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Activity-focused Motor Interventions for Infants and Young Children With Neurological Conditions

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This article presents a model to guide activity-focused motor interventions as a component of early intervention services for physical and occupational therapists working with infants and young children with neurological conditions and other developmental disabilities. Activity-focused interventions involve structured practice and repetition of functional actions, and are directed toward the learning of motor tasks that will increase the child's participation in daily routines. According to this model, the pediatric physical therapist or occupational therapist, as a member of the intervention team, develops activity-related goals in collaboration with the child's family. The therapist plans activity-focused interventions by (1) using guidelines based on principles from motor learning and motor development, (2) adapting these guidelines, when necessary, to address the young child's individual strengths and needs, and (3) integrating impairment-focused interventions with activity-focused interventions, optimally within the context of everyday routines and activities. The elements of this model will be discussed through an example that is applicable to early intervention. **Key words:** *early intervention*, *pediatric occupational therapy*, *pediatric physical therapy*

ACTIVITY-FOCUSED motor interventions for infants and young children with neurological-based motor conditions emphasize the need for practice and repetition of purposeful motor actions to increase the child's participation in daily routines. These movement experiences are, optimally, incorporated into the infant's or young child's daily routines by parents and other caretakers with support of their physical and occupational therapists through the provision of early intervention services. Activity-focused interventions are consistent with current models of intervention for children with neurological disorders, which stress the learning of functional developmental motor skills that will increase the infant's ability to interact with family and the environment (Heriza & Sweeney, 1994). This emphasis on activity is consistent with the federal legislation of the Individuals with Disabilities Education Act (IDEA), Part C (2004) to meet the developmental needs of each child and maximise potential for living independently. Support also comes from recent advances in neurosciences that predict that coordination and motor control emerge in the context of functional activity (Hadders-Algra, 2000; Shumway-Cook & Woollacott, 2001; Sporns & Edelman, 1993). In spite of the support for activity-focused approaches, there is an absence of practical guidelines available to physical and occupational therapists in structuring these interventions. The purpose of this article is to present a model of activity-focused motor intervention for infants and young children with neurological

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conditions that not only gives primacy to activity that promotes motor competence but also addresses impairments typical for children with neurological disorders. The model for infants and young children is adapted from the model for activity-focused interventions for school-aged children (Valvano, 2004).

Terms such as "participation-based" and "activity-based" have been used to describe curriculum models that involve integrating learning skills into child-initiated activities as the focus of early intervention and developmental activities (Bruder, 2001; Gestwicki, 1995). This article uses the term "activity-focused" as yet another term to discuss a similar concept. The difference here is that activity-focused intervention involves a physical or occupational therapist, who structures opportunities for motor learning by the child *in addition to* facilitating actions by the child's parents or caretakers *as part of* their daily activities and routines. Activity-focused interventions for infants and young children are based on principles of motor learning and development that can be generalized to interventions by physical and occupational therapists across the lifespan.

In activity-focused interventions, physical and occupational therapists are challenged to plan effective movement experiences that promote motor learning by infants and young children within the context of the daily routines of the child and family. A fundamental assumption in activity-focused interventions is the significance of active motor learning processes in the acquisition of developmental skills that are important for daily routines, such as reaching and locomotion. The relationship of motor learning to development is complex, theoretically (Anderson, 2004). *Motor development* can be viewed as the changes in motor behavior over the lifespan and processes that accompany these changes (Whitall, 2004). Learning is an important process that underlies these behavioral changes over time. According to Spencer and Thelen (2003), the processes of motor learning and development interact with each other, and there is no way to parcel out changes in an infant's behavior to the process of learning or development. Changes in internal movement systems and interaction with the environment are important to the constructs of both learning and development.

Therefore, guidelines for planning and executing activity-focused interventions can be based on principles from both the motor learning and motor development literature. However, principles that are the foundation for understanding and promoting motor skill acquisition in typical infants and young children may not directly translate into motor learning guidelines for children with neurological diagnoses. Knowledge of principles about motor learning and development should be complemented by knowledge of impairments associated with neurological disorders and how these impairments may affect the process of motor skill acquisition. Guidelines for pactice of motor activities, derived from the motor learning and developmental literature, may have to be adapted to account for individual strengths and individual learning needs of children with neurological diagnoses.

Physical therapists and occupational therapists consider neurological impairments to be an important focus of interventions for infants and young children because they limit the performance of developmental motor skills. Furthermore, early intervention is believed to be important in reducing the progression of impairments and preventing secondary impairments that have long-term effects on functional activities (American Physical Therapy Association, 2001; Bartlett & Palisano, 2002).

According to the *International Classification of Functioning, Disability, and Health* (World Health Organization, 2001), impairments in body structures and functions are consequences of a disorder or pathological process. They represent problems in physiologic functions of the body or anatomic structures that limit the child's ability to perform functional activities, which are important for participation in daily routines. For infants and young children, daily routines may include eating, bathing, playing, and being otherwise involved in routines of family life.

