which children move are expected. For this society, movement (e.g., on the playground, in the backyard) is valued and viewed as important for the child’s development. The environment plays a major role in children’s learning of motor skills and thus must be considered in designing intervention strategies to teach children movement.

**MOTOR LEARNING**

Motor learning refers to the acquisition or modification of motor skills. Motor learning literature explores transfer of learning, sequencing, and adapting tasks, type and amount of practice, error-based learning, timing, and type of feedback and mental rehearsal. These concepts provide useful information on techniques involved in the teaching-learning process of movement. Being knowledgeable and aware of the teaching-learning process enables therapists to incorporate motor learning principles into practice so that children learn and retain motor function for their daily lives (Box 9-4).

**Transfer of Learning**

Transfer of learning, or generalization, refers to applying learning to new situations. The goal of occupational therapy intervention is that the child transfer learning performed in the clinic or intervention setting to the natural context. For example, after working on maneuvering a new wheelchair through an obstacle course at the clinic with ease, the therapist hopes the child will be able to maneuver the wheelchair through the school hallway.

Children are best able to transfer motor skills when they have practiced the motor skill within the natural context or in the “real world” situation. Therefore, the best way to help the child be successful in maneuvering the wheelchair through the school hallway is to practice in that setting. The occupational therapist may need to start by teaching some basic wheelchair skills to the child, practice in the hallway after school hours (to decrease obstacles) and work up to maneuvering the wheelchair during class change. Research suggests that children transfer the task more quickly with this intervention strategy than with practicing in a clinic setting only.24,114

Transfer of learning occurs more easily when the motor task is performed during a functional activity or actual occupation, scheduled at its natural time and place, and in the real context.24,32,41,89 In addition, motor skills with similar components are more likely to transfer. For example, a child who has just successfully learned to throw a ball would more easily learn to throw a bean bag at a target.

**Sequencing and Adapting Tasks**

Grading and adapting motor tasks so that children are successful constitute part of the occupational therapy process
Generally, discrete tasks are easier to accomplish than continuous tasks. Tasks involving uni-manual movements are often learned or mastered before bi-manual movements. Skills manipulating stationary objects develop before skills with objects to be manipulated, e.g., use a balloon for catching instead of a ball.

“Closed tasks are those in which the environment is stationary during task performance” (p. 407), whereas open tasks are ones in which the environment is changing or in motion and involve some inter-trial variability. Closed tasks are generally simpler for most children to accomplish.

Therapists also consider the cognitive demands of activities; children complete simple motor tasks that have fewer cognitive requirements more easily. Tasks with fewer steps are accomplished more readily than those with multiple steps (e.g., throwing at a target is easier than picking up a ball from the container, moving to the starting line, and then throwing
at a target). Children acquire tasks that require less precision (e.g., scribbling will be easier than coloring within the lines) more easily than those that require more precision. When sequencing and adapting activities for children, therapists consider the amount of direction required; movement requiring less direction is easier to learn than those requiring multiple directions.

The structure of the environment plays an important role in the nature and complexity of the demands of the activity. For example, environments with variability and extraneous stimuli (e.g., other children) are more challenging and thus more difficult for children because they must continually adapt and adjust.

**Practice Levels and Types**

Practice is an essential feature of occupational therapy intervention. A considerable amount of research has been conducted on the use of practice to improve or develop motor skills. Massed practice (also known as blocked) is defined as practice in which the period performing the movement is greater than the rest period. This type of practice works best during the cognitive stage, as the subject is just beginning to learn the movements. An example of blocked practice may include working on grasp pattern and release by asking a child to pick up 10 blocks and put them all in a container before taking a break and then repeating the game again.

Distributed practice is defined as practice in which rest between trials is greater than the time of the trial and is most useful during the associative stage (Figure 9-14). A clinical example of distributed practice includes asking the child to pick up bean bags placed on the floor while engaged in a game of swinging. In this scenario, the child is still practicing grasp and release, but the child is also working on postural control and processing vestibular input. Therefore, the child grasps and releases a few bean bags, has a rest while swinging in which he must work on other aspects of skill, and then returns to grasp and release.

Variable or random practice is most effective during the autonomous stage. Variable practice requires that learners repeat the same patterns but make small changes as necessary (Figure 9-15). This type of practice increases the ability to adapt and generalize learning. In general, short frequent practice is better than longer, less frequent practice because it decreases fatigue and increases reinforcement. For example, a child is doing random practice when working on grasp and release as he or she engages in a variety of play activities during the intervention. This type of practice is most closely related to the actual occupation. The child must pick up and release toys as the play requires. The child must pick up a variety of objects: small blocks, large swings, light toys, and heavy scooter boards.

Mental practice includes performing the skill in the imagination, without any action involved. It may consist of role playing, watching a video, or imagining. Mental practice is effective in teaching motor skills and re-training the timing and coordination of muscle group activity. Much of the research on mental practice is conducted on athletes trying to maximize their performance. Imagery techniques are relatively simple and have been shown to work with children as young as 6 years of age. Many theorists suggest it is effective because it requires cognitive processes and helps children problem-solve motor solutions.

Driskell and colleagues provide some specific feedback that may assist therapists using mental practice in clinical settings. They suggest that practitioners using mental practice consider the type of task, duration of mental practice, and time between practice and performance for retention. Tasks in which the child may have had some experience may be easier to imagine. However, the child may be able to imagine movements after observing them on a video or seeing someone else perform them. Therapists should be cautious not to incorporate a too-long mental practice because this may be difficult for children and result in a lack of motivation. Finally, therapists should incorporate actual performance shortly after the mental practice for the best retention. Techniques of watching a video, pointing out components of the movement, or simply reviewing mentally how the movement will look in combination with physical practice may provide improved motor learning.
Children learn movement by making errors or mistakes and self-correcting. Therefore, clinicians must sometimes allow the challenge to exceed the capacity of the child so that he or she is given the opportunity to make errors, correct them.

**RESEARCH NOTE 9-1**


The authors examined the effect of mental practice compared with physical practice for a bimanual coordination task on children, adults, and older adults. Subjects in each group were randomly assigned into a mental practice or a physical practice group. Thirty children (ages 9-10 years), 30 adults (21-40 years), and 29 older adults (65-70 years) participated in the study. Participants in the physical practice groups practiced 5 trials and rested for 15 seconds between each. The task involved holding a device with both hands and tracing a star (Lafayette Instrument Co., Model 32532). Participants in the mental practice group performed the physical practice and then were asked to image the performance for 10 seconds. Mental practice improved the performance for children and older adults in the acquisition phase. In the retention phase, older adults benefited.

This study suggests that children may benefit from mental practice when learning novel skills.

**Error-Based Learning**

Children learn movement by making errors or mistakes and self-correcting. Therefore, clinicians must sometimes allow the challenge to exceed the capacity of the child so that he or she is given the opportunity to make errors, correct them.
(if possible), and learn from the experience. Children with disabilities must learn to adapt to new, different, or unexpected situations. In the past, therapists typically have been hesitant to allow children to learn through making errors. However, making errors in controlled settings allows children to resolve problems and is important for facilitating their motor skill learning. Encouraging children to explore, adjust movements, and evaluate their responses and reactions helps them learn and refine motor skills.

**Feedback**

Intrinsic feedback, which allows the child to self-correct, is most effective for sustaining motor performance and should be the goal of intervention sessions. Intrinsic feedback may be elicited through discovery, a situation in which the therapist sets up the environment and the child is allowed to explore and discover, make errors, and consequently learn new ways of moving.

Children may require extrinsic feedback in the early stages of motor skill development. Extrinsic feedback consists of providing verbal cueing or physical guidance. Demonstrative feedback refers to modeling or imitating movements. Demonstrative feedback is best if it is provided before the child actually practices the movement, as well as throughout early stages of skill acquisition. It should not be given with verbal commentary, because that decreases the child’s attention to the movement.

**Knowledge of Performance**

Feedback to improve movement is most helpful when it is specific and clear. Knowledge of performance helps children understand how they performed the desired movement. Knowledge of performance is helpful in refining and adjusting motor skills and therefore is useful after the child has established basic skills. Therapists may provide descriptive feedback to the child about performance of a specific task such as writing, such as “you held the pencil between thumb and fingers and pressed lightly” or therapists may provide prescriptive feedback, such as “next time, press a little more.”

**Knowledge of Results**

Feedback related to the desired outcome helps children understand movement. Providing this knowledge is most effective when specific information on the movement’s goal is stated. Thus, “each button is lined up with its buttonhole” is preferred over “good job.” Knowledge of results is motivating and encourages children to continue; it is most helpful when learning new motor tasks.

**Verbal Feedback**

Verbal praise and reinforcement are useful in motivating clients and changing behaviors but may be overused in clinical settings. Allowing children to make their own assessments of their performance is beneficial and will increase their sense of efficacy. Verbal feedback is best if provided immediately after completion of the task. Using one to three brief cue words that can be repeated easily by the performer is best. Knowledge of correct performance motivates a child to continue practicing, so such reinforcement may be used frequently. Positive feedback with specific cues improves performance such as “you pressed firmly with the pencil!”

### APPLICATION OF MOTOR CONTROL/LEARNING THEORY IN OCCUPATIONAL THERAPY PRACTICE

Case Study 9-8 illustrates how therapists may apply current motor control/motor learning principles to practice. Specifically, this example applies dynamical systems theory from an occupational therapy perspective to intervention of a child’s motor deficits.

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**CASE STUDY 9-8**

Paul is a 7-year-old boy referred to occupational therapy after his mother expressed concern that he has difficulty using his hands, completing school work, playing on the playground, and often falls on the playground. Paul’s mother states “he has trouble coloring, doing anything with his hands, and can’t climb up the slide or get on the swing.”

**OCCUPATIONAL PROFILE**

Paul enjoys playing with trucks and being outside. He shows an interest in the swings, but does not get on them. Rather, Paul sits close by and watches others on the swings. His mother notes that Paul enjoys playing on the floor in the living room with his trucks. Paul’s mother is concerned that he is not active on the playground and falls frequently. She is worried that his difficulty with coloring and writing will interfere with his school tasks and he will not like school. She has already noticed Paul seems to get stomachaches frequently and dislikes mornings.

Paul lives with his parents and 2-year-old sister in a quiet suburb. There are plenty of children in the neighborhood and they frequently play together outside. Paul states he has “one good friend” and he spends afternoons playing with that child. Paul participates in recreational soccer (although he says, “I’m not very good”).

He is currently in the first grade and having trouble with handwriting and reading. The teacher is concerned that Paul is not “picking up things” as quickly as his peers, although verbally he has plenty to say and contributes to the class.

**OCCUPATIONAL PERFORMANCE**

Paul presented as a thin, small 7-year-old boy, who stood with his shoulders depressed. Range of motion was within normal limits. His muscle tone throughout was slightly low, especially in the trunk. He sat with a rounded back and could not maintain balance with eyes closed. Paul ran with his feet apart and his arms did not swing consistently or in rhythm. He had
difficulty changing positions as observed by stopping and reor-}

tenting himself as his friend ran around him. Paul showed poor sequencing and timing of movements—he could not jump with both feet together and was unable to catch a ball.

Fine motor skills were delayed as well. Paul held a pencil in a tight pronated grasp and made dark marks on the paper. He was unable to draw a straight line (3 inches) within the ¼" markings—his line went over in more than 5 places. He sat independently with his feet on the floor, his back was rounded, and his face was close to the paper. He showed some associated reactions (e.g., facial movements) when writing. He was unable to do alternating hand movements or imitate tasks.

Paul was able to put on his coat and hat. He had difficulty with the buttons, but was able to do it with adequate time. He could not tie his shoes, but made multiple knots instead.

Paul was the last child to go outside for recess. He played with his friend and watched others. His friend waited for him and frequently repeated, “Hurry up, Paul.”

### SYSTEMS CONTRIBUTING TO PERFORMANCE

#### Environment

Paul lives in the country in a 3-bedroom home. He has access to toys inside and outside. His home is child-friendly. The backyard is fenced in and includes a swing set, slide, and sandbox. Paul plays with his best friend daily and sometimes will “hang out” with his sister. He likes being outdoors and looking for things in the woods. He does not ride a bike, swing, or go down the slide.

#### School

Paul attends a local elementary school; there are 15 students in his class. The teacher provides structure and is consistent. She expressed concern that Paul is falling behind his classmates and states he has great difficulty with handwriting, paying attention, and getting things done in a timely manner. She notices Paul is always the last one out the door, forgets things in the classroom, and seems frustrated at times. However, she also notes that Paul is verbal and answers questions readily. She states he is well liked by his peers and teachers and is always polite and well behaved.

#### Neuromuscular

Paul’s low muscle tone, poor postural control, and difficulty with timing and sequencing are interfering with his ability to move in a coordinated fashion. Paul shows some soft neurological signs, such as associated reactions. He is unable to balance with his eyes closed.

#### Sensory

Paul’s poor balance and motor planning may be a result of difficulty processing vestibular information. There is also some indication that he has some visual perceptual deficits interfering with motor control. Paul’s body awareness is somewhat affected because he is unable to identify right-left, which would be expected at his age. His internal body awareness is not quite developed.

### INTERVENTION PLANNING

The occupational therapist, Cora, a school-based practitioner, developed an intervention plan based on a top-down approach focusing on helping Paul play with his peers and perform in the classroom. This plan addresses the parents’ concern that Paul’s motor skills are interfering with his motivation to attend school and thus, the therapist felt this was the place to start. Secondly, working on Paul’s handwriting ability will help him be successful in school.

Keeping in mind that children learn best when they are presented with the whole versus a part of the activity, Cora designed a variety of gross motor games. The intent of intervention was to help Paul play with peers by developing postural control, motor planning abilities, and body awareness while completing fun games and helping him feel better about his abilities. Furthermore, helping Paul develop postural control, motor planning, and body awareness may also help him with his handwriting abilities.

During the first session, the therapist targeted postural control and balance for play by setting up a detailed obstacle course, Cora demonstrated the moves and stood back, asking Paul to perform. Paul made many mistakes but started to problem-solve toward the end of the course. Upon completion, he said, “Let me try it again and see if I can go faster.” Cora provided some key points about one particular part of the course with which he had trouble. Providing verbal feedback after the child has performed on only a few key aspects is recommended for motor learning. Furthermore, allowing Paul to make and learn from his own motor mistakes allowed him to internalize the motor learning. This technique has been found to improve generalization. The therapist periodically changed the format, allowing Paul to make some revisions in the course, to ensure that the course was meaningful. At the end of the session, Cora suggested that next week they go out on the playground and see what was there. She wanted to conduct the session in the actual context of the activity because she knew this provided the most variability and meaning for Paul and consequently was the best for motor control and motor learning. She did not invite peers yet to participate because she wanted Paul to feel comfortable in the setting first and meet some motor challenges on his own before increasing the emotional factors.

Cora ended the session by talking to Paul about his writing and discussing strategies that might help make it easier for him in terms of motor functioning. Paul decided he would do better if he held the paper down with his left thumb; he liked the idea of using a mechanical pencil with a new pencil grip. Research suggest that discussing handwriting performance may help children improve motor performance. For example, Banks, Rodger, and Polatajko found that discussing strategies (so the children come up with the solutions) helped four children with developmental coordination disorder to improve handwriting performance more than physical practice alone.

This may not work with all groups of children and requires and adequate level of cognition. More research needs to be

**Continued**
done to show this is effective. Since mental practice has been found to be effective in motor learning, Cora also talked to Paul about visualizing how he would complete his writing tasks in school. The therapist asked Paul to sit and visualize this for a moment before beginning the writing task.

Cora provided Paul with a variety of activities to promote his postural control that were meaningful and fun for him. Periodically, she found she had to stop the activity and review a certain skill (e.g., catch the ball with two hands, like this). When she reviewed specific skills, she provided only a few key phrases and paid close attention to the non-verbal and verbal cues Paul gave her. She considered how to facilitate his learning through the therapeutic use of self. She used a block practice schedule to teach the new skills. As Paul becomes more able, she will move to a distributed practice schedule and later a random or variable schedule. Understanding how he views the challenge is important in motor learning. If the skill appeared to be too difficult, she quickly and almost effortlessly graded the activity to make it easier. Conversely, she could make the activity more difficult so Paul is adequately challenged.

Cora also considered the social-emotional aspects of the motor challenges. Paul stated “everyone else can tie their shoes, but I can’t.” This told her a great deal and Cora decided now is the time to work on this skill. She also considered how body schema interfered with his ability to tie his shoes—he did not seem to have a sense of his body in space. Thus, Cora decided to integrate body awareness and body image activities in sessions. She incorporated such games as “Where is the shoe? Is it close to you?” and “hide and seek” of objects. They also played Simon Says in the mirror (reflective self-awareness) and games involving laterality and directionality.

Throughout the sessions, the therapist examined how Paul’s sensory functioning, specifically his poor visual and vestibular processing, interfered with his movement. Consequently, she decided to design activities to challenge these systems in movement. Key to her intervention is keeping the intervention client-focused and working with Paul to develop strategies.

The therapist designed intervention to improve Paul’s ability to play with other children and handwriting. Further analysis of Paul’s motor difficulties included an evaluation of balance and posture, sensory processing, and timing and sequencing. Using the natural environment to facilitate movement, Cora arranged occupational therapy sessions at times when the child was outside playing, initially. Because Paul enjoyed outside activities, Cora decided to work with him there until Paul felt comfortable and had some success. After therapy progressed, the therapist worked with Paul inside with smaller trucks to encourage Paul to manipulate smaller objects. By targeting activities that were meaningful, Cora used Paul’s volition as a way to increase motor skills. Cora carefully chose activities in which Paul could be successful. Cora also included other children in therapy sessions as Paul developed skills. This increased the environmental stimulation and required Paul adapt to the unpredictability of the other children. Because variability is key to movements and motor control, intervention sessions were full of many activities promoting gross and fine motor functioning.

This example shows how therapists acknowledge the multiple systems involved in movement to evaluate and design intervention. Furthermore, the therapist used principles of variability, meaning, occupation, and natural context when designing intervention. The therapist also incorporated motor learning principles of feedback, demonstration, practice, and sequencing and adapting tasks.

By capturing the child’s goals of playing outside and the parent’s goal of helping him play with his peers and school, the therapist targeted intervention to help the child improve occupational performance in a meaningful way. This approach promotes practice and learning by empowering children to meet their own occupational goals.

**SUMMARY**

This chapter defined motor control and motor learning and presented case examples to illustrate how to apply current research to occupational therapy practice with children and youth. Also defined was dynamical systems theory, and the components of movement, including postural control, balance, visual perception, and body awareness were described. An overview of motor learning concepts of practice, feedback, modeling or demonstration, and mental practice was provided. A final case example illustrated the application of motor control/motor learning principles to occupational therapy practice.

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CHAPTER 11

Sensory Integration

L. Diane Parham • Zoe Mailloux

KEY TERMS

- Ayres Sensory Integration (ASI)
- Sensory nourishment
- Adaptive responses
- Neural plasticity
- Sensory processing
- Sensory modulation
- Underresponsiveness
- Sensory registration
- Sensation seeking
- Overresponsiveness
- Sensory discrimination
- Praxis
- Dyspraxia

OBJECTIVES

1. Explain the neurobiological concepts that are basic to an individual’s sensory integrative function.
2. Explain the link between sensory input from the environment and the child’s adaptive response.
3. Describe the development of sensory integration from prenatal life through childhood.
4. Explain the clinical picture and hypothesized basis for problems in sensory modulation and sensory discrimination.
5. Describe atypical vestibular-bilateral functions and the types of behaviors that children with these problems often demonstrate.
6. Define developmental dyspraxia, and identify examples of behaviors that might be observed in a child with this problem.
7. Relate the Ayres Sensory Integration® (ASI) approach to childhood occupation and to the Occupational Therapy Practice Framework.
8. Discuss the evaluation of sensory integration within varying contexts such as home and school.
9. Identify and describe tests, interviews, and instruments used to evaluate sensory integration.
10. Describe ASI intervention and discuss the disadvantages and benefits of using such an intervention approach.
11. Explain some considerations for determining whether ASI may be an appropriate frame of reference for an individual child.
12. Describe specific skill training, group programming, and consultative interventions (such as activity or environmental modifications), including the benefits and limitations of using these approaches in conjunction with or instead of ASI intervention.
13. Identify the expected outcomes of an occupational therapy program using ASI intervention.
14. Discuss published research related to the effectiveness of ASI intervention.
15. Identify some of challenges when evaluating the effectiveness of ASI intervention.

The term sensory integration holds special meaning for occupational therapists. In some contexts it is used to refer to a particular way of viewing the neural organization of sensory information for functional behavior. In other situations this term refers to a clinical frame of reference for the assessment and treatment of people who have functional disorders in sensory processing. Both of these meanings originated in the work of A. Jean Ayres, an occupational therapist and psychologist whose brilliant clinical insights and original research revolutionized occupational therapy practice with children.

Ayres’ ideas ushered in a new way of looking at children and understanding many of the developmental, learning, and emotional problems that arise during childhood. Her innovative practice and groundbreaking research met a tremendous amount of resistance within the profession when introduced in the late 1960s and 1970s. Today, the treatment methods that she pioneered continue to be questioned and investigated, but there is little doubt that her perspective has had a profound influence on occupational therapy practice. The presence of sensory integration concepts in nearly all of the chapters of this book attests to the extent to which these ideas have affected the thinking of pediatric occupational therapists. Furthermore, the research base of the sensory integration approach to practice is extensive.

This chapter provides an in-depth orientation to this fascinating aspect of occupational therapy practice. The reader will gain a general sense of how sensory integration as a brain function is related to everyday occupations. Following is a description of how sensory integration is manifested in typically developing children and in relation to the daily life problems of children who experience difficulty with sensory integration. The history of research on sensory integration problems is reviewed to give the reader a perspective on how this field came into being, what the major constructs are, and how they have changed—and continue to change—over time.

Sensory integration, as an intervention approach developed by Ayres, is now trademarked through the Franklin B. Baker/A. Jean Ayres Baker Trust as Ayres Sensory Integration® (ASI).
According to the trademark document, ASI encompasses the theory, assessment methods, patterns of sensory integration and praxis problems, and intervention concepts, principles, and techniques developed by Ayres. In this chapter, ASI is described with respect to different types of sensory integration problems encountered by children, methods of clinical assessment, and characteristics of both direct and indirect modes of intervention, with emphasis on the principles of individual ASI intervention. Effectiveness research on individual ASI intervention is presented and case examples of children who have been helped by occupational therapists using an ASI approach are provided.

**SENSORY INTEGRATION IN CHILD DEVELOPMENT**

One of the most distinctive contributions that Ayres made to understanding child development was her focus on sensory processing, particularly with respect to the proximal senses (vestibular, tactile, and proprioceptive). From the sensory integration viewpoint, these senses are emphasized because they are primitive and primary; they dominate the child’s interactions with the world early in life. The distal senses of vision and hearing are critical and become increasingly more dominant as the child matures. Ayres believed, however, that the body-centered senses are a foundation on which complex occupations are scaffolded. Furthermore, when Ayres began her work, the vestibular, tactile, and proprioceptive senses were virtually ignored by scholars and clinicians who were interested in child development. She devoted her career to studying the roles that these previously forgotten senses play in development and in the genesis of developmental problems of children.

Ayres’ basic assumption was that brain function is a critical factor in human behavior. She reasoned, therefore, that knowledge of brain function and dysfunction would give her insight into child development and would help her understand the developmental problems of children. However, Ayres also had a pragmatic orientation that sprang from her professional background as an occupational therapist. She was concerned particularly with how brain functions affected the child’s ability to participate successfully in daily occupations. The environment continuously “feeds” the child a variety of nourishing sensations in the flow of everyday life.

As Ayres developed her ideas about sensory integration, she used terms such as sensory integration, adaptive response, and praxis in ways that reflected her orientation. A glossary of terms that are commonly used within the framework of sensory integration theory is presented on the Evolve website. It may be helpful to the reader to refer to these definitions frequently while reading this chapter.

Ayres coined some of these terms, whereas other terms were drawn from the literature of other fields. When Ayres borrowed a term from another field, however, she imparted a particular meaning to it. For example, Ayres did not use the term sensory integration to refer solely to intricate synaptic connections within the brain, as neuroscientists typically do. Rather, she applied it to neural processes as they relate to functional behavior. Hence, her definition of sensory integration is the “organization of sensation for use” (p. 5). It is the inclusion of the final clause “for use” that is Ayres’s hallmark, because it ties sensory processing to the person’s occupation.

Ayres introduced a new vocabulary of sensory integration theory and synthesized important concepts from the neurobiologic literature to organize her views of child development and dysfunction. Many of these ideas were first published in her classic book *Sensory Integration and Learning Disorders*. Later she wrote a book for parents, *Sensory Integration and the Child*, outlining the behavioral changes that can be observed in a child as sensory integration develops. Major points made in these books regarding neurobiologic concepts in relationship to development and the ontogeny of sensory integration are presented in the following section.

**NEUROBIOLOGICALLY BASED CONCEPTS**

**Sensory Support for Development and Brain Function**

Sensory input is necessary for optimal brain function. The brain is designed to constantly take in sensory information, and it malfunctions if deprived of it. Sensory deprivation experiments conducted in the 1950s and 1960s made it clear that without an adequate inflow of sensation, the brain generates its own input in the form of hallucinations and subsequently distorts incoming sensory stimuli. If adequate sensory stimulation is not available at critical periods in development, brain abnormalities and resulting behavioral disorders result. It is now well established that persistent, serious impairments in cognitive, social, and emotional functioning often result when infants and young children are institutionalized in environments that are impoverished with respect to availability of a wide range of sensory experiences, the presence of a nurturing caregiver, and opportunities for sensory-motor exploration.

Ayres considered sensory input to be *sensory nourishment* for the brain, just as food is nourishment for the body. Wilbarger, a colleague of Ayres, built on this concept with the *sensory diet*, designed to provide individualized sensory experiences for the child with sensory integrative dysfunction. The therapeutic sensory diet provides an optimal combination of sensory-based activities at the appropriate intensities for a specific child. For most typically developing children, the sensory diet does not require conscious monitoring by caregivers. The environment continuously “feeds” the child a variety of nourishing sensations in the flow of everyday life.

As critical as input is to the developing brain, the mere provision of sensory stimulation is limited in value. Too much stimulation can generate stress that is detrimental to brain development and may reduce the person’s subsequent ability to cope with stress. To have an optimal effect on development, learning, and behavior, the sensory input must be actively organized and used by the child to act on and respond to the environment.
Adaptive Response

A child does not passively absorb whatever sensations come along. Rather the child actively selects the sensations most useful at the time and organizes them in a fashion that facilitates accomplishing goals. This is the process of sensory integration. When this process is going well, the child organizes a successful, goal-directed action on the environment, which is called an adaptive response. When a child makes an adaptive response, he or she successfully meets some challenge presented in the environment. The adaptive response is possible because the brain has been able to efficiently organize incoming sensory information, which then provides a basis for action (Figure 11-1).

Adaptive responses are powerful forces that drive development forward. When a child makes an adaptive response that is more complex than any previously accomplished response, the brain attains a more organized state and its capacity for further sensory integration is enhanced. Thus, sensory integration leads to adaptive responses, which in turn result in sensory integration that is more efficient.

Ayres provides the example of learning to ride a bicycle to illustrate this process. The child must integrate sensations, particularly from the vestibular and proprioceptive systems, to learn how to balance on the bicycle. The senses must accurately and quickly detect when the child begins to fall. Eventually, perhaps after many trials of falling, the child integrates sensory information efficiently enough to make the appropriate weight shifts over the bicycle to maintain balance. This is an adaptive response, and once made, the child is able to balance more effectively on the next attempt to ride the bike. The child’s nervous system has changed, so the child is now more adept at bicycle riding.

In making adaptive responses, the child is an active doer, not a passive recipient. Adaptive responses come from within the child. No one can force a child to respond adaptively, although a situation may be set up that is likely to elicit adaptive responses from the child. For typically developing children and for most children with disabilities, there is an innate drive to develop sensory integration through adaptive responses. Ayres called this inner drive and speculated that it is generated primarily by the limbic system of the brain, a structure known to be critical in both motivation and memory. Ayres designed therapeutic activities and environments to engage the child’s inner drive (elicit adaptive responses) and, in so doing, advance sensory integrative development and the child’s occupational competence.

Neural Plasticity

It is thought that when a child makes an adaptive response, change occurs at a neuronal synaptic level. This change is a function of the brain’s neural plasticity. Plasticity is the ability of a structure and concomitant function to be changed gradually by its own ongoing activity. It is well established in the neuroscientific literature that when organisms are permitted to explore interesting environments, significant increases in dendritic branching, synaptic connections, synaptic efficiency, and size of brain tissue result. These changes are most dramatic in a young animal and probably represent a major mechanism of brain development, although it is clear that such manifestations of plasticity are characteristic of optimal brain functioning throughout the lifespan.

Studies of the effects of enriched environments on animals indicate that the essential ingredient for positive brain changes is that the organism actively interacts with a meaningful and challenging environment. Passive exposure to sensory stimulation does not produce these same positive changes. It can be hypothesized from these findings that adaptive responses activate the brain’s neuroplastic capabilities. Furthermore, the brain’s plasticity makes it possible for an adaptive response to increase the efficiency of sensory integration at a neuronal level.

Central Nervous System Organization

Ayres looked to the organization of the central nervous system (CNS) for clues to how children organize and use sensory information and how sensory integration develops over time. At the time that she was developing her theory, hierarchical models of the CNS dominated thinking in the neurosciences.
Hierarchic models view the nervous system in terms of vertically arranged levels, with the spinal cord at the bottom, the cerebral hemispheres at the top, and the brainstem sandwiched in between. These levels are interdependent yet reflect a trend of ascending control and specialization. Thus, the cerebral cortex at the top of the hierarchy is highly specialized and analyzes precise details of sensory information. Ordinarily the cortex assumes a directive role over lower levels of the hierarchy. For example, the cortex may command lower centers to “ignore” certain stimuli deemed unimportant. This process is called descending inhibition and is critical in enabling higher brain functions to work efficiently. The lower levels of the CNS, however, have functions that are more diffuse and primitive, less specialized, and yet potentially more pervasive in influence compared with those of the higher levels. One of the important responsibilities of the lower levels is to filter and refine sensory information before relaying organized sensory messages upward to the cerebral cortex. Thus, cortical centers depend on lower centers for the receipt of essential, well-organized sensory information to analyze in preparation for the planning of action. According to hierarchic views, the higher levels of the CNS superimpose functions that are more sophisticated on the lower levels, but these do not replace the important lower level functions.

Ayres believed that critical aspects of sensory integration are seated in the lower levels of the CNS, particularly the brainstem and thalamus. Most of the CNS processing of vestibular information occurs in the brainstem, and much somatosensory processing takes place there and in the thalamus. One of the basic tenets of Ayres’s theory is that, because of the dependence of higher CNS structures on lower structures, increased efficiency at the levels of the brainstem and thalamus enhance higher order functioning. This view varies from traditional neuropsychology and education models, which have tended to emphasize the direct study and remediation of high-level, cortically directed skills such as reading and writing. However, newer models of education have considered “readiness” for academics and the importance of other modes such as “kinesthetic” learning.

In adopting a hierarchic view of the CNS, Ayres also assumed that the CNS develops hierarchically from bottom to top, with spinal and brainstem structures maturing before higher level centers. At the time that Ayres was developing her theory, this was somewhat speculative, although generally accepted by neuroscientists. In research conducted in more recent years, the use of positron electron tomography (PET) scans on infants has provided direct support for the notion that brain development proceeds in a bottom-to-top direction.

The hierarchic approach to CNS functioning and development led Ayres to emphasize the more primitive vestibular and somatosensory systems in her work with young children. These systems mature early and are seated in the lower CNS centers (particularly the brainstem, cerebellum, and thalamus). Using the logic of hierarchy, Ayres reasoned that the refinement of primitive functions, such as postural control, balance, and tactile perception, provides a sensorimotor foundation for higher-order functions, such as academic ability, behavioral self-regulation, and complex motor skills (e.g., those required in sports). Thus, she viewed the developmental process as one in which primitive body-centered functions serve as building blocks upon which complex cognitive and social skills can be scaffolded. This view undergirds a basic premise of the therapy approach that she developed: enhancing lower-level functions related to the proximal senses might have a positive influence on higher-level functions.

On some points Ayres departed from a strictly hierarchic view of the CNS. For example, she noted that each level of the CNS can function as a self-contained sensory integration system. Therefore, the brainstem can independently direct some sensorimotor patterns without being directed by the higher level cortex. Furthermore, the sensory integrative process involves the brain working as a whole, not simply as a series of hierarchically controlled messages, as rigid hierarchic models might suggest. These ideas are more consistent with the view of some contemporary biologists that the brain is a heterarchic system. A heterarchy is a system in which different parts may assume the controlling role in different situations; control does not always flow in a top-down direction. Ayres was ahead of her time in suggesting that the brain does not operate exclusively as a hierarchy but has holistic characteristics. These heterarchic notions strengthened her view that functions considered primitive were worthy of serious consideration in therapy.

**SENSORY INTEGRATIVE DEVELOPMENT AND CHILDHOOD OCCUPATIONS**

Ayres believed that the first 7 years of life is a period of rapid development in sensory integration. She drew this conclusion not only from her many years of observing children, but also from research in which she gathered normative data on tests of sensory integration. By the time most children reach 7 or 8 years of age, their scores on standardized tests of sensory integrative capabilities reflect almost as much maturity as an adult’s.

Development, from a sensory integrative standpoint, occurs as the CNS organizes sensory information and adaptive responses with increasing degrees of complexity. Sensory integration, of course, enables adaptive responses to occur, which in turn promote the development of sensory integration and the emergence of occupational engagement and social participation. As this process unfolds in infancy, the developing child begins to attach meaning to the stream of sensations experienced. The child becomes increasingly adept at shifting attention to what he or she perceives as meaningful, tuning out that which is irrelevant to current needs and interests. As a result, the child can organize play behavior for increasing lengths of time and gain control in the regulation of emotions.

Inner drive leads the child to search for opportunities in the environment that are “just right challenges.” These are challenges that are not so complex that they overwhelm or induce failure, nor so simple that they are routine or uninteresting. The just right challenge is one that requires effort but is accomplishable. Because there is an element of challenge, a successful adaptive response engenders feelings of mastery and a sense of oneself as a competent being.

