Theories of Motor Development

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An infant is born, and the journey of documenting developmental changes begins. Families celebrate and record a series of firsts—first smile, first roll, first tooth, first step. When these milestones appear at the expected age, it is confirmation that their infant is developing as anticipated. For parents of infants with an increased risk of developmental challenges, the appearance of these firsts at the expected time is affirmation that their child is developing appropriately for their age. It is also important to identify if an infant is not reaching milestones within the expected age range so that families can be supported.

Infants at risk for developmental concerns are followed closely during their first 2 years to identify delays and, if necessary, to initiate early intervention programs to support the infant and family. Members of neonatal follow-up clinics (neonatologists, pediatricians, nurses, physical therapists, and occupational therapists) monitor the motor abilities of infants attending follow-up programs. Gross motor milestones provide one of the earliest windows into an infant’s developmental progress. To identify atypical motor development, therapists require an in-depth knowledge of typical motor development. Requiring more than a developmental checklist of motor skills, therapists need to understand the theoretical frameworks used to explain the process of development, in addition to the output of developmental maturation. A theoretical framework provides an explanation of how motor skills appear, and change can assist in the design of intervention programs to encourage the development of more mature motor skills.

Consisting of a series of statements describing the laws, theoretical principles, or beliefs, a theory summarizes and explains observations and provides a basis for making predictions about the behavior studied. By definition, theoretical principles are tentative and require further research to be deemed valid (Lefrancois, 2006). These statements or hypotheses require thorough examination through experimental observation and manipulations. Beliefs are statements that are often personal observations and are even less substantiated by experimental results than theoretical principles. Laws, on the other hand, represent statements with accuracy beyond reasonable doubt; theories in the natural sciences such as chemistry and physics are characterized by a number of laws.

Applied sciences such as physical and occupational therapy have typically relied on theoretical principles and beliefs rather than laws. Theoretical frameworks adopted in applied professions are not merely esoteric descriptions of observations and predictions; they guide clinical decision making. Theories of infant motor development provide a platform to generate hypotheses or predictions about which factors influence the emergence of gross motor skills. These hypotheses then inform assessment and intervention approaches for infants who are either at risk for motor delay or who are exhibiting motor dysfunction.

A paradigm shift in theoretical frameworks used to explain infant motor development has occurred over the last 3 decades. An array of contemporary theoretical frameworks has replaced the established neuromaturational theory (NMT) that dominated clinical approaches to gross motor assessment and intervention for young infants for almost a century. The new frameworks have been described collectively as “developmental systems” theories (Ulrich, 2010) and include specific theories such as dynamic systems theory (DST) (Thelen & Bates, 1994), neuronal group selection theory (NGST) (Sporns & Edelman, 1993), neuroconstructionism (Karmiloff-Smith, 2006),

1The term parents is used to represent families and caregivers of varying structures.
2Throughout this manual we refer to therapists; however, the Alberta Infant Motor Scale (AIMS) is appropriate for use by other health professionals who have a knowledge of infant gross motor development.
probabilistic epigenesis (Gottlieb & Lickliter, 2007), and perception action theory (Gibson, 1988). All of these theoretical frameworks reject the NMT tenet that motor skill maturation is primarily dependent on neurological maturation. Instead they present interactionist models of development that consider factors within the child, the environment, and the parameters of the functional task that behave synergistically to modulate the appearance of infant gross motor skills. Child-related influences include neurological, behavioral, and physical factors. Neurological integrity has a major impact on an infant's movement choices, but contemporary theories also consider how other child factors such as muscle strength, range of motion, anthropometric ratios, temperament, cognition, and motivation modify motor behavior. Environmental influences represent external factors not related to a specific task. For example, gravity is a significant environmental factor shaping an infant's motor abilities in the first few months after birth. Other examples of environmental factors that may influence motor maturation include noise level, ambient temperature, and even restrictive clothing. Caregivers' influence on motor development is also receiving increasing interest. A review by Spittle and Treyvaud (2016) suggest that parents and the parent-infant relationship have the strongest influence on infant development.

Gross motor skills are universally represented by descriptions of motor milestones such as rolling, reaching, sitting independently, creeping, and pulling to stand. Functional motor tasks represent the choices that infants use to explore their environments. Specific characteristics of the task can influence the functional motor solution infants use to accomplish a motor skill. For example, when first pulling to stand, depending on the height of the surface, infants may change their strategy from pulling up with their arms to using their legs. Or when creeping on a rough surface, infants may choose to creep on hands and feet (bear-walking) rather than on hands and knees. Functional motor solutions are influenced by environmental constraints and facilitators.

In this chapter we review the constructs of three theoretical frameworks. Traditional NMT is included because many of its assumptions are still evident in current therapeutic clinical decision making (Rahlin et al., 2019). DST and NGST are discussed because contemporary assessment and intervention strategies are based on these two theories (Akbari Ziegler et al., 2019). Commonalities and differences across the three theoretical frameworks are highlighted, and the implications for assessment and therapy intervention for infants at risk of or demonstrating atypical gross motor development are discussed.

### NEUROMATURATIONAL THEORY

Until the 1980s NMT theory dominated the literature describing how infant motor skills appear and mature in the neonate, infant, and toddler. Arnold Gesell (1945), Myrtle McGraw (1945), and Mary Shirley (1931) undertook meticulous longitudinal studies to document the evolution of infant motor skills over time and to link that evolution to neurological maturation. The primary tenet of their NMT framework was that the emergence of infant motor skills is dependent on the inhibition of the subcortical centers of the brain as a result of the maturation of the motor cortex. Their hypotheses were influenced by the work of neuroanatomical and embryological researchers such as Coghill (1929) and Hooker (1952) who were investigating the direct relationship between stimulation of brain structures and motor output. Their work gave rise to a neuromaturationist paradigm suggesting that neural maturation dictated infant motor behaviors.

Gesell, McGraw, and Shirley independently followed cohorts of infants from the first few weeks following birth to the emergence of independent walking and beyond, documenting not only the chronological appearance of new motor skills but also providing explanations of how they emerged. From rigorous longitudinal observation of infants, they described the emergence of motor skills according to three patterns of maturation: reflexive to voluntary, cephalocaudal, and proximal to distal. Reflex movements preceded controlled voluntary movement. Purposeful movements emerged in a predictable