Bartlett and Palisano (2002) differentiate between primary impairments, which are limitations directly resulting from the pathology associated with the disorder and secondary impairments that develop over time. Hypertonicity, or increased muscle tone in the upper extremity of a child with hemiplegic cerebral palsy (involvement on one side of the body), is an example of a primary impairment. Limitations in wrist or thumb range of motion or weakness of hand muscles required for precision grip are examples of secondary impairments that may develop over time due to chronic "nonuse" of the involved hand. Ultimately, reaching and/or grasping for toys may be affected by the primary and/or the secondary impairment described above.

The model described in this article embodies 3 practical steps for planning motor interventions:

1. Develop *activity-related goals and objectives* that will increase participation of the infant in daily routines, based on priorities of the family, in collaboration with the intervention team.
2. Plan *activity-focused interventions* that involve opportunities for practice of functional actions. Opportunities for practice of motor tasks are enhanced by practice guidelines that are based on principles of typical motor development and learning, but may be enhanced or adapted to meet the individual learning strengths and needs of the infant or young child.
3. Integrate *impairment-focused interventions* with activity-focused intervention to reduce secondary impairments that may develop over time. These impairments can, ideally, be addressed in the context of a functional activity. They may also be addressed by therapeutic procedures executed outside of the context of a functional activity, when necessary.

A model for activity-focused intervention that has previously been applied to school-aged children (Valvano, 2004) will be applied to a 15-month-old child with a diagnosis of spastic diplegic cerebral palsy. Specifically, the model will be applied to the activity of playing with toys while sitting independently (ie, no external support) on the floor.

CASE HISTORY

Marc is a 15-month-old child who was born at 26 weeks gestation weighing 1000 grams. Medical complications in the neonatal period placed Marc at risk for delay or disorder in motor development. In addition to his gestational age of 26 weeks and his very low birth weight, other complications included a grade IV intraventricular hemorrhage (bleeding into the area around the ventricles of the brain caused by immaturity of the capillary system) and respiratory distress requiring artificial ventilation for 29 days. Marc was discharged home from the transition nursery at 60 days of age on oxygen delivered through a nasal canula. At the time of discharge, he was able to drink from a bottle but was experiencing some difficulties with gastroesophageal reflux, and he weighed 5 lb 5 oz. At a corrected age of about 6 months, Marc was diagnosed with spastic diplegic cerebral palsy.

Marc is alert, communicative, and playful with his parents, older siblings, and other family members. He shows interest in his environment and all that is going on around him by looking and turning himself toward action and sounds. Marc responds to his name and to simple verbal instructions, and he has begun using pointing gestures to give additional information regarding his wants and needs. He engages his family with a variety of playful vocalizations, typical of his corrected age. His cognitive, social, and language development all seem appropriate and on track, based on his corrected age. Marc sits independently on the floor with his legs in front (modified ring sitting position) for at least 1 minute. When sitting on the floor, he can use both hands to grasp, hold, or play with a toy placed within his base of support. Marc rolls independently in both directions, pivots on the floor in prone (on his tummy), and is beginning to show some forward movement, mostly by pulling with his arms along the floor.

APPLICATION OF MODEL

Step 1: Develop activity-related goals and objectives

Developing activity-related goals is the first step in developing intervention plans that will increase independence and participation for young children with neurological movement disorders resulting in motor delay. According to current "top-down" approaches (Campbell, 1991), goals related to functional outcomes that are important to the family are determined first. In the case of infants and young children, these activities may improve functional mobility, interaction with the family, play behaviors, and other daily routines such as bathing and eating. After the desired functional outcomes are determined, components that limit these outcomes are assessed. These goals and objectives are incorporated into the child's Individualized Family Service Plan, a process that is consistent with activity-focused interventions.

The objective for Marc was to play with toys while sitting independently (unsupported). The activity included reaching for toys and playing with them while maintaining his sitting balance. Marc's ability to sit and play was important to his parents because it would enable Marc to participate in family time and engage in greater opportunities for interactive play with his parents and siblings. It would also allow for some independent play time while his parents were close by taking care of household chores and tending to the other children. In the evenings, Marc's siblings, aged 3 and 5, and parents would typically retreat to the family room to play games, solve puzzles, or participate in other family activities that generally occur on the floor. Marc's parents also were hopeful that this increased competence in sitting unsupported would generalize to other daily routines, including feeding and bathing.