It is fascinating to watch this process unfold. Most children require no adult guidance or teaching to acquire basic
developmental skills such as manipulating objects, sitting, walking, and climbing. Little, if any, step-by-step instruction is needed to learn daily occupations such as playing on playground equipment, dressing and feeding oneself, drawing and painting, and constructing with blocks. These achievements seem to just happen. They are the product of an active nervous system busily organizing sensory information and searching for challenges that bring forth more complex behaviors, all shaped within the context of a world saturated with sociocultural expectations and meanings.114

In this section, developmental hallmarks of sensory integration are identified and connected to the occupational achievements of childhood. The proximal senses dominate early infancy and continue to exert their influence in critical ways as the visual and auditory systems gain ascendance. Although there is some variability across children in the sequence in which developmental achievements unfold during the first year of life, this variability becomes increasingly apparent after this first year. By kindergarten age, skills vary tremendously among children because of differences in environmental opportunities, familial and cultural influences, personal experiences, and genetic endowment. It is important to keep in mind that, throughout development, sensory integrative processes contribute to the child’s construction of his or her identity, but many other influences are powerful as well—the family and cultures that shape the child’s occupational routines, the interpretations given to the child’s behaviors by others, the child’s talents and abilities, and even chance events that carry special meaning to the child.114

**Prenatal Period**

The first known responses to sensory stimuli occur early in life, at approximately 5½ weeks after conception.78 These first responses are to tactile stimuli. Specifically, they involve reflexive avoidance reactions to a perioral stimulus (e.g., the embryo bends its head and upper trunk away from a light touch stimulus around the mouth). This is a primitive protective reaction. It is not until about 9 weeks’ gestational age that an approach response (moving of the head toward the chest) occurs,78 probably as a function of proprioception.

The first known responses to vestibular input in the form of the Moro reflex also appear at about 9 weeks after conception. The fetus continues to develop a repertoire of reflexes such as rooting, sucking, Babkin, grasp, flexor withdrawal, Galant, neck righting, Moro, and positive supporting in utero that are fairly well established by the time of birth. Thus, when the time comes to leave the uterus, the newborn is well equipped with the capacity to form a strong bond with a caregiver and to actively participate in the critical occupation of nursing. These innate capacities require rudimentary aspects of sensory integration that are built into the nervous system. However, even in this earliest period of development, environmental influences, such as maternal stress, can have a significant impact on the quality of sensory integrative development. For example, Schneider and her colleagues found that infant rhesus monkeys born to mothers who had experienced stress in early pregnancy had signs of diminished responses to vestibular input, such as impaired righting responses, weak muscle tone, and attenuated postrotary nystagmus.138,139

**Neonatal Period**

Touch, smell, and movement sensations are particularly important to the newborn infant, who uses these to maintain contact with a caregiver through nursing, nuzzling, and cuddling. Tactile sensations, especially, are critical in establishing a primary attachment relationship with a caregiver and fostering feelings of security in the infant. This is just the beginning of the important role that the tactile system plays in a person’s emotional life because it is directly involved in making physical contact with others (Figure 11-2). Proprioception is also critical in the mother–infant relationship, enabling the infant to mold to the adult caregiver’s body in a cuddly manner. The phasic movements of the infant’s limbs generate additional proprioceptive inputs. Together, all of these tactile and proprioceptive inputs set the stage for the eventual development of body scheme (the brain’s map of the body and how its parts interrelate).

The vestibular system is fully functional at birth, although refinement of its sensory integrative functions, particularly its integration with visual and proprioceptive systems, continues through childhood. Of all the sensory systems, the vestibular system is the first to mature.98 Most caregivers who use rocking and carrying to soothe and calm the infant instinctively appreciate the influence of vestibular stimuli on the infant’s arousal level. Ayres pointed out that sensations such as these, which make a child contented and organized, tend to be integrating for the child’s nervous system.18

![FIGURE 11-2 Tactile sensations play a critical role in generating feelings of security and comfort in the infant and are influential in emotional development and social relationships throughout the lifespan. (Courtesy Shay McAtee.)](Image)
Experiences that activate the vestibular sense have other integrating effects on the infant as well. Being lifted into an upright position against the caregiver’s shoulder is known to increase alertness and visual pursuit. While being held in such a position, the young infant’s vestibular system detects the pull of gravity and begins to stimulate the neck muscles to raise the head off the caregiver’s shoulder. This adaptive response reaches full maturation within 6 months. In the first month of life, head righting may be minimal and intermittent with much wobbling, but it will gradually stabilize and become firmly established as the baby assumes different positions (first when the baby lies in a prone position and later in the supine position).

The visual and auditory systems of the newborn are immature. The newborn orients to some visual and auditory inputs and is particularly interested in human faces and voices, although meaning is not yet attached to these sensations. Visually the infant is attracted to high-contrast stimuli, such as black-and-white designs, and the range of visual acuity for most stimuli is limited to approximately 10 inches. The infant’s visual acuity and responsiveness to visual patterns expand dramatically over the first few months of life. During this time the infant begins to use eye contact to relate to the caregiver, further strengthening the bond between them.

Stimulation in each of the sensory systems potentially affects the infant’s state of arousal. The infant’s capacity to behaviorally adapt to changing sensations is another important aspect of sensory integrative development—the development of self-regulation. It is relatively easy to overstimulate young infants, for example, with changes in water temperature, changes in body position, or an increase in auditory or visual stimuli. However, as sensory integration develops, the older child is better able to self-regulate his or her responses to changing stimuli by initiating behaviors that will be calming and soothing (such as thumb sucking or cuddling with a favorite blanket) or exciting and energizing (such as jumping or singing). This process of self-regulation begins in the neonatal period and develops throughout early childhood.

**First 6 Months**

By 4 to 6 months of age, a shift occurs in the infant’s behavioral organization. The sensory systems have matured to the extent that the baby has much greater awareness and interest in the world, and developing vestibular–proprioceptive–visual connections provide the beginnings of postural control. During the first half of the first year, the infant begins to show a strong inner drive to rise up against gravity (Figure 11-3), and this drive is evident in much of the baby’s spontaneous play. Body positions during the first 6 months characteristically involve the prone position, with gradually increasing extension from the neck down through the trunk as the arms gradually bear more weight to help push the chest off the floor. By 6 months of age, many infants spend a great deal of time in the prone position with full active trunk extension, and most are able to sit independently, at least if propped with their own hands. These body positions usually are the infant’s preferred positions for play and are reflecting the maturing of the lateral vestibulospinal tract. Head control is well established by 6 months of age and provides a stable base for control of eye muscles. This, of course, reflects the growing integration of vestibular, proprioceptive, and visual systems, which becomes increasingly important in providing a stable visual field as the baby becomes mobile.

Somatosensory achievements at this time are particularly evident in the infant’s hands. The infant uses tactile and proprioceptive sensations to grasp objects, albeit with primitive grasps. Touch and visual information are integrated as the baby begins to reach for and wave or bang objects. The infant has a strong inner drive to play with the hands by bringing them to midline while watching and touching them. Connections between the tactile and visual systems pave the way for later hand–eye coordination skills. Midline hand play is a significant milestone in the integration of sensations from the two sides of the body.

By now, neonatal reflexes no longer dominate behavior; the baby is beginning to exercise voluntary control over movements during play. The earliest episodes of motor planning occur as the infant works to produce novel actions. This becomes evident as the infant handles objects and begins to initiate transitions from one body position to another, as in rolling from prone position to supine. Although reflexes play a role in such actions (such as grasp and neck righting reflexes), the infant’s actions have a goal-directed, volitional quality and are not stereotypically reflex bound. The emergence of intentionality is a marker of the beginning of occupational engagement.

**Second 6 Months**

Another major transition occurs during the latter half of the first year. Infants become mobile in their environments, and by the first birthday they can willfully move from one place to another, many walking while others creep or crawl. These locomotor skills are the product of the many adaptive responses that have gone before, resulting in increasingly more sophisticated integration of somatosensory, vestibular, and visual inputs.

As the infant explores the environment, greater opportunities are generated for integrating a variety of complex sensations, particularly those responsible for developing body scheme and spatial perception. The child learns about environmental space...
and about the body’s relationship to external space through sensorimotor experiences.

During the second 6 months after birth, tactile perception becomes further refined and plays a critical role in the child’s developing hand skills. The infant relies on precise tactile feedback in developing a fine pincer grasp, which is used to pick up small objects. Proprioceptive information is also an important influence in developing manipulative skills, and now the baby experiments with objects using a variety of actions. These somatosensory-based adaptive responses contribute to development of motor planning ability. Further development of midline skills is also apparent as the baby easily transfers objects from one hand to the other and may occasionally cross the midline while holding an object.

Through the first year, auditory processing plays a significant role in the infant’s awareness of environment, especially the social environment. Auditory information is integrated with tactile and proprioceptive sensations in and around the mouth as the infant vocalizes. The fruits of this process begin to blossom in the latter half of this first year, when the infant begins to experiment with creating the sounds of the language used by caregivers. Vocalizations such as consonant–vowel repetitions (“baba” and “mamama”) are common. Parents often attach meaning to these infant vocalizations and strongly encourage them, thus leading the infant also to attach meaning to these sounds. By their first birthday, many infants have a small vocabulary of words or wordlike sounds that they use meaningfully to communicate desires to caregivers.

Another major landmark toward the end of the first year is beginning independence in self-feeding. This complex achievement requires refined somatosensory processing of information from the lips, the jaw, and inside the mouth to guide oral movements in the chewing and swallowing of food. Taste and smell sensations are also integral to this process, but self-feeding involves more than the mouth. All of the acquired sensory integrative milestones involving hand–eye coordination are important to self-feeding. The infant at this period of life uses the fingers directly to feed him or herself and to explore the textures of foods. At this stage, use of a utensil such as a spoon is not very functional and is messy because motor planning skills have not progressed to the point that the child can manipulate the utensil successfully. However, many infants begin to demonstrate a drive to use the spoon in self-feeding by the end of the first year. For many contemporary American infants, use of a spoon is the first real experience in using a tool (Figure 11-4).

The occupation of dining, then, begins to emerge in infancy as sensory integrative abilities mature, allowing the child to engage in self-feeding. As an occupation, dining in its fullest sense goes far beyond the physical, sensorimotor act of feeding. Dining usually takes place within a social context, whether at a family dinner at home or in a formal restaurant, so social standards for acceptable behavior and etiquette become increasingly important as the child develops. Furthermore, partaking in a meal and sharing certain types of food gradually come to take on powerful symbolic meanings. The sensory integrative underpinnings of the dining experience influence how the child experiences mealtimes and how others view the child as a dining partner, thus playing a role in shaping the social and symbolic aspects of this vitally important occupation.

Second Year

As the child moves into the second year, the basic vestibular–proprioceptive–visual connections that were laid down earlier continue to refine, resulting in growing finesse in balance and fluidity of dynamic postural control. Discrimination and localization of tactile sensations also become much more precise, allowing for further refinement of fine motor skills.

Increasingly complex somatosensory processing contributes to the continuing development of body scheme. Ayres hypothesized that as body scheme becomes more sophisticated, so does motor planning ability.11 This is because the child draws on knowledge of how the body works to program novel actions (Figure 11-5). Throughout the second year, the typically developing toddler experiments with many variations in body movements. Imitation of the actions of others contributes further to the child’s movement repertoire. In experiencing new actions, the child generates new sensory experiences, thus building an elaborate base of information from which to plan future actions.

While motor planning ability becomes increasingly more complex in the second year, another aspect of praxis, ideation,
begins to emerge. Ideation is the ability to conceptualize what to do in a given situation. Ideation is made possible by the cognitive ability to use symbols, first expressed gesturally and then vocally during the second year of life.102 Symbolic functioning enables the child to engage in pretend actions and to imagine doing actions, even actions that the child has never before done. By the end of the second year, the toddler can join several pretend actions in a play sequence.102 Furthermore, the 2-year-old child demonstrates that he or she has a plan before performing an action sequence, either through a verbal announcement or through a search for a needed object.102 Thus, a surge in praxic development occurs in the second year as the child generates many new ideas for actions and begins to plan actions in a systematic sequence.

The burgeoning of praxic abilities plays an important role in the development of self-concept. Infant psychiatrist Daniel Stern suggests that the sense of an integrated core self begins in infancy as an outcome of the volition and the proprioceptive feedback involved in motor planning.147 The consequences of the child’s voluntary, planned actions add to the developing sense of self as an active agent in the world. As praxis takes giant leaps during the second year, so does this sense of self as an agent of power. The child feels in command of his or her own life when sensory integration allows the child to move freely and effectively through the world.18

Third through Seventh Years

The child’s competencies in the sensorimotor realm mature in the third through seventh years of life, which Ayres considered a crucial period for sensory integration because of the brain’s receptiveness to sensations and its capacity for organizing them at this time.18 This is the period when sensorimotor functions become consolidated as a foundation for higher intellectual abilities. Although further sensory integrative development can and usually does occur beyond the eighth birthday, the changes that take place are likely to be more limited than those that occurred earlier.

In the third through seventh years, children have strong inner drives to produce adaptive responses that not only meet complicated sensorimotor demands but also sometimes require interfacing with peers. The challenges posed by children’s games and play activities attest to this complexity. In the visual-motor realm, sophistication develops through involvement in crafts, drawing and painting, constructional play with blocks and other building toys, and video games (Figure 11-6). Children are

FIGURE 11-5  As motor planning develops during the second year of life, the infant experiments with a variety of body movements and learns how to transition easily from one position to another. These experiences are thought to reflect the development of body scheme. (Courtesy Shay McAtee.)

FIGURE 11-6  Adaptive responses involved in this activity require precise tactile feedback and sophisticated praxis. During activities such as this one, the preschooler becomes adept at handling tools and objects that are encountered in daily occupations throughout life. (Courtesy Shay McAtee.)
driven to explore playground equipment by swinging, sliding, climbing, jumping, riding, pushing, pulling, and pumping. Toward the end of this period they enthusiastically grapple with the motor-planning challenges posed by games such as jump rope, jacks, marbles, and hopscotch. It is also during this period that children become expert with cultural tools such as scissors, pencils, zippers, buttons, forks and knives, pails, shovels, brooms, and rakes (Figure 11-7). Many children begin to participate in occupations that present sensorimotor challenges for years to come, such as soccer, softball, karate, gymnastics, playing a musical instrument, and ballet. Furthermore, children develop the ability to organize their behavior into more complex sequences over longer time frames. This makes it possible for them to become more autonomous in orchestrating daily routines, such as getting ready for school in the morning, completing homework and other school projects, and performing household chores.

As children participate in these occupations, they must frequently anticipate how to move in relation to changing environmental events by accurately timing and sequencing their actions. This is particularly challenging in sports when peers, with their often unpredictable moves, are involved. Their bodies are challenged to maintain balance through dynamic changes in body position. In fine motor tasks, children must efficiently coordinate visual with somatosensory information to guide eye and hand movements with accuracy and precision while maintaining a stable postural base.

Children meet these challenges with varying degrees of success. Some are more talented than others with respect to sensory integrative abilities, but most children eventually achieve a degree of competency that allows them to fully participate in the daily occupations that they are expected to do and wish to do at home, in school, and in the community. Furthermore, most children experience feelings of satisfaction and self-efficacy as they master occupations that depend heavily on sensory integration.

**FIGURE 11-7** By the time a child reaches school age, sensory integrative capacities are almost mature. The child now can devote full attention to the demands of academic tasks because basic sensorimotor functions, such as maintaining an upright posture and guiding hand movements while holding a tool, have become automatic. (Courtesy Shay McAtee.)
To begin answering the questions that arose as she worked with children, Ayres initiated the process of developing standardized tests of sensory integration during the 1960s. She originally developed these tests solely as research tools to aid in theory development. At the time, she was working with children with learning disabilities, many of whom she suspected had covert difficulties processing sensory information, and she sought to uncover the nature of whatever sensory integrative difficulties might exist. It was after her initial efforts at research using her tests that other therapists asked to have access to the tests, instigating their publication by Western Psychological Services.

The first group of tests Ayres created was published as the Southern California Sensory Integration Tests (SCSIT). These were later revised and renamed the Sensory Integration and Praxis Tests (SIPT). Normative data were collected on a regional scale for the SCSIT and on a national scale for the SIPT. The tests were designed to measure aspects of visual, tactile, kinesthetic, and vestibular sensory processing as well as motor planning abilities.

Using first the SCSIT and later the SIPT with samples of children, Ayres used a statistical procedure called factor analysis to develop a typology of sensory integrative function and dysfunction. Tables 11-1 and 11-2 summarize results of her factor analytic studies, along with results of several studies conducted by other researchers. In factor analysis, sets of test scores are grouped according to their associations with one another. The resulting groups of associated test scores are called factors. Ayres interpreted the factors that emerged from her studies as representative of neural substrates underlying learning and behavior in children. For example, in her 1968 study, Ayres found that the tactile tests correlated highly with the motor planning tests, forming a factor. She hypothesized that there is an ability called motor planning that depends on somatosensory processing and influences one’s interactions with the physical world. Apraxia is the term she used to identify a disorder in this ability. In her later work, she subsumed the notion of motor planning under the construct of praxis and replaced the term apraxia with dyspraxia when referring to children.

In her last set of analyses with the SIPT, just before her death in 1988, Ayres used both factor analysis and another statistical technique called cluster analysis, which groups together children with similar SIPT profiles (see Table 11-1). This approach was used to further carve out diagnostic groupings of children that might be useful clinically. Today, consideration of both factor analysis and cluster groupings is a critical component in the interpretation of a child’s SIPT scores.

Through the years as Ayres conducted her studies with different groups of children, she continually revisited her theory, bringing along new hypotheses based on new research results. Of particular interest were the patterns that recurred despite being generated from different samples of children. Among the most consistent findings was that children who had been identified as having learning or developmental problems often displayed difficulties in more than one sensory system. Ayres interpreted this finding in light of the neurobiologic literature on intersensory integration, which indicates that the sensory systems tend to function synergistically with each other rather than in isolation. Thus, the idea of intersensory integration as critical to human function became one of the major tenets of sensory integration theory.

Another finding, which emerged in early studies and in later SIPT studies, was that some patterns of scores were seen only in groups of children who had been identified as having disorders. In other words, some factors were not evident in typically developing children at any age. This led to the proposal that the sensory integrative problems associated with these particular patterns were representative of neural dysfunction rather than developmental lag.

Yet another recurrent pattern was a relationship between tactile perception and praxis scores. This association appeared repeatedly in her studies and led Ayres to theorize that the tactile system contributes importantly to the development of efficient practical functions. The robustness of this finding across many studies influenced Ayres to emphasize the relationship between the tactile system and praxis, a relationship that has become a cornerstone of sensory integration theory.

Throughout her research, several patterns emerged that Ayres suspected were related to a discrete involvement of cortical rather than brainstem or intersensory dysfunction. Ayres came to view these types of problems as different than those classified as sensory integrative disorders and less likely to be responsive to the treatment techniques that she was developing. An example is the association of low Praxis on Verbal Command scores with high postrotary nystagmus scores. Praxis on Verbal Command is the only test on the SIPT with a strong language comprehension component. Postrotary nystagmus is a test that may reflect cortical dysfunction if scores are extremely high. In this example, it is hypothesized that an underlying cortical dysfunction, possibly involving the left hemisphere (where language centers are located), is responsible for the pattern of scores. Ayres did not view this particular pattern as a sensory integrative dysfunction, although it might be detected by her tests.

In spite of small sample sizes, Ayres found similar factors across multiple studies (see Tables 11-1 and 11-2). Many of these findings were replicated by Mulligan (1998) in a confirmatory factor analytic study of more than 10,000 children. Mailloux, Mulligan, Smith Roley, et al. found a very close replication of the same factors identified by Ayres. In a study of children with suspected sensory integrative problems, factors emerged that reflected associations among (1) visual and tactile perception with praxis, (2) vestibular and proprioceptive processing with bilateral functions, (3) attention and tactile defensiveness, and (4) visual and tactile discrimination. The robustness of some of these findings across many studies strengthens the hypothesis that they reflect underlying patterns of function.

Ayres conducted her factor and cluster analyses to shed light on the types of sensory integrative dysfunctions that children experience, yet she did not view the resulting typologies as specific diagnostic labels to pin on individual children. Rather, the typologies were seen as general patterns exhibited time after time by groups of children who were struggling in school or with some other aspect of behavior or development. They provide the therapist with relevant information to consider when conducting clinical assessments. They do not provide prefabricated slots in which to fit children. Ultimately, the important job of interpreting an individual child’s pattern of scores in relation to his or her unique life situation lies in the purview of the therapist’s judgment, using research, training, and experience to guide decision making.

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<table>
<thead>
<tr>
<th>Author</th>
<th>Purpose</th>
<th>Instruments</th>
<th>Hypothesis</th>
<th>Analysis</th>
<th>Subjects</th>
<th>Results</th>
<th>Contributions to Theory</th>
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</table>

**TABLE 11-1** Purpose, Methods, Results, and Contributions of Studies of Sensory Integrative Patterns
<table>
<thead>
<tr>
<th>Author</th>
<th>Purpose</th>
<th>Instruments</th>
<th>Hypothesis</th>
<th>Analysis</th>
<th>Subjects</th>
<th>Results</th>
<th>Contributions to Theory</th>
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</thead>
<tbody>
<tr>
<td>Ayres (1966b)</td>
<td>Provide an understanding of whether syndromes represent dysfunction or developmental lag. Establish construct validity.</td>
<td>Nearly the same as in Ayres, 1966a.</td>
<td>That variation in perceptual-motor abilities would be small in a group of typical children.</td>
<td>Sixteen tests Two behavioral parameters. R-technique factor analysis.</td>
<td>n = 64 Adopted, all normal on Gesell.</td>
<td>Visual motor ability accounted for most variation. Praxis and tactile perception were least variable. Hyperactivity, distractibility, tactile defensiveness factor. Factors weak because of lack of variance in performance of normal children. Suggested that low scores in praxis and tactile perception represent developmental delay. Little systematic variation when tests given to normal children. Tactile defensiveness: Hyperactivity may have a maturational component.</td>
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<tr>
<td>Ayres (1971)</td>
<td>Identify predictors of severity of sensory integrative syndromes.</td>
<td>Forty-eight tests and observations: SCSIT, psycholinguistic, intelligence, eye-hand usage, postural responses.</td>
<td>That predictive equations would emerge.</td>
<td>Ten-step regression equations for each syndrome calculated.</td>
<td>n = 140 Educationally handicapped children.</td>
<td>Presence of more than one type of disorder was the norm. Prone extension best predictor of postural-bilateral integration. Imitation of postures best predictor of praxis. Somatosensory and praxis linked again. Elucidated best predictors of syndromes. As many children may have apraxia as have postural and bilateral coordination problems.</td>
<td></td>
</tr>
<tr>
<td>Ayres (1972)</td>
<td>Further analyze and refine factors. Establish construct validity.</td>
<td>Same as above.</td>
<td>That similar factors as presented previously would emerge.</td>
<td>R-technique factor analysis.</td>
<td>n = 148 Educationally handicapped children.</td>
<td>Six factors identified: form and space perception; auditory language; postural ocular; motor planning; reading, spelling, and IQ; hyperactivity, tactile perception. Further confirmed left hemisphere dysfunction. Reconfirmed syndromes found in other samples of learning-disabled children.</td>
<td></td>
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</tbody>
</table>
Ayres (1977) Further analyze interrelationships (add SCPNT) so that differential diagnosis can be further refined. That clusters would continue to be refined. Series of R-technique factor analyses (not all measures entered each time). n = 128 Learning-disabled children. Five major domains identified: somatosensory-motor planning; auditory-language, postural-ocular, eye-hand coordination, postrotary nystagmus. Further elucidated nature of interhemispheric integration. Role of vestibular system clarified.

Ayres, Mailloux, & Wendler (1987) Continue to attempt to differentiate types of sensory integration dysfunction. New praxis tests as well as many of the tests that had been used in past studies. Is praxis a unitary function? Would computer-generated clusters match those that had been identified clinically and through factor analysis? n = 182 Learning or behavior disorders. Praxis tests were related with one another. Visual tests correlated with tactile tests. Somatovisual-practic factor identified. Tactile scores and praxis related; short duration postrotary nystagmus; statistical association with praxis. Suggestion of a general somatopractic function. Further verified close association of tactile score and praxis. Computer-generated clusters were not meaningful.

Ayres (1989) Factor analyses: to clarify the nature of the constructs measured by the Sensory Integration and Praxis Tests (SIPT). That factors related to those of the SCSIT would emerge. Principal components analysis. Three analyses: n = 1750. Normative sample. n = 125 Learning or sensory integrative disorders. n = 293 Combined sample of learning or sensory integrative disorders and matched children from normative sample. Visuopraxis and somatopraxis factors emerged in all three analyses. Bilateral integration and sequencing factor and praxis on verbal command factor seen only in dysfunctional sample. Other factors related to vestibular and somatosensory processing identified. Expanded understanding of vestibular-bilateral disorders to include sequencing element. Somatopraxis factor reinforced previous findings linking tactile perception and praxis. Visuopraxis factor provided support for previous visual-motor linkages.
<table>
<thead>
<tr>
<th>Author</th>
<th>Purpose</th>
<th>Instruments</th>
<th>Hypothesis</th>
<th>Analysis</th>
<th>Subjects</th>
<th>Results</th>
<th>Contributions to Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayres (1989)</td>
<td>Cluster analyses: to assist in identifying children in need of different types of remediation or services.</td>
<td>SIPT (17 tests).</td>
<td>That meaningful diagnostic groupings would emerge.</td>
<td>Agglomerative cluster analysis, Ward’s method.</td>
<td>n = 293 Same sample as above, combined dysfunctional and normative.</td>
<td>Six cluster groups identified: low average bilateral integration and sequencing, generalized sensory integrative dysfunction, visuo- and somatodyspraxia, low average sensory integration and praxis, dyspraxia on verbal command, high average sensory integration and praxis.</td>
<td>Children with and without dysfunction can be differentiated on the basis of SIPT profiles. Identified specific SIPT profile that may be characteristic of left hemisphere dysfunction.</td>
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<tr>
<td>Mulligan (2000)</td>
<td>To explore subgroupings of children referred for SIPT testing and to provide information about the validity of the six cluster groups identified in the SIPT manual.</td>
<td>SIPT.</td>
<td>That cluster groups similar to those identified by Ayres (1989) would emerge.</td>
<td>Agglomerative cluster analysis, Ward’s method.</td>
<td>n = 1961 children assessed with the SIPT between 1989 and 1993.</td>
<td>Five cluster groups identified: generalized sensory integration dysfunction and dyspraxia-severe, generalized sensory integration dysfunction and dyspraxia-moderate, low average bilateral integration and sequencing, average sensory integration and praxis.</td>
<td>Demonstrated many similarities with Ayres’s cluster analysis, with some differences. Supports evidence of dyspraxia, bilateral integration and sequencing deficit, dyspraxia on verbal command, and more general dyspraxia. More helpful in identifying degree of dysfunction rather than type, as this sample did not include a normative sample as did Ayres’s analysis.</td>
</tr>
<tr>
<td>Parham (1998)</td>
<td>To examine whether sensory integrative measures are predictive of school achievement, when intelligence and other factors are taken into account, concurrently and over a 4-year period.</td>
<td>SIPT, converted into 3 factor scores: praxis, visual perception, and somato-sensory. Intelligence, reading, and math achievement. Socioeconomic status.</td>
<td>That sensory integrative performance at ages 6–8 years is related to achievement concurrently and predictively 4 years later.</td>
<td>Multiple regression analyses.</td>
<td>n = 91, of whom 43 were identified as learning disabled. Children were 6–8 years old initially, 10–12 years old at follow-up.</td>
<td>When controlling for IQ sensory integration: at ages 6–8 significantly correlated with math, but not reading; at ages 6–8 significantly predicted math and reading 4 years later; at ages 10–12 significantly predicted math and reading at same age. Strong relationships between praxis and math achievement identified.</td>
<td>Supported the hypothesis that sensory integration, especially praxis, is related to achievement when taking IQ into account. Sensory integration continues to contribute to achievement at middle school age.</td>
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</table>
Mailloux, Mulligan, Roley, et al. (In preparation) explore relationships among modulation measures; examine low and high PRN as separate measures. 18 test scores from the SIPT; subtests for directionality, laterality and crossing midline; SPM items measuring sensory over responsiveness; parent report of problems in attention. Low PRN & measures of directionality, laterality and crossing midline would be associated with measures of vestibular bilateral integration; SPM items measuring sensory over responsiveness would be more related to attention than other sensory or praxis functions. Exploratory factor analyses using Varimax and Promax rotations. 273 children from a retrospective clinical sample. PRN scores fell primarily in the low to average range. Four factors: visuo- and somatodyspraxia, vestibular bilateral integration and sequencing, tactile defensiveness and attention, tactile and visual discrimination. Low PRN is related to vestibular and bilateral integration functions; tactile defensiveness is more strongly related to attention problems than to perception measures or praxis; measures of directionality, laterality and crossing midline and modulation items other than for tactile defensiveness were not significant on factors.

CFA, Confirmatory factor analysis; ITPA, Illinois Test of Psycholinguistic Abilities; SCPNT, Southern California Postrotary Nystagmus Test; SCSIT, Southern California Sensory Integration Test; SIPT, Sensory Integration and Praxis Tests; SEM, structural equation modeling.

<table>
<thead>
<tr>
<th>Author and Date of Study</th>
<th>Somatodyspraxia</th>
<th>Visual Perception &amp; Visuomotor/Visuopraxis</th>
<th>Vestibular, Postural, and Bilateral Integration</th>
<th>Auditory Language Functions</th>
<th>Somatosensory Perception</th>
<th>Tactile Defensiveness and Attention</th>
<th>Other Findings</th>
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<tr>
<td>Ayres (1965)</td>
<td>Tactile tests</td>
<td>Frostig tests</td>
<td>Not tested</td>
<td>Tactile and kinesthesia</td>
<td>No specific factor</td>
<td>Hyperactive/ distractible</td>
<td>Figure-ground a separate factor</td>
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<td>Motor planning</td>
<td>Kinesthesia</td>
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<td>Motor accuracy</td>
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<td>behavior and tactile</td>
<td>Eye-hand agreement not related to</td>
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<td></td>
<td>(imitation of</td>
<td>Manual form Perception</td>
<td></td>
<td>Frostig spatial relations</td>
<td></td>
<td>defensiveness</td>
<td>perceptual-motor dysfunction</td>
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<tr>
<td></td>
<td>posture, motor</td>
<td>Ayres’ Space Test</td>
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<td>Ayres’ Space Test</td>
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<td>Identified two main</td>
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<td>accuracy)</td>
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<td>factors in normal</td>
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<td></td>
<td>Eye pursuits</td>
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<td>sample: general perceptual-motor-</td>
</tr>
<tr>
<td>Ayres (1966a)</td>
<td>Accounted for most variance</td>
<td>Figure-ground Frostig spatial relations</td>
<td>Not tested</td>
<td>Tactile defensiveness</td>
<td>Low association of tactile</td>
<td>Tactile defensiveness and</td>
<td>Visual-motor ability accounted</td>
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<td>Motor planning</td>
<td>Frostig spatial relations</td>
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<td>with praxis factor</td>
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<td>hyperactivity; may be a</td>
<td>for most variation in normal</td>
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<td></td>
<td>maturational factor involved</td>
<td>children</td>
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<td></td>
<td>Motor accuracy</td>
<td>Frostig tests</td>
<td>Integration two sides of body and tactile perception</td>
<td>Not tested</td>
<td>No specific factor</td>
<td>Tactile defensiveness and hyperactivity; may be a maturational factor involved</td>
<td>Poor motor planning—tactile perception not seen in normal children</td>
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<tr>
<td>Ayres (1966b)</td>
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<td>Frostig tests</td>
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<td>Tactile and tactile</td>
<td>No specific factor</td>
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<td>Poor motor planning—tactile</td>
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<td></td>
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<td>Most SCSIT; visual tests not included in analysis</td>
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<td>Possible left hemisphere dysfunction: auditory-language</td>
<td></td>
<td></td>
<td>children</td>
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<tr>
<td></td>
<td></td>
<td>Possible right hemisphere dysfunction: eye movement deficits, better right- than left-sided function</td>
<td>Bilateral integration Postural reactions Reading and language problems</td>
<td>Auditory- language Reading achievement Auditory and visual-motor sequencing</td>
<td></td>
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<td>Poor motor planning—tactile</td>
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<td></td>
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<td>perception not seen in normal</td>
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<td>Ayres (1969)</td>
<td>Tactile tests</td>
<td>Most SCSIT; visual tests not included in analysis</td>
<td>Bilateral integration Postural reactions Reading and language problems</td>
<td>Possible left hemisphere dysfunction: auditory-language Reading achievement Auditory and visual-motor sequencing</td>
<td>No specific factor</td>
<td>Tactile defensiveness, hyperactivity, and attention related to each other, but not a distinct factor</td>
<td>Poor motor planning—tactile perception not seen in normal children</td>
</tr>
<tr>
<td>Ayres (1972)</td>
<td>Motor planning</td>
<td>Poor praxis related to hyperactivity and tactile defensiveness</td>
<td>Poor ocular control</td>
<td>Auditory language intelligence</td>
<td>Tactile perception and hyperactivity formed a factor separate from praxis</td>
<td>Reading-spelling load together</td>
<td></td>
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<tr>
<td>Hyperactivity</td>
<td>Tactile defensiveness</td>
<td>(more emphasis on motor than tactile)</td>
<td>Excessive residual primitive postural responses</td>
<td>Relatively good left-hand coordination</td>
<td>Praxis on verbal command factor</td>
<td>Motor accuracy highly associated with all parameters</td>
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<tr>
<td>Ayres (1977)</td>
<td>Analysis 5: imitation of postures</td>
<td>Composite tactile Kinesthesia</td>
<td>Analysis 5: prone extension</td>
<td>Analysis 5: composite language (ITPA)</td>
<td>Analysis 5: Composite tactile Kinesthesia</td>
<td>Visual tests have strong cognitive component (loaded with IQ on Analysis 2)</td>
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<td></td>
<td>Composite tactile visual tests</td>
<td>Kinesthesia</td>
<td>Flexion posture</td>
<td>Dichotic listening</td>
<td>Bilateral integration symptom did not load</td>
<td>SVCU associated with lateralization indices</td>
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<td>Analysis 3: Manual form Perception</td>
<td>Composite tactile Kinesthesia</td>
<td>Composite tactile Kinesthesia</td>
<td>Flowers-Costello (auditory)</td>
<td>No specific factor</td>
<td>Motor accuracy loaded separately on all parameters</td>
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<td></td>
<td></td>
<td></td>
<td>Bilateral integration</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>symptom did not load</td>
<td></td>
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<tr>
<td>Ayres (1989)</td>
<td>Somatopraxis factor</td>
<td>Visuo-praxis factor</td>
<td>Bilateral integration and sequencing factor</td>
<td>Praxis on verbal command factor</td>
<td>Somatosensory perception factor</td>
<td>High-functioning group identified within normative sample</td>
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<tr>
<td>(Oral Praxis, Postural Praxis, Graphesthesia)</td>
<td>(Constructional Praxis, Design Copying, Space Visualization, Figure-Ground)</td>
<td>(Sequencing Praxis, Bilateral Motor Coordination, Standing and Walking Balance)</td>
<td>Low average bilateral integration and sequencing cluster</td>
<td>Dyspraxia on verbal command cluster (high Postratory Nystagmus with low Praxis on Verbal Command)</td>
<td>Not studied</td>
<td>Generalized dysfunction group identified within group with learning disorders and sensory integrative dysfunction</td>
<td></td>
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<tr>
<td>Visuo- and somatodyspraxia cluster</td>
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Continued
TABLE 11-2  Factors and Clusters Identified in Research—Cont’d

<table>
<thead>
<tr>
<th>Author and Date of Study</th>
<th>Somatodyspraxia</th>
<th>Visual Perception &amp; Visuomotor/Visuopraxis</th>
<th>Vestibular, Postural, and Bilateral Integration</th>
<th>Auditory Language Functions</th>
<th>Somatosensory Perception</th>
<th>Tactile Defensiveness and Attention</th>
<th>Other Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulligan (1998)</td>
<td>Dyspraxia (Oral Praxis, Postural Praxis, and Praxis on Verbal Command); also suggests generalized function underlying all other factors</td>
<td>Visual Perceptual Deficit (Design Copying, Constructional Praxis, Space Visualization, Manual Form Perception, Figure Ground Perception)</td>
<td>Bilateral integration and sequencing deficit (Sequencing Praxis and Bilateral Motor Coordination)</td>
<td>Not tested</td>
<td>Tactile tests and Kinesthesia</td>
<td>Not studied</td>
<td></td>
</tr>
<tr>
<td>Mailloux, Mulligan, Roley, et al., (manuscript in preparation)</td>
<td>Some somatopraxis tests seen within the visuopraxis factor</td>
<td>Visuopraxis formed a distinct factor</td>
<td>PRN included as part of a bilateral integration and sequencing factor</td>
<td>Not tested</td>
<td>Tactile perception loaded with visual perception</td>
<td>Tactile defensiveness items loaded with signs of attention problems</td>
<td></td>
</tr>
</tbody>
</table>

*ITPA, Illinois Test of Psycholinguistic Abilities; SCSIT, Southern California Sensory Integration Test; SVCU, Space Visualization Contralateral Use.*


Mailloux, Z., Mulligan, Smith, Roley (in prep).


SENSORY INTEGRATIVE PROBLEMS

The results of research, combined with the experiences of clinicians and the work of scholars in the field, have generated many different ways of conceptualizing sensory integrative problems over the past 30 years. The complexity of this domain can be daunting for the novice therapist, but is also a reflection of the growth in knowledge in this field. The terms sensory integrative disorder, sensory integrative dysfunction, and sensory integrative problems do not refer to one specific type of difficulty but describe a heterogeneous group of problems that are thought to reflect subtle neural differences involving multisensory and motor systems.

Most discussions of sensory integrative problems assume normal sensory receptor function. In other words, sensory integrative problems involve central, rather than peripheral, sensory functions. This assumption has been supported in several well-designed studies. For instance, Parush, Sohmer, Steinberg, and Kaitz found that the somatosensory-evoked potentials of children with attention deficit–hyperactivity disorder (ADHD) differ from those of typically developing children with respect to indicators of central tactile processing but not peripheral receptor responses.119 Many of the children with ADHD in this study were also identified as having tactile defensiveness, a sensory integrative problem. In another study, researchers found that children with learning disabilities, compared with nondisabled children, had impaired postural responses involving central integration of vestibular, proprioceptive, and visual inputs, whereas measures of peripheral receptor functions were normal.142 Thus, when sensory integrative problems involving the vestibular system are discussed, these problems are generally thought to be based within CNS structures and pathways (i.e., the vestibular nuclei and its connections) rather than the vestibular receptors (i.e., the semicircular canals, utricle, or saccule).159 In this chapter, the discussions of sensory integrative problems assume that peripheral function is normal.

As noted previously, different conceptualizations of sensory integrative problems have been generated over the years. Although perfect consensus on how to categorize these problems does not exist, clearly there are recurring themes across authors. Distinct but overlapping taxonomies of sensory integrative problems include, for example, those of Bundy and Murray39 and Kimball.81 Bundy and Murray presented a taxonomic model that depicts sensory integrative dysfunction as manifested in two major ways: poor sensory modulation and poor praxis.39 Miller, Anzalone, Lane, Cermak, and Osten proposed a nosology of Sensory Processing Disorders (SPD) that includes three main types of disorder: sensory modulation disorder, sensory-based motor disorder, and sensory discrimination disorder.158 Subtypes within their category of sensory modulation disorder are overresponsivity, underresponsivity, and sensory seeking. Subtypes within their sensory-based motor disorder category include postural disorders and dyspraxia.

For the purposes of this chapter, sensory integrative problems are divided into four general categories:

1. Sensory modulation problems
2. Poor sensory discrimination and perception
3. Problems related to vestibular-proprioceptive functions
4. Difficulties related to praxis

These four categories are used here because they are consistent with the research data available at this time. Although variations were reported across studies, these patterns emerged in research on different samples of children over many decades. This research indicated that the patterns are interrelated and often coexist in individual children. When planning intervention, occupational therapists need to carefully analyze assessment data to discern whether one or more specific patterns of sensory integration problems seem to be affecting an individual child’s participation in activities. Each of the main categories of sensory integration problems is presented in the next section.

Sensory Modulation Problems

Modulation refers to CNS regulation of its own activity.18 The term sensory modulation refers to the tendency to generate responses that are appropriately graded in relation to incoming sensory stimuli, rather than underreacting or overreacting to them. Cermak45 and Royeen131 hypothesized that there is a continuum of sensory responsivity, with hyporesponsivity at one end and hyperresponsivity at the other. An optimal level of arousal and orientation lies in the center of the continuum (Figure 11-8). This is where most activity falls for most individuals, although everyone experiences fluctuations across this continuum of sensory responsivity in the course of a day. In the continuum model, dysfunction is indicated when the fluctuations within an individual are extreme or when an individual tends to function primarily at one extreme of the continuum or the other. The individual who tends to function at the extremely underresponsive end of the continuum may fail to notice sensory stimuli that would elicit the attention of most people. This characteristic often is identified as a problem in sensory registration. At a less severe degree of underresponsiveness, the individual notices sensory stimuli, but is slow to respond or seems to crave intense sensory input. At the opposite extreme of the continuum is the overresponsive individual with sensory defensiveness. This person is overwhelmed and overstressed by ordinary sensory stimuli.

Originally, Ayres thought of sensory registration problems as different in nature from sensory modulation problems such as tactile defensiveness.19 Soon after she introduced the concept of sensory registration, however, other experts in the field of sensory integration suggested that sensory registration and tactile defensiveness might be related through common...
underlying neural functions.166, 134 This idea contributed to the continuum model. Experts soon found that this simple continuum model did not adequately address the complexity of child behaviors, however. For example, Royeen and Lane hypothesized that the relationship between underresponsiveness and overresponsiveness may be circular instead of linear, because a child who is extremely defensive may be overloaded to the point of shutting down and becoming underresponsive.14

Previously, we have criticized the continuum model as overly simplistic because sensory modulation very likely is influenced by the individual’s history of personal experiences and interpretation of the situation, as well as interactions among multiple neural systems.147 Furthermore, individuals who are unusually underresponsive to input from one sensory system may tend to be overresponsive in another system. For example, a child may be overresponsive to touch, but at the same time be underresponsive to vestibular sensations. The continuum model does not account for this phenomenon.

Dunn presented a conceptual model that takes into account the potential roles of various neural processes in generating patterns of underresponsiveness and overresponsiveness (Figure 11-9).61, 63 In her model, four main patterns represent individual differences in sensory responding: low registration, sensation seeking, sensitivity to stimuli, and sensation avoiding. Dunn hypothesized these patterns emerge from individual differences in the neural processes of habituation, sensitization, threshold, and maintenance of homeostasis. The person who falls in the low-registration quadrant of the model is underresponsive due to a high threshold for reactivity and therefore needs to have a high level of intensity in environmental stimuli in order to notice and attend. The person who falls in the sensation-seeking quadrant is also considered underresponsive with a high threshold but expresses this behaviorally by actively seeking out intense sensory input. The sensory sensitivity and sensation-avoiding quadrants represent overresponsive patterns. Individuals who fall in the sensory sensitivity quadrant have heightened awareness of, and are distracted by, sensory stimuli due to a low threshold, but they tend to passively cope with these sensations. In contrast, those who are sensation-avoiding not only have heightened awareness of sensory stimuli but actively attempt to avoid the ordinary sensations that they experience as noxious. One of the most important contributions of this model is that it can be used to consider what kinds of work and play or leisure environments present an optimal match for an individual’s sensory modulation characteristics.64

In another model that addresses the complexity of sensory modulation, Miller, Reisman, McIntosh, and Simon differentiate between physiologic and behavioral elements of what they call sensory modulation disorders (SMDs).107 Their ecologic model includes both external and internal dimensions affecting sensory modulation (Figure 11-10). External dimensions identified are culture, environment, relationships, and tasks, whereas internal dimensions are sensory processing, emotion, and attention. The external dimensions highlight the importance of context, whereas the internal dimensions focus on enduring differences among individuals. In this model, external and internal dimensions are interlinked through multidirectional, rather than linear, relationships and must be viewed together to design interventions for children with SMDs.

These models of sensory modulation help us to organize the complex information relevant to understanding children with difficulties in overresponding or underresponding to sensory information in everyday situations. Many unanswered questions about modulation remain. For example, some research indicates that many children frequently demonstrate behavioral characteristics of both underresponding and overresponding, often within the same sensory system.66 This may be particularly the case for children with autism.67, 148 Existing models do not yet do an adequate job of explaining these phenomena. Nevertheless, these models are important because they provide a foundation upon which research programs can be built to explicate the complex issues that are involved. Today, research on patterns of sensory modulation and their manifestations in everyday activities is an area of focused investigation in occupational therapy.28, 67, 107 In addition, the relationship between physiologic measures and patterns of behavior that characterize sensory modulation problems continues to be explored—for example, through studies of brain electrical activity27 and autonomic responses106, 137 to sensory input.

Although there remains much to learn about sensory modulation, a general consensus exists among sensory integration experts regarding the behaviors that characterize different kinds of sensory modulation difficulties. These behaviors are described next.

**Sensory Registration Problems**

As noted previously in this chapter, sensory integration is the “organization of sensory input for use” (p. 184).18 However, before sensory information can be used functionally, it must be registered within the CNS. When the CNS is working well, it knows when to “pay attention” to a stimulus and when to “ignore” it. Most of the time, this process occurs automatically and efficiently. For example, a student may not be aware of the noise of traffic outside the window of a classroom while listening to a lecture, instead focusing attention on the sound of the lecturer’s words. In this situation, the student registers the auditory stimuli generated by the lecturer but not the stimuli generated by the traffic. The process of sensory registration is critical in enabling efficient function so that people pay attention to those stimuli that enable them to accomplish desired goals. Simultaneously, if the process is working well, energy is not wasted attending to irrelevant sensory information.

<table>
<thead>
<tr>
<th>Thresholds/Reactivity</th>
<th>Responding/Self-Regulation Strategies</th>
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<tbody>
<tr>
<td></td>
<td>Passive</td>
</tr>
<tr>
<td>High</td>
<td>Low Registration</td>
</tr>
<tr>
<td></td>
<td>Sensory Sensitivity</td>
</tr>
</tbody>
</table>

**FIGURE 11-9** Dunn’s Model of Sensory Processing. (Adapted from Dunn, W. [1997]. The impact of sensory processing abilities on the daily lives of young children and families: A conceptual model. *Infants and Young Children, 9*(4) 23-25.)
Traditionally, occupational therapists, beginning with Ayres, have used the term *sensory registration problem* to refer to the difficulties of the person who frequently fails to attend to or register relevant environmental stimuli. This kind of problem is often seen in individuals with autism, but it may also be seen in other individuals with developmental problems. When a sensory registration problem is present, the child often seems oblivious to touch, pain, movement, taste, smells, sights, or sounds. Usually more than one sensory system is involved, but for some children one system may be particularly affected. Sometimes the same child who does not register relevant stimuli may be overfocused on irrelevant stimuli; this is commonly seen with autism. It is also common for children with severe developmental problems, such as autism, to lack sensory registration in some situations but react with extreme sensory defensiveness in other situations.

Safety concerns are frequently an important issue among children with sensory registration problems. For example, the child who does not register pain sensations has not learned that certain actions naturally lead to negative consequences, such as pain, and therefore may not withdraw adequately from dangerous situations. Instead of avoiding situations likely to result in pain, the child may repeatedly engage in activities that may be injurious, such as jumping from a dangerous height onto a hard surface or touching a hot object. Other children with sensory registration problems may not register noxious tastes and smells that warn of hazards. Similarly, sights and sounds such as sirens, flashing lights, firm voice commands, and hand signals or signs that are meant to warn of perils go unheeded if not registered.

This can be a life-endangering problem in some circumstances (e.g., when a child steps in front of a moving car).

A sensory registration problem interferes with the child’s ability to attach meaning to an activity or situation. Consequently, in severe cases, the child lacks the inner drive that compels most children to master ordinary childhood occupations (e.g., the child who is generally unmotivated to engage in play activities or to practice skills). Therefore the long-term effects on the child’s development can be profound.

**Sensation-Seeking Behavior**

Some children register sensations, but may be “underresponsive” to the incoming stimuli. These children seem to seek intense stimulation in the sensory modalities that are affected. The child who is hyporesponsive to vestibular stimuli may seek large quantities of intense stimulation when introduced to suspended equipment in a clinic setting. This child registers the vestibular sensations and usually shows signs of pleasure from the sensations, but the input does not affect the nervous system to the extent that it does for most other children. The underresponsive child may not become dizzy or show the expected autonomic responses to stimulation that is so intense it would be overwhelming for most peers. This is called *hyporesponsivity* because it refers to the underlying mode of sensory processing rather than to observable motor behavior. Although the child may appear to be active motorically, the child is not reacting to intense vestibular stimuli to the degree that most children do. In everyday settings, these children often appear to be restless, motorically driven, and thrill seeking.
Some children seem to seek greater than average amounts of proprioceptive input. Typically these children often seek active resistance to muscles, deep touch pressure stimulation, or joint compression and traction (e.g., by stomping instead of walking; intentionally falling or bumping into objects, including other people; or pushing against large objects). They may tend to use strong ballistic movements such as throwing objects forcefully. Some of these children may not seem to register the positions of body parts unless intense proprioceptive stimulation is present.

Some children who seek large amounts of proprioceptive input demonstrate signs of tactile defensiveness or gravitational insecurity. Because proprioception is thought to have an inhibitory effect on tactile and vestibular sensations, these children may be seeking increased proprioceptive input in order to help themselves modulate the overwhelming touch and movement sensations that they often experience.

The behaviors generated by sensation-seeking children may be disruptive or inappropriate in social situations. Safety issues frequently are of paramount concern, and often these children are labeled as having social or behavioral problems. A challenge for the occupational therapist working with these children may be to identify strategies by which they can receive the high levels of stimulation that they seek without being socially disruptive, inappropriate, or dangerous to themselves or others.

**Overresponsiveness**

At the opposite end of the sensory modulation continuum are problems associated with overresponsiveness, sometimes called 
overresponsivity or sensory defensiveness. The child who is overresponsive is overwhelmed by ordinary sensory input and reacts defensively to it, often with strong negative emotion and activation of the sympathetic nervous system. This condition may occur as a general response to all types of sensory input, or it may be specific to one or a few sensory systems.

The term sensory defensiveness was first introduced by Knickerbocker84 and later used by Wilbarger and Wilbarger152 to describe sensory modulation disorders involving multisensory systems. Sensory modulation problems include overreactions to touch, movement, sounds, odors, and tastes, any of which may create discomfort, avoidance, distractibility, and anxiety. Most of the research-based and clinical knowledge regarding overresponsiveness is related to the tactile and vestibular systems.

**Tactile Defensiveness**

Tactile defensiveness involves a tendency to overreact to ordinary touch sensations.4,11,18 It is one of the most commonly observed sensory integrative disorders involving sensory modulation. Individuals with tactile defensiveness experience irritation and discomfort from sensations that most people do not find bothersome. Light touch sensations are especially likely to be disturbing. Common irritants include certain textures of clothing, grass or sand against bare skin, glue or paint on the skin, the light brush of another person passing by, the sensations generated when having one’s hair or teeth brushed, and certain textures of food. Common responses to such irritants include anxiety, distractibility, restlessness, anger, throwing a tantrum, aggression, fear, and emotional distress.

Common self-care activities such as dressing, bathing, grooming, and eating are often affected by tactile defensiveness. Classroom activities such as finger painting, sand and water play, and crafts may be avoided. Social situations involving close proximity to others, such as playing near other children or standing in line, tend to be uncomfortable and may be disturbing enough to lead to emotional outbursts. Thus, ordinary daily routines can become traumatic for children with tactile defensiveness and for their parents. Teachers and friends are likely to misinterpret the child with tactile defensiveness as being rejecting, aggressive, or simply negative.

It is difficult for individuals with tactile defensiveness to cope with the fact that others do not share their discomforts and may actually enjoy situations that they find so upsetting. For a child with this disorder, who may not be able to verbalize or even recognize the problem, the accompanying feelings of anxiety and frustration can be overwhelming and the influence on functional behavior is likely to be significant.

An occupational therapist working with a child who is tactually defensive must become aware of the specific kinds of tactile input that are aversive and the kinds that are tolerated well by that particular child. Usually light touch stimuli are aversive, especially when they occur in the most sensitive body areas such as the face, abdomen, and palmar surfaces of the upper and lower extremities. Generally, tactile stimuli that are actively self-applied by the child are tolerated much better than stimuli that are passively received, as when being touched by another person. Tactile stimuli may be especially threatening if the child cannot see the source of the touch. Most individuals with tactile defensiveness feel comfortable with deep touch stimuli and may experience relief from irritating stimuli when deep pressure is applied over the involved skin areas.

Knowledge of these characteristics of tactile defensiveness helps the occupational therapist identify strategies that help the child and others who interact with the child to cope with this condition. For example, the occupational therapist may recommend to the teacher that if the child needs to be touched, it should be done with firm pressure in the child’s view, rather than with a light touch from behind the child.

**Gravitational Insecurity**

Gravitational insecurity is a form of overresponsiveness to vestibular sensations, particularly sensations from the otolith organs, which detect linear movement through space and the pull of gravity.18 Children with this problem have an insecure relationship to gravity characterized by excessive fear during ordinary movement activities. The gravitationally insecure child is overwhelmed by changes in head position and movement, especially when moving backward or upward through space. Fear of heights, even those involving only slight distances from the ground, is a common problem associated with this condition.

Children who display gravitational insecurity often show signs of inordinate fear, anxiety, or avoidance in relation to stairs, escalators or elevators, moving or high pieces of playground equipment, and uneven or unpredictable surfaces. Some children are so insecure that only a small change from one surface to another, as when stepping off the curb or from the sidewalk to the grass, is enough to send them into a state of high anxiety or panic.

Common reactions of children with gravitational insecurity include extreme fearfulness during low-intensity movement or when anticipating movement and avoidance of tilting the head in different planes (especially backward). They tend to move slowly and carefully, and they may refuse to participate in many gross motor activities. When they do engage in movement activities such as swinging, many of these children refuse to lift their
feet off the ground. When threatened by simple motor activities, they may try to gain as much contact with the ground as possible or they may tightly clench a nearby adult for security. These children often have signs of poor proprioception in addition to the vestibular overresponsiveness. May-Benson and Koomar developed a Gravitational Insecurity (GI) Assessment and found that scores on this standardized tool, which involves activities such as performing a backward roll and stepping off a chair with eyes closed, significantly discriminated between children with gravitational insecurity and typical children.\(^\text{101}\)

Playground and park activities are often difficult for children with gravitational insecurity, as are other common childhood activities such as bicycle riding, ice skating, roller skating, skateboarding, skiing, and hiking. Ability to play with peers and to explore the environment is therefore significantly affected. Functioning in the community may also be affected when the child needs to use escalators, stairs, and elevators.

A distinction may be made between gravitational insecurity and a similar condition called postural insecurity. Postural insecurity was the term Ayres originally used to refer to all children with fears related to movement. Later, however, she hypothesized that some children moved slowly and displayed fears of movement not because of a hyperresponsivity to vestibular input but because they lacked adequate motor control to perform many activities without falling. The fears of these children, then, seemed to be based on a learned, realistic appraisal of their motor limitations. The term posturally insecure is used to refer to these children.

Often it is difficult to discern whether a child’s anxiety is based on sensory overresponsivity or limited motor control because these two conditions can, and often do, coexist in the same child. Sometimes, however, the distinction is clear. Children with mild spastic diplegia, for example, commonly have postural but not gravitational insecurity. These children typically (and appropriately) react with anxiety when faced with a minimal climbing task; however, they may show pleasure at receiving vestibular stimulation, including having the head radically tilted in different planes so long as they are securely held and do not have to rely on their own motor skills to maintain a safe position.

**Overresponsiveness in Other Sensory Modalities**

Hyperresponsivities in other sensory systems can also have a significant influence on a person’s life. For example, overreactions to sounds, odors, and tastes are often problematic for children with heightened sensitivities. These types of problems, like overresponsiveness to touch and movement, may create discomfort, avoidance, distractibility, and anxiety. Most people interpret the raucous sounds found at birthday parties, parades, playgrounds, and carnivals as happy sounds, but these can be overwhelming to a child with auditory defensiveness. A visually busy and unfamiliar environment may evoke an unusual degree of anxiety in a child with visual defensiveness. Similarly, the variety of tastes and odors encountered in some environments may be disturbing to a child with overresponsivity in these systems.

**Sensory Discrimination and Perception Problems**

Sensory discrimination and perception allow for refined organization and interpretation of sensory stimuli. Some types of sensory integrative disorders involve inefficient or inaccurate organization of sensory information (e.g., difficulty differentiating one stimulus from another or difficulty perceiving the spatial or temporal relationships among stimuli). A classic example involving the visual system is that of the older child with a learning disability who persists in confusing a b with a d. A child with an auditory discrimination problem may be unable to distinguish between the sounds of the words doll and tall. A child with a tactile perception problem may not be able to distinguish between a square block and a hexagonal block using touch only, without visual cues.

Some children with perceptual problems have no difficulty with sensory modulation. However, modulation problems often coexist with perceptual problems. It makes sense that these two types of problems are associated. A child who often does not register stimuli probably has a deficit in perceptual skills because of a lack of experience interacting with sensory information. Conversely, the child who has sensory defensiveness may exert a lot of energy trying to avoid certain sensory experiences. Defensive reactions may make it difficult to attend to the detailed features of a stimulus and thereby may impede perception.

**Discrimination or perception problems can occur in any sensory system. They are best detected by standardized tests, except in the case of proprioception, which is difficult to measure in a standardized manner. Discrimination or perception problems can occur in any sensory system. They are best detected by standardized tests, except in the case of proprioception, which is difficult to measure in a standardized manner. Although most factor analytic studies of the SIPT test scores revealed patterns that linked sensory perception with motor functions, certain patterns reflected specific sensory perception factors (e.g., a visual form and space perception factor, or a tactile perception factor, as well as a somatosensory perception factor). Professionals in many fields, such as neuropsychology, special education, and speech language pathology, are trained to evaluate perceptual problems, and their focus usually is on the visual and auditory systems. In contrast, occupational therapists are unique in their understanding of the functional relevance of lesser known areas of sensory perception such as tactile, kinesthetic, and vestibular sensory processing.**

**Tactile Discrimination and Perception Problems**

Poor tactile perception is one of the most common sensory integrative disorders. Children with this disorder have difficulty interpreting tactile stimuli in a precise and efficient manner. For example, they may have difficulty localizing precisely where an object has brushed against them or using stereognosis to manipulate an object that is out of sight. Fine motor skills are likely to suffer when a tactile perception problem is present, especially if tactile defensiveness is also present.\(^{44}\)

As discussed previously, the tactile system is a critical modality for learning during infancy and early childhood. Tactile exploration using the hands and mouth is particularly important. If tactile perception is vague or inaccurate, the child is at a disadvantage in learning about the different properties of objects and substances. It may be difficult for a child with such problems to develop the manipulative skills needed to efficiently perform tasks such as connecting pieces of constructional toys, fastening buttons or snaps, braiding hair, or playing marbles. Inadequate tactile perception also interferes with the feedback that is normally used to precisely guide motor tasks such as
writing with a pencil, manipulating a spoon, or holding a piece of paper with one hand while cutting with the other.

Tactile perception is associated with visual perception; thus, it is fairly common to see children with problems in both of these sensory systems. Not surprisingly, these children tend to have concomitant problems with hand–eye coordination. A discrete somatosensory perception factor emerged as a pattern in analyses of the SIPT, but a more striking finding is the factor analytic studies of sensory integration tests over many decades was the link between tactile perception and motor planning, which recurred in many different studies. These findings led Ayres to hypothesize that tactile perception is an important contributor to the ability to plan actions. She speculated that the tactile system is responsible for the development of body scheme, which then becomes an important foundation for praxis.

Ordinarily, tactile perception operates at such an automatic level that, when it is impaired, compensation strategies take a great deal of energy. An example of this is that of the child who cannot make the subtle manipulations needed to fasten a button without looking at it. Because this child needs to use compensatory visual guidance, the task of buttoning, which is usually performed rapidly and automatically, becomes tedious, tiring, and frustrating. The necessity of using such compensatory strategies throughout the day tends to interrupt the child’s ability to focus on the more complex conceptual and social elements of tasks and situations.

**Proprioception Problems**

Another type of perceptual problem involves proprioception, which arises from the muscles and joints to inform the brain about the position of body parts. This is a difficult area to research because direct standardized measures of proprioception are not available. However, the experience of many master clinicians suggests that many children have serious difficulties interpreting proprioceptive information.

Children who do not receive reliable information about body position often appear clumsy, distracted, and awkward. As with poor tactile perception, these children must often rely on visual cues or other cognitive strategies (e.g., use of verbalizations) to perform simple aspects of tasks, such as staying in a chair or using a fork correctly. Other common attributes of children with poor proprioception include using too much or too little force in activities such as writing, clapping, marching, or typing. Breaking toys, bumping into others, and misjudging personal space are other consequences of poor proprioception that have strong social implications.

Many children thought to have proprioception problems seek firm pressure to their skin or joint compression and traction. These sensation-seeking behaviors may be an attempt to gain additional feedback about body position, or they may reflect a concomitant hypersensitivity to tactile and proprioceptive sensations. In any case, if these behaviors are done in socially inappropriate ways or at inopportune times, such as leaning on another child during circle time or hanging from a doorway at school, the child’s behavior may be misinterpreted as being willfully disruptive.

**Visual Perception Problems**

Visual perception is an important factor in the competent performance of many constructional play activities and fine motor tasks. Early factor analyses of sensory integration test scores revealed a form and space perception factor. Tests are available to measure figure-ground perception, spatial orientation, depth perception, and visual closure, to name just a few of the many aspects of visual perception that have been of concern to professionals in many disciplines.

Problems with visual perception are commonly seen in children with sensory integrative disorders, particularly when poor tactile perception or dyspraxia is present. Whereas some children have only a specific visual perception problem without any other sign of a sensory integrative dysfunction, many others have difficulties in visual perceptual abilities as a component of broader sensory integration difficulties. Henderson, Pehoski, and Murray point out the many relationships between visual spatial abilities and functions such as grasp, balance, locomotion, construction, and cognition. As these authors note, low scores on tests of visual perception can occur for a variety of reasons and in some cases will represent a problem that therapists would not view as reflective of a sensory integrative issue.

A sensory integrative treatment approach, as described later in this chapter, may be appropriate for the child who demonstrates visual perception problems along with other indicators of sensory integrative difficulties, such as poor tactile perception or praxis. A sensory integration approach may not be appropriate for children who show discrete visual perceptual problems. When other sensory integration issues are not present or have been resolved with intervention, the occupational therapist may choose to work with the child using another treatment approach, such as visual perception training, use of compensatory strategies, or skill training in specific activities.

**Other Perceptual Problems**

Many other dimensions of perception and sensory discrimination exist. For example, perception of movement through space involves the integration of vestibular, proprioceptive, and visual integration and may be affected in children with vestibular-proprioceptive problems. Auditory perception is an important function that may, when impaired, contribute to sensory integrative disorders in some children. Central auditory processing disorders recently have received increasing attention in the literature, and some authors have suggested that more attention should be given to the role of the auditory system in the sensory integration literature. However, since so much of the function of the auditory system is related to the functions of hearing, speech, and language, this area of study in sensory integration may be most appropriately pursued in collaboration with speech–language pathologists and audiologists. Although auditory perception problems are not usually considered to be a type of sensory integrative dysfunction when seen in isolation, difficulties with auditory perception and language development often coexist with signs of sensory integrative dysfunction. The relationship between these processes warrants further research.

**Vestibular-Proprioceptive Problems**

In her research, Ayres identified a pattern of problems thought to reflect inefficient central vestibular processing. Clinical signs related to this type of problem involve the motor functions that are outcomes of vestibular processing, such as poor equilibrium reactions and low muscle tone, particularly of the
extensor muscles, which are strongly influenced by the vestibular system. These disorders are assessed using informal and formal clinical observations and standardized test scores.

Different names have been applied to vestibular processing problems at different points in time because of the changing patterns of research findings. In her early factor analytic studies, Ayres identified a linkage between postural-ocular mechanisms and integration of the two sides of the body. Clinically, she called the related dysfunction a disorder in postural and bilateral integration, and she noted that it often occurred in children with learning disabilities, especially those with reading disorders. Additional problems commonly seen in this disorder include low muscle tone, immature righting and equilibrium reactions, poor right-left discrimination, and lack of clearly defined hand dominance.

Later in the 1970s, Ayres included the Southern California Postrotary Nystagmus Test (SCPNT) in her research as a more specific measure of vestibular processing. This test continues to be used and is part of the SIPT. Based on analysis of SCPNT scores, Ayres identified a vestibular processing component to the postural and bilateral integration (PBI) concept. At this point she replaced the old PBI concept with the term vestibular-bilateral integration (VBI) disorder. One of the main characteristics of this problem was depressed postrotary nystagmus scores, suggesting inefficient central processing of vestibular input. Also characteristic were other signs of vestibular-related dysfunction, such as low muscle tone, postural-ocular deficits, and diminished balance and equilibrium reactions. In addition, poor bilateral coordination was implicated in VBI disorder.

Factor and cluster analyses using the SIPT led to further evolution of the concept of vestibular processing disorders. The SIPT studies identified a bilateral integration and sequencing (BIS) factor characterized by poor bilateral coordination and difficulty sequencing actions, which Ayres proposed was influenced primarily by vestibular functioning. Building on Ayres ideas, Fisher suggested that poor vestibular-proprioceptive processing is the basis for a type of sensory integrative dysfunction characterized by poor bilateral integration and sequencing. She used the term vestibular-proprioceptive to emphasize that these two sensory systems work so closely together that their functions are intertwined.

In addition, Fisher introduced an interesting new concept in relation to the BIS pattern: the notion of projected action sequences. To perform a projected action sequence, the child anticipates how to move as his or her spatial relationship to the environment changes, as when running to kick a ball or catching a moving ball. Fisher suggested that difficulty with projected action sequences is related to poor vestibular-proprioceptive processing, and, furthermore, that such deficits are a form of motor planning disorder. Thus, Fisher proposed a formal link between vestibular processing and praxis through the production of bilateral and sequenced movements.

Following Fisher’s work, other experts recently addressed the BIS pattern as a mild form of praxis disorder that generally is associated with vestibular-proprioceptive difficulties and characterized by problems with bilateral coordination as well as anticipatory actions. These authors also acknowledged that there may be a subset of children with BIS problems who do not have sensory integrative difficulties, in much the same way that children with isolated visual or auditory perception problems are not thought to have a sensory integration disorder.

Despite the variety of ways that have been used to describe vestibular-proprioceptive problems, certain classic clinical signs are common to all. In general, many children with these problems do not have a severe level of dysfunction, so the problem is easy to overlook. These children often exhibit poor equilibrium reactions, lower than average muscle tone (particularly in extensor muscles), poor postural stability, a tendency toward slouching, and difficulty in keeping the head upright. Inefficiency of the vestibularocular pathways may adversely affect function in directing head and eye movements while moving, as when watching a rolling soccer ball while running to kick it. Impaired balance and equilibrium reactions are likely to affect competence in performing activities such as bicycle riding, roller-skating, skiing, and playing games like hopscotch. Poor bilateral integration interferes with these activities as well. In addition, poor bilateral integration makes activities such as cutting with scissors, buttoning a shirt, or doing jumping jacks especially challenging. Bilateral integration difficulties are sometimes manifested in delays in body midline skill development, such as hand preference, spontaneous crossing of the body midline, and right-left discrimination. Neural connections between the vestibular centers in the brainstem and the reticular activating system also put children with vestibular processing disorders at risk for problems with attention, organization of behavior, communication, and modulation of arousal.

**Praxis Problems**

Praxis is the ability to conceptualize, plan, and execute a non-habitual motor act. Problems with praxis are often referred to as dyspraxia. When the term dyspraxia is used in regard to children, it usually refers to a condition characterized by difficulty with praxis that cannot be explained by a medical diagnosis or developmental disability and that occurs despite ordinary environmental opportunities for motor experiences. When Ayres originally wrote about dyspraxia, she used the term developmental apraxia. However, because the term apraxia is often associated with brain damage in adults, she later replaced this term with developmental dyspraxia. The prefix developmental implies that the condition emerges in early childhood development and is not the result of traumatic injury.