Step 2. Plan individualized activity-focused interventions

According to current theory, learning a developmental motor skill represents a transition, or change from one preferred motor behavior to another. Therefore, a physical therapist or occupational therapist providing early intervention services would work in collaboration with parents, as change agents, to support positive change in motor behaviors

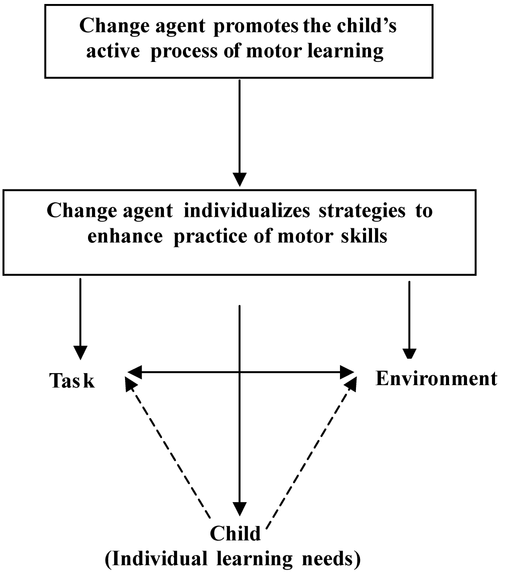

Figure 1. Model depicting the role of the physical therapist, occupational therapist, or parent as a change agent in conducting activity-focused interventions.

(Newell & Valvano, 1998). Therapists, and other early intervention providers, can provide support by helping a child's parents to structure opportunities so that the infant or young child can practice motor skills in the context of the family routines. Figure 1 depicts the contribution of the physical therapist or occupational therapist, as a change agent, in activity-focused interventions. The change agent role, derived from the concept of transition in the dynamic systems' perspective on motor learning, is parallel to the role that can be assumed by a physical or occupational therapist under the coaching model of service delivery (Hanft, Rush, & Shelden, 2004). According to the model, the change agent intervenes with practice strategies related to the task and the environment to support the learning of new functional activities. The strategies for practicing motor activities are adapted to meet the individual learning characteristics of the child, determined by his or her learning strengths and needs. This model is based on the concept, from the dynamic systems' perspective, that the outcome of practice is influenced by the interaction of the task, environment, and characteristics of the young learner.

The model in Figure 1 highlights the importance of addressing the child's individual learning characteristics in terms of strengths and needs. The broken lines in the diagram depict the important connection between the characteristics of the child and the features of the task and environment that will optimize practice opportunities for the child within the context of everyday routines and activities.

In this section, the process of planning individualized activity-focused interventions for Marc is discussed. First, we provide a background review of selected principles of typical motor learning and development that provide the foundation for activity-focused interventions. Second, we discuss guidelines from the current literature for structuring the task and the environment to enhance the benefits of practice of motor skills by the infant or young child. Then, we discuss how impairments in body structures and functions can limit the process of motor learning for Marc. Finally, we model the process of enhancing or adapting motor learning guidelines to address individual learning needs associated with these impairments.

Background

Concept of multiple systems

Neurological development, in terms of increased brain size and increased myelination, is critical for progress in motor development. Current neuroscience describes complex, distributed neural networks that support developmental change (Spencer & Thelen, 2003). However, according to the dynamic systems perspective, progress in motor skill development does not occur because of neurological changes alone. Rather, a certain motor behavior emerges as the preferred or "natural" behavior, in a given task and environmental context, because of the interaction of multiple elements of a complex movement system (Heriza, 1991; Zanone, Kelso, & Jeka, 1993). Theoretically, progression in the components of the movement system, such as neurological development, physical growth, or improved strength, creates opportunities for the emergence of new, preferred motor behaviors (Heriza, 1991; Spencer & Schoner, 2003). For example, in the transition to independent stepping by infants, each of the multiple systems associated with stepping progresses at its own rate. If all of the subsystems (including motivation, strength, tone control, and body characteristics) are at a specific state or level of organization, walking emerges as the preferred pattern of locomotion. If one of the participating systems is not at the proper state (eg, hip extension strength not developed), independent stepping does not emerge as the preferred behavior (Heriza, 1991; Thelen, 1986a). It is important to note however that for stepping behaviors to emerge, the infant must be actively engaged by an action goal, such as moving toward a desired object in the environment (eg, a parent or favorite toy).

Dynamics of behavioral change

The concept of change in motor behavior is fundamental in the dynamic systems' perspective (Newell, 1996; Scholz, 1990; Zanone & Kelso, 1991). A *control parameter* is a variable that provides conditions for change when it takes on a critical value. Applied clinically, control parameters are factors that influence change in behavior. They are called constraints because they constrain, or limit, the possible outcomes for emerging motor behaviors (Newell & Valvano, 1998). Constraints can reside in the individual (eg, motor control, strength) or can be external to the infant in the task and environment. In the model depicted in Figure 1, the elements of the triangle represent a confluence of constraints, both intrinsic and extrinsic to the child, that influence change with activity-focused interventions.

Purposeful activity, or practice, under specified task and environmental conditions can induce behavioral change, or a change in the preferred movement behaviors (Wenderoth, Bock, & Krohn, 2002; Zanone & Kelso, 1994). The literature that looks at similar concepts in adults suggests that practice creates instability in stable movement behaviors and new, practiced solutions replace them (Scholz & Kelso, 1990; Zanone & Kelso, 1994). Let us take the example of an adult learning a new golf swing. Many contributing systems determine the individual's "preferred" golf swing. Practice of an alternative golf swing creates instability in the previous behavior and a new preferred behavior (golf swing) emerges. Changes in systems, which support this new coordination, such as flexibility in the trunk, strength in the arms, and neural reorganization, support this behavioral change.

Likewise, we propose that individualized, purposeful activity in activity-focused interventions can support changes in functional motor behavior in infants. Thelen (1986a) demonstrated the effects of practice by having young infants walk on a treadmill with support. This activity accelerated the acquisition of coordinated stepping behaviors in these infants. In activity-focused interventions, the challenge for the change agent is to structure practice and sensorimotor experiences that support the target motor behaviors and increase participation.

Importance of repetition and problem solving

Self-exploration and problem solving are critical to the behavioral changes associated with motor learning by infants and young children. Through experience, the infant learns to discover and rediscover solutions to novel problems. The problem solving is directed to the action level. Action involves the accomplishment of a task with the intention to realize a functional goal and a strategy to achieve the goal (Gentile, 1992; Newell & Valvano, 1998). Through repetition, the infant acquires and refines the coordination or movement patterns necessary to achieve the functional action goal.

Adolph, Vereijken, and Shrout (2003) report that practice is the more important developmental factor, relative to age and duration of walking experience, for helping infants improve strength and balance in independent ambulation. The importance of repetition in learning motor skills is typified by the amount of practice typical infants seek naturally when learning to crawl and walk. Adolph and colleagues reported that infants, who were refining the skill of crawling, spent up to 40% of their time on the floor and covered between 27 and 43 m/h (Adolph, 2003; Adolph et al., 2003). Infants learning to walk spent about 50% of their time practicing and took up to 9000 steps per day and covered about 2700 m. The rate and quality of learning are stage-dependent during practice. In the early phase of practice, children are identifying the critical parameters of the task and change is most rapid. In the later phases of practice, the infant refines the skill and change is less rapid (Adolph, 2003; Gentile, 1992).

As infants and young children engage in motor learning, they gather information from the environment to make movement decisions. Theories of direct perception stress the natural linkage of the environment to action. According to this perspective, objects in the environment, called affordances, provide opportunities for action (Adolph, Eppler, & Gibson, 1993), and the individual characteristics of the infant (including body dimensions) help to determine the environment-action fit. Through functional play and exploration, an infant's perception of affordances is scaled and refined, thereby expanding the action repertoire for locomotion or object manipulation.

On the other hand, the cognitive aspects of extracting information from the environment, making movement decisions, and activating a motor plan can be emphasized. Functions of visual information processing, memory, and attention are important for motor skill learning by infants. The speed of processing visual information, which has implications for effectively making movement decisions, has a developmental progression (Rose, Feldman, & Jankowski, 2002). Memory representations contribute to permanence of practiced movements, even in young infants. Physical and occupational therapists often fail to consider memory when practicing movement tasks with infants. However, memory storage and consolidation in the first years of life have been examined in a significant body of literature. Attention functions also impact on motor learning by infants. There is developmental change in attention competencies, such as duration and shift of visual gaze over the first year of life, and these competencies have been related to speed of information processing (Rose, Feldman, & Jankowski, 2003)

Guidelines that enhance the effects of practice

In this section, selected guidelines related to the task and the environmental constraints that support typical motor skill acquisition will be reviewed. These guidelines assume the importance of active problem solving for motor learning.

Guidelines: Task

The role of the task in activity-focused interventions is depicted in Figure 1. Task-related parameters determine the actual goal of the task that is practiced, the content of the practice, the rules for performance, and any implements (eg, toys) used during practice. Well-chosen toys are critical to engage infants in meaningful activity. An interesting task should encourage exploration, repetition, and problem solving critical for learning. Remember that play is the work of children and creativity by the change agent is imperative.

In terms of difficulty, the task should provide the appropriate challenge for the infant. The complexity of the task can be graded by how many elements there are to be achieved and whether it is an open or closed task. In a closed task, the task remains the same from one practice trial to another. In an open task, on the other hand, the conditions change on each trial, so there are many solutions along with increased processing demands (Gentile, 1992). Adaptations to practice may provide a less-difficult version of the task, so an optimal level of performance can be maintained. A gradual transition to a more difficult version of the task is made as the child progresses. Part-task training is another adaptation that grades the complexity or difficulty of a motor task. It is generally defined as practice on some component of the whole task as pretraining for performance of the whole task. Part-practice training is most useful with serial tasks, which involve discrete components strung together. The transfer of the parts to the target task can be enhanced by helping the child string the parts together in the target task and choosing the parts that are naturally occurring subunits of the target task (Schmidt & Wrisberg, 2004; Winstein, 1991).