As noted previously, Ayres was struck with the relationship between tactile perception and praxis that emerged in study after study. She hypothesized that good tactile perception contributes to development of an accurate and precise body scheme, which serves as a reservoir of knowledge to be drawn on in planning new actions. Her interest in praxis appeared to grow over time, as is evident in the number of praxis tests included in the SIPT as opposed to the older SCST. When Ayres discussed praxis in relation to her SIPT studies, she introduced the idea that praxis problems may be manifested in different forms, not all of which are sensory integrative in nature. She coined the term somatopraxia to refer to the aspect of praxis that is sensory integrative in origin and grounded in somatosensory processing. At the same time she introduced the term somatodevelopmental dyspraxia to refer to a sensory integrative deficit that involves poor praxis and impaired tactile
and proprioceptive processing. By definition, somatosensory praxis involves a disorder in tactile discrimination and perception. Cermak noted that not all children with developmental dyspraxia demonstrate poor tactile perception. The term *somatosensory praxis* applies only to those who do.

The child with somatosensory praxis typically appears clumsy and awkward. Novel motor activities are performed with great difficulty and often result in failure. Transitioning from one body position to another or sequencing and timing the actions involved in a motor task may pose a great challenge. These children typically have difficulty relating their bodies to physical objects in environmental space. They often have difficulty accurately imitating actions of others. Directionality of movement may be disturbed, resulting in unintentional breakage of toys when the child forcefully pushes an object that should be pulled. Many of these children have difficulties with oral praxis, which may affect eating skills or speech articulation.

Some children with dyspraxia have problems with *ideation* (i.e., they have difficulty generating ideas of what to do in a novel situation). When asked to simply play, without being given specific directions, these children may not initiate any activity or they may initiate activity that is habitual and limited or seems to lack a goal. Typical responses may include to wander aimlessly; to perform simple repetitive actions such as patting or pushing objects around; to randomly pile up objects with no apparent plan; or for the more sophisticated child, to wait to observe others doing an activity and then imitate them rather than initiating an activity independently. May-Benson expanded on the role of ideation in praxis, highlighting the role of language and the social environment and reviewing the neuroanatomic foundations for this important function.

For children with dyspraxia, skills that most children attain rather easily can be excessively challenging (e.g., donning a sweater, feeding oneself with utensils, writing the alphabet, jumping rope, completing a puzzle). These skills can be mastered only with high motivation on the part of the child, coupled with a great deal of practice, far more than most children require. Participation in sports is often embarrassing and frustrating, and organization of schoolwork may be a problem of particular concern. Children who have somatosensory praxis and are aware of their deficits often avoid difficult motor challenges and may attempt to gain control over such situations by assuming a directing or controlling role over others.

Praxis is best evaluated using the SIPT, which is sensitive to difficulties in this area. However, parent interview and formal observations provide critical pieces in the assessment process. These are essential in evaluating ideation because currently available standardized tests on large normative samples are extremely limited in their measurement of this aspect of praxis. The new Test of Ideational Praxis is promising as a standardized, objective means for assessing ideation.

**Secondary Problems Related to Sensory Integrative Difficulties**

As already shown, sensory integration difficulties often impose some limitation on the quality of the child’s participation in occupations that he or she wants or needs to do as a member of a family, classroom, or community. How others respond to the child’s struggles may have a powerful effect on the child’s developing competence. In addition, the child’s willingness to grapple with challenging experiences will influence his or her occupational life over the years. Unfortunately, a number of secondary problems often arise in conjunction with sensory integration problems. These secondary problems may actually have a more powerful impact on the child’s life outcomes than the original sensory integration difficulty. In some cases, what started out as a minor sensory integration difficulty can become magnified into a major barrier to life satisfaction. Following is an explanation of several of these indirect, but significant, influences on the child and family.

First, sensory integrative dysfunction is an “invisible” disability (i.e., not directly and easily detected by the casual observer) that is easily misinterpreted. Sensory integrative disorders can fluctuate in severity from one time to another within the same child. Moreover, the severity of dysfunction and the ways in which dysfunction is expressed vary tremendously from one individual to another. This variability makes it difficult to predict which situations cause problems for a particular child, how much discomfort results, and when distress is likely to occur. Parents and teachers of children with these disorders often find the unpredictability of the child’s behavior to be frustrating and difficult to understand. As a result, sensory integrative problems are frequently misinterpreted as purely behavioral or psychological issues. Consequently, the child may be punished or responded to inappropriately, which may lead to chronic feelings of hopelessness as the child develops a self-view as bad or incapable.

A second indirect effect of sensory integrative dysfunction on the child’s life is its negative influence on skill development secondary to limited participation in childhood occupations. The child who avoids finger painting because of tactile defensiveness or who rarely attempts climbing on the jungle gym because of dyspraxia misses more than these singular experiences. The child also misses experiences that hone underlying functions such as tactile discrimination, hand strength and dexterity, shoulder stability, balance and equilibrium, hand-eye coordination, bilateral coordination, ideation, and motor planning. If the child misses a substantial amount of such experiences over time, the gap between the child’s sensorimotor skills and the skills of peers may grow.

In addition to interference with the development of sensorimotor functions, interactions important to the development of communication and social skills may not occur. Thus, some children with sensory integrative disorders may lack the ability to play successfully with peers partly because they have not been able to participate fully in the play occupations in which sensory, motor, cognitive, and social skills emerge and develop. The fear, anxiety, or discomfort that accompanies many everyday situations is also likely to work against the expression of the child’s inner drive toward growth-inducing experiences. Therefore lack of experience and diminished drive to participate compound the direct effects of a sensory integrative disorder. Consequently, the development of competence in many domains of development may be seriously compromised.

A third indirect effect of sensory integrative problems is the undermining of self-esteem and self-confidence over time. Children with sensory integrative problems are often aware
of their struggles with commonplace tasks, so it is natural for them to react with frustration. Frustration is likely to mount as the child observes peers mastering these same tasks effortlessly. Chronic frustration can negatively affect and detract from the child’s feelings of self-efficacy. Instead, the child may develop feelings of helplessness. This leads to further limitations in the child’s experiences because the child becomes less likely to attempt challenging activities.

ASSESSMENT OF SENSORY INTEGRATIVE FUNCTIONS

Assessment of sensory integration, like all other areas addressed in occupational therapy, requires a multifaceted approach because of the need to understand presenting problems, not only in relation to the individual who is being assessed but also with respect to the family and environments in which that individual participates. Assessment by the occupational therapist begins with a general exploration of the occupations of the child and family, focusing on their concerns and hopes in relation to the child’s strengths and challenges in routine activities. A variety of tools are needed to help the therapist detect problems in sensory integration, to understand the nature and scope of these difficulties, and to decide whether intervention should be recommended. Assessment tools employed by occupational therapists using a sensory integration perspective include interviews and questionnaires, informal and formal observations, standardized tests, and consideration of services and resources available to and appropriate for the family. Roley127 provided an excellent discussion of how this process of assessment is consistent with the guidelines laid out in the Occupational Therapy Practice Framework.1

Interviews and Questionnaires

The need for an occupational therapy assessment of sensory integration usually arises when a parent, teacher, physician, or other person who knows the child notices problems that the child is experiencing that are not easily explained by other conditions or considerations. The referral source, family members, and others who work with the child may all be valuable sources of information through interview or questionnaire (Figure 11-11). This initial phase of evaluation identifies the presenting problems, or main concerns, about the child and begins the process of determining whether sensory integration difficulties might account for the concerns about the child.

The initial interview with the parent, teacher, or other referral source provides an opportunity for the therapist to gather important information about signs of sensory integration problems that may be present. For example, the teacher may report that the child is always fighting while standing in line and cannot seem to stay seated during reading circle time. Further questioning by the therapist may disclose signs of tactile defensiveness that might explain the child’s behavior but were not considered by the teacher, who is unfamiliar with this condition. A parent may be able to provide critical information about the child’s development, which may be helpful in identifying early signs of sensory integrative dysfunction. For instance, parents may have noticed that specific tasks, such as cutting with scissors or pedaling a tricycle, were especially difficult for the child.

Since difficulty coordinating the two sides of the body is common when vestibular processing difficulties are present, this type of information can inform the therapist about additional observations and tests needed. Another important role of the interview is to uncover alternative explanations of the child’s difficulties that may rule out sensory integration problems, such as when a recent emotional crisis (e.g., a divorce or death) coincides with the onset of problems. Miller and Summers provided examples of the kinds of questions to ask in a parent interview.108 Questionnaires, checklists, and histories given by caregivers and other adults who know the child well are other means for gathering information that aid in identifying presenting problems, or main concerns, about the child and begins the process of determining whether sensory integration difficulties might account for the concerns about the child.

FIGURE 11-11 Because parents know their child better than anyone else, they are invaluable sources of information to the therapist, especially in beginning phases of the assessment process. (Courtesy Shay McAtee.)
The Sensory Profile (SPM) and the Sensory Processing Measure (SPM) are two sensory questionnaires used extensively in pediatric occupational therapy. The Sensory Profile is available in versions for parents of infants and toddlers and of children in early and middle childhood, as well as for self-reports of adolescents and adults. Additionally, a Sensory Profile School Companion is available for teacher report of child behavior at school. The SPM has two forms, Home and Main Classroom, that are standardized on the same sample of 5- to 12-year-old children and can furnish a score that aids the therapist in discerning whether a child’s sensory issues are manifested differently in the context of home versus school. In addition, the SPM contains separate rating scales for school personnel other than the main teacher, such as art teacher, music teacher, or bus driver.

An additional way to gather information in the initial phases of assessment is through review of records, including previous reports from other professionals as well as educational and medical histories. It is useful to talk with the child directly when possible. Roeyen and Fortune developed a child questionnaire for the assessment of tactile defensiveness, called the Touch Inventory for Elementary School-Aged Children (TIE). Children with sufficient verbal skills to discuss their own abilities, perceptions, and difficulties can sometimes provide invaluable insight into their condition through such a questionnaire-based interview. The Alert Program, a group intervention program for older children and adults, includes a self-assessment of sensory preferences that can be adapted for assessment of younger children to help them identify and communicate their characteristic sensory responses.

The information garnered through the initial interview process is used to decide whether further assessment is warranted and, if so, which evaluation procedures are most appropriate. This information is also critical in interpreting the final pool of information gathered through assessment and in prioritizing goals for the child in light of the main concerns of the family.

Informal and Formal Observations of the Child

Direct observation of the child is essential to the evaluation of sensory integration. Informal observations, clinical observations, and standardized testing are commonly used.

Informal Observations

Informal observation of the child in natural settings, such as a classroom, playground, or home, is informative and helpful whenever feasible. Informal observation will influence the conclusion as to whether a sensory integrative disorder is present and will, perhaps more importantly, indicate how the child’s difficulties are interfering with daily occupations. For example, an experienced therapist can often detect signs of poor body awareness by observing the child at school. Such signs may include exerting too much pressure on a pencil, standing too close to classmates in line, poor foot placement when climbing on a jungle gym, or sitting in an ineffective position in a chair while doing class assignments. Teachers may not necessarily report these behaviors to the therapist if they perceive them as typical signs of inattentiveness or clumsiness.

Informal observation of the child in the clinical setting can also be useful in showing how the child responds to situations that are novel or unpredictable. A child with dyspraxia may have a great deal of difficulty problem-solving how to mount an unfamiliar climbing structure in the clinic, even though performance is adequate on similar tasks at home or at school, where the child has practiced them. The novelty of the clinical therapy room elicits responses from children that may be diagnostically relevant. For children with good ideation and sensory processing abilities, the endless opportunities afforded by sensory integration equipment in the clinic can be exhilarating. For the child with a disorder like dyspraxia, the same environment may be confusing, puzzling, or frustrating. A child with gravitational insecurity may be terrified by the prospect of equipment that moves, whereas a child with autism may be distressed by the clinic environment because of its unpredictability and discrepancy from familiar settings. Parham has provided some guidelines for organizing informal observations in the clinic, with special attention to issues related to praxis. Although her suggestions are focused on the assessment of preschoolers, they can also be applied to older children and may be particularly helpful in evaluating older children who are unable to cooperate with standardized testing. Roley and Windsor, Roley, and Szklar provide additional guidelines for assessing praxis through informal observations.

Clinical Observations

Formal observations that are highly structured and similar to test items are often used in an occupational therapy assessment of sensory integration. Usually referred to as clinical observations, these typically involve a set of specific procedures that allow the therapist to observe signs of nervous system integrity that are associated with sensory integrative functioning. Ayres included measures of such formal observations in her factor analytic studies, along with standardized tests. She also developed a set of clinical observations that she used in clinical practice. These unpublished, nonstandardized evaluation tools were intended to supplement standardized test scores and subsequently were revised, expanded upon, and studied by many other therapists over the years.

Examples of some of the most commonly used clinical observations are presented in Box 11-1.

One of the difficulties in using clinical observations as an assessment tool is that often the administration and scoring criteria have not been standardized. This means that they are administered using different procedures from one clinician to another. Furthermore, most of them lack normative data to aid in interpretation of the scores obtained. Some, but not all, clinical observations are supported by research using standardized administration to inform interpretation.

Occupational therapists must rely on the information from these studies, as well as their personal expertise and judgment, to interpret the results of clinical observations. Without the requisite data in hand, occupational therapists are cautioned to avoid overinterpretation of clinical observations in light of the lack of standardized procedures and inadequate information regarding expected performance across age, gender, and other demographically related groups.

Most clinical observations address motor functions that may be strongly affected by conditions other than sensory


integration problems. Therefore, the therapist must use sound clinical reasoning with advanced knowledge of sensory integration theory in order to appropriately interpret these observations.

**Standardized Testing**

Occupational therapists frequently use standardized tests to evaluate sensory integration. Although several tests are available that contribute incidental information regarding sensory integrative functions, the SIPT protocol is the only set of standardized tests designed specifically for in-depth evaluation of sensory integration. The SIPT evolved from a series of tests that Ayres developed in the 1960s\(^4\) and later published as the SCSIT\(^1\) and the SCPNT.\(^2\) The standardization process used in the development of the SIPT was rigorous, involving normative data on approximately 2000 children in North America and extensive reliability and validity studies.\(^2\) Its 17 tests measure tactile, vestibular, and proprioceptive sensory processing; form and space perception and visuomotor coordination; bilateral integration and sequencing abilities; and praxis.\(^2\) A list of the 17 tests and the functions measured by each is presented in Table 11-3.

The SIPT protocol requires about 1½ to 2 hours to administer and another 30 to 45 minutes to score. Raw scores may be translated into standard scores by the therapist using a computer diskette available from the publisher. Alternatively, raw scores may be sent to the publisher, Western Psychological Services, for an analysis using the normative data. After normative scores are obtained, the therapist critically examines them to determine if patterns of sensory integrative dysfunction are evident. Not only are patterns of test scores scrutinized, but also the therapist’s observations of child behavior during testing are considered in interpreting test scores. Finally, test scores and test behaviors are integrated with all other sources of information from the assessment in reaching a conclusion regarding the status of sensory integrative functioning.

Like all standardized tests, the SIPT protocol is administered with adherence to standardized procedures (Figure 11-12). Specialized training is required for administration and interpretation. This tool is a complex set of tests and, unlike most
published tests, cannot be self-taught by simply reading the manual. In addition to formal training for the SIPT, it is strongly recommended that therapists practice administration of the tests with children who do not have any known problems and with children who have recognized difficulties. With this experience and training, the therapist can administer the tests in a manner that produces reliable scores while allowing for observation of behaviors that provide additional information about the child’s sensory integration and praxis abilities.

Other pediatric tests include items or subtests from which inferences regarding sensory integration may be drawn. For example, the Miller Function & Participation Scales includes tests of praxis, visual-motor integration, figure–ground perception, and some vestibular functions. A number of tests, such as the Bruininks-Oseretsky Test of Motor Proficiency, (BOT-2), measure aspects of fine and gross motor skills (such as bilateral coordination) that are related to sensory integrative functions. Other tests, such as the Developmental Test of Visual Motor Integration, provide specific information related to visual-perceptual and perceptual-motor skills.

Some tests geared toward the broader evaluation of occupation, such as the School Function Assessment (SFA) or the Social Participation Scale of the SPM, are useful for identifying the extent to which sensory integrative disorders may be affecting the child’s participation in occupations within specific settings. For the child with suspected sensory integrative problems, tests such as the SFA are most effectively used along with specific measures of sensory integration. When combined, these tests identify the functional problems to target in intervention and the reasons for the child’s difficulties.

**Consideration of Available Services and Resources**

In addition to the information that is gathered about the child, an occupational therapy assessment of sensory integration takes into consideration the services and resources that are available to the child and family. Information regarding the type of services that the child is currently receiving, how he or she is responding to these services, and what services, programs, and resources are available to the child need careful consideration in light of the purpose and findings of the evaluation before recommendations can be formulated. For example, an occupational therapist may be asked to provide a reevaluation of a child who has been receiving occupational therapy for several years. If the child continues to demonstrate significant sensory integrative problems and has shown a diminishing response to treatment using a sensory integration approach, the recommendations would be different from those for a child no longer showed evidence of a significant sensory integrative problem.

Similarly, a child who lives in an area where no occupational therapists are qualified to provide sensory integration intervention needs a different program recommendation from that for a child who has easy access to this type of service. Understanding family aspirations and values, as well as resources, such as funding, transportation, time, and caregivers, is also critical in identifying the types of services that will be most helpful to the child and family. These issues are as important to the assessment process as the child factors that are addressed in a sensory integration evaluation.

**Interpretation of Assessment Findings**

Once all of the information from interviews, questionnaires, informal and formal observations, standardized tests, and consideration of available services and resources has been collected, the occupational therapist must integrate and interpret these data to reach meaningful conclusions and appropriate recommendations for the individual child. Conclusions and recommendations are framed with an overriding consideration of the occupations of the child and family and the contexts that influence occupational engagement. Burke, Schaaf, and Hall advocate the strategy of creating a narrative, or story, to form an integrated understanding of the child and family in order to focus assessment and intervention planning on issues that are most meaningful and important to them. In using such a future-oriented, top-down approach, the therapist not only generates a picture of the child and family in the present, but also imagines how changes might unfold over the next few years. Therapists use research as well as training and experience to formulate conclusions and recommendations. (See Research Note 11-1 for an example of research that can inform interpretation of how assessment data relate to a child’s academic functioning in school.)

One of the important steps in interpretation of assessment findings is to evaluate whether a sensory integrative problem may contribute to the occupational challenges of the child. To do this, data are classified into categories that either support or refute the presence of particular types of sensory integrative problems. After a detailed analysis of the constellation of assessment findings, a hypothesis is generated as to whether
RESEARCH NOTE 11-1

OBJECTIVES. The objective of the study was to examine the relationship between sensory integrative development and academic achievement in math and reading in elementary school children across a 4-year period, while statistically controlling for other influences on achievement.

METHOD. A total of 67 children participated, 32 of whom had previously been identified as having learning disabilities. The remaining 35 children had no history of learning problems. Children completed the Sensory Integration and Praxis Tests, as well as intelligence and achievement tests. Demographic information was gathered from parents. Data were gathered prospectively in two data collection waves: first when the children were 6 to 8 years old, and 4 years later, when they were 10 to 12 years old.

RESULTS. Sensory integration measures significantly predicted math scores contemporaneously when the children were 6 to 8 years old as well as 4 years later, while controlling for intelligence, socioeconomic status, and other variables. Praxis in particular was a strong predictor of math achievement. Sensory integration measures did not predict reading at ages 6 to 8, after controlling for intelligence and socioeconomic status. However, praxis and visual perception did predict reading 4 years later, after controlling for other factors.

CONCLUSION. Sensory integration difficulties place a young child at risk for achievement problems in school, even when intellectual ability and socioeconomic status are high. Praxis difficulties may especially place a child at risk for problems with math achievement from elementary to middle school years.

IMPLICATIONS FOR PRACTICE
Therapists can use this study to advocate that children who have documented SI problems receive support to maximize their academic achievement in school, because Sensory integration problems place them at risk. This study did not examine intervention effectiveness, so other sources of information must be used to make decisions about what kinds of interventions or support are appropriate for specific children.

If an assessment leads to a recommendation for intervention, it generally includes an estimate of the duration of time that the child should receive therapy, some indication of prognosis, and a statement regarding expected areas of change. The anticipated gains can be further clarified through the establishment of specific goals and objectives. Writing and explaining goals will provide the occupational therapist with an opportunity to illuminate the ways in which the identified sensory integration issues intersect with the presenting problems and desired functional outcomes. Regardless of the types of goals that are written, goals are established in a manner that is culturally relevant for the family and considers the needs and wishes of the individual child.

The format in which goals are specified is often a function of the setting in which therapy is delivered. For example, a school district may include certain types of goals as part of an individualized education plan, whereas a hospital setting may require medically related outcomes. Goal attainment scaling is a specific method for writing goals that are individualized and then quantified to allow for comparison of outcomes across a large group of children. In this process, individualized goals are carefully placed on a standard scale that allows for quantitative comparison of changes across dissimilar outcomes (e.g., the amount of change in pumping a swing in comparison with the amount of change in tolerance of food textures). Although this method was developed for outcomes research, it may be useful in documenting intervention effectiveness across a large group of children for purposes of program evaluation.

INTERVENTIONS FOR CHILDREN WITH SENSORY INTEGRATIVE PROBLEMS
Planning an occupational therapy program for a child with a sensory integrative problem requires the same careful analysis used in applying any theoretical framework in clinical practice. The constellation of child and family characteristics is analyzed in relation to the occupations of the individuals involved. Intervention is designed to focus on engagement in occupation in order to support the participation of the child in the everyday contexts of his or her life. When a sensory integration approach is used in occupational therapy, the unique ways in which sensory integrative problems affect engagement and participation in the occupations of the particular child and his or her family provide the cornerstone upon which decisions regarding treatment are made. Intervention is continually planned and evaluated in relation to the occupations that the child wants and needs to do in the contexts of home, school, and community.

The assessment process helps the therapist decide whether any intervention is recommended and, if so, in what format: individual therapy, group sessions, or collaborative consultation with parents and teachers. Regardless of the form in which intervention is delivered, theory-based concepts regarding the nature of sensory integration are applied whenever a sensory integration approach is selected. Guiding principles of the ASI approach are summarized in Box 11.2. The key ideas behind these principles were introduced previously in this chapter in the sections on sensory integrative development and problems.
Therapists who plan interventions for children with sensory integrative problems are responsible for developing their professional expertise through advanced training, mentorship, and review of the research literature. The field of sensory integration is a complex, specialized area of occupational therapy practice that demands that the therapist synthesize information from many sources. Because it is a dynamically changing field of practice, it is important that the therapist stay abreast of research evidence, as well as of new developments in sensory integration theory and practice, to guide practice decisions. These sources of information, in combination with the unique situation of the child and family being helped, all influence the decision of whether to intervene and, if so, how.

In this section, four of the primary methods of occupational therapy intervention for children with sensory integrative problems are described: (1) individual ASI intervention to improve underlying sensory integration abilities, (2) individual skill development training, (3) group skill development intervention, and (4) consultation, including modifications of activities, routines, and environments at home and in school. These forms of intervention are often used in combination with each other, rather than as the sole service delivery method. With careful consideration on the part of the therapist, interventions based on other theoretical frameworks and treatment models may be used along with those discussed in the following sections of this chapter. The therapist must be mindful that if the intervention strategies being combined are not compatible owing to contradictory underlying principles, intervention effectiveness may be reduced. Therefore, although selection of a combination of intervention approaches is often desirable, it must be done with care.

**Individual Ayres Sensory Integration (ASI) Intervention**

Individual occupational therapy using Ayres Sensory Integration® (ASI) intervention is the most intensive form of occupational therapy available for children with sensory integration problems. The term *Ayres Sensory Integration®* (ASI) was trademarked by the Franklin B. Baker/J. Jean Ayres Baker Trust, “for the purpose of protecting and promoting Dr. Ayres’ body of work and to assist in differentiation of this approach from others that might share some similar terminology or techniques.”

In this chapter, the term ASI intervention refers to the kind of individual occupational therapy that Ayres developed specifically to remediate sensory integrative problems in children. In this intervention, the therapist presents activity challenges that are individually tailored to improve the specific sensory integration problems affecting the child’s performance. This intervention is designed to help a child gain improved sensory integrative capabilities when problems with sensory integration are interfering with the child’s occupations at home, in play, at school, or in the community (Case Study 11-1). Although Ayres originally designed this therapy for children with learning disabilities, she and many other expert practitioners have used this kind of intervention, along with specific skill training and consultation, to help children with other disabilities, including autism.

In designing this specialized form of occupational therapy, Ayres was influenced by the neurobiologic literature, which shows that the nervous system has plasticity or changeability. Plasticity is particularly characteristic of the developing young child. This led Ayres to hypothesize that the neural systems that impair function may be remediable, especially in the young child. Accordingly, she set out to design therapy that capitalized on the plasticity of the nervous system to remediate sensory integrative dysfunction. This is not to say that ASI intervention cures conditions such as learning disability, autism, or developmental delays. Rather, the intent is to improve the efficiency with which the nervous system interprets and uses sensory information for functional use. Therefore ASI is aimed at promoting underlying capabilities to the greatest degree possible.

ASI intervention has several defining characteristics. It is applied on an *individual* basis because the therapist must adjust therapeutic activities moment by moment in relation to the individual child’s interest in the activity or response to a specific challenge or sensory experience. This requires the therapist to continually focus attention on the child while being mindful of opportunities in the environment for eliciting adaptive responses. The therapist’s decisions regarding how and when to intervene involve a delicate interplay between the therapist’s judgment regarding the potential therapeutic value of an activity and the child’s motivation to do the activity. The therapist does not use a “cookbook” approach in providing this therapy (e.g., by entering the therapy situation with a predetermined schedule of activities that the child is required to follow). Rather, the therapist enters into a relationship with the child that fosters the child’s inner drive to actively explore the environment and to master challenges posed by the environment.

Intervention involves a *balance between structure and freedom*, and its effectiveness is contingent on the proficiency of the therapist in making judgments regarding when to step in to provide structure and when to step back and allow the child to choose activities. The therapist’s job is to create an environment that evokes increasingly complex adaptive responses from the child. In order to accomplish this, the therapist respects the child’s needs and interests while structuring opportunities to help the child successfully meet a challenge. An example is a child who needs to develop more efficient righting and equilibrium reactions and chooses to sit and swing on a platform swing. The therapist may allow the child to swing awhile to become accustomed to the vestibular sensations. Once the child seems comfortable,
CASE STUDY 11-1  Karen

HISTORY
Karen was born after a full-term pregnancy complicated by gestational diabetes. Labor, which was induced at 40 weeks, was prolonged, and it was believed that Karen broke her right collarbone during delivery. Karen achieved her early motor and language milestones within average age ranges. However, she was described as an irritable baby who had difficulty breast feeding, startled easily, and could be calmed only by swinging. Karen attended a parent cooperative child development program as a toddler, and at 4 years of age she was eligible for a special education preschool program through her school district. She has not been given any specific medical or educational diagnosis.

REASON FOR REFERRAL
Karen’s mother expressed concern about Karen’s fine and gross motor skills to a neurologist, who referred Karen for an occupational therapy assessment when she was 4 years of age. When asked why she was seeking an evaluation for Karen, her mother wrote, “Up until recently I had been very patiently waiting for normal development to occur (for example, handedness, fine motor). The school psychologist feels that this still may occur, but I am convinced that something isn’t right. Karen’s increasing frustration and decreasing belief in herself prompted me to seek evaluations. While a part of me wishes to have a ‘normal child,’ the other part will be relieved to find that the child I have had so many doubts about since infancy does indeed have some behaviors and actions that are unusual.”

EVALUATION PROCEDURE
The Sensory Integration and Praxis Tests (SIPT) were administered in one testing session. Karen was also observed in a clinical therapy setting and at home. In addition, Karen’s mother was interviewed, and she completed a developmental and sensory history on which she provided detailed accounts of Karen’s early and current sensorimotor, language, cognitive, social, and self-care development.

EVALUATION RESULTS
On the SIPT, Karen scored below average for age expectations on 7 of 17 tests. This profile was generated through computer scoring by the test publisher. The unit of measure represented by the scores is a statistical measure called a standard deviation, which represents how different the child’s score is from that of an average child of the same age. The closer a child’s score is to 0 on the horizontal axis, the closer to average is the child’s performance on that test. Karen’s scores are plotted as solid squares that are connected by a dark line on the computer-generated profile. Scores falling below –1.0 on the horizontal axis are considered to be possibly indicative of dysfunction.

One of Karen’s scores was low on a motor-free visual perception test (spac visualization), and it was noted that she had difficulty fitting a geometric form into a puzzle board during this test. Her mother reported that Karen knew colors at 18 months of age but had trouble learning shapes.

However, she was reported to have a strong visual memory for roads, signs, and faces. These findings suggested difficulty with spatial orientation of objects but relative strengths in visual memory.

Karen had several low scores and showed signs of difficulty performing on several of the tests of somatosensory and vestibular processing. A low score on finger identification suggested inefficient tactile feedback involving the hands. This was corroborated by observations of poor manipulative skills during activities such as buttoning and using utensils. She was also observed to have signs of tactile defensiveness, also corroborated by her mother’s report. Her low score on Kinesthesia, as well as her difficulty in exerting the appropriate amount of pressure on a pencil and in positioning her body for dressing, suggested problems with proprioceptive feedback. Karen’s lowest score on the SIPT was on the Postrotary Nystagmus test (–2.2 standard deviations). This low score, as well as below-average scores on Standing and Walking Balance, observations of poor functional balance in dressing and playground activities, a tendency not to cross her body midline, poor bilateral coordination in activities such as cutting, and reports that she never appeared to get dizzy, pointed to the possibility of vestibular processing problems.

Karen showed above-average performance on a praxis test on which she could rely on verbal directions. However, tests of motor planning that were more somatosensory dependent (Oral Praxis and Postural Praxis) were substantially more difficult for her. Karen was unable to ride a tricycle, pump a swing, or skip. She had extreme difficulty planning her movements to dress herself or even to let someone else dress her. She also had a great deal of difficulty using utensils during eating and often choked on food and drinks. Writing skills were particularly difficult for Karen, and her lack of hand preference, immature grasp, and hesitancy to cross her midline hampered her attempts at drawing or writing.

Karen was reported to be a social child who was liked by adults and younger peers. However, her mother worried that she did not seem able to “pick up on the hints and unwritten rules of her peers” and was “definitely starting to march to her own beat.” She noticed increasing signs of frustration that she thought were beginning to impinge on Karen’s willingness to participate with peers.

Overall, the evaluation results suggested deficits in sensory processing of some aspects of visual, tactile, proprioceptive, and vestibular sensory information. These difficulties were seen as related to somatodyspraxia, poor balance and bilateral integration, difficulties with specific gross and fine motor skills, and emerging concerns around socialization. Karen’s strengths included age-appropriate cognitive and language skills, good ability to motor plan actions using verbal directions, and an exceptionally supportive and involved family.

RECOMMENDATION
Based on the evaluation results and a meeting of Karen’s IEP team, who met shortly after the assessment, it was recommended that Karen receive individual occupational therapy...
the therapist steps in to jiggle the swing to stimulate the desired responses. However, if the child responds to this challenge with signs of anxiety or fear, the therapist needs to intervene quickly to help the child feel safer. For example, the therapist might set an inner tube on the swing to provide a base to stabilize the lower part of the child’s body and increase feelings of security while the child’s upper body is free to make the required righting reactions. Therapeutic activities thus emerge from the interaction between therapist and child. Such individualized treatment can be fully realized only with one-to-one interaction between therapist and child (Figure 11-13).

The emphasis on the inner drive of the child is another key characteristic of ASI intervention. Self-direction on the part of the child is encouraged because therapeutic gains are maximized if the child is fully invested as an active participant. However, this is not to say that the child is permitted to engage in free play with no adult guidance. The optimal therapy situation is one in which a balance is struck between the structure provided by the therapist and some degree of freedom of choice on the part of the child. Drawing on the child’s interests and imagination is often key to encouraging greater effort on a difficult task or staying with a challenging activity for a longer time. However, because children with sensory integrative problems do not always demonstrate inner drive toward growth-inducing activities, it is often necessary to modify activities and to find ways to entice such children toward interaction. A relatively high degree of directedness often is needed when working with children with autism or other children whose inner drive is limited. Occasionally a therapist may use a high degree of directedness within the context of a particular activity to show a child that the challenging activity is possible not only to achieve, but also to enjoy.

Related to inner drive is another key feature of ASI intervention—the valuing of active participation, rather than passive participation, on the part of the child. Because the ability to plan new or unusual motor actions. Although these are significant gains for Karen, she continues to exhibit substantial difficulties with many aspects of sensory processing, general motor planning ability, and many age-appropriate fine and gross motor skills. If she continues to respond to occupational therapy using an ASI approach, it is expected that by the beginning of the next school year (in about 6 months), she will have improved in basic sensory and motor functions to the extent that some specific skill training will become more appropriate. It is likely that at that time some therapy will occur at school with the introduction of a consultation program for her teacher. Her parents have already begun a home program, which appears to support the gains she is making through direct services. Karen’s young age and initial positive response to therapy make her an optimal candidate for application of the sensory integration approach, and her long-term outlook is excellent.

**FIGURE 11-13** Individual ASI intervention requires the therapist to attend closely to the child on a moment-by-moment basis to ensure that therapeutic activities are individually tailored to changing needs and interests of the child. (Courtesy Shay McAtee.)
brain responds differently and learns more effectively when an individual is actively involved in a task rather than merely receiving passive stimulation, it is considered optimal for a child to be an active participant to the greatest degree possible. For example, sensory integration theory posits that a child experiences a greater degree of integration from pumping a swing or pulling on a rope to make it go than from being swung passively.