Great amounts of variable practice, distributed throughout the day, seem to enhance the natural repetition of motor skills by infants (Adolph, 2003). With variable practice by infants and young children, the tasks are structured to allow the rehearsal of a number of variations of a task during a session of practice. On the other hand, constant practice involves rehearsal of only one variation of a given class of action. Variable practice is advisable in infants because it leads to flexibility in skills learning and the ability to adapt to changing conditions (Adolph, 2003). The hallmark of infant skill is the ability to achieve flexibility and cope with variations in addition to adapting ongoing behaviors to the current conditions.

Guidelines: Physical environment

According to Figure 1, the environment provides the context for motor learning. Environmental parameters are multidimensional and include the physical environment, the psychosocial environment, and the performance environment. These will be described in the sections that follow.

The physical environment includes objects and persons in the environment as well as sensory features of the environment. It should furnish affordances that provide opportunities to scale movement behaviors to the environmental demands.

Guidelines: Psychosocial environment

Psychosocial environment includes factors that relate to the interaction of the child with parents and therapists as change agents. Physical and occupational therapists address this area through family-centered interventions and by the realization that relationships between parents and children can be used to foster and guide the child's development through the use of naturally occurring positive and instructive comments and feedback.

Guidelines: Performance environment

The *performance environment*, in the motor learning literature, refers to the augmented information provided during the learning situation by the change agent. *Augmented information* involves information provided by an external source to complement the intrinsic information that is naturally available to the learner through problem solving and performance of the task (Schmidt & Wrisberg, 2004). According to the dynamic systems' perspective, the change agent provides augmented information to guide the child's search for the movement patterns or the coordination that will enable the functional action to be achieved. It is needed when the infant is unable to initiate his or her own solution, or when the infant's preferred solution for coordination is inefficient or unsafe.

Feedback is the mode that dominates the literature on augmented information for practice of motor skills by school-aged children and adults. Other types of augmented information are more suited to practice by infants and young children. The modes of augmented information include verbal, visual, and physical. The utility of verbal cues is obviously limited by developmental and cognitive factors. Visual cues provided by demonstration are, theoretically, of value to infants and young children, due to the primacy of the visual system for motor learning in young children. Imitation is a strong mechanism that uses visual cues even with very young children well before they can understand and respond to language. Physical guidance is a mode that helps provide infants and young children a general "feel" for a movement that will achieve an action (Valvano, Shewokis, & Harbourne, 2003; Wulf, Shea, & Whitacre, 1998). The motor learning literature cautions that less-augmented information is better. Too much guidance during practice theoretically interferes with the information processing that aids retention and generalization of skill (Schmidt & Wrisberg, 2004; Winstein, 1991).

The performance environment might also include strategies by the change agent that increase the likelihood of exploratory behavior and sustained participation in the motor activity. Procedures from the domain of applied behavior analysis, such as positive reinforcement, are based on the fundamental assumption that adaptive behavior is the result of its immediate antecedents and consequences (Parrish, 2002). Procedures such as shaping, chaining, and graduated guidance are complementary to physical and verbal guidance procedures from the motor learning domain.

Effects of impairments on motor learning

Recall that the target activity, reaching for and playing with toys while sitting independently, was planned for Marc at 15 months of age. Marc had already demonstrated good social interaction, cognitive abilities, basic motor competencies, and the interest in play. He enjoyed a rich and supportive family environment. On the other hand, impairments in body structures and functions associated with his diagnosis of spastic diplegia interfered with the coordination or movement patterns that would enable him to efficiently achieve the functional action goal. Marc demonstrated impairments in muscle tone, strength, and selective control of proximal muscles of the trunk that led to secondary impairments in the control of posture and balance in sitting. These impairments limited his ability to maintain a stable sitting posture and make adjustments to perturbations of his center of mass. For example, he was unable to maintain balance if he became excited and vigorously shook toys as he played, or if he reached for toys outside his base of support. In addition, the instability in his trunk placed limitations on the free movement of his upper extremities. He held his arms close to his body with his shoulders elevated. This tendency to keep his arms tucked in close into the center of the body is called "fixing" because the assumed upper extremity postures are a compensation that ultimately help him to maintain a static posture and remain upright while sitting.

Impairments in tone, strength, and selective control limited the range of active movements of his trunk while sitting, especially lateral and rotational trunk movements. There was a tendency for arching of the trunk during attempts to move from the sitting position. Therefore, Marc began to develop secondary limitations in flexibility, affecting lateral and rotational movements of his trunk. Hypertonicity (increased tone) was noted in Marc's legs by the resistance to passive movement and stiffness with weight bearing during play, dressing, diapering, or bathing activities. These findings represent an imbalance of muscle activity, with a bias toward extension, which could affect pelvic alignment for stable sitting.