Maximal active involvement generally takes place when therapeutic activities are at just the right level of complexity, at which the child not only feels comfortable and nonthreatened but also experiences some challenge that requires effort. The course of therapy usually begins with activities in which the child feels comfortable and competent and then moves toward increasing challenges. For example, for children with gravitational insecurity, therapy usually begins with activities close to the ground and with close physical support from the therapist to help the child feel secure. Gradually, over weeks of therapy, activities that require stepping up on different surfaces and moving away from the floor are introduced as the therapist subtly withdraws physical support. Introducing just the right level of challenge, while respecting the child’s need to feel secure and in control, is a key to maximizing the child’s active involvement in therapy (Figure 11-14).

However, there are situations in which passive stimulation is needed to help prepare a child for more complex or challenging activities. For example, the child with autism may show improved sensory registration after receiving passive linear vestibular stimulation.144 The improved registration means that the child has greater awareness of the environment, and thus the passive stimulation is a stepping stone toward active involvement in an activity. Another example is the use of passive tactile stimulation as a means for reducing tactile defensiveness.11,153 However, this aspect of therapy is seen as a limited component of a sensory integrative treatment program and then only as a step toward facilitating more active participation.

Another key characteristic of ASI intervention is the setting in which it takes place. The provision of a special therapeutic environment is an important aspect of this kind of intervention and has been described in detail by other authors.143,150 Based on the research that shows that brain structure and function are enhanced when animals are permitted to actively explore an interesting environment,79 a sensory-enriched environment is designed to evoke active exploration on the part of the child. The clinic that is designed for ASI intervention contains large activity areas with an array of specialized equipment. The availability of suspended equipment is a hallmark of this treatment approach.49,85 Suspended equipment provides rich opportunities for stimulating and challenging the vestibular system. In addition, equipment and materials are available that provide a variety of somatosensory stimuli, including tactile, vibratory, and proprioceptive. Mats and large pillows are used for safety. Overall, this special environment provides the child with a safe and interesting place in which to explore his or her capabilities. At the same time it provides the therapist with a tool kit for creating sensory experiences that are enticing and for gently guiding the child toward activities that challenge perception, dynamic postural control, and motor planning (Figure 11-15).

Because of the prominence of vestibular based activities in the environments in which ASI is applied, a few cautionary words are in order regarding this powerful tool. Activation of the vestibular system, most often in the form of linear movement, is commonly introduced early in the course of treatment for many children because it is believed to have an organizing effect on other sensory systems.11,18,19 However, it can have a highly disturbing and disorganizing effect on the child if used carelessly. Vestibular system activation may produce strong autonomic responses, such as blanching and nausea. It directly influences the arousal level and, if not regulated carefully, may produce hyperactive, distractible states or lethargic, drowsy states. ASI intervention emphasizes active participation on the part of the child; therefore, vestibular stimulation is not

**FIGURE 11-14** Rather than passively imposing vestibular input on the child, classic sensory integration treatment emphasizes active participation and self-direction of the child. (Courtesy Shay McAtee.)

**FIGURE 11-15** The setting in which classical sensory integration treatment takes place provides a variety of sensory experiences. Immersion in a pool of balls presents challenges to sensory modulation. (Courtesy Shay McAtee.)
School-based occupational therapists have found ways to incorporate the central principles of ASI into the educational setting, including bringing specialized equipment into classrooms and playgrounds in ways that help to organize and prepare a child for learning. Successful therapy programs frequently involve helping families to understand and use the sensory integrative concepts that support and facilitate their children’s success by developing activities at home and identifying resources within the community that reinforce the experiences emphasized during therapy.120

Training in Specific Skill Development

Although ASI intervention is focused on improving foundational neural functions that allow a wide range of capabilities and skills to emerge, therapists will often want to help a child and family to develop specific skills or short-term coping strategies to deal immediately with the special challenges posed by sensory integration problems. For example, a child with poor proprioceptive feedback may need to keep up with handwriting exercises assigned in class. Application of individual ASI intervention would aim to help the child develop better body awareness that eventually will help not only with writing but also with catching, throwing, cutting, buttoning, and many other proprioception-dependent skills. However, because of everyday classroom stress from the demands of handwriting, the child may not be able to afford to wait for these generalized capabilities to develop through sensory integrative treatment. For this child, specific handwriting training may be used to help develop better handwriting skills, despite poor proprioceptive feedback. When working on specific skill development, the occupational therapist can still be mindful of the guiding principles of sensory integration theory (see Box 11-2). For example, it is optimal to involve self-direction and active participation as much as possible. This might be accomplished with the child in this example by having the child write stories related to individual interests and experiences. In addition, handwriting exercises that require active movement are expected to accomplish more than those dependent on passive guidance of the child’s hand. The therapist’s ability to read the child’s responses to writing activities helps ensure that the activities remain motivating and appropriately challenging.

Group Intervention

The occupational therapist working with a group of children cannot provide the same level of vigilance to individual responses that takes place during individual therapy. Therefore, some of the highly individualized applications of ASI intervention cannot be used within a group, nor can the therapist give the close guidance that is finely tuned to the individual child’s needs every moment of the treatment session. Again, however, the principles of ASI outlined in Box 11-3 are important concepts to incorporate into the group format as much as possible.

Working with children in a group provides the opportunity to observe some of the ways in which sensory integrative problems disrupt participation in a social context (Figure 11-16). Some problems emerge only in a group situation and may not be evident during individual therapy. For example, tactile defensiveness may not be apparent in the safe constraints of individual therapy but may become obvious as a child tries to...
their levels of alertness change throughout the day, to identify
groups helps children learn to recognize how they feel when
Shellenberger.154 Through a group format, their Alert Pro-
cept to groups is reflected in the work of Williams and
s are not expected to lead to the same outcomes.
rials, taking into consideration such outside factors, rather
It is important that occupational therapists make recommen-
ations, availability of staff, or organizational policies create
the need for children to receive therapy in a group setting.
It is important that occupational therapists make recommend-
ations based primarily on the needs of the children being
ved, taking into consideration such outside factors, rather
than allowing the external factors to dictate the type of inter-
vention that is provided. It is also important to differentiate
between what can be accomplished within a group versus an
individual therapy session. Because group programs do not
permit the same degree of intensive, individualized work, they
are not expected to lead to the same outcomes.
An especially innovative application of sensory integration
concepts to groups is reflected in the work of Williams and
Shellenberger.154 Through a group format, their Alert Pro-
gram helps children learn to recognize how they feel when
their levels of alertness change throughout the day, to identify

Consultation on Modification of Activities, Routines, and Environments
Sensory integrative problems are complex and are often misin-
terpreted as behavioral, psychological, or emotional in origin. Helping family members, teachers, and others to understand
the nature of the problem can be a powerful means toward
helping the child. Providing information to those who are in
ongoing contact with the child and developing strategies
collaboration with them are important ways in which
the therapist can indirectly intervene to influence the child’s
life positively across a variety of settings. Indirect intervention
in the form of consultation is often critical for success in a
comprehensive occupational therapy program for the child
with sensory integration challenges.
Although many sensory integration concepts are not famil-
lar to family members, teachers, or other professionals, once
they are explained in everyday terms, a new understanding of
the child often ensues. Cermak aptly referred to this process
as *demystification.*47 Parents commonly express relief at finally
having a name for behaviors that they have observed, and they
may experience release from feeling that they have caused these
problems through a maladaptive parenting style. Teachers also
may appreciate having an alternative way to view child beha-
viors, especially when this new perspective is coupled with
the application of strategies that promote responses from the
child that are more productive.
Helping those around the child understand their own sen-
sory integrative processes is sometimes a good way to
make these new concepts more meaningful. Williams and
Shellenberger use this tactic when introducing their Alert
Program to promote optimal states of organization and levels
of alertness.154 They encourage the adults being trained to
administer the program to develop awareness and insight into
their own sensorimotor preferences. This first step in initi-
ating consultation is to help the significant adults in the child’s
life better understand sensory integration in general and in
relation to the specific child. This can be achieved through
several avenues, including parent/teacher conferences, expe-
rimental sessions, lecture and discussion groups, professional
in-services, and ongoing education programs. Whatever
format is used, it is likely that the greater the understanding
of the basic concepts of sensory integration, the greater
the openness and willingness to address these problems
(Figure 11-17).
**CASE STUDY 11-2 | Drew**

**HISTORY**

Drew was diagnosed with autism (high functioning) when he was 7 years of age. His mother is Korean, and his father is American. All of Drew’s early developmental milestones were attained within normal limits, except for language acquisition. He did not speak any words until 2 years of age, and by 3 years of age his family was concerned about his development because of delayed language skills. Drew attended an English-language preschool at 3 years of age and then a Korean-language preschool. (His family speaks both Korean and English at home.) He was asked to leave the second preschool because of aggressive behavior. At 4 years of age, Drew attended a private special education school where he received speech therapy and participated in a language-intensive playgroup. When Drew reached kindergarten age, he was enrolled in public special education programs, where he attended specialized classrooms for speech and language disorders, autism, and multiple handicaps.

**REASON FOR REFERRAL**

Drew initially was referred by the state regional center for developmental disabilities to an occupational therapy private practice for evaluation when he was nearly 8 years of age. His regional center counselor thought that Drew had signs of a sensory integrative disorder, and he believed that Drew might benefit from occupational therapy. Drew’s mother reported that her main concerns for Drew were related to his poor socialization skills, his limited ability to play with games and toys, and his tendency to become easily frustrated.

**EVALUATION PROCEDURE**

Although the Sensory Integration and Praxis Tests (SIPT) were attempted during the initial occupational therapy assessment, Drew was unable to follow the directions or attend to the tests sufficiently to obtain reliable scores. Therefore, his occupational therapy evaluation consisted of a parent interview, including completion of a developmental and sensory history, and observation of Drew in a clinical therapy setting. At the time of assessment it was not possible to interview Drew’s teacher. However, Drew’s mother, who often observed him in the classroom, provided information about his performance at school.

**EVALUATION RESULTS**

Drew demonstrated inefficiencies in sensory processing in a number of sensory systems. During the assessment, signs of inconsistent responses to tactile input were evident. For example, Drew demonstrated a complete lack of response to some stimuli such as a puff of air on the back of his neck or the light touch of a cotton ball applied to his feet when he was not visually attending. However, he withdrew in an agitated fashion when the therapist attempted to position him. His mother reported that he showed extreme dislike for certain textures of food and clothing and that he disliked being touched. She also stated that he seemed to become irritated by being near other children at school and sometimes pinched or pushed peers who came close to him. Drew also appeared easily overstimulated by extraneous visual and auditory stimuli. His mother stated that he often covered his ears at home when loud noises were present and that at school he sometimes seemed confused as to the direction of sounds. He was observed to pick up objects and look at them very closely, and he appeared to rely on his vision a great deal to complete tasks. In response to movement, he enjoyed swinging slowly but became fearful with an increase in velocity. His mother stated that he often became fearful at the park when climbing.

Drew’s balance was observed to be poor, and his equilibrium reactions were inconsistent. He also had trouble positioning himself on various pieces of equipment, showing poor body awareness. During the assessment he appeared to seek touch-pressure stimuli, including total body compression. He was reported to jump a great deal at home and at school. These types of proprioception-generating actions appeared to have a calming effect on Drew.

In the areas of praxis, Drew was able to imitate positions and follow verbal directions to complete motor actions, but he had a great deal of difficulty initiating activities on his own or attempting something that was unfamiliar to him. He also had difficulty timing and sequencing his actions. His mother reported that he tended not to participate in sports or in park activities and that he had trouble throwing, catching, and kicking balls. Drew was able to complete puzzles, string beads, and write his name; however, bilateral activities such as cutting and pasting were difficult for him.

Socially, Drew demonstrated poor eye contact and tended to use repetitive phrases that he had heard in the past. His mother stated that he wanted to play with peers but found it hard to make friends. Drew was independent in all self-care skills, except for tying shoes and managing some fasteners.

Based on an interview and questionnaire with Drew’s mother, as well as observation of Drew in a clinical therapy setting, it was determined that he displayed irregularities in sensory processing, including hypersensitivity to some aspects of touch, movement, visual, and auditory stimuli. He also demonstrated difficulty with position sense, balance, bilateral integration, and the ideation, timing, and sequencing aspects of praxis. These difficulties were thought to interfere with Drew’s ability to play purposefully with toys and to participate in age-appropriate games and sports. These problems, in combination with his language delays, were interfering significantly with his social skills and his ability to make friends, and they were increasing his tendency to become frustrated, all of which were the major concerns of his parents.

**RECOMMENDATION**

Individual occupational therapy was recommended to address Drew’s sensory integration problems and the development of specific fine and gross motor skills. Because socialization issues were such a major concern for Drew’s family and were interfering with his performance at school, the evaluating therapist also recommended that Drew participate in an after-school group occupational therapy program to facilitate the acquisition of social skills.
CASE STUDY 11-2  Drew—cont’d

OCCUPATIONAL THERAPY PROGRAM

Drew received individual and group occupational therapy in a therapy clinic for 1 year. The individual therapy involved a combination of Ayres Sensory Integration® (ASI) intervention and a specific skill development approach. During this time, Drew demonstrated significant gains in sensory processing with no further significant signs of tactile defensive-ness or fear of movement activities. Motor planning of novel actions improved but continued to be of some concern for Drew. He did make notable gains in being able to catch and throw a ball and in writing and scissors skills. Through the group occupational therapy program, Drew became able to initiate and maintain interaction with peers, share objects, and play cooperatively with some assistance and structure from adults.

After this year of clinically based individual and group occupational therapy, it was recommended that individual therapy be continued at school. The focus of this occupational therapy program was to help Drew apply his improved sensorimotor and social skills in the natural context of school. Through a combination of direct service and consultation, several activities and adaptations were made to facilitate his performance at school. Because the initial year of intensive therapy using an ASI approach had helped Drew tolerate and respond appropriately to sensory information and because he had developed many of the specific skills that he needed in the classroom during individual therapy, he was much better able to focus on the demands expected of him at school at that time. By the end of the school year, Drew’s occupational therapist recommended that occupational therapy be discontinued because she believed that his teacher would be able to continue to help him in the areas that had been addressed through the consultation program.

However, when the individualized educational program (IEP) team met to discuss Drew’s transition to a new school, they had significant concerns about the possibility of Drew’s regressing in a new setting, where he would need to adjust to many different routines. The IEP team requested that occupational therapy continue to ensure a smooth transition for Drew and to put in place a plan that would continue to help him develop socially.

When school resumed in the fall, the occupational therapist had arranged a “big buddy” program with a local high school. Two high school seniors worked with Drew as part of a social service assignment during recess for the fall semester. The occupational therapist trained the high school students to carry out a socialization program aimed at helping Drew feel comfortable with a new set of peers. Drew seemed to look up to the high school students and responded well to the “big buddy” program.

By the end of the fall semester in the new school, Drew played cooperatively with peers, interacting independently and communicating appropriately. His occupational therapy program was formally discontinued at this time, although the occupational therapist continued to check in with Drew’s teacher when at his school site to work with other children. No additional intervention has been needed, but the option for further consultation or direct intervention is available should the need arise.

Perhaps the most important component of any consultation program is providing guidance for identifying, preventing, and coping with the challenges in everyday life that stem from the sensory integrative problems. Sometimes specific activities can be suggested that will help a child to prepare for a challenging task. For example, a child who has tactile defensiveness may be better able to tolerate activities such as finger painting or sand play if some desensitization techniques, such as applying firm touch-pressure to the skin, are used just before the activity. Modifying the activity might involve providing tools to use with the paint or sand to give the child a ready “break” from the unpleasant sensation. A home program that includes gradual introduction of tactile sensation in a safe place, such as the bathtub, can also help to lessen reactions. The therapist can also promote success in activities by suggesting individualized ways to help a child through difficult tasks. For example, some children with dyspraxia are likely to be more successful in completing a novel task when they receive verbal directions, whereas others respond optimally to visual demonstrations, and still others need physical assistance with the motion. Determining which method or combination of methods is most likely to help the individual child can assist adults in facilitating success.

Making adjustments in the environment can be especially important in the school setting since children spend large amounts of time in this environment. For example, children with autism are often highly affected by the sensory characteristics of their environments. Finding ways to manage sound, lighting, contact with other people, environmental odors, and visual distractions in the classroom, playground, cafeteria, and assembly rooms can make an important difference in attention,
behavior, and, ultimately, performance. Dunn’s work has led to a deeper understanding of how the sensory aspects of ordinary environments affect individuals who have the various sensory modulation styles that are depicted in her model (see Figure 11-9).61,63 Because individual differences in sensory processing tend to be lifelong tendencies, Dunn emphasizes how important it is for a person to learn to construct daily routines and manipulate sensory aspects of work and play environments in order to live as comfortably and successfully as possible.64 Consultation to develop the family’s insight into a child’s sensory characteristics, or to foster the child’s own insight, along with ideas for home and community-based activities, may be critical to intervention.

Procedures or techniques that require advanced training of an occupational therapist should not be recommended for parents and other professionals. For example, an appropriate consultation program never attempts to train a parent or teacher to provide individual therapeutic activities that require advanced training for monitoring the child’s response. Therapists should also be familiar enough with the child to be aware of any precautions that might apply before they make any suggestions. For example, some children display delayed responses to vestibular stimulation and can become overstimulated or lethargic hours after engaging in activities involving this type of sensation. Some sensory integrative techniques can lead to adverse reactions and must be used with care. Consultation services, environmental modifications, and home programs are meant to supplement, not replace, direct intervention. Used appropriately, they provide effective avenues for supporting the child, as well as family members, teachers, and other professionals who share in the efforts to help the child succeed.

The same therapist qualifications needed to provide individual ASI intervention are desirable in using consultation because the therapist needs to be able to predict what the child’s likely responses will be to various activities and situations, given the characteristics of the child’s sensory integrative difficulties. In addition, the therapist should be well enough versed in sensory integration concepts to be able to explain them in simple yet meaningful terms. Also, it is imperative that the therapist have excellent communication skills and respect for the various people and environments that are involved. Bundy provided an excellent description of the communication process involved in a good consultation program.58

Expected Outcomes of Occupational Therapy

As discussed previously, occupational therapy is not expected to “cure” sensory integrative problems. Rather, occupational therapy aims to improve the child’s health and quality of life through engagement in meaningful and important occupations or activities. To accomplish this with a child who has sensory integrative problems, the occupational therapist may aim to improve sensory integrative functions through direct remediation via ASI intervention, to minimize the effects of the problems by teaching the child specific skills and strategies, and by consulting with parents and teachers to plan modifications of activities, routines, and environments. Often remediation, skill training, and consultation are thoughtfully combined in an intervention plan that is tailored to the particular needs of the child and family.

The goals and objectives that are formulated as part of a child’s intervention plan target specific occupations in which positive changes are expected. These goals and objectives can be conceptualized as falling under the traditional occupational categories of work, rest, play, and self-care. For example, a toddler who tends to be overstimulated much of the time because of severe sensory modulation problems may consequently have difficulty falling asleep and staying asleep. One result of this situation is sleep deprivation, which aggravates defensiveness and behavior problems. A goal addressing the occupational domain of rest may be for the child to acquire more predictable sleep patterns with adequate amounts of sleep. A corresponding behavioral objective might be that the child will take a midday nap of at least 1 hour for 3 days per week. The intervention could involve direct remediation to reduce the sensory defensiveness as well as parent consultation on strategies such as calming activities, a very predictable activity schedule including a specific rest time ritual, and creation of an arousal-reducing environment after lunch (e.g., lights dimmed and noise reduced and screened with rhythmic sounds or “white noise”).

Sometimes specific behavioral objectives that address performance skills are appropriate as a way to monitor progress toward the desired changes in daily occupations. Goals can be conceptualized as falling into seven general categories of expected outcomes that address performance skills and patterns, as well as occupational engagement. These outcomes are summarized in Box 11-3; more detailed descriptions of each category follow.

Increase in the Frequency or Duration of Adaptive Responses

As discussed in the introduction of this chapter, adaptive responses occur when an individual responds to environmental challenges with success. Application of ASI principles helps the therapist envision how to create opportunities for the child to make adaptive responses. This may be accomplished through systematic use of sensory input to promote organization within the child’s nervous system. Ensuring that the sensory inputs inherent in activities are organizing rather than disorganizing and integrating rather than overwhelming requires careful monitoring on the part of the therapist, who must be sensitive to the child’s response to each aspect of an activity and to each type of sensory input involved. The ASI intervention approach intensively focuses on the child’s demonstration of higher level adaptive responses. However, specific skill training, group intervention, and consultation services may also boost the frequency and duration of adaptive responses by changing the child’s everyday environments in ways that enable the child to make adaptive responses more easily.

Increasing the duration and frequency of adaptive responses is an important outcome of sensory integration because functional behavior and skills are developed by mastering simple adaptive responses. For example, a child who has difficulty staying with an activity for more than a few seconds tends to shift from one activity to another. A desirable outcome for that child might be to stay for a longer time with a simple activity, such as swinging, in a therapy environment. Achievement of this simple adaptive response may eventually contribute to the functional behavior of staying with the reading circle in the school classroom for the required amount of time, despite the many distractions and cognitive challenges imposed by this occupation.
Development of Increasingly More Complex Adaptive Responses

Adaptive responses can vary in complexity, quality, and effectiveness. A simple adaptive response might be simply holding onto a moving swing. A more complex adaptive response involving timing of action might be releasing grasp on a trapeze at just the right moment to land on a pillow. Over time, effective ASI intervention is expected to enable the child to make adaptive responses that are more complex. This outcome is based on the assumption that sensory integrative procedures promote more efficient organization of multisensory input at primitive levels of functioning, which in turn is expected to enhance functions that are more complex. The result is an improvement in the child’s ability to make judgments about the environment, what can be done with objects, and what specific actions need to be taken to accomplish a goal.

Although repetition of a familiar activity may be important while a child is assimilating a new skill and may be useful in helping a child get ready for another, more challenging activity, development of increasingly more complex abilities occurs only when tasks become slightly more challenging than the child’s previous accomplishments. Presenting activities slightly above the child’s current skills levels is one of the main tenets of ASI intervention. Because of the high degree of personal attention continuously given to the child during this kind of therapy, a fine gradient of complexity can be built into therapeutic activities while simultaneously ensuring that the child experiences success and a growing sense of “I can do it!”

Group programs, compared with individual therapy, tend to place greater demands on children for several reasons, including limited opportunity for individualization of activities, the presence of other children with their unpredictable behaviors, and reduced opportunity for direct assistance from the therapist. Thus, a limitation posed by group programs is that challenges imposed on the group may at times be too great for an individual child, leading to frustration and failure. The therapist who provides a group program needs to be alert to the potential for this undesirable effect and strive to avoid it as much as possible. Whatever format for intervention is used, the therapist uses activity analysis, assessment information, ongoing observations, and knowledge of child development to ensure that the program engages the child’s inner drive as much as possible to draw forth increasingly more complex interactions within the clinical, school, home, or community environments.

Improvement in Gross and Fine Motor Skills

The child who makes consistent and more complex adaptive responses shows evidence of improved sensory integration. Moreover, this child meets new challenges with greater self-confidence. A net result of these gains frequently is greater mastery in the motor domain. An example is the child with a vestibular processing problem who exhibits greater competency and interest in playground activities and sports after individual ASI intervention, even though these activities were not practiced during therapy. Motor skills may be among the earliest complex skills to show measurable change in response to an ASI approach, probably because of the extent of the motor activity inherent in this intervention approach. Skill training, group intervention, or consultation for children with sensory integrative problems should result in improvement of specific motor skills if these are targeted by the intervention. For example, if a skill-training approach to handwriting is used to help a child with poor somatosensory perception, specific gains in handwriting performance should follow if the intervention is successful.

Improvement in Cognitive, Language, or Academic Performance

Although cognitive, language, and academic skills are not usually the specific objectives of sensory integration–based occupational therapy, improvement in these domains has been detected in some effectiveness studies involving the provision of ASI intervention. Application of ASI therapeutic procedures is thought to generate broad-based changes in these areas secondary to enhancement of sensory modulation, perception, postural control, or praxis. For example, a child with autism may be helped through a sensory integrative approach to respond in a more adaptive way to sights, sounds, touch, and movement experiences that initially were disturbing. This improvement in sensory modulation may lead to a better ability to attend to language and academic tasks; thus, improvement in these areas may follow. A child who has a vestibular processing disorder may improve in postural control and equilibrium, freeing the child to more efficiently concentrate on academic material without the distraction of frequent loss of sitting balance or loss of place while copying from the blackboard. This child’s vestibular-related improvements are also likely to have a positive effect on playground and sports activities because effects of classic sensory integration treatment are expected to generalize to a wide range of outcome areas.

Occupational therapy aimed at developing specific skills such as improved handwriting also may free the child to focus on the conceptual aspects of academic tasks rather than the perceptual-motor details of how to write letters on a page or how to keep a sentence on a printed line. For such interventions, effects on outcome skills tend to be limited to the specific task of concern. Similarly, consultation programs may enhance language, cognitive, or academic skills by providing strategies for reducing the effect of sensory integrative disorders on these functions. For instance, helping a teacher understand how best to seat a child in class (such as in a beanbag chair versus a firm wooden chair or in the front corner of the room near the teacher’s desk) may help reduce the negative effects of a sensory integrative problem by making it easier for the child to attend to instruction in the classroom.

Increase in Self-Confidence and Self-Esteem

Ayers asserted that enhanced ability to make adaptive responses promotes self-actualization by allowing the child to experience the joy of accomplishing a task that previously could not be done. The outcome of therapy that encourages successful, self-directed experiences is a child who perceives the self as a competent actor in the world. Individual and group programs and direct and indirect services all can be geared to helping the child master the activities that are
personally meaningful and essential to success in the world of everyday occupations. Mastery of such activities is expected to result in feelings of personal control that, in turn, lead to increased willingness to take risks and to try new things. For example, a child with gravitational insecurity may experience not only fear responses to climbing and movement activities, but also feelings of failure and frustration at not being able to participate in the play of peers. In such a case, an increase in self-confidence and comfort in one’s physical body is often accompanied by a general boost in feelings of self-efficacy and worth. Cohn, Miller, and Tickle-Degnen noted that parents’ perceptions of the benefits of occupational therapy using a sensory integrative approach included a reconstruction of self-worth, in addition to improvement in abilities and activities. Parents in this study perceived that this intervention enabled their children to take more risks and to try new things, thus opening the door to greater possibilities.

Enhanced Occupational Engagement and Social Participation

Occupational therapy programs that address sensory integrative problems encourage the child to organize his or her own activity, particularly in the ASI intervention approach. As the child develops general sensory integrative capabilities and improved strategies for planning action, gains are seen in relation to the ability to master self-care tasks, to cope with daily routines, and to organize behavior more generally. As a result, the child often is able to participate more fully in the occupations that are typical for his or her peers, a broad but critically important outcome for social participation. For example, intervention may help the child who is overly sensitive to touch or movement to deal with sensations in a more adaptive manner. As a result, the child approaches and engages in the challenges of everyday occupations, such as getting himself or herself ready for school in the morning, sharing a table with others in the school cafeteria, behaving appropriately in the classroom, and playing with friends on the playground with greater security and confidence. As noted previously, Cohn et al. reported that parents viewed their children as more willing to try new experiences following intervention, thus enhancing their opportunities for social participation. Not only is participation in daily occupations performed with greater competency and satisfaction, but relationships with others are likely to become more comfortable and less threatening. Group therapy programs are ideal arenas in which the increases in self-confidence made in individual therapy can be tried out in the more challenging context of a social setting. Gains in occupational engagement and social participation are among the most significant of intervention outcomes.

Enhanced Family Life

When children with sensory integrative problems experience positive changes during intervention, their lives and the lives of other family members may be enhanced. One possible by-product of intervention based on ASI principles is that parents gain a better understanding of their children’s behavior and begin to generate their own strategies for organizing family routines in a way that supports the entire family system. This kind of change can be particularly powerful for parents of children with autism, whose perceptions of child behaviors may be reframed as they become familiar with the sensory integrative perspective. For example, behavior that is interpreted as bizarre, such as insistently wearing rubber bands on the arms, may be reframed as a meaningful strategy that the child uses to obtain deep pressure input for self-calming. Instead of viewing the behavior as a frustrating, pathologic sign that should be eliminated, reframing may lead the parents to explore other ways that they could provide the child with the deep pressure experiences that he or she seeks. Thus, an important outcome of sensory integrative intervention may include changes in parents’ understanding of the child, leading to new coping strategies and alleviation of parental stress. In her studies of parental perspectives, Cohn has found that an important outcome of the sensory integrative approach is that parents tend to “reframe” their view and expectations of their children in a positive manner.

Measuring Outcomes

Because every child with a sensory integrative problem is unique, the expected outcomes of occupational therapy using an ASI approach are individualized and diverse. Outcomes are sometimes measured using standardized tests. In fact, some of the SIPT tests (e.g., Design Copying, Standing and Walking Balance, and most of the praxis tests) are good measures of change because of their strong test–retest reliability, in addition to being relevant to concerns that are commonly voiced by parents and teachers. However, standardized tests often do not address key occupational issues.

Goal attainment scaling (GAS) is an alternative to standardized tests that addresses the uniquely individualized nature of expected outcomes of ASI. The GAS method was developed in the mental health arena as a program evaluation tool to facilitate patient participation in the goal-setting process. GAS provides a means to prioritize goals that are specifically relevant to individuals and their families and to quantify the results using a standard metric that allows comparison of achievement across different types of goals. This process also captures functional and meaningful aspects of an individual’s progress that are often challenging to assess using available standardized measures. For this reason, GAS is an attractive methodology for measuring change during occupational therapy, and it has now been successfully applied in occupational therapy effectiveness research in a variety of settings, including rehabilitation, school systems, and mental health programs. This approach seems promising for capturing the diverse changes that are reported following ASI intervention programs. Case examples demonstrating how GAS has been applied to measure outcomes of ASI-based occupational therapy are described by Miller and Summers. In a randomized, controlled clinical trial, GAS detected significant improvements among children who received ASI intervention, compared to children receiving alternative conditions.

Research on Effectiveness of Intervention

Therapists who wish to use an ASI approach in practice need to keep up to date on research in this field to ensure that intervention is informed by the growing knowledge base. Research on the effectiveness of ASI-based interventions
is particularly critical to evidence-based practice in this specialty area.

In a meta-analysis of experimental research on sensory integrative treatment, Vargas and Camilli analyzed 16 studies comparing sensory integrative treatment with no treatment and 16 studies comparing sensory integrative treatment with alternative treatments.149 These included studies of adults as well as studies in which the descriptions of intervention were inconsistent with ASI principles. A significant overall average effect size of 0.29 was found for sensory integrative treatment compared with no treatment, indicating an advantage for children receiving the treatment. The largest effect sizes were found for psychoeducational and motor outcome measures. However, older studies had a significantly higher effect size than more recent studies, which did not have a significant effect size when considered by themselves. The average effect size for sensory integrative treatment compared with alternative treatments was 0.09, a quite small effect, and the sensory integrative treatments did not differ significantly from alternative treatments in effect size.

The decline in effect size of sensory integrative treatment studies over the years is puzzling. The authors of the meta-analysis suggest that the reason for this finding may lie in some unidentified difference in treatment implementation, or with selection and assignment of participants to experimental and control groups in the older studies versus the more recent ones.149 They point out that, in general, the studies examined sensory integration intervention in isolation and therefore do not represent the ways that sensory integration is implemented clinically, which usually involve incorporation of other treatment methods in addition to those that adhere to ASI principles. Another plausible explanation not explored by these authors is that, although the studies included in this meta-analysis all claimed to study intervention based on the work of Ayres, the interventions delivered in the studies were not all consistent with the core elements and key therapeutic strategies of ASI. This limitation is called a problem with fidelity, discussed further on.

After examining the effectiveness research on sensory integration, both Miller103 and Mulligan112 concluded that the effectiveness of sensory integration–based occupational therapy is neither proved nor unproved. This is because all of the existing studies that support the effectiveness of sensory integration intervention, as well as those that do not support its effectiveness, are flawed. Randomized, controlled clinical trials are considered to yield valid results only if they adhere to four standards: replicable intervention, homogeneous sample, sensitive and relevant outcome measures, and rigorous methodology.34

Many studies used unclear or unsound methods to identify who is to receive sensory integration treatment. This created the possibility that some children who do not have sensory integrative dysfunction were inappropriately assigned to this treatment. An exemplary pilot study with respect to selection of participants is the small randomized, controlled clinical trial conducted by Miller, Coll, and Schoen, who focused on effectiveness of ASI intervention for children with sensory modulation disorders (Research Note 11-2).106 These researchers carefully selected children using behavioral and physiologic measures to confirm the presence of sensory modulation disorder and then randomly assigned each child to one of three conditions: individual ASI intervention, an alternative tabletop activity program, or a passive placebo condition. Results showed that children who had received ASI intervention had better outcomes than children in the other conditions, and that some of their gains were statistically significant, specifically in Goal Attainment Scaling measures, as well as measures of attention and cognitive/social functioning.

Another common flaw is lack of fidelity. Fidelity refers to the extent to which the intervention provided in a study is faithful to the key elements of the intervention approach. Sometimes investigators use a rigid or very limited treatment protocol in an effort to ensure that the sensory integration treatment is well defined and adheres to strict criteria. Although the purpose of this strategy is laudable (i.e., to ensure that the treatment is
replicable), it may result in an intervention that lacks fidelity to the core elements of the sensory integration approach. This is because a rigid treatment protocol is incompatible with the highly individualized, child-centered, fluid nature of ASI intervention; therefore, any results obtained do not represent the effects of ASI intervention. On the other hand, if treatment guidelines are too vague, or are not checked systematically during the delivery of the intervention, one cannot trust that the intervention was delivered in a consistent manner across the participants and across the intervention period of the study.

To examine fidelity in sensory integration research, Parham et al. conducted a systematic review of 61 separate published studies that purportedly evaluated the effectiveness of sensory integration–based occupational therapy.116 Of the 61 studies, 34 provided this intervention to participants in the age range for which it was developed, preschool through elementary school age, without combining it with a non–sensory integration intervention. These 34 studies were analyzed for whether their descriptions of intervention adhered to key elements of ASI intervention that the authors and collaborating clinicians had extracted from the sensory integration literature. Results showed that only one of the key elements, “presents sensory opportunities,” was described in the majority of studies. More than one third of the studies contained sensory integration intervention descriptions that were contrary to one of the key elements, “collaborates with child on activity choice.” This is because, in these studies, the specific activities to be used in the intervention were determined by the researcher or the treating therapist prior to provision of intervention, rather than emerging from the interactions between child and therapist. Moreover, only one study used a quantifiable instrument to measure fidelity of intervention, and this instrument documented use of activities and equipment rather than the process of intervention. Parham et al. concluded that the effectiveness of sensory integration intervention cannot yet be made with confidence due to the lack of intervention fidelity in this research.116 To address this fidelity problem, a national network of occupational therapy researchers and practitioners, the Sensory Integration Research Collaborative (SIRC), developed a reliable and valid instrument, the Sensory Integration Fidelity Measure, to be used in research on ASI intervention.118 This instrument contains ratings of the structural background aspects of intervention, such as therapist qualifications and equipment, as well as ratings of the process of therapy (i.e., the therapeutic strategies used by the intervenor during a therapy session), that reflect the core elements of ASI intervention.