Although Marc showed no significant cognitive deficits at 15 months, his attention and information processing were suspect as they may be in babies born prematurely (Rose et al., 2002; Rose, Feldman, McCarton, & Wolfson, 1988). He demonstrated difficulties with engaging and sustaining focus on toys and activities during play and other daily routines. Impairments in information processing were suggested by the increase in time required by Marc to adapt to his motor behaviors (eg, grasping) when variations were made to familiar objects during play. Processing of tactile or proprioceptive sensations may have been impaired for Marc, thereby limiting information processing. These impairments are reportedly common in children with cerebral palsy (Clayton, Fleming, & Copley, 2003). However, these impairments are very difficult to confirm by observations of a young child's behavior. Marc tended to be somewhat irritable and fussy, and, sometimes, overreactive to sensory stimuli, especially tactile input. However, he responded well to calming touch and modulated sensory inputs.

It is helpful to integrate knowledge about impairments with principles of motor learning and control that drive our interventions. In applying the principles related to the complex movement system and dynamics of change discussed above, we find that in typical development there is dependence on progression in multiple systems to promote developmental change in motor behaviors. For children with cerebral palsy, motor impairments or impairments in information processing functions limit progression in those systems. If change does not occur in these rate-limiting systems, old patterns of coordination become stable and progress toward new behaviors is limited.

Impairments associated with spastic diplegia also limit the exploration that is important for acquisition and generalization of motor behaviors. Impairments in selective control of movement (Howle, 1999; Sugden & Keogh, 1990) limit the initiation and production of movement patterns required for the repeated trials of an action. Trial and error, associated with problem solving, is limited by a reduced movement repertoire. Reduced muscle tone in the trunk creates functional weakness, making initiation of movement difficult and affecting endurance required for sustained exploration in young children with cerebral palsy, such as Marc. In addition, impairments in sensory processing affect the ability to extract and interpret task-specific information and the intrinsic feedback necessary for error detection.

Motor learning guidelines adapted to address impairments

Guidelines for structuring the task and the environment, based on motor learning principles, enhance the benefits of practice of purposeful motor skills. In some cases, these guidelines should be adapted to meet individual learning characteristics of the child.

This process for enhancing or adapting practice guidelines is modeled through 2 examples, as shown in Table 1. These proposed adaptations, directed toward the task and the environment, integrate the knowledge of neurological impairments with principles of motor learning. As infants perform a functional activity, these motor learning guidelines may be complemented by therapeutic handling procedures, directed toward ameliorating the child's impairments. The latter will be discussed in sections that follow. The adaptations described in the table are based on the theory and on the clinical experience of the authors, but have not yet been empirically tested.

Step 3: Execute impairment-focused interventions

The individual needs of the child may require attention to impairment-level interventions. Impairments associated with neurological diagnoses are numerous and have a unique expression in each child. Likewise, the interventions are numerous and should be individualized. The following section will describe 2 categories of impairment-focused interventions that can be systematically integrated into a model that stresses activity-based motor interventions: intervention strategies involving purposeful functional activity and strategies involving passive procedures. These categories are depicted in Figure 2.

Impairment-focused interventions involving functional activity

Active impairment-level interventions involve purposeful activity. Impairments that limit task-specific critical components of movement may be ameliorated through focused practice of a purposeful action because, theoretically, motor control emerges in the context of performing a purposeful task. Through well-planned activity, the gains can be 2-fold. Functional performance may improve, and impairments that limit the performance of a task-specific movement pattern may be ameliorated. Functional activity can be used to address impairments in 2 ways: (1) practice of complementary activities, related to the target activity, that address task-specific movement components limited by impairments; and (2) therapeutic enhancements to the functional activity.

Related activities that address a task-relevant component

When components of the movement important for the target task are limited by impairments, the change agent may structure a task or developmental play activity to address a single component of movement that is required for the target activity. For example, Marc's parents played a game of peek-a-boo with him that targeted the development of better axial flexion and reduced arching in his neck and back. Marc's mother carefully tilted him back during the game while he sat on her lap. This encouraged him to respond with neck and trunk flexion and keep his head erect to maintain visual contact with his father. They also performed activities that improved his ability to shift weight during sitting with the goal of reaching for a toy while maintaining his balance in sitting as the final goal. Another game that his mother pursued with the goal of weight shifting in mind involved encouraging Marc to touch her eyes, nose, and hair on verbal request through the context of a game. During this game, she supported Marc at his pelvis while he sat on his brother's soccer ball and shifted his weight to reach forward or to the side to touch the designated facial feature. Also, Marc's mother provided many opportunities for him to reach and grasp toys from varied positions to improve range of shoulder movements for visually guided reaching.