Another common problem in sensory integration outcomes research is related to selection of outcome measures. Often children’s responses to ASI intervention are as individualized as the intervention strategies, making it difficult, perhaps impossible, for the researcher to select tests and other measurements that target the precise areas of gain for individual children. Moreover, it is likely that children with different types of sensory integrative problems respond to this treatment with different kinds of gains. For example, children with tactile defensiveness are likely to show gains in outcome domains different from those in which children with vestibular processing difficulties made progress; yet almost all of the research studies lump children together with sensory integrative problems as if they should have similar responses to a standard treatment. This certainly was not Ayres’s view, because she spent considerable effort attempting to identify subgroups of children with sensory integrative problems who might differ from one another with respect to degree and type of responsiveness to intervention.10,37,26 It is hoped that researchers who conduct future effectiveness studies will become more sensitive to this important issue.

Another important issue that is rarely addressed is the maintenance of long-term gains after completion of a period of ASI-based occupational therapy is completed. An encouraging finding reported by Wilson and Kaplan suggests that children who receive sensory integration intervention may obtain long-term benefits that are not obtained by children who receive other interventions.155 These researchers retested children who had participated in an earlier randomized, controlled clinical trial comparing sensory integration intervention with tutoring. Although no significant differences in outcomes were found between the two intervention groups in the original study,156 at follow-up 2 years later, only the children who had received the sensory integration treatment maintained the gross motor gains that they had made after intervention. Maintenance of intervention gains is a critical issue that has an influence on cost-effectiveness questions. Replication of Wilson and Kaplan’s findings using the Sensory Integration Fidelity Measure to document the intervention would make an important contribution to understanding the extent to which gains after sensory integration treatment can be maintained.

Although group experimental treatment designs are considered to be the gold standard of effectiveness studies, other research designs examining treatment outcomes also make valuable contributions to an understanding of the potential effects of sensory integration intervention. Single system research has been particularly useful in revealing individual differences in responses to sensory integrative treatment. In this kind of research, a child serves as his or her own control and is monitored repeatedly before intervention (the baseline phase) and during intervention. An advantage to this approach is that behavioral outcomes can be highly individualized and tracked over time to provide a snapshot of each child’s response to intervention. An example of this type of research is the study conducted by Linderman and Stewart on two preschoolers with pervasive developmental disorders. The researchers measured three behavioral outcomes for each child.99 Each outcome was observed in the child’s home and was tailored to address functional issues for each child (e.g., response to holding and hugging for one child and functional communication during mealtime for the other). Results indicate significant improvements between baseline and intervention phases for five of the six outcomes measured.

A great deal of investigation remains to be done to explore questions regarding effectiveness of interventions based in ASI. It would be particularly beneficial to be able to better predict who will best respond to individual ASI intervention and who may be better served by other interventions. The effectiveness of combining individual ASI intervention with other ASI-informed interventions, such as specific skill training, group programs, or consultation, is another area in need of research, particularly because such intervention combinations are typically done in clinical practice. The kinds of outcomes likely to proceed from various treatment approaches and the timeframes in which those outcomes can be expected to emerge deserve
close examination in effectiveness studies. Long-term maintenance of gains, particularly of those related to outcomes that are measures of social participation, is a particularly important question that should be addressed in research. Finally, studies need to explore which intervention outcomes are most meaningful to the families of children with sensory integration problems to ensure that intervention programs are responsive to the needs of the people served.

REFERENCES


CHAPTER 12
Visual Perception

Colleen M. Schneck

KEY TERMS
Visual perception
Visual-receptive component
Visual-cognitive component
Visual attention
Visual memory
Visual discrimination
Object (form) perception
Spatial perception

OBJECTIVES
1. Define visual perception.
2. Describe the typical development of visual-perceptual skills.
3. Identify factors that contribute to typical or atypical development of visual perception.
4. Explain the effects of visual-perceptual problems on occupations and life activities such as activities of daily living, education, work, play, leisure, and social participation.
5. Describe models and theories that may be used in structuring intervention plans for children who have problems with visual-perceptual skills.
6. Identify assessments and methods useful in the evaluation of visual-perceptual skills in children.
7. Describe intervention strategies for assisting children in improving or compensating for problems with visual-perceptual skills.
8. Give case examples, including principles of evaluation and intervention.

Some consider vision to be the most influential sense in humans. There is little argument that vision is the dominant sense in human perception of the external world; it helps the individual to monitor what is happening in the environment outside the body. Because of the complexity of the visual system, it is difficult to imagine the impact of a visual-perceptual deficit on daily living. Functional problems that may result include difficulties with eating, dressing, reading, writing, locating objects, driving, and many other activities necessary for engagement in an occupation.

Given that occupational therapists focus on individuals’ participation in activities of daily living (ADLs), education, work, play, leisure, and social activities, the focus on the client factor of visual perception and its effects on performance skills, including literacy, can be critical. Literacy is embedded within all areas of occupational performance, from ADLs (reading recipes) and education (taking notes in class) to social participation (reading bus schedules). The reauthorization of both the Individuals with Disabilities Education Act (IDEA, 2004) and the No Child Left Behind Act (NCLB, 2001) addresses the need to better address literacy for children in public schools. Part C of the reauthorized IDEA requires that preliteracy be addressed in the very young child. For children of any age, occupational therapists can support literacy in many ways, including providing services to improve visual perception.

Although visual perception is a major intervention emphasis of occupational therapists working with children, it is one of the least understood areas of evaluation and treatment. The information presented in this chapter reflects current knowledge of visual perception that relates to evaluation of and intervention for children. The information in this area continues to evolve as research confirms or disproves explanatory models of the visual-perceptual system.

DEFINITIONS

Visual perception is defined as the total process responsible for the reception (sensory functions) and cognition (specific mental functions) of visual stimuli. The sensory function or visual-receptive component is the process of extracting and organizing information from the environment, and the specific mental functions that constitute the visual-cognitive component provide the capacity to organize, structure, and interpret visual stimuli, giving meaning to what is seen. Together these two components enable a person to understand what he or she sees, and both are necessary for functional vision. Visual-perceptual skills include the recognition and identification of shapes, objects, colors, and other qualities. Visual perception allows a person to make accurate judgments on the size, configuration, and spatial relationships of objects. The visual-receptive components are described in the Occupational Therapy Practice Framework: Domain and Process, 2nd Edition, under client factors of sensory functions and pain, and the visual-cognitive components are described under specific mental functions.
THE VISUAL SYSTEM

Hearing and vision are the distant senses that allow a person to understand what is happening in the environment outside his or her body or in extrapersonal space. These sense organs transmit information to the brain, the primary function of which is to receive information from the world for processing and coding. The visual sensory stimuli are then integrated with other sensory input and associated with past experiences. Approximately 70% of the sensory receptors in humans are allocated to vision. The eye, oculomotor muscles and pathways, optic nerve, optic tract, occipital cortex, and associative areas of the cerebral cortex (parietal and temporal lobes) are all included in this process. It is imperative that occupational therapists gain an understanding of the neurophysiologic interactions in the central nervous system (CNS) so that they can effectively evaluate and treat children with problems in the visual system. This discussion begins with the sensory receptor, the eye.

Anatomy of the Eye

A basic understanding of the anatomy and physiology of the eye aids comprehension of its influence on perception (Figure 12-1). The eye functions to transmit light to the retina, on which it focuses images of the environment. The eye is shaped to refract light rays such that the most sensitive part of the retina receives rays at a convergent point. The cornea covers the front of the eye and is part of the outermost layer of the eyeball. It plays a significant part in the focusing or bending of light rays that enter the eye. Behind the cornea is the aqueous humor, a clear fluid; the pressure of this fluid helps both to maintain the shape of the cornea and to focus light rays. The colored part of the eye, the iris, with its center hole, the pupil, is directly behind the cornea. The iris controls the amount of light entering the eye by increasing or decreasing the size of the pupil. The light then progresses through the crystalline lens, which does the fine focusing for near or far vision, and through a jelly-like substance called the vitreous humor.

FIGURE 12-1  Cross-section of the eye.  (From Ingalls, A. J., & Salerno, M. C. [1983]. Maternal and child health nursing [5th ed.]. St. Louis: Mosby.)
The eye has three layers: the sclera, the choroid, and the retina. The sclera, which is fibrous and elastic, helps hold the rest of the eye structure in place; the choroid is composed primarily of blood vessels that nourish the eye; and the retina is the innermost layer. The retinal layer is composed of receptor cell types that contain a chemical activated by light. The retina has three types of receptor cells: cones, which are used for color perception and visual acuity; rods, which are used for night and peripheral vision; and pupillary cells, which control opening (dilation) and closing (constriction) of the pupil.

The fovea centralis, which is located in the retina, is the point of sharpest and clearest vision. It is most responsive to daylight and must receive a certain amount of light before it transmits the signal to the optic nerve. The retina responds to spatial differences in the intensity of light stimulation, especially at contrasting border areas, and provides basic information about light and dark areas. Light stimulates the visual receptor cells in the retina, causing electrochemical changes that trigger an electrical impulse to flow to the optic nerve. The optic nerve (cranial nerve II) transmits the visual sensory messages to the brain for processing. This information travels to the brain in a special way. Fibers from the nasal half of each retina divisible, and half of the fibers cross to the contralateral side of the brain. Fibers from the outer half of each retina do not divide; therefore, they carry visual information ipsilaterally. Thus visual information from either the left or right visual field enters the opposite portion of each retina and then travels to the same hemisphere of the brain. This organization means that even with the loss of vision in one eye, information is transmitted to both hemispheres of the brain. It also means that damage in the region of the left or right occipital cortex can cause a loss of vision, referred to as a field cut, in the opposite visual field.72

The optic nerve leads from the back of the eye to the lateral geniculate nucleus in the optic thalamus. It is here that binocular information is received and integrated at a basic level, which may contribute to crude depth perception. Information then passes from the two lateral geniculate bodies of the thalamus to the visual cortex in the occipital lobe (area 17). From the occipital cortex the refined visual information is sent in two directions via visual area 18 or 19.109,110 Some impulses flow upward to the posterior parietal lobe, where visual-spatial processing occurs, focusing on the location of objects and their relationships to objects in space. This pathway is referred to as the ventral stream. The magnocellular channel is dominant in the dorsal stream; this channel is associated with motion and depth detection, stereoscopic vision, and interpretation of spatial organization.69 Other impulses flow downward to the inferior temporal lobe, where visual object processing takes place. Information sent here is analyzed for the specific details of color, form, and size needed for accurate object identification; the focus is on pattern recognition and detail and on remembrance of the qualities of objects. This is referred to as the ventral stream. The parvocellular channel is dominant in the ventral stream; this channel is thought to be important for color perception and for detailed analysis of the shape and surface properties of objects.82

**Visual-Receptive Functions**

The oculomotor system enables the reception of visual stimuli (visual-receptive process). The visual-receptive components include visual fixation, pursuit and saccadic eye movements, acuity, accommodation, binocular fusion and stereopsis, and convergence and divergence. Visual fixation on a stationary object is a prerequisite skill for other oculomotor responses, such as shifting the gaze between objects (scanning) or tracking. Each eye is moved by the coordinated actions of the six extraocular muscles. These are innervated by cranial nerves III, IV, and VI (oculomotor, trochlear, and abducens nerves). The oculomotor nuclei are responsible for automatic conjugate eye movements (lateral, vertical, and convergence). They also help regulate the position of the eyes in relation to the position of the head. The nuclei receive most of their information from the superior colliculus.

Two types of eye movements are used to gather information from the environment: pursuit eye movements, or tracking, and saccadic eye movements, or scanning. Visual pursuit, or tracking, involves continued fixation on a moving object so that the image is maintained continuously on the fovea. The smooth pursuit system is characterized by slow, smooth movements. Tracking may occur with the eyes and head moving together or with the eyes moving independently of the head. Saccadic eye movements, or scanning, are defined as a rapid change of fixation from one point in the visual field to another. A saccade may be voluntary, as when localizing a quickly displaced stimulus or when reading, or it may be involuntary, as during the fast phases of vestibular nystagmus. A saccadic movement is precise, although the presence of a slight overshoot or undershoot is normal.

In addition to voluntary control of eye movements, the vestibulo-ocular pathways control conjugate eye movements reflexively in response to head movement and position in space. These pathways enable the eyes to remain fixed on a stationary object while the head and body move.

In addition to the tasks of visual fixation, pursuit movements, and saccadic movements, other visual-receptive components include the following:

- **Acuity:** The capacity to discriminate the fine details of objects in the visual field. A visual acuity measurement of 20/20 means that a person can perceive as small an object as an average person can perceive at 20 feet.
- **Accommodation:** The ability of each eye to compensate for a blurred image. Accommodation refers to the process used to obtain clear vision (i.e., to focus on an object at varying distances). This occurs when the internal ocular muscle (the ciliary muscle) contracts and causes a change in the crystalline lens of the eye to adjust for objects at different distances. Focusing must take place efficiently at all distances, and the eyes must be able to make the transition from focusing at near point (a book or a piece of paper) to far point (the teacher and the blackboard) and vice versa. It should take only a split second for this process of accommodation to occur.
- **Binocular fusion:** The ability mentally to combine the images from the two eyes into a single percept. There are two prerequisites for binocular fusion. First, the two eyes must be aligned on the object of regard; this is called **motor fusion,** and it requires coordination of the six extraocular muscles of each eye and precision between the two eyes. Second, the size and clarity of the two images must be compatible; this is known as **sensory fusion.** Only when these two prerequisites have been met can the brain combine what the two eyes see into a single percept.
- **Stereopsis:** Binocular depth perception or three-dimensional vision.
Different disciplines may define the same terms differently. Use different terms and categories to define the same visual-perceptual processes; however, this has not been consistently defined, resources on visual perception are available.

Visual-Cognitive Functions

Interpretation of the visual stimulus is a mental process involving cognition, which gives meaning to the visual stimulus (visual-cognitive process). The visual-cognitive components are visual attention, visual memory, visual discrimination, and visual imagery.

Visual Attention

Visual attention involves the selection of visual input. It also provides an appropriate time frame through which visual information is passed by the eye to the primary visual cortex of the brain, where visual-perceptual processing can occur. Voluntary eye movements of localization, fixation, ocular pursuit, and gaze shift lay the foundation for optimal functioning of visual attention. The following are the four components of visual attention:

- **Alertness**: Reflected in the natural state of arousal. Alerting is the transition from an awake to the attentive and ready state needed for active learning and adaptive behavior.
- **Selective attention**: The ability to choose relevant visual information while ignoring less relevant information; it is conscious, focused attention.
- **Visual vigilance**: The conscious mental effort to concentrate and persist at a visual task. This skill is exhibited when a child plays diligently with a toy or writes a letter.
- **Divided, or shared, attention**: The ability to respond to two or more simultaneous tasks. This skill is exhibited when a child is engaged in one task that is automatic while visually monitoring another task.

Visual Memory

Visual memory involves the integration of visual information with previous experiences. Long-term memory, the permanent storehouse, has expansive capacity. In contrast, short-term memory can hold a limited number of unrelated bits of information for approximately 30 seconds.

Visual Discrimination

Visual discrimination is the ability to detect features of stimuli for recognition, matching, and categorization. Recognition is the ability to note key features of a stimulus and relate them to memory; matching is the ability to note the similarities among visual stimuli; and categorization is the ability mentally to determine a quality or category by which similarities or differences can be noted. These three abilities require the capability both to note similarities and differences among forms and symbols with increasing complexity and to relate these findings to information previously stored in long-term memory.

Visual-perceptual abilities aid the manipulation of a visual stimulus for visual discrimination. Because visual perception has not been consistently defined, resources on visual perception use different terms and categories to define the same visual-perceptual skills. At this time this contributes to confusion, because different disciplines may define the same terms differently.

It is also important to note that a distinction exists between object (form) vision (ventral stream) and spatial vision (dorsal stream). Object vision is implicated in the visual identification of objects by color, texture, shape, and size (i.e., what things are). Spatial vision, which is concerned with the visual location of objects in space (i.e., where things are), responds to motor information and seems to be integral to egocentric localization during visuomotor tasks. As discussed earlier, these two classes of function are mediated by separate neural systems. The cortical tracts for both object vision and spatial vision are projected to the primary visual cortex, but the object vision pathway goes to the temporal lobe and the spatial vision pathway goes to the inferior parietal lobe. These anatomic divisions have been verified repeatedly. However, researchers have emphasized differences in how these two areas use visual information. Visual information about object characteristics permits the formation of long-term perceptual representations that support object identification and visual learning. Spatial vision provides information about the location of object qualities that are needed to guide action, such as adjusting the hand during reach to the size and orientation of an object.

Based on studies done with individuals who had acquired brain damage, these two functions have been shown to be independent. That is, disturbances of object recognition can occur without spatial disability, and spatial disability can occur with normal object perception. Following are definitions of the object (form) and spatial-perceptual skills, although they are not entirely separate entities.

**Object (Form) Perception**

Form discrimination and processing involves multiple visual areas in the brain. It is thought that form perception is accomplished by two processes with two separate systems carrying different aspects of form information. The first system, the abstract visual form system (AVF) is thought to perform abstract processing to recognize types of forms. The AVF system is used when the visual form information should be processed and stored in an abstract, nonspecific manner. For example, when a child is scanning the gym supply cabinet for a soccer ball, he is attempting to find a ball but not a specific ball. The second system, specific visual form (SVF) system, provides specific processing to distinguish different instances of a type of form. The SVF system processes input in a manner that produces specific output representations that distinguish different instances of the same type of form—for example, the child searching for his soccer ball among those of his teammates after practice is over.

- **Form constancy**: The recognition of forms and objects as the same in various environments, positions, and sizes. Form constancy helps a person develop stability and consistency in the visual world. It enables the person to recognize objects despite differences in orientation or detail. Form constancy enables a person to make assumptions regarding the size of an object even though visual stimuli may vary under different circumstances. The visual image of an object in the distance is much smaller than the image of the same object at close range, yet the person knows that the actual sizes are equivalent. For example, a school-aged child can identify the letter A whether it is typed, written in manuscript, written in cursive, written in upper or lower case letters, or italicized.
- **Visual closure**: The identification of forms or objects from incomplete presentations. This enables the person quickly to
recognize objects, shapes, and forms by mentally completing the image or by matching it to information previously stored in memory. This allows the person to make assumptions regarding what the object is without having to see the complete presentation. For example, a child working at his or her desk is able to distinguish a pencil from a pen, even when both are partly hidden under some papers.

- **Figure-ground recognition:** The differentiation between foreground or background forms and objects. It is the ability to separate essential data from distracting surrounding information and the ability to attend to one aspect of a visual field while perceiving it in relation to the rest of the field. It is the ability to visually attend to what is important. For example, a child is able visually to find a favorite toy in a box filled with toys, scissors in a cluttered drawer, his or her mother in a crowded room, or a shirtsleeve on a monochromatic shirt.

**Spatial Perception**

There are two types of spatial relations: categorical spatial relations (above-below, right-left, on-off) and coordinate spatial relations (specify locations in a way that can be used for precise movements).130

- **Position in space/visual spatial orientation:** The determination of the spatial relationship of figures and objects to oneself or other forms and objects. This provides the awareness of an object’s position in relation to the observer or the perception of the direction in which it is turned. This perceptual ability is important to understanding directional language concepts such as in, out, up, down, in front of, behind, between, left, and right. In addition, position in space perception provides the ability to differentiate among letters and sequences of letters in a word or in a sentence. For example, the child knows how to place letters equal spaces apart and touching the line; he or she is able to recognize letters that extend below the line, such as p, a, q, or y. Another aspect of spatial perception, now referred to as object-focused spatial abilities, focuses on the spatial relations of objects irrespective of the individual.134 This includes skills evaluated by many formal assessments; however, poor performance on a formal test may or may not be linked to functional behavior.

- **Depth perception:** The determination of the relative distance between objects, figures, or landmarks and the observer and changes in planes of surfaces. This perceptual ability provides an awareness of how far away something is, and it also helps people move in space (e.g., walking down stairs, catching a ball, pouring water into a glass, parking a car). Depth perception is the third dimension beyond the two-dimensional image in the retina.123 Binocular vision, along with monocular cues such as texture, shading and linear perspective, all contribute to perception of three-dimensional shape and distance. Visual acuity and ocular alignment must also be adequate. The parietal lobe has been associated with depth perception.

- **Topographic orientation:** The determination of the location of objects and settings and the route to the location. **Wayfinding** depends on a cognitive map of the environment. These maps include information about the destination, spatial information, instructions for execution of travel plans, recognition of places, keeping track of where one is while moving about, and anticipation of features. These are important means of monitoring one’s movement from place to place.46 In addition, the images a person sees must be recognized if he or she is to make sense of what is viewed and if the individual is to find his or her way around.46 For example, the child is able to leave the classroom for a drink of water from the water fountain down the hall and then return to his or her desk.

**Visual Imagery**

Another important component in visual cognition is visual imagery, or **visualization**. Visual imagery refers to the ability to “picture” people, ideas, and objects in the mind’s eye even when the objects are not physically present. Developmentally, the child is first able to picture objects that make certain sounds and those that are familiar by taste or smell. The ability to picture what words say while reading is the next step. For example, the child can imagine the character of a book based on the written description. This level of visual-verbal matching provides the foundation for reading comprehension and spelling.

**Motor and Process Skills**

Client factors may affect performance skills that in turn may affect activities and occupations. Motor skills of posture, mobility, and coordination may be affected by poor visual skills. For example, in the area of mobility, research has shown the importance of vision in the development of proprioception of the hand prior to the onset of reaching in newborn infants.23 This can explain why young babies spend much time visually examining their hands. By 5 to 7 months, infants, in preparation for reaching, may use the current sight of the object's orientation, or the memory of it, to orient the hand for grasping; sight of the hand has no effect on hand orientation at this point.90 If problems occur in visual memory affecting the memory of the hand, the hand may not be properly oriented during reach, and this affects coordination.

Process skills of knowledge, temporal organization, organization of space and objects, and adaptation all can be affected by visual perception. Children who have acquired damage to the white matter around the lateral ventricles or damage to the posterior parietal lobes can find it difficult to use vision to guide their body movements.47 For example, a floor boundary between carpet and linoleum can be difficult to cross because it looks the same as a step. Black-and-white tiled floors can be frightening to walk across. At a curb, the foot may be lifted to the wrong height, too early, or too late, and walking down stairs without a banister is difficult and dangerous.

**Developmental Framework for Intervention**

Warren presented a developmental framework based on a bottom-up approach to evaluation and treatment.157 Using the work of Moore,62 Warren suggested that with knowledge of where the deficit is located in the visual system, the therapist could design appropriate evaluation and treatment strategies to remediate basic problems and improve perceptual function.157 To apply this approach, the occupational therapist must have an understanding of the visual system, including both the visual-receptive and visual-cognitive components. Although Warren’s model was presented as a developmental
framework for evaluation and treatment of visual-perceptual dysfunction in adults with acquired brain injuries, it is useful as a model for children with visual-perceptual deficits. A hierarchy of visual-perceptual skill development in the central nervous system is presented in Figure 12-2. The definitions of components of each level are provided in the following list and are used in later descriptions of intervention.

1. **Primary visual skills** form the foundation of all visual functions.
   - **Oculomotor control** provides efficient eye movements that ensure that the scan path is accomplished.
   - **Visual fields** register the complete visual scene.
   - **Visual acuity** ensures that the visual information sent to the CNS is accurate.

2. **Visual attention.** The thoroughness of the scan path depends on visual attention.

3. **Scanning.** Pattern recognition depends on organized, thorough scanning of the visual environment. The retina must record all the detail of the scene systematically through the use of a scan path.

4. **Pattern recognition.** The ability to store information in memory requires pattern detection and recognition. This is the identification of the salient features of an object.
   - **Configural aspects** (shape, contour, and general features)
   - **Specific features** of an object (details of color, shading, and texture)

5. **Visual memory.** Mental manipulation of visual information needed for visual cognition requires the ability either to retain the information in memory for immediate recall or to store for later retrieval.

6. **Visual cognition.** This is the ability to mentally manipulate visual information and integrate it with other sensory information to solve problems, formulate plans, and make decisions.

Warren’s model provides a framework for assessing vision alone, without consideration of the other sensory systems. When visual-perceptual problems relate to sensory integration (SI) dysfunction, models based on SI theories can guide evaluation and intervention. These models consider organization of multisensory systems and the influence of vision as it integrates with other sensory systems.

Vision can be viewed as a dynamic blending of sensory information in which new visual and motor input are combined with previously stored data and then used to guide a reaction. Research demonstrates an expansive interconnectivity of sensory systems. Studies of brain activity confirm that when an individual is using the visual system, many areas of the brain are activated. Evidence of full brain activity during visualization supports the concept that vision should be viewed in the totality of all sensory systems.

**DEVELOPMENTAL SEQUENCE**

**Visual-Receptive Functions**

As with other areas of development, the development of visual-receptive process and abilities takes place according to a prescribed timetable, which begins in the womb. By gestational week 24, gross anatomic structures are in place, and the visual pathway is complete. Between gestational weeks 24 and 40, the visual system, particularly the retina and visual cortex, undergoes extensive maturation, differentiation, and remodeling. As early as the fifth gestational month, eye movements are produced by vestibular influences. At birth the infant has rudimentary visual fixation ability and brief reflexive tracking ability. The visual system at this age is relatively immature compared with other sensory systems, and considerable development occurs over the next 6 months.

Toward the end of the second month, accommodation, convergence, and oculomotor subsystems are established. Stereopsis is evident at about 2 months of age; it does not appear to depend on visual recognition and does not need to be taught. Maximum accommodation is reached at 5 years of age, and the child should be able to sustain this skill effort for protracted periods at a fixed distance.

Controlled tracking skills progress in a developmental pattern from horizontal eye movements to eye movements in vertical, diagonal, and circular directions. By kindergarten a child should be able to move the eyes with smooth control and coordination in all directions. This can be demonstrated by asking the child to follow the eyes a moving object located 8 to 12 inches from the child’s face. If the child moves the head as a unit along with the eyes, this skill is still developing. Visual acuity is best at 18 years of age and tends to decline thereafter.

**Visual-Cognitive Functions**

Vision enables infants to acquire information from multiple locations at a range of distances and is a means for infants to organize information received from their other senses. By coordinating visual and auditory input, infants accumulate information as they explore places, events, and individuals in the physical and social environments. Some visual-cognitive capacities are present at birth, whereas other higher-level visual-cognitive abilities are not fully developed until adolescence. This development occurs through perceptual learning, the process of extracting information from the environment.
Perceptual learning increases with experience and practice and through stimulation from the environment.

**Object (Form) Vision**

Long before infants can manipulate objects or move around space, they have well-developed visual-perceptual abilities, including pattern recognition, form constancy, and depth perception. Infants as young as 1 week of age show a differential response to patterns, with complex designs and human faces receiving more attention than simple circles and triangles. The infant learns to attend to relevant aspects of visual stimuli, to make discriminations, and to interpret available cues according to experiences. Babies can organize visual information in at least three ways. Perception of brightness emerges first by 2 months of age. By 4 months, most infants can group objects by shape and proximity.49

Visual perception develops as the child matures, with most developmental changes taking place by 9 years of age. However, children vary in the rate at which they acquire perceptual abilities, in their effective use of these capacities, and in the versatility and comfort with which they apply these functions.59

The child first learns to recognize an object based on its general appearance and not by specific details. As the child learns to classify objects into categories and types, it becomes apparent that he or she is able to extract the features that make the object part of that category.108 For example, the child learns to categorize cars as certain types or to classify animals according to their species. Williams estimated the developmental ages when primary visual-perceptual skills develop (Table 12-1).101 Bouska and colleagues described three areas in which a child demonstrates increasing ability to discriminate visually.15 These areas include (1) the ability to recognize and distinguish specific distinctive features (e.g., that b and d are different because of one feature); (2) the ability to observe invariant relationships in events that occur repeatedly over time (e.g., a favorite toy is the same even when distance makes it appear smaller); and (3) the ability to find a hierarchy of pattern or structure, allowing the processing of the largest unit possible for adaptive use during a particular task (e.g., a map is scanned globally for the shape of a country, but subordinate features are scanned for the route of a river).59 These skills are important for learning to read and write. Justice and Ezell described emergent literacy as comprising two broad yet highly interrelated domains of knowledge: written language awareness and phonologic awareness.79 Written language awareness, also referred to as print awareness,135 describes children’s knowledge of the forms and functions of printed language (e.g., distinctive features of alphabet letters, storybook conventions, environmental signs).

The child’s first perceptions of the world develop primarily from tactile, kinesthetic, and vestibular input. As these three basic senses become integrated with the higher level senses, vision and audition gradually become dominant. Young children or beginning readers tend to prefer learning through their tactile and kinesthetic senses and have lower preferences for visual and auditory learning.26 At 6 or 7 years of age, most children appear to prefer kinesthetic, tactile, visual, and auditory learning, in that order. They learn easily through their sense of touch and whole-body movement and have difficulty learning through listening activities. The predominant reading style of primary grade children and struggling readers is global, tactile, and kinesthetic.26 Global reading methods (i.e., recorded stories, shared reading) start with a modeled story, practice words from the story, and teach phonics skills. This differs from analytic reading methods (e.g., phonics) that teach sounds letters make, then practice words containing the sounds taught, and proceed to stories. Tactile learners recall what they touch, are often doodlers, and learn better when they can touch or manipulate objects (such as a reading game). Kinesthetic learners recall what they experience and learn when engaged in physical activity (e.g., acting in plays, floor games, building models).27

Research shows that struggling readers prefer and do better in classrooms that allow for movement, have some comfortable seating and varied lighting, and enable students to work with relevant ease in different groupings.44 Research indicates that when the student’s environmental preferences are met, they are more likely to associate reading with pleasure, to read for longer periods, and overall read at higher levels.44 Generally, boys are less auditory and verbal and remain kinesthetic longer than girls. Around third grade most children become highly visual, and not until fifth grade do many children learn well through their auditory sense. However, it is important to remember that reading style strengths and preferences develop at different times and rates.26

In the young child, visual discrimination of forms precedes by years the visual-motor ability to copy forms. Throughout elementary school, the child assimilates more internal detail of figures and develops greater ability to understand, recall, and recreate such configurations. Children begin to use

| TABLE 12-1 Developmental Ages for Emergence of Visual-Perceptual Skills |
|----------------|-------------------------------------------------|
| Perception | Developmental Age |
| **OBJECT (FORM)** | | |
| Figure-ground perception | Improves between 3 and 5 years of age; growth stabilizes at 6 to 7 years of age |
| Form constancy | Dramatic improvement between 6 and 7 years of age; less improvement from 8 to 9 years of age |
| **SPATIAL** | | |
| Position in space | Development complete at 7 to 9 years of age |
| Spatial relationships | Improves to approximately 10 years of age |

simultaneous and sequential data to develop strategies, and cognitive or learning styles begin to emerge. In addition, children learn best through their dominant sensory input channel. About 40% of school-age children remember visually presented information, whereas only 20% to 30% recall what is heard. Information processing in the visual-perceptual–motor domain has been identified as one of the major factors that predict readiness for the first grade. There is evidence that the child who enters school with delayed perceptual development may not catch up with his or her peers in academic achievement. Of the children who have difficulty reading in first grade, 88% have difficulty reading at the end of fourth grade. Adequate perceptual discrimination is considered necessary for the development of the literacy skills of reading and writing. An important aspect of developing early literacy is termed alphabets. This includes phonemic and phonologic awareness, letter recognition, print awareness, and phonics. Letter recognition/identification, defined as knowing the names of the letters of the alphabet, supports reading acquisition. Measures of the ability to name letters have been shown to be predictors of reading development, especially when letter naming is taught in conjunction with other beginning reading skills. Print awareness refers to knowledge or concepts about print, such as the following: (1) print carries a message; (2) there are conventions of print such as directionality (left to right, top to bottom), differences between letters and words, distinctions between upper and lower case, punctuation; and (3) books have some common characteristics (e.g. author, title, front/back). It has been shown that print awareness supports reading acquisition (e.g., decoding). Occupational therapists are not primarily responsible for teaching students to read or write but may address many of the performance skills to support student literacy outcomes.

Children gradually develop the abilities to attend to, integrate, sort, and retrieve increasingly larger chunks of visual data. These stimuli from the environment usually arrive for processing either in a simultaneous array or in a specific serial order. An example of simultaneous processing involves observing and later trying to recall what someone wore. Sequential processing involves the integration of separate elements into groups, where the elements have a specific arrangement in time with each element leads only to one other. Sequential processing enables the child to perceive an ordered series of events. An example of sequential processing is the visual information provided in the written instructions for assembling a plastic model. An effective learner in the classroom needs to be able to evaluate, retain, process, and produce both simultaneous and sequential packages of information or action. In addition, children must learn to analyze and synthesize material containing more detail at a faster rate.

In adolescence, perceptual skills are enhanced by their interrelationship with expanding cognitive skill. Thus the adolescent can imagine, create, and construct complex visual forms. The adolescent is able to manipulate visual information mentally to solve increasingly complex problems, formulate plans, and make decisions. Of the children who are poor readers at the end of third grade, 75% remain poor readers in high school. Teenager rites of passage such as obtaining a driver’s license or independent dating may be challenging or impossible for an individual with severe visual-perceptual deficits.

Spatial Vision

In the developmental process of organizing space, the child first acquires a concept of vertical dimensions, followed by a concept of horizontal dimensions. Oblique and diagonal dimensions are more complex, and perception of these spatial coordinates matures later. A 3- to 4-year-old child can discriminate vertical lines from horizontal ones, but children are unable to distinguish oblique lines until about 6 years of age. The ability to discriminate between mirror- or reverse-image numbers and letters, such as $b$ and $d$, and $p$ and $q$, does not mature in some children until around 7 years of age.

The child develops an understanding of left and right from the internal awareness that his or her body has two sides, this understanding of left and right, called laterality, proceeds in stages. A child’s awareness of his or her own body is generally established by 6 or 7 years of age. Before 7 years of age, a child is not yet ready to handle spatial concepts on a strictly visual basis. The child must relate them to his or her own body. Around the eighth year the child begins to project laterality concepts outside himself or herself. The child then develops directionality, or the understanding of an external object’s position in space in relation to himself or herself. This allows the child to handle spatial phenomena almost exclusively in a visual manner. By sensing a difference between body sides, the child becomes aware that figures and objects also have a right and a left. The child “feels” this visually.

Directionality is thought to be important in the visual discrimination of letters and numbers for both reading and writing. The child first learns these concepts in relation to himself or herself and then transfers them to symbols and words.

Role of Vision in Social Development

The importance of vision in facilitating infants’ participation in social interactions has been widely recognized. Facial expressions are an important way to communicate emotions. Infants respond to attentive, social initiations from their parents by visually focusing on their parents’ eyes, smiling, and occasionally shifting gaze to scan their parents’ faces and the environment. Mutual gaze between parents and infants facilitates emotional attachment. Adults’ facial expressions appear to be the major driving force during social interactions with infants younger than 6 months. Infants discriminate between happy and sad facial expressions by 3 months of age. Toward the end of the first year an infant can shift attention from one person to another person, or to an object of mutual interest in joint attention paradigms. Social imitation then shifts from simple reactions to another person’s facial expressions to imitations of another person’s actions with objects. Toddlers will imitate a peer’s action on an object, but only when identical objects are available.

Visual-Receptive Functions

The importance of good vision for classroom work cannot be overemphasized. More than 50% of a student’s time is spent working at near-point visual tasks such as reading and writing.
Another 20% is spent on tasks that require the student to shift focus from distance to near and near to distance, such as copying from the board. For more than 70% of the day, therefore, tremendous stress is put on the visual system. Many students with visual dysfunction may have difficulty meeting the behavioral demands of sitting still, sustaining attention, and completing their work. Academic instruction in the first years places great demand on the child’s visual processing skills, with emphasis on recognition, matching, and recall. In early elementary grades, periods of sustained near work are infrequent, and visual stimuli (letters) are relatively large and widely spaced.

Visual efficiency becomes a more significant need in later elementary grades, middle school, and high school. Letters and text become smaller and more closely spaced and reading requires more comprehension effort for extended periods of time. Students visually attend for sustained periods of near work.

Learning-related vision problems represent deficits in two broad visual system components: visual efficiency and visual information processing. Figure 12-3 presents a sample list of behaviors noted in children with specific visual problems. In addition, individuals with functional vision problems may exhibit:

- Difficulty completing school tasks in a timely manner
- Avoidance of reading work
- Visual fatigue
- Adaptation of the visual system through the development of a refractive error to perform near-centered visual tasks
- Distraction or inattention as a secondary problem, thus decreasing the opportunity for practice and learning

Impairment of oculomotor control can occur through disruption of cranial nerve function or disruption of central neural control. The pattern of oculomotor dysfunction depends on the areas of the brain that have been injured and the nature of the injury. Oculomotor problems can limit the ability to control and direct gaze. In addition, when large amounts of energy must be used on the motor components of vision, little energy may be left for visual-cognitive processing. Warren and Scheiman present detailed descriptions of oculomotor deficits and other deficits seen in visual-receptive components.

At least 20% of students with learning disabilities have been found to have prominent visual information-processing problems. The prevalence of visual efficiency problems in children with learning disabilities is thought to be in the 15% to 20% range. Accommodative disorders have been reported in 60% to 80% of individuals with visual efficiency problems; accommodative insufficiency is the most prevalent type.

Convergence insufficiency is the most common convergence anomaly.

### Refractive Errors

A child who is nearsighted has blurred distant vision but generalizes experiences clarity at near point. The child who is farsighted frequently has clear distant and near vision but has to exert extra effort to maintain clear vision at near point. The child with astigmatism experiences blurred vision at distance and near, with the degree of loss of clarity depending on the severity of the astigmatism. Measures of visual acuity alone do not predict how well children interpret visual information.

Other determinants include the ability to see objects in low-contrast lighting conditions, the ability of the eye to adapt to different lighting conditions, visual field problems, accommodation, and other oculomotor functions.

If accommodation takes longer than previously described, words appear blurry and the child tends to lose his or her place, missing important information and understanding. When accommodation for near objects is poor, presbyopia exists; this individual is described as farsighted.

If the conditions of motor fusion and sensory fusion have not been met, allowing binocular fusion to occur (this process was described previously), single binocular vision is at best difficult and at worst impossible. If one eye overtly turns in, out, up, or down because of muscular imbalance, the condition is known as strabismus, sometimes referred to as a crossed or wandering eye. This can result in double vision or mental suppression of one of the images. This, in turn, can affect the development of visual perception. Some children have surgery to correct an eye turn. Although this intervention can correct the eye cosmetically, it does not always result in binocular vision.

Another type of binocular dysfunction is called phoria. Phoria refers to a tendency for one eye to turn slightly in, out, up, or down, but overt misalignment of the two eyes is absent. Phoria requires the child to expend additional mechanical effort to maintain motor fusion of the two eyes, whether focusing near or far. The extra effort frequently detracts from the child’s ability to process and interpret the meaning of what he or she sees.

### Visual-Cognitive Functions

#### Attention

The integrity of the attention system is considered to be a prerequisite for higher cognitive functions. To review, visual attention is composed of alertness, selective attention, vigilance, and shared attention. If the child’s state of alertness or arousal is impaired, the child may demonstrate behaviors of overattentiveness, underattentiveness, or poor sustained attention. Children who are overattentive may be compelled to respond to visual stimuli around them rather than attend to the task at hand, may be easily distracted by visual stimuli, and may demonstrate continual visual searching behaviors. Children who are underattentive may have difficulty orienting to visual stimuli, may habituate quickly to a visual stimulus, and may fatigue easily. At this level a child may refrain from attending to a familiar stimulus. A child with poor sustained attention may demonstrate a high activity level and may be easily distracted.

Selective attention is the next level of visual attention, and a child with difficulty in this area demonstrates a reduced ability to focus on a visual target. The child may have difficulty screening out unimportant or irrelevant information and may focus on or may be distracted by irrelevant stimuli. A child with difficulty in selective attention is easily confused. The child may focus on unnecessary tasks or information and therefore not obtain the specific information needed for the task. Selective attention is critical for encoding information into memory and successfully executing goal-directed behavior.

A child with reduced vigilance skills shows reduced persistence on a visual task and poor or cursory examination of visual stimuli. The child cannot maintain visual attention. The more
complex the visual structure of an object, the lengthier the process of visual analysis and the greater the vigilance skills needed. Impaired sustained attention is associated with error awareness as well as working memory to hold and manipulate information. A child with deficits in shared attention can focus well only on one task at a time. He or she may be easily confused or distracted if required to share visual attention between two tasks.

Enns and Cameron suggested that visual inattention is the result of an inability to select the features that differentiate

### CHECKLIST OF OBSERVABLE CLUES TO CLASSROOM VISION PROBLEMS

<table>
<thead>
<tr>
<th>1. Appearance of eyes</th>
<th>d. Visual-form perception (visual comparison, visual imagery, visualization)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One eye turns in or out at any time</td>
<td>Mistakes words with same or similar beginnings</td>
</tr>
<tr>
<td>Reddened eyes or lids</td>
<td>Fails to recognize same word in next sentence</td>
</tr>
<tr>
<td>Eyes tear excessively</td>
<td>Reverses letters and/or words in writing and copying</td>
</tr>
<tr>
<td>Encrusted eyelids</td>
<td>Confuses likenesses and minor differences</td>
</tr>
<tr>
<td>Frequent styes on lids</td>
<td>Confuses same word in same sentence</td>
</tr>
</tbody>
</table>

| 2. Complaints when using eyes at desk |  
|--------------------------------------|--------------------------------------------------|
| Headaches in forehead or temples | Repeatedly confuses similar beginnings and endings of words |
| Burning or itching after reading or desk work | |
| Nausea or dizziness | |
| Print blurs after reading a short time | |

| 3. Behavioral signs of visual problems |  
|-------------------------------------|--------------------------------------------------|
| a. Eye movement abilities (ocular motility) |  
| Head turns as reads across pages |  
| Loses place often during reading |  
| Needs finger or marker to keep place |  
| Displays short attention span in reading or copying |  
| Too frequently omits words |  
| Repeatedly omits “small” words |  
| Writes uphill or downhill on paper |  
| Rereads or skips lines unknowingly |  
| Orients drawings poorly on page |  

| b. Eye teaming abilities (binocularity) |  
| Complains of seeing double (diplopia) |  
| Repeats letters within words |  
| Omits letters, numbers, or phrases |  
| Misaligns digits in number columns |  
| Squints, closes, or covers one eye |  
| Tilts head at extreme angle while working at desk |  
| Consistently shows gross postural deviations at all desk activities |  

| c. Eye-hand coordination abilities |  
| Must feel things to assist in any interpretation required |  
| Eyes not used to “steer” hand movement (extreme lack of orientation, placement of words or drawings on page) |  
| Writes crookedly, poorly spaced: cannot stay on ruled lines |  
| Misaligns both horizontal and vertical series of numbers |  
| Uses hand or fingers to keep place on the page |  
| Uses other hand as “spacer” to control spacing and alignment on page |  

| d. Visual-form perception (visual comparison, visual imagery, visualization) |  
| Mistakes words with same or similar beginnings |  
| Fails to recognize same word in next sentence |  

| e. Refractive status (e.g., nearsightedness, farsightedness, focus problems) |  
| Comprehension reduces as reading continued; loses interest too quickly |  
| Mispronounces similar words as continues reading |  
| Blinks excessively at desk tasks and/or reading; not elsewhere |  
| Holds book too closely; face too close to desk surface |  
| Avoids all possible near-centered tasks |  
| Complains of discomfort in tasks that demand visual interpretation |  
| Closes or covers one eye when reading or doing desk work |  

Note: Students found to have any of the visual or eye problems on the checklist should be referred to a behavioral optometrist. Referral lists of behavioral optometrists are available from Optometric Extension Program Foundation, 2912 S. Daimler, Santa Ana, CA 92705.
objects in a visual array. The child cannot see, recognize, or isolate the salient features and therefore does not know where to focus visual attention. Luria suggested that problems of visual recognition represent a breakdown of the active feature by feature analysis necessary for interpretation of a visual image. The current psychological literature focuses on such constructs as mental resource, automaticity, and stimulus selection. The research focuses on the attention demands that numerous competing stimuli make on individuals with a limited capacity to process those stimuli and on the fact that these exteroceptive stimuli can be processed either with awareness (i.e., effortful processing) or automatically (i.e., effortless processing).

**Memory**

The child with visual memory deficits has poor or reduced ability to recognize or retrieve visual information and to store visual information in short- or long-term memory. The child may fail to attend adequately, may fail to allow for storage of visual information, or may show a prolonged response time. The child may demonstrate the inability to recognize or match visual stimuli presented previously because he or she has not stored this information in memory, or the child may be unable to retrieve it from memory. The child may have good memory for life experiences but not for factual material and may fail to relate information to prior knowledge. He or she may demonstrate inconsistent recall abilities and poor ability to use mnemonic strategies for storage.

Visual sequential memory problems are seen when the child has difficulty recalling the exact sequence of letters, numbers, symbols, or objects. Visual spatial memory deficits are seen when the child has difficulty recalling the spatial location of a previously seen stimulus and is unable to identify or reproduce it.

**Visual Discrimination**

The child with poor discrimination abilities may demonstrate impaired ability to recognize, match, and categorize. Ulman proposed that a finite set of visual operations, or *routines,* are performed to extract shape properties and spatial relationships. Usually an individual recognizes an object by orienting to its top or bottom. A child with poor matching skills may demonstrate difficulty matching the same shape presented in a different spatial orientation or may confuse similar shapes. A child with poor matching skills also may have difficulty recognizing form in a complex field.

**Object (Form) Vision**

Children with form constancy problems may have difficulty recognizing forms and objects when they are presented in different sizes or different orientations in space or when differences in detail exist. This interferes with the child’s ability to organize and classify perceptual experiences for meaningful cognitive operations. This may result in difficulty recognizing letters or words in different styles of print or in making the transition from printed to cursive letters.

A child with a visual closure deficit may be unable to identify a form or object if an incomplete presentation is made; the child therefore would always need to see the complete object to identify it. For example, a child would have difficulty reading a sign if the letters were partly occluded by tree branches.

The child with figure-ground problems may not be able to pick out a specific toy from a shelf. He or she also may have difficulty sorting and organizing personal belongings. The child may overattend to details and miss the big picture or may overlook details and miss the important information. Children with figure-ground problems may have difficulty attending to a word on a printed page because they cannot block out other words around it. The child with figure-ground difficulties may not have good visual search strategies. Marr suggested that control of the direction of gaze is a prerequisite for efficiency of visual search.

**Spatial Vision**

A child with position in space difficulty has trouble discriminating among objects because of their placement in space. These children also have difficulty planning their actions in relation to objects around them and may show delayed gross motor skills. They may show letter reversals in writing or reading past 8 years of age and may show confusion regarding the sequence of letters or numbers in a word or math problem (e.g., was/saw). Writing and spacing letters and words on paper may be a problem. The children may show difficulty understanding directional language such as in, out, on, under, next to, up, down, and in front of. They may show inconsistent directional attack when reading.

Decreased depth perception can affect the child’s ability to walk through spaces and to catch a ball. The child may be unable to determine visually when the surface plane has changed and may have difficulty with steps and curbs. Transference of visual-spatial notations across two visual planes can make copying from the blackboard difficult. Faulty interpretation of the spatial relationships can contribute to a problem with sorting and organizing personal belongings. The child may show confusion in right and left.

A child who has diminished topographic orientation may be easily lost and unable to find his or her way from one location to the next. The child may also demonstrate difficulty determining the location of objects and settings and may not recognize the images that help people find their way around the environment. The child may be unable to walk from home to school without getting lost.
Diagnoses with Problems in Visual Perception

When children with disabling conditions have visual problems, the effects of the visual impairments can be tremendous. Numerous studies have found a high frequency of vision problems among individuals with disabilities.17 Severe refractive errors are common among children with developmental problems,117 and impaired visual attention can have a pervasive negative influence on the functional behavior of these children. Often considered distractible, these children may be able to locate objects but have difficulty sustaining eye contact or recognizing objects visually.117

Retinopathy of prematurity (ROP) is the single most cited cause of blindness in preterm infants. However, the number of infants with ROP has declined in past 25 years because of changes in medical interventions for premature infants.136 Cortical visual impairment also occurs in preterm infants and is generally associated with severe CNS damage, such as periventricular leukomalacia. Other visual disorders common in preterm children include lenses that are too thick, poor visual acuity, astigmatism, extreme myopia, strabismus, amblyopia, and anisometropia (unequal refraction of the eyes).5 These children also have difficulty processing visual information. Scores for visual attention, pattern discrimination, visual recognition, memory, and visual-motor integration are lower than those for full-term infants.29,120,132 Studies of older children suggest that these problems often persist.117

Children with developmental disabilities commonly have a coexisting diagnosis of blindness or visual impairment. These children also may have sensory integrative deficits that further complicate their functional abilities.119

Children with cerebral palsy (CP) frequently have been identified as a group with visual-perceptual deficits.17,21 Children with CP often have a strabismus, oculomotor problems, convergence insufficiencies, or nystagmus. These problems may also limit the ability to control and direct visual gaze.117

Early research indicated that the degree of perceptual impairment in individuals with CP was related to the type and severity of the motor impairment.10 In a comparison study, children with CP scored significantly lower on a motor-free test of visual perception than typical children.96 These findings supported earlier studies that showed that a group of children with spastic quadriplegia demonstrated the greatest problems in visual perception. Children with left hemiplegia scored significantly lower than control children on motor-free visual tests, but children with right hemiplegia did not.21

In children with language delay, poorly developed visual perception may contribute to the language difficulties. For example, language moves from the general to the specific. Young children call every animal with four legs a dog. Eventually they are able to discriminate visually between dogs and lions, and the vocabulary follows the visual-perceptual lead. Next, they can tell Dalmatians from Dachshunds, but they are unable to recognize that both are dogs. Finally, the ability to categorize and generalize emerges somewhere between 7 and 9 years of age. In addition, the child who has visual-spatial perception deficits may show difficulty understanding directional language, such as in, on, under, and next to.

Visual-perceptual problems are found more frequently in individuals who have significantly higher verbal scores than performance scores on intelligence testing. Not all children with learning disabilities have visual-perceptual problems.70 A recent study suggests that early brain damage can give rise to specific visual-perceptual deficits, independent of, although occurring in association with, selective impairment in nonverbal intelligence.138

Children with learning disabilities may have difficulty filtering out irrelevant environmental stimuli and therefore have erratic visual attention skills. Children who have difficulty interpreting and using visual information effectively are described as having visual-perceptual problems because they have not acquired adequate visual-perceptual skills despite having normal vision.144 Children with developmental coordination disorder (DCD) obtained significantly lower scores compared with typically developing children on a motor-free test of visual perception.147 Although group differences were statistically significant, some of the children with DCD did not have general visual-perceptual dysfunction.

Dyslexia is best understood as a neurocognitive deficit that is specifically related to reading and spelling processes. Dyslexia can occur for two different reasons. One cause is that the reader has difficulty decoding words (single word identification) and encoding words (spelling).132 A second reason for dyslexia is that the reader makes a significant number of letter reversals (b – d), letter transpositions in words when reading or writing (sign – sing) or has right-left confusion.56

Daniels and Ryley studied the incidence of visual-perceptual and visual-motor deficits in children with psychiatric disorders.39 In their study, deficits in visual-motor skills occurred far more frequently than deficits in visual-perceptual skills. When visual-perceptual problems occurred, they did so in conjunction with visual-motor skill problems.

Some children with autism have demonstrated poor oculomotor function.121 Children with autism often do not appear to focus their vision directly on what they are doing.103 A possible explanation is that they use peripheral vision to the exclusion of focal vision. One study found that children with autism spend the same amount of time inspecting socially oriented pictures, have the same total number of fixations, and have scan path lengths similar to those of typically developing children.153 These results do not support the generally held notion that children with autism have a specific problem in processing socially loaded visual stimuli. The study authors suggested that the often-reported abnormal use of gaze in everyday life is not related to the nature of the visual stimuli, but that other factors, such as social interaction, may play a role.

Effects of Visual-Perceptual Problems on Performance Skills and Occupations

The effects of visual-perceptual problems may be subtle. However, when the child is asked to perform a visual-perceptual task, he or she may be slow or unable to perform it. Because visual-perceptual dysfunction affects the child’s ability to use tools and to relate materials to one another,4 bilateral manipulative skills are affected to a greater degree than the child’s basic prehension patterns indicate. The child with visual-perceptual deficits may show problems with cutting, coloring, constructing with blocks or other construction toys, doing puzzles, using fasteners, and tying shoes. Visual perception
deficits also can influence children's areas of occupation, such as activities of daily living (ADLs), education, work, play, leisure, and social participation.

Children with visual-perceptual problems may demonstrate difficulty with ADLs. In grooming, the child may have difficulty obtaining the necessary supplies and using a brush and comb and mirror to comb and style the hair. Applying toothpaste to the toothbrush may be difficult for the child. Using fasteners; donning and doffing clothing, prostheses, and orthoses; tying shoes; and matching clothes may present problems. Skilled use of handwriting, telephones, computers, and communication devices may present difficulty for the child with visual-cognitive problems. Instrumental ADLs, such as home management, may present problems. For example, the child may have trouble sorting and folding clothes. Community mobility may be difficult because the child is unable to locate objects and find his or her way. In play, the child may demonstrate difficulty with playing games and sports, drawing and coloring, cutting with scissors, pasting, constructing, and doing puzzles.

Classroom assignments may present problems for the child with visual-perceptual problems. He or she may have difficulty with educational activities such as reading, spelling, handwriting, and math. The educational problems seen in the school-aged child are considered in some detail next. Visual processing deficits are considered developmental. With maturation and experience the performance of the child with deficits improves, but the rate of maturation of skill continues to lag.

Problems in Reading

The role of phonologic processing deficits in the understanding of reading disability is significant. The deficits are manifested in the failure to use or properly understand phonologic information when processing written or oral language. This is seen in the inadequacy of phonemic awareness, the poor understanding of sound-symbol correspondence rules, and the improper storage and retrieval of phonologic information. Deficits in short- and long-term memory can also affect comprehension.

At least a subgroup of children with reading problems confuses orientation and visual recognition of letters. The characteristics of printed (written) information make reading possible; these include a word’s graphic configuration, orthography (order of letters), phonology (sounds represented), and semantics (meaning). The child benefits from these multiple simultaneous cues in reading. If the child has difficulty with one characteristic, he or she can rely on perception of the other characteristics to extract the meaning. In early reading, children first encounter the visual configuration (graphics) and orthographics of a printed word. The child then must break the written word into its component phonemes (phonology), hold them in active working memory, and synthesize and blend the phonemes to form recognizable words (semantics). Visual word recognition seems to involve a subphonemic level of processing. After practice, this step is accomplished and the word then can be dealt with as a gestalt or in its entirety rather than letter by letter and added to the child's growing sight vocabulary. Sight vocabulary consists of words that are instantly recognized as gestals. As the child’s reliance on sight vocabulary increases, decoding takes less time and automaticity develops, which allows the child to begin to concentrate on comprehension and retention.

Understanding sentences requires adding two more variables, context (word order) and syntax (grammatical construction), to the skills previously discussed. For reading paragraphs, chapters, and texts, it is assumed that decoding is automatic. A hierarchy can be assumed such that any developmental dysfunctions that impair decoding or sentence comprehension impede text reading.

The segmenting of written words in early reading calls for a variety of skills. First, children must be able to recognize individual letter symbols. This requires visual attention, visual memory, and visual discrimination. Two aspects of word reading are important for comprehension: accuracy and speed. The more attentional resources are consumed by lower level process (i.e., word identification), the fewer resources are available for comprehension.

Letter knowledge contributes significantly to reading and should be measured in preschool, kindergarten, and first grade. The prerequisite skills of letter naming and phonemic awareness should be assessed early in kindergarten.

Visual-perceptual attributes are different from the capacity to assimilate visual detail. The child may be diagnosed as having visual-perceptual problems when he or she is limited in attending to or extracting data presented simultaneously. In this instance the child does not have difficulty with the specific perceptual content but with the amount of information that must be simultaneously perceived to understand the whole.

Children with visual discrimination deficits may not be able to recognize symbols and therefore may be slow to master the alphabet and numbers. Their relatively weak grasp of constancy of forms may make visual discrimination an inefficient process. Some children cannot readily discern the differences between visually similar symbols. Confusion between the letters b, d, and g and between a and o, as well as letter reversals, may result, such as the notorious differentiation between b and d. A meta-analysis was conducted using 161 studies to examine the relationship between visual-perceptual skills and reading achievement. The findings suggest that visual perception is an important correlate of reading achievement and should be included in the complex of factors predicting it. Visual discrimination abilities (form perception and spatial perception) are somewhat less important at advanced stages of the learning-to-read process than they are during the initial stages of reading acquisition.

Confusion over the directionality and other spatial characteristics of a word may result in weak registration in visual memory, again possibly causing significant delays in the consolidation of a sight vocabulary. Even frequently encountered words need to be analyzed anew each time they appear. A child with visual-spatial deficits has difficulty with map reading and interpretation of instructional graphics such as charts and diagrams. Graphic representations require the child to integrate, extract the most salient elements from, condense, and organize the large amount of stimuli presented at once. Again, the child may not have difficulty with the perceptual content, but the amount of information to be assimilated simultaneously is more than the child can integrate and remember.

Memory deficits affect reading in a number of ways. Children with visual memory problems may be unable to remember the visual shape of letters and words. Such children may
also demonstrate an inability to associate these shapes with letters, sounds, and words. Children with weaknesses of visual-verbal associative memory have difficulty establishing easily retrievable or recognizable sound-symbol associations. They are unable to associate the sound, visual configuration, or meaning of the word with what is seen or heard. Children who have difficulty with active working memory also may have difficulty holding one aspect of the reading process in suspension while pursuing another component. This ability is closely related to perceptual span, or the ability to recall the beginning of the sentence while reading the end of it. The child must take a second look at the beginning of a sentence after reading the end of it.

With severe dysfunction, recognition of words may be impaired, which interferes with the acquisition of sight vocabulary. Problems with visual perception might be suspected in a child who appears to be better at understanding what was read than at actually decoding the words. This child has good language abilities but some trouble processing written words.

According to Raymond and Sorensen, children with dyslexia have been shown to have normal detection but abnormal integration of visual-motion perception. The authors suggest that perhaps a collection of inefficient information-processing mechanisms produces the characteristic symptoms of dyslexia.

Problems in Spelling

Research by Giles and Terrel does not support the hypothesis that proficient spelling is mediated by visual memory. They suggest that spelling skills may depend on both visual recognition or visual imagery ability. Children with impaired processing of simultaneous visual stimuli may have difficulty with spelling. Their inability to visualize words may result from indistinct or distorted initial visual registration. Such children who have strong sound-symbol association may spell the word phonetically (e.g., lite for light) yet incorrectly.

Problems in Handwriting and Visual Motor Integration

Handwriting requires the ability to integrate the visual image of letters or shapes with the appropriate motor response. Handwriting difficulties affect between 10% to 30% of school-age children. Visual-cognitive abilities may affect writing in a variety of situations. Children with problems in attention may have difficulty with correct letter formation, spelling and the mechanics of grammar, punctuation, and capitalization. They also have difficulty formulating a sequential flow of ideas necessary for written communication. For a child to write spontaneously, he or she must be able to visualize letters and words without visual cues. A child with visual memory problems may have difficulty recalling the shape and formation of letters and numbers. Other problems seen in the child with poor visual memory include mixing small and capital letters in a sentence, writing the same letter many different ways on the same page, and being unable to print the alphabet from memory. In addition, legibility may be poor, and the child may need a model to write.

Visual discrimination problems may also affect the child’s handwriting. The child with poor form constancy does not recognize errors in his or her own handwriting. The child may be unable to recognize letters or words in different prints and therefore may have difficulty copying from a different type of print to handwriting. The child may also show poor recognition of letters or numbers in different environments, positions, or sizes. If the child is unable to discriminate a letter, he or she may have difficulty forming it. A child with visual-closure difficulty always needs to see the complete presentation of what he or she is to copy. A child with figure-ground problems may have difficulty copying because he or she is unable to determine what is to be written; the child therefore may omit important segments or may be slower than peers in producing written products.

Visual-spatial problems can affect a child’s handwriting in many ways. The child may reverse letters such as m, w, h, d, s, c, t, and z and numbers such as 2, 3, 5, 6, 7, and 9. If the child is unable to discriminate left from right, he or she may have difficulty with left–to-right progression in writing words and sentences. The child may overspace or underspace between words and letters and may have trouble keeping within the margins. The most common spatial errors in handwriting involve incorrect and inconsistent spacing between writing units, and variability in orientation of major letter features when the letter is written repeatedly. When a child has a spatial disability, he or she may be unable to relate one part of a letter to another part and may demonstrate poor shaping or closure of individual letters or a lack of uniformity in orientation and letter size. The child may have difficulty placing letters on a line and adapting letter sizes to the space provided on the paper or worksheet. Pilot studies have begun to explore the relationship between visual-cognitive skills and handwriting. Tseng and Cermak found that visual perception shows little relationship to handwriting, whereas kinesethesia, visual-motor integration, and motor planning appear to be more closely related to it.

Further research is necessary to better understand the role of visual perception in handwriting.

Failure on visual-motor tests may be caused by underlying visual-cognitive deficits, including visual discrimination, poor fine motor ability, or inability to integrate visual-cognitive and motor processes, or by a combination of these disabilities. Therefore, careful analysis is necessary to determine the underlying problem. Tseng and Murray examined the relationship of perceptual-motor measures to legibility of handwriting in Chinese school-age children. They found visual-motor integration to be the best predictor of handwriting. Weil and Cunningham-Amundson studied the relationship between visual-motor integration skills and the ability to copy letters legibly in kindergarten students. A moderate correlation was found between students’ visual-motor skills and their ability to copy letters legibly. The researchers found that as students’ scores on the Developmental Test of Visual-Motor Integration (VMI) increased, so did scores on the Scale of Children’s Readiness in Printwriting (SCRIPT). Also, students who were able to copy the first nine forms on the VMI were found to perform better on the SCRIPT. Daly, Kelley, and Krauss partly replicated the Weil and Cunningham-Amundson study and found a strong positive relationship between kindergarten students’ performance on the VMI and their ability to copy letter forms legibly. They suggest that students are ready for formal handwriting.
instruction once they have the ability to copy the first nine forms on the VMI.

Extensive research on the relationship between visual-motor integration and handwriting skills has been completed. Studies of handwriting remediation suggest that intervention is effective. There is some evidence that handwriting difficulties do not resolve without intervention.81

Problems in Mathematics

Poor visual-perceptual ability is significantly related to poor achievement in mathematics, even when controlling for verbal cognitive ability. Therefore, visual perceptual ability, and particularly visual memory, should be considered to be among the skills significantly related to mathematics achievement.85 Consequently, visual-perceptual ability, and particularly visual memory skill, should be assessed in children with poor achievement in mathematics. The child with visual-perceptual problems can have difficulty aligning columns for calculation, and answers therefore are incorrect because of alignment problems and not calculation skills. Worksheets with many rows and columns of math problems may be disorienting to children with figure-ground problems. Children with poor visual memory may have difficulty using a calculator. Visual memory difficulties also may present problems when addition and subtraction problems require multiple steps. Geometry, because of its spatial characteristics, is very difficult for the child with visual-spatial perception problems. Recognition, discrimination, and comparison of object form and space are part of the foundation of higher-level mathematical skills. The visual imagery required to match and compare forms and shapes is difficult for students with visual-perceptual problems, which interfere with their ability to learn these underlying skills.

A longitudinal investigation that studied the relationship of sensory integrative development to achievement found that sensory integrative factors, particularly praxis, were strongly related to arithmetic achievement.102 This relationship was found at younger ages (6 to 8 years), and the strength of the association declined with age (10 to 12 years).

Evaluation of Visual-Receptive Functions

Evaluation should begin by focusing on the integrity of the visual-receptive processes, including visual fields, visual acuity, and oculomotor control.158 When children who have deficits in these foundational skills, insufficient or inaccurate information about the location and features of objects is sent to the CNS, and the quality of their learning through the visual sense is severely affected. Warren suggested that what sometimes appear to be visual-cognitive deficits are actually visual-receptive problems, which may include oculomotor disturbances.156 Therefore, visual-receptive and visual-cognitive deficits may be misdiagnosed. The occupational therapist should be familiar with visual screening, because evaluation of vision and oculomotor skills assists in the assessment and analysis of their influence on visual perception and functional performance.144

Visual screening consists of basic tests administered to determine which children are at risk for inadequate visual functions.15,72 The purpose of the screening is to determine which children should be referred for a complete diagnostic visual evaluation. Therefore, the purpose of screening the visual-receptive system is to determine how efficient the eyes are in acquiring visual information for further visual-cognitive interpretation. The checklist presented in Figure 12-3 can alert the therapist to visual symptoms commonly found in children who demonstrate poor visual performance.

Perimetry (computerized measurement of visual field by systematically showing lights of differing brightness and size in the peripheral visual field), confrontation, and careful observation of the child as he or she performs daily activities provide useful information about field integrity.165 For example, missing or misreading the beginning or end of words or numbers may indicate a central field deficit.

The child’s refractive status, which is the clinical measurement of the eye, should be determined. A school nurse or vision specialist usually performs this test. The refractive status reflects whether the student is nearsighted (myopic),
farsighted (hyperopic), or has astigmatism. Several methods can be used to determine a child’s refractive status. One method, the Snellen test, is used to screen children at school or in the physician’s office. However, it measures only eyesight (visual acuity) at 20 feet. This figure, expressed commonly as 20/20 for normal vision, has little predictive value for how well a child uses his or her vision. It is estimated that the Snellen Test detects fewer than 5% of visual problems. When a child passes this screening, he or she may be told that the existing vision is fine. However, it is only the eyesight at 20 feet that is fine.

Some schools and clinics use a Telebinocular or similar instrument in vision screening. This device provides information on clarity or visual acuity at both near and far distances, as well as information on depth perception and binocularity (two-eyed coordination). Warren suggested that the Contrast Sensitivity Test is best for measuring acuity. A pediatric version of this test is available (Vistech Consultants, Dayton, Ohio).

The occupational therapist may observe oculomotor dysfunction in the child. The screening test should answer several questions, including the following:

1. Do the eyes work together? How well?
2. Where is visual control most efficient and effective? Least efficient and effective?
3. What types of eye movements are quick and accurate? Which are not?
4. Does the child move his head excessively when reading? Skip lines when reading?

Screening tests that can be used by occupational therapists are presented in Table 12-2.

In addition, the child’s ocular health should be evaluated. The presence of a disease or other pathologic condition, such as glaucoma, cataracts, or deterioration of the nerves or any part of the eye, must be ruled out. An interview with the family regarding significant visual history helps identify any conditions that may be associated with visual limitations. This information can also be obtained from a review of the child’s records and from consultation with other professionals involved in direct care of the child (e.g., teacher or physician).

When visual problems are detected in screening, the child may be referred to a vision specialist such as an optometrist. The specialist can help determine whether the child has a visual problem that might be causing or contributing to school difficulties. The therapist then will be able to understand the effect those deficits have on function and can devise intervention strategies by designing and selecting appropriate activities that are within the child’s visual capacity.