The positive transfer of components to the target activity determines the value of practicing related tasks that focus on a component of the target activity. The extent to which components of movement practiced in a related activity transfer to the target functional activity requires further empirical study. In general, motor learning theory predicts a small amount of transfer between tasks, so practice of the target skill is recommended (Schmidt &

Table 1. Process of adapting practice guidelines to address neurological impairments and application of the process using a case study

Example of guideline for structuring practice	Impairments that might interact with practice guideline	Proposed enhancements or adaptations to guideline	Application to case study (15-month-old child, Marc)
Use toys to promote play, exploration, and problem solving.	Impairments in motor control limit initiation of movement for exploration, postural control during object manipulation, repertoire of movement patterns for problem solving, and endurance required for repeated trials. Inefficient patterns of coordination may emerge. Impairments in attention may limit information processing, required for problem solving.	When presenting toys, focus on strategies in the environment and tasks that increase the child's access to the goal activity. Analyze the task to determine the optimal progression in terms of complexity and difficulty. Children may have to practice parts, so chain them together. When presenting the task, help focus the child's attention on the important aspects of performance. Schedule many practice trials by distributing the practice throughout the day. Extra planning might be required to have practice distributed throughout the day.	In Marc's case, a toy was chosen that had surface features that made the toy easy for him to contact. The environment was adapted, early on, by placing the toy on a large block that made reaching from the floor easier. The support surface was adapted to his needs. Marc was given assistance with balance when reaching for toys in the first few trials. The challenge, in terms of the range of trunk displacement required to reach for the toy, was gradually increased. The mass and other properties of the toys were considered. Rather than just placing the toys within Marc's reach, his mother focused his attention on the toy, demonstrated picking it up, and physically guided him. She provided motivating cues and events to encourage continued contact with the task. For Marc, distributed practice was accomplished by incorporating the structured tasks into daily routines after diapering, during bath. Practicing the tasks in the natural environment insures better transfer of the tasks.

(*continued*)

Table 1. Process of adapting practice guidelines to address neurological impairments and application of the process using a case study (*Continued*)

Example of guideline for structuring practice	Impairments that might interact with practice guideline	Proposed enhancements or adaptations to guideline	Application to case study (15-month-old child, Marc)
Change agent provides augmented information before, during, or after the practice trial to support motor learning. However, emphasis is on discovery learning.	Motor control impairments limit the ability to develop a movement plan to achieve an action. There is increased intertrial variability, in terms of a motor response, which makes intrinsic feedback about performance less reliable in trial-to-trial comparisons. Impaired somatosensory processing may reduce intrinsic information provided by active performance of the trial, which is important for developing a reference for the correct movement. Speed of information processing may be reduced.	The early phase of learning is prolonged, and the requirement for guidance, especially physical guidance, may be increased in children with neurological diagnoses. When the variations of a task are provided, children may require guidance to generalize previous experience to the new exemplar. Provide the child enough time to process the effects of the practice trial and the guidance or feedback they received.	Marc was given demonstrations, providing him the opportunity to imitate. Also, physical guidance was provided to help him get the "feel" of the weight shift in varied planes as he reached for toys. Physical guidance of the reach and contact with the toys was also provided. However, this guidance was withdrawn after Marc seemed to get the idea of the movement patterns, and explored on his own. Marc's mother observed his ability to transfer the competency to sitting during bath time and in his high chair, and provided him the guidance with generalizing the skill to the new environment. For Marc, providing several seconds between trials seemed to help his performance.

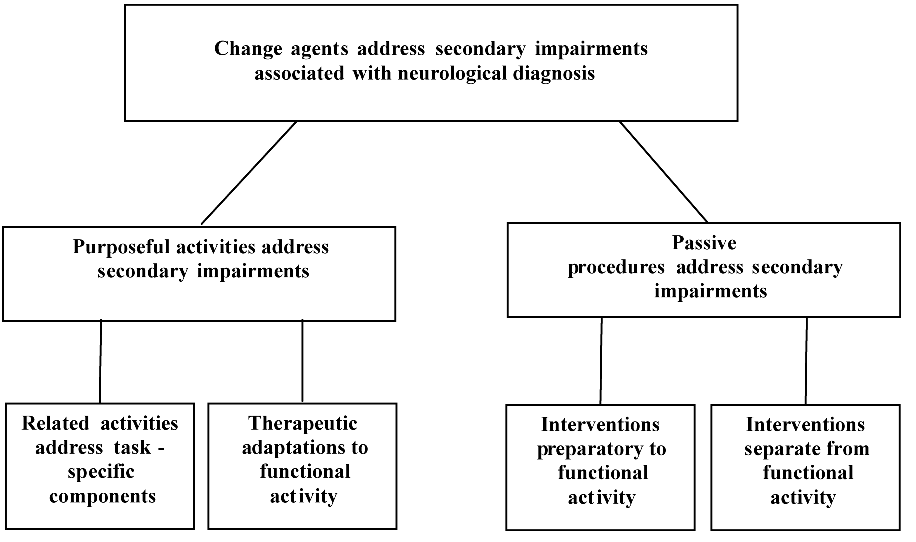

Figure 2. Intervention strategies used to address secondary impairments in the context of activity-focused interventions.