### Table 12-2: Vision Screening Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Authors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Screening</td>
<td>Bouska, Kauffman, &amp; Marcus (1990)</td>
<td>Comprehensive screening test of distance and near vision, convergence near point, horizontal pursuits, distant and near fixations, and stereoscopic visual skills to identify children who should be referred to a qualified vision specialist for a complete diagnostic visual evaluation.</td>
</tr>
<tr>
<td>Pediatric Clinical Vision Screening</td>
<td>Scheiman (1991)†</td>
<td>A test that screens accommodation, binocular vision, and ocular motility.</td>
</tr>
<tr>
<td>for Occupational Therapists</td>
<td></td>
<td>Description methods for testing vision in early intervention programs.</td>
</tr>
<tr>
<td>Clinical Observations of Infants</td>
<td>Ciner, Macks, &amp; Schanel-Klitsch (1991)</td>
<td></td>
</tr>
</tbody>
</table>


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**Evaluation of Visual-Cognitive Functions**

Clinical evaluation and observation may be the occupational therapist’s most useful assessment methods. The therapist should observe the child for difficulty selecting, storing, retrieving, or classifying visual information. Observations may include visual search strategies used during visual-perceptual tasks (e.g., outside borders to inside), how the child approaches the task, how the child processes and interprets visual information, the child’s flexibility in analyzing visual information, methods used for storage and retrieval of visual information, the amount of stress associated with visual activities, and whether the child fatigues easily during visual tasks. The therapist should analyze the tasks observed carefully to determine what visual skills are needed and to identify the areas in which the child has difficulty.

Tsurumi and Todd have applied task analysis to the nonmotor tests of visual perception. This information greatly assists the therapist in analyzing the results of these tests. Currently, the best method for evaluating visual attention in children is informal observation during occupational performance tasks. Standardized assessments that may be used include the following:

* Bruininks-Oseretsky Test of Motor Proficiency (2nd Ed.) (BOT-2): An individually administered, standardized test for individuals 4 through 21 years of age. The test measures a wide array of motor skills. The eight subtests include fine motor precision, fine motor integration, manual dexterity,
bilateral coordination, balance, running speed and agility, upper-limb coordination, and strength. This test has been the most widely used standardized measure of motor proficiency and has good reliability and validity. • Test of Visual Analysis Skills \(^{22}\): An untimed, individually administered, criterion-referenced test for children 5 to 8 years of age. The child is asked to copy simple to complex geometric patterns. The purpose of the assessment is to determine if the child is competent at or in need of remediation for perception of the visual relationships necessary for integrating letter and word shapes. Reliability and validity of this test indicate that the psychometric properties are adequate.

**Visual-Spatial Tests**
- **Jordan Left-Right Reversal Test, revised\(^{27}\):** An untimed, standardized test for children 5 to 12 years of age that can be administered individually or to a group. It is used to detect visual reversals of letters, numbers, and words, and the test manual includes remediation exercises for reversal problems. The test takes about 20 minutes to administer and score and has good test-retest reliability and criterion-related validity.

**Visual-Perceptual Tests**
- **Test of Visual-Perceptual Skills (Non-Motor), Third Edition \(\text{(TVPS-R)}\)^{94}:** A norm-referenced test for children 4 to 18 years of age that can be administered individually or to a small group. The subtests include visual discrimination, visual memory, visual-spatial relationships, form constancy, visual-segmental memory, visual figure-ground and visual closure. The test uses black and white designs as stimuli for perceptual tasks, and responses are made vocally or by pointing.
- **Developmental Test of Visual Perception, Second Edition \(\text{(DTVP-2)}\)^{98}:** A norm-referenced test for children 4 to 10 years of age that is unbiased relative to race, gender, and handedness. The eight subtests include hand-eye coordination, copying, spatial relationships, position in space, figure-ground competence, visual closure, visual-motor speed, and form constancy. This test has been shown to have strong normative data and good reliability and validity.
- **Componential Assessment of Visual Perception \(\text{(CAVP)}\)^{113}:** A computer-assisted evaluation tool that was designed as a process-based approach to the evaluation of visual-perceptual functioning in children and adults with neurologic disorders. Promising clinical usefulness has been reported in terms of utility, ease of use, format, and appeal.\(^{112}\)
- **Motor-Free Visual Perception Test, Third Edition \(\text{(MVPT-3)}\)^{35}:** A norm-referenced test that is quick and easy to administer. Scoring requires adding the number of correct choice responses. This test has a high test-retest reliability and internal validity. Also, criterion validity is determined relative to academic performance.
- **Test of Pictures, Forms, Letters, Numbers, Spatial Orientation, and Sequencing Skills\(^{24}\):** A norm-referenced test for children 5 to 9 years of age that can be administered individually or to a group. The test, which has seven subtests, measures the ability to perceive forms, letters, and numbers in the correct direction and to perceive words with letters in the correct sequence.

**Visual-Motor Integration Tests**
- **Wide Range Assessment of Visual Motor Abilities \(\text{(WRAVMA)}\)^{1}:** A norm-referenced, standardized test for children 3 to 17 years of age. Assesses and compares visual-spatial skills through the matching subtest, fine motor skills through the pegboard subtest and integrated visual-motor skills through the drawing subtest. Each subtest requires 4 to 10 minutes and offers easy administration and sound psychometric properties.
- **The Developmental Test of Visual-Motor Integration, 5th Edition, Revised \(\text{(VMI)}\)^{9}:** This test assesses three subtest areas for individuals 2 to 19 years of age and has strong content, concurrent and construct validity. These tests can be used to evaluate how the child is processing, organizing, and using visual-cognitive information. Care should be taken in interpreting and reporting test results because it is not always clear what visual-perceptual tests are measuring. Because of the complexity of the tests, it is certain that they tap different kinds and levels of function, including language abilities.

The effectiveness of any treatment method is largely determined by how the child is diagnosed; therefore, careful analysis of test results and observations is important. Burtner et al. provided a critical review of seven norm-referenced, standardized tests of visual-perceptual skills frequently administered by pediatric therapists.\(^{22}\) Each assessment tool was critically appraised for its purpose, clinical utility, test construction, standardization reliability, and validity. Discussion focused on the usefulness of these assessment tools for describing, evaluating, and predicting visual-perceptual functioning in children.

**INTERVENTION**

**Theoretical Approaches**
The theoretical approaches that guide evaluation and treatment of visual-perceptual skills can be categorized as developmental, neurophysiologic, or compensatory. The developmental model devised by Warren,\(^{157,158}\) described in a previous section, is based on the concept that higher level skills evolve from integration of lower level skills and are subsequently affected by disruption of lower level skills. Skill levels in the hierarchy function as a single entity and provide a unified structure for visual perception. As pictured in Figure 12-2, oculomotor control, visual field, and acuity form the foundational skills, followed by visual attention, scanning, pattern recognition or detection, memory, and visual cognition. Identification and remediation of deficits in lower level skills permit integration of higher-level skills. Occupational therapists who follow this model need to evaluate lower level skills before proceeding to higher level skills to determine where
The deficit is in the visual hierarchy and to design appropriate evaluation and intervention strategies. The neurophysiologic approaches address the maturation of the human nervous system and the link to human performance. These approaches help create environmental accommodations to sensory hypersensitivity and visual distractibility. They also promote organization of movement around a goal, reinforcing the sensory feedback from that movement. Neurophysiologic approaches emphasize the importance of postural stability for oculomotor efficiency. The role of visual perception as part of sensory integration and the way the child perceives his or her environment are discussed in Chapter 11. The neurophysiologic approaches focus on improving visual-receptive and visual-cognitive components to enhance a child’s occupational performance.

Learning theories and behavioral approaches emphasize a child’s development of visual analysis skills. The therapist provides the child with a systematic method for identifying the pertinent, concrete features of spatially organized patterns, thereby enabling the child to recognize how new information relates to previously acquired knowledge on the basis of similar and different attributes. Because the child learns to generalize to dissimilar tasks, that improvement in visual-perceptual skills leads to increased levels of occupational performance.

In compensatory approaches, classroom materials or instructional methods are modified to accommodate the child’s limitations. The environment can also be altered or adapted. The therapist may work with the classroom teacher on behalf of the child to provide necessary supports. Adaptation and compensation techniques can include reducing classroom visual distractions, providing visual stimuli to direct attention and guide response, and modifying the input and output of computer programs. In daily living skills, adaptations to increase grooming, dressing, eating, and communication skills can be made. In play situations, toys can be made more accessible, and in work activities, adaptations can be made to promote copying, writing, and organizational skills. Box 12-1 outlines compensatory instruction guidelines.

Perceptual training programs use learning theories to remediate deficits or prerequisite skills and have been implemented in the public schools for more than 2 decades. Occupational therapists generally use activities from these approaches in combination with neurophysiologic and compensatory approaches.

Optometry and occupational therapy have common goals related to the effects of vision on performance.125 When a visual dysfunction is identified, sometimes only environmental modifications (e.g., changes in lighting, desk height, or surface tilt) are needed to alleviate the problem. In many cases, glasses (lens therapy) are prescribed to reduce the stress of close work or to correct refractive errors. In other cases, optometric vision therapy may be prescribed by an optometrist and carried out collaboratively with an occupational therapist. Through vision therapy, optometrists provide structured visual experiences to enhance basic skills and perception. Vision training is well supported by evidence but should be performed only under supervision of an optometrist. Collaboration between the occupational therapist and the optometrist is supported by case studies and clinical judgment.

**Intervention Strategies**

For a child of any age, an important treatment strategy is education regarding the problem the child is experiencing.150 The occupational therapist can help interpret the functional implications of the vision problem for the child and his or her parents, caregivers, and teachers. At times this can be the most helpful intervention for the child. This section presents intervention suggestions according to age groups. However, activities should be analyzed and then selected according to the child’s needs rather than according to his or her age group.

These activities illustrate both the developmental and compensatory approaches. Often activities combine approaches. For example, when classroom materials are adapted so that the print is larger and less visual information is presented (compensatory approach), the child might be better able to use visual-perceptual skills, with resulting improvement in those skills (developmental approach). For each age group, the focus of intervention is occupation in natural environments. The aim of occupational therapy intervention is to reduce activity limitations and enhance participation in everyday activities.145

**Infants**

Glass presented a protocol for working with preterm infants in a neonatal intensive care unit (NICU).62 Dim lighting allows the newborn to spontaneously open his or her eyes. Stimulation of the body senses (e.g., tactile-vestibular stimulation) can influence the development of distance sense (e.g., visual), which matures later.120,131 On the basis of research of neonatal vision, Glass suggested ways to use the human face as the infant’s first source of visual stimulation. The intensity, amplitude, and distance of the stimulus depend on whether the intent is to arouse or quiet the infant. Glass also recommended beginning with softer, simpler forms and three-dimensional objects and varying the stimuli based on whether the intent is to soothe or arouse the infant. Mobiles hung over cribs should be placed approximately 2 feet above the infant and slightly to one side. This allows for selective attention by the infant. In addition, Glass suggested that black and white patterns be reserved for full-term infants who are visually impaired and unable to attend to a face or toy.62 Once a visual response is elicited with the high-contrast pattern, a shift to a pattern with less contrast should be made. Recent studies suggest that 3- to 5-month-old infants may be attracted to toys that reflect

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**BOX 12-1 Compensatory Instruction Guidelines**

1. Limit the amount of new material presented in any single lesson.
2. Present new information in a simple, organized way that highlights what is especially pertinent.
3. Link new information with the information the child already knows.
4. Use all senses.
5. Provide repeated experiences to establish the information securely in long-term memory; practice until the child knows it and does not need to figure it out.
light or flash light congruently with a sound. At the age of 4½ months, the preference for the familiar precedes the preference for novel as infants examine visual stimuli. This presentation of stimuli is important in the formation of memory representations.

Preschool and Kindergarten

Occupational therapists can help preschool and kindergarten teachers organize the classroom activities to help children develop the readiness skills needed for visual perception. Teachers should understand the increased need for a multisensory approach with young children who are struggling with shape, letter, and number recognition. For example, the child might benefit from tactile input to learn shapes, letters, and numbers. By using letters with textures, the child has additional sensory experiences on which he or she can rely when visual skills are diminished. Children should be encouraged to feel shapes, letters, and words through their hands and bodies. Letters can be formed with clay, sandpaper, beads, or chocolate pudding (Figure 12-4). Studies have shown that the incorporation of visuo-haptic and haptic exploration of letters in reading training programs facilitates 5-year-old children’s understanding of the alphabet.

All preschool, kindergarten, and primary classes should include frequent activities that develop body-in-space concepts to improve spatial perception. Even with a range of levels of understanding among young students, group activities, such as Statue, shadow dancing, and Simon Says, can reinforce body-in-space comprehension. Children benefit from watching and imitating one another. The therapist may pair children so that one can model for the other in an obstacle course or other gross motor activity. Appendix 12-A on the Evolve website lists publications describing activities for both classroom teachers and therapists.

Shared storybook reading has been found to provide a particularly useful context within which to promote at-risk preschoolers’ emergent literacy knowledge. Further study has shown placing that emphasis on the print concepts by talking about and by pointing to the print increases visual attention to it. Children attended to print significantly more often when being read a storybook with large narrative print, relatively few words per page, and multiple instances of print embedded within the illustrations. Studies of handwriting suggest that no significant difference in letter writing legibility exists between kindergartners who use paper with lines and those who use paper without lines. The study investigators suggest that teachers allow kindergarten children to experiment with various types of writing paper when initially learning proper letter formation.

Elementary School

Therapy should begin at the level of the visual hierarchy where the child is experiencing difficulty. If the child is experiencing difficulty with visual-receptive skills, cooperative efforts between the occupational therapist and the optometrist may be helpful. The school-based occupational therapist’s objectives for improving visual-receptive skills (as these appear on student’s individualized education program) are to support the child’s academic goals and appropriate curricular outcomes.

Organizing the Environment

Visual perception affects a child’s view of the entire learning environment. Visually distracting and competing information can be problematic to the child who has not yet fully developed his or her skills. The child may require that the classroom be less “busy” visually to allow him or her to focus on learning. Limiting a distractible child’s peripheral vision by using a carrel is often helpful (Figure 12-5). In addition, the level of illumination needs to be monitored, and glare must be controlled.

The child needs a stable postural base that allows his or her eyes to work together. Children often sit at ill-fitting furniture, which can compound their problems. The occupational therapist can help the teacher properly position the child. The therapist can add bolsters to seat backs, put blocks under the child’s feet, or provide the child with a slant board if any of these materials will help the child use vision more efficiently or increase productivity. The therapist can also stress the importance of encouraging different positions for visual activity. Figure 12-6 shows such alternative positions as prone, “television position” for sitting, and side-lying for visual-perceptual activities such as reading. Each position should place the child in good alignment and should offer adequate postural support.

Children may benefit from color-coded worksheets to help them attend to what visually goes together. However, children with color vision problems may have difficulty with educational materials that are color coded, particularly when the colors are pastel or muddy. Therefore, it is important to differentiate an actual visual color deficit from a problem either with color naming or with color identification.

Christenson and Rascho proposed strategies to assist the elderly in topographic orientation, and these can be adapted for children. The authors found that use of landmarks and signage can enhance wayfinding skills and topographic orientation. They recommend the use of pictures or signs that are

FIGURE 12-4 Kyle making letters with clay.
realistic and simple and that have high color contrast. For example, a simple, graphic depiction of a lunch tray with food could be used for the cafeteria door.

**Visual Attention**

With a sensory processing approach, general sensory stimulation or inhibition may be provided during or before visually oriented activities to improve visual attending skills. If the child is overaroused, the therapist can diminish sensory input to calm him or her; if the child is underaroused, the therapist selects alerting activities to increase the level of arousal.

For the child with impaired visual attention, the therapist addresses goals using varied activities and time segments that are achievable. The therapist identifies activities that are intrinsically motivating to the child because these help maintain the child’s attention. The therapist should plan activities together with the child and use as many novel activities as possible. Most challenging to the therapist is adapting or modifying task activities while maintaining a playful learning environment for the child. For example, the therapist may have many activities focusing on the same visual-perceptual problem, and he or she changes activities frequently, depending on the child’s sustained attention to the task. The therapist also gradually increases the amount of sustained attention needed to complete the task. Elimination of extraneous environmental stimuli is helpful at each level of visual attention.

The occupational therapist can be a consultant to the classroom teacher suggesting ways to improve the child’s attention to learning in the classroom. For instance, the therapist can provide activities during a classroom session and then leave further suggestions for activities that the teacher can implement during the week. Specific components of attention could be addressed in a hierarchical manner so that intervention tasks gradually place greater demands on attention (e.g., progressing from sustained attention to divided attention).

Visual attention skills are enhanced by activities that are developmentally appropriate and visually and tactically stimulating. Manual activities such as drawing or manipulating clay encourage the eyes to view the movements involved. In addition, the hand helps educate the eye about object qualities such as weight, volume, and texture and helps direct the eye to the object. Simultaneous hand and eye movements construct internal representations of objects and improve object recognition.

Activities to compensate for limitations in attention include (1) placing a black mat that is larger than the worksheet underneath it to increase high contrast, thereby assisting visual attention to the worksheet; (2) drawing lines to group materials; and (3) reorganizing worksheets. Visual stimuli on a worksheet or in a book can be reduced by covering the entire page except the activity on which the student is working or by using a mask that uncovers one line at a time (Figure 12-7). Reducing competing sensory input in both the auditory and visual modalities can be helpful for some students with poor visual attention.
Visual Memory

Children with visual memory problems need consistent experiences; the therapist therefore should consult with the parents and teachers so that this consistency can be maintained at home and in the classroom. There is no evidence that repetitive practice of word lists or objects generalizes to other material. Instead, memory strategies may help with encoding or with the retrieval of memory. Grouping information in ways that provide retrieval cues can help a child remember interrelated data. Several strategies may be helpful. **Chunking** is organizing information into smaller units, or chunks. This can be done by cutting up worksheets and presenting one unit or task at a time. **Maintenance rehearsal** (repetition) helps the child hold information in his or her short-term memory but seems to have no effect on long-term storage. An example of this strategy would be repeating a phone number until the number is dialed. **Elaborative rehearsal** is a strategy by which new information is consciously related to knowledge already stored in long-term memory. By the time a child is 8 years of age, he or she can rehearse more than one item at a time and can rehearse information together as a set to remember. Children can also relate ideas to more than one other idea.

Mnemonic devices are memory-directed tactics that help transform or organize information to enhance its retrievability through use of language cues such as songs, rhymes, and acronyms. Gibson suggested that memory is composed primarily of distinctive features (what makes something different). If the child has good visualization, this can be used as a memory strategy for encoding information. Occupational therapists can help the child determine differences in visual stimuli to promote storage in memory. Playing games such as Concentration, copying a sequence after viewing it for a few seconds, or remembering what was removed from a tray of several items can be enjoyable ways to increase visual memory (Case Study 12-1). The therapist first provides the student with short, simple tasks that he or she can complete quickly and successfully; gradually, as the student accomplishes tasks, the therapist increases their length and complexity.

External strategies and aids can also be used, such as note-books, hand-held computers, and tape recorders, to name a few. Also, tasks and environments can be rearranged so that they are less demanding on memory. Examples include labeling drawers with the contents inside them, making cue cards with directions for tasks, and posting signs to help the child find his or her classroom. Emotional memory has been shown to be the strongest kind of memory. When students are deeply interested and emotionally involved in what they are reading, they are more likely to comprehend and learn from it.

**Visual Discrimination**

The therapist must use task analysis to design an intervention program. Remediation should follow an orderly design so that the child can make sense of each performance. By analyzing the continuum of a task, the therapist can grade the activity from simple to complex to allow success while challenging the child’s visual abilities. Intervention strategies should aim to help children recognize and attend to the identifying features by teaching them to use their vision to locate objects and then to use object features as well as other cues to form identification hypotheses. Teaching children to scan or search pictures visually instructs the child in the value of looking for and finding meaning. With high-interest materials the therapist can teach the child to look from top to bottom and left to right. Using pictures from magazines, the therapist removes an important part of a picture and asks the student to identify what part is missing. Drawing, painting, and other art and craft activities encourage exploration and manipulation of visual forms. As the child moves from awareness to attention and then to selection, he or she becomes better able to discriminate between the important and unimportant features of the environment.

Occupational therapists can assist teachers in reorganizing the child’s worksheets. Color-coding different problems may assist the child in visually attending to the correct section. Worksheets can also be cut up and reorganized to match the

FIGURE 12-7  Todd uses a mask to uncover one line at a time.
CASE STUDY 12-1  Todd

When Todd was a 9-year-old student in the third grade, most of his day was spent in the regular third grade classroom, where he functioned at grade level in all areas of academics except reading. Todd received daily resource room instruction in this area. This instruction consisted of copying, worksheet completion, and drill and repetition techniques and did not include opportunities for manipulative activities.

An occupational therapy evaluation indicated that Todd’s perceptual skills were delayed about 2 years, with weaknesses noted in visual-spatial relations, figure-ground perception, and visual sequential memory. From interviewing the teacher, the therapist learned that Todd was not moving from learning to read to reading to learn. His decoding was not automatic; therefore, he was spending considerable time figuring out what the words were rather than comprehending what he was reading. He also reported that his eyes tired easily while reading. Good eye movements were needed to sustain reading for longer periods. Because of poor spatial abilities, Todd had difficulty discerning differences in visually similar symbols and had difficulty with words that differed only by sequence (three and there) or spatial orientation (dad and bad). The third grade reading books had more print per page and fewer illustrations to give cues. Too many words on the page made it difficult for Todd because of his poor figure-ground abilities. He demonstrated an inability to recall the exact order of words, poor sight vocabulary, and poor spelling caused by poor visual sequential memory.

The therapist referred Todd for optometric evaluation because of his reported visual fatigue during reading tasks. Planning together with Todd, the therapist and the teacher developed strategies to assist him in increasing his visual memory. Initially, short visual memory tasks were used, and gradually the length of tasks was increased. This was done using visual memory games (such as Concentration) and activities on the computer. In addition, visual discrimination tasks were started, beginning with simple forms and moving to forms that were more complex.

In consultation with the teacher, the therapist recommended reducing the amount of print per page and masking what was not immediately needed when this could not be done. Phonics approaches to word recognition were recommended (see Table 12-3), as were using verbal mediation to decode words.

Reduction of the amount of print on a page (less print, fewer math problems) and providing mathematical problems on graph paper with numbers in columns in the 1s, 10s, and 100s places helps students with figure-ground difficulties. Masking the part of the worksheet not being worked on can help the child focus on one problem at a time. Cooper proposed a theoretic model for the implementation of color contrast to enhance visual ability in the older adult. Principles of color contrast and the ways in which color contrast can be achieved by varying hue, brightness, or color saturation, of an object in relation to its environment are the foundation of the method of intervention. This helps a child identify the relevant information, such as the classroom materials and supplies.

Decoding Problems in Reading
Children who have difficulty distinguishing between similar visual symbols may benefit from a multisensory approach. This includes tracing the shapes and letters, hearing them, saying them, and then feeling them, allowing a number of routes of processing to help supplement weak visual-perceptual processing. Thus the child sees it, hears it, traces it, and writes it. Eating letters is an activity children love; alphabet cereal, gelatin jiggles, and cookies in the shape of letters can be served for snacks. Children can trace the letters with frosting from tubes onto cookies and with catsup from packets.

For children with word recognition difficulty, the initial emphasis should be on recognition rather than retrieval. The child can be given a choice of visually similar words to complete sentences that have single words missing. In addition, using word families (ball, call, and tall) to increase sight vocabulary enhances word recognition skills. Phonics approaches may also be the best reading instruction method for children with poor word recognition. Textbooks recorded on CDs can be ordered from local and state libraries from the American Printing House for the Blind (1839 Frankfurt Ave., P.O. Box 6085, Frankfurt, KY 40206). The student can hear and read the textbook at the same time, which provides input through two sensory modalities.

If the child has strong verbal skills, verbal mediation (talking through printed words) should be stressed, and the child could be encouraged to describe what he or she sees to retain the information. A strategy that may assist a child who reverses letters in words is to follow along the printed lines with a finger. This technique helps stress reading the letters in the correct sequence. Reading material rich in pictorial content (e.g., comic books), pictures with captions and cartoons, and computer software designed to enhance sight vocabulary can strengthen these associations. Verbal instruction to guide and support the child’s nonverbal problem-solving processes and direct verbal training on a spatial task have been shown to be an effective treatment strategy for children with nonverbal learning difficulties.
Several studies support the use of colored filters to improve reading skills.\textsuperscript{14,128} Color overlays have been used for children with difficulty reading due to visual fatigue and visual perceptual distortions that are reported as movement of the print (jumping, fading, disappearing, blurring), merging of the print and background, and patterns within the print. Research suggests that they may be a beneficial tool to use when children have reading difficulties. Blaskey et al. investigated the effectiveness of Irlen (colored) filters for improving comfort and reading performance and for determining whether traditional optometric intervention would be effective in relieving the symptoms commonly reported by people seeking help through the use of Irlen filters.\textsuperscript{12} Results revealed that subjects in both treatment groups showed improvement in vision functioning. Although the subjects in the Irlen filter group did not show any significant gains in reading rate, work recognition in context, or comprehension, they did report increased comfort in vision when reading.

The What Works Clearinghouse collects, reviews, and reports on studies of education programs, products, practices, and policies in selected topic areas, using a set of standards based on scientifically valid criteria. Programs in early childhood education including print awareness and beginning reading are reviewed. The site can be accessed at http://www.w-w-c.org or http://www.whatworks.ed.gov.

**Visualization**

The development of visualization techniques, or visual imagery, may be delayed. Like all skills, this proceeds from the concrete to the abstract. Therapists can start by helping students picture something that they can touch or feel. Using a grab bag with toys or objects inside that the child identifies without vision is a good way to do this.

As material becomes less concrete, more visual skills are drawn into play. A student might be asked to visualize something that he or she has done. The occupational therapist can facilitate the child’s thinking by reminding him or her to consider various factors, such as color, brightness, size, sounds, temperature, space, movement, smells, and tastes. The hope is that once the child practices verbally, he or she will generalize the visualization process to reading.\textsuperscript{7}

Children with poor visualization may have difficulty spelling and may need to learn spelling rules thoroughly. They may also demonstrate reading comprehension problems. In addition, they may have difficulty forming letters because they are unable to visualize them. This would become evident when the child writes from dictation. Sometimes the child can visualize a letter from the sound, but it is reversed or missing parts.

**Learning Styles**

All students have a preferred learning style.\textsuperscript{24,26} When a student is taught through his or her preferred style, the child can learn with less effort and remember better.\textsuperscript{44,114} Figure 12-8 shows diagnostic learning styles. All students need to be taught through their strongest senses and then reinforced through their next strongest sense.

Auditory learners recall at least 75% of what is discussed or heard in a normal 40- to 45-minute period. Visual learners remember what they see and can retrieve details and events by concentrating on the things that they have seen. Tactile and kinesthetic learners assimilate best by touching, manipulating, and handling objects. They remember more easily when they write, doodle, draw, or move their fingers. It is best to introduce material to them through art activities, baking, cooking, building, making, interviewing, and acting experiences. If a child has weaknesses in visual processing, it is more
In addition to perceptual strengths, the therapist must keep in mind the child’s preferred manner of approaching new material. For instance, global learners require an overall comprehension first and then can attend to the details. Analytic learners piece details together to form an understanding.

Visual-Motor Integration

To review, the therapist should first focus on the underlying visual-receptive functions and then focus on the visual-cognitive functions. This should proceed in the sequence of visual attention, visual memory, visual discrimination, and specific visual discrimination skills. A multisensory approach to handwriting may be helpful to a child with visual-cognitive problems. Working with the eyes closed can be effective in reducing the influence of increased effort that vision can create and in lessening the visual distractions. Keeping the eyes closed can also improve the awareness of the kinesthetic feedback from letter formation.

The therapist should be aware of which handwriting approach is used in the classroom. The child whose preferred learning style is based on an auditory system can be assisted in learning handwriting through use of a talking pen. Handwriting programs that appear easier for children with visual-cognitive problems include loops and other groups9 and handwriting without tears.10 Olsen described strategies to help children correct or avoid reversals. During handwriting lessons, the child should proofread his or her own work and circle the best-formed letters. Chapter 19 has comprehensive information on developing handwriting skills.

Children with visual-spatial problems often choose random starting points, which can confuse the writing task from the onset. Concrete cues must be used to teach abstract handwriting concepts. For example, colored lines on the paper or paper with raised lines can be helpful for the child who has difficulty knowing where to place the letters on the page. In addition, green lines drawn to symbolize go on the left side of the paper and red lines to symbolize stop on the right side may help a child know which direction to write his or her letters and

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words. Upright orientation of the writing surface may also lessen directional confusion of letter formation (up means up and down means down) versus orientation at a desk on a horizontal surface, where up means away from oneself and down means toward oneself.127

Directional cues can be paired with verbal cues for the child who commonly reverses letters and numbers. These cognitive cues rely on visual images for distinguishing letters and include the following:

1. With palms facing the chest and thumbs up, the student makes two fists. The left hand will form a \( b \) and the right hand will form a \( d \).
2. Lower case \( b \) is like \( B \) only without the top loop.
3. To make a lower case \( d \), remember that \( c \) comes first, then add a line to make a \( d \).

The therapist can develop cue cards for the student to keep at his or her desk with common reversals. Lee has developed a frame of reference for reversal errors in handwriting based on visual-perceptual theory.97 See Box 12-3 for the postulates for change as outlined by Lee.

Children with visual-cognitive problems often overspace or underspace words. The correct space should be slightly more than the width of a single lower case letter. When a child has handwriting spacing problems, the occupational therapist may recommend using a decorated tongue depressor or a pencil to space words, or simply have the child use his or her finger as a guide. The child can also imagine a letter in the space to aid in judging the distance.

When students need additional help to stop at lines, templates with windows can be used in teaching handwriting. These templates can be made out of cardboard with three windows; one for one-line letters (\( a, c, e, i, m, \) and \( n \)), one for two-line letters (\( b, d, h, f, d, \) and \( t \)), and the third for three-line letters (\( f, g, j, p, q, z, \) and \( y \)). It is important to consider that visual memory is used to recognize the letters or words to be written, and motor memory starts the engraving for producing the written product. Therefore it may be that motor memory, not visual memory, is the basis for the problem.

Dankert, Davies, and Gavin evaluated whether preschool children with developmental delays who received occupational therapy would demonstrate improvement in visual-motor skills.40 The children received a minimum of one individual 30-minute session and one group 30-minute session per week for one school year. Their performance was compared with that of two control groups: typically developing peers who received occupational therapy and typically developing peers who did not receive occupational therapy. The results showed that the students with developmental delays demonstrated statistically significant improvement in visual-motor skills and developed skills at a rate faster than expected compared with typically developing peers.

### Computers

Many excellent educational computer programs for young children are already on the market. Software programs that are highly motivating for children of all ages are available. Living books on the computer reinforce the written word with the spoken word and assist in developing a sight-word vocabulary.

The computer can be used as a motivational device to help increase the child’s attention to the task. It also provides a means to practice skills in an independent manner. Drill and practice software record data on accuracy and the time taken to complete the drills, allowing the therapist to record the child’s progress. The therapist can adapt the computer program by changing the background colors to those that enhance the child’s visual-perceptual skills. The therapist can also enlarge the written information so that less information is present on the screen. Sands and Buchholz provide a discussion on the use of computers in reading instruction.124 Appendix 12-A on the Evolve website includes a list of computer software and hardware companies that provide current information on technologic and educational resources available for children with a variety of special needs.

Studies have shown that children’s use of computer-based activities resulted in improved performance. For example, using single-subject reversal design study, Cardona, Martinez, and Hinojosa examined five children 3 to 5 years of age who had developmental disabilities to measure the effectiveness of using a computer to increase attention to developmentally appropriate visual analysis activities.28 The results suggested that each child’s attention to task performance improved during the computer-based activities as measured by the number of off-task behaviors. Sitting tolerance and visual attention to

### BOX 12-3 Postulates for Change

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<th>Reversal error in individual letters and numbers. Occupational therapists can take an active role in helping to reduce letter and number reversal errors by providing the following:</th>
<th>Reversal error in letter order of words and numbers. Occupational therapists can take an active role in reducing reversal errors in letter order of words and numbers by engaging students in the following:</th>
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<tr>
<td>• Activities that offer an opportunity to practice writing individual letters and numbers, focusing on the distinctive features of letter forms with contrasting orientation, such as ( b ) and ( d ).</td>
<td>• Activities that provide an opportunity to practice writing words, focusing on the distinctive features of letter forms with contrasting sequences, such as was and saw.</td>
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<tr>
<td>• Activities that afford an opportunity to practice detecting distinctive features of individual letters and numbers, such as tracing, coloring, and pointing.</td>
<td>• Activities that encourage the child to start writing at the left position of a line.</td>
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<tr>
<td>• Demonstration, naming of letters and numbers, and descriptions of the differences between the orientations of individual letter forms that are likely to be reversed.</td>
<td>• Prompts or visual cues at the left side of the paper as a reminder of where to start writing.</td>
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the task did not change. All participants seemed to be interested in and motivated to engage in the computer-based activities.

More research is needed to examine a longer intervention phase and the effectiveness of computer-based intervention in natural settings such as a classroom. Authors who have studied the effects of computer games in kindergarten-age children recommend their use in improving visual-perceptual skills.104 Their findings indicate that, on the basis of required time and motivation level, computer games are more efficient than other educational programs.

Currently a considerable body of literature supports the use of virtual environment technology to train spatial behavior in the real world.45 Occupational therapists should incorporate this information into their interventions.

**SUMMARY**

Children with visual-perceptual problems often receive the services of occupational therapists. This chapter described a developmental approach that emphasizes methods of identifying the underlying client strengths and deficits in visual-receptive and visual-cognitive skills. The relationship of these components to various performance skills was described. Using the developmental approach, the occupational therapist helps the child increase his or her visual-perceptual skills by addressing the skill problems that appear to be limiting function. By adapting classroom materials and instruction methods, the therapist also helps the child compensate for visual-perceptual problems. Intervention often includes a combination of developmental and compensatory activities. This holistic approach enables the child with visual-perceptual problems to achieve optimal function and learning.

Little evidence exists in the occupational therapy literature regarding treatment effectiveness for visual-perceptual problems in children. See Table 12-4 for results of visual-perceptual treatment. As a profession, occupational therapy has identified that visual-perceptual problems are within its domain of practice. Further, occupational therapy practitioners, authors, and researchers have defined practice models and intervention activities to remediate visual-perceptual problems. The next step is to systematically test the effectiveness of these intervention programs.

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<th>TABLE 12-4 Evidence of Visual-Perceptual and Visual-Motor Treatment</th>
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