Wrisberg, 2004; Winstein, 1991). However, practice of related tasks, which focus on shared movement components, may play an increased role in motor learning by young children with neurological disorders, who have a limited coordination repertoire. Horne, Warren, and Jones (1995) reported that children, aged 21 to 34 months, who practiced activities that targeted specific movement components, were able to increase the performance of the targeted activity and generalize the movement components to untreated exemplar activities. For children with cognitive limitations, practice of prerequisite skills may not be advisable because of difficulty with transfer to the target task (McEwen, 2000).

There are two points, related to practice of functional activities, that address task-specific components of movement:

1. Practice of the motor skill should focus on the action, not the component or pattern of movement. The child's efforts to meet task requirements drive the change in motor behavior (van der Weel, van der Meer, & Lee, 1991).
2. Normal movement quality is not the goal of practice of a motor task. A task can be achieved through many different means, and preferred coordination patterns are individual, based on the child's unique movement capabilities (Bernstein, 1967; Newell, 1996; Newell & Valvano, 1998). However, if the child chooses a coordination mode that brings about an unsuccessful or unsafe outcome, or, if the preferred pattern can cause secondary complications over time, the therapist may direct the child to a more appropriate pattern (Darrah & Bartlett, 1995). On the other hand, therapists must be careful in making decisions about the efficiency on the basis of qualitative aspects of the child's movement (Darrah & Bartlett, 1995).

Therapeutic adaptations to activity

Therapeutic handling techniques, used by the change agent and delivered during the context of daily routines and activities, might help children to initiate movement or produce a difficult movement. For example, Marc's therapist might suggest strategies for providing tactile input to the anterior surface of his trunk during play while sitting, to cue activation of his trunk flexors as balance against the increased trunk extension.

Or, the therapist might suggest strategies for providing pelvic stabilization to improve weight shift of the trunk during reaching. The neurodevelopment treatment approach provides many practical procedures for addressing components of movement during daily routines and activities that have become limited by impairments in muscle tone and selective control (Bly, 1991; Finnie, 1997; Girolami & Campbell, 1994). Although these procedures may be helpful in early phases of learning, it is critical that the infant does not become dependent on these therapeutic handling procedures in the functional environment.

Passive impairment-focused interventions

Passive procedures do not involve purposeful activity by the child, but they are relevant to the goal of improving purposeful activities during daily routines. These procedures might be grouped into (1) procedures not administered in the context of a purposeful task or activity and (2) passive procedures that are preparatory to a purposeful task or activity. Passive procedures not administered within the context of purposeful activities are usually interventions directed toward reducing secondary impairments of joint limitations or soft tissue contractures associated with muscle tone disorders. If limitations developed, Marc's parents might learn procedures or strategies to maintain ankle and hip range of motion through sustained stretching in a long-sitting position.

The second group of passive procedures includes preparatory activities performed by the therapist to create a state of optimal readiness for practice of a motor activity. These preparatory activities are usually directed to the musculoskeletal system and are conducted prior to a motor learning experience. Procedures to reduce soft tissue findings associated with the symptoms of spasticity are often used by physical and occupational therapists as preparatory to practice of a motor activity (Boehme, 1988; Kluzik, Fetters, & Coryell, 1990). For example, a parent might provide gentle rhythmic passive movements at the Marc's shoulders to reduce the "fixing" postures to make reaching more successful. Or, gentle elongation of the overactive trunk extensors might facilitate the activity in the trunk flexors, which is required for controlled weight shift during reaching. Finally, sensory modulation activities can be used to address neurological immaturity and to help better prepare Marc for interaction with his environment. Marc's parents could provide sustained, tactile input to his hands prior to reaching activities to reduce oversensitivity to touch.

As with any passive procedure, the ability of the child, over time, to perform his or her own preparatory activity should be considered and encouraged when it appears that the child may be able to make this a more active and independent activity in the daily repertoire.

SUMMARY

Early intervention services should be family-focused and provided within the context of daily routines. When young children have difficulty in developing motor skills, a pediatric occupational or physical therapist may provide intervention as primary service providers or as part of an early intervention team. Regardless of which team member serves as the primary service provider, the goal remains the same—functional independence within typical daily routines. Activity-focused motor interventions are designed with this goal in mind. This article walked you through a process of planning activity-focused interventions by

- using guidelines based on principles from motor learning and motor development;
- adapting these guidelines to address individual strengths and needs; and
- integrating impairment-focused interventions with activity-focused interventions within the context of everyday routines and activities.

Evidence-based research is essential to verify the use of this model in improving functional outcomes in young children. However, prior application of activity-focused or task-oriented intervention models to adults with neurological conditions leads us to believe that the underlying concepts can be successfully adapted to interventions for infants and young children with neurological conditions.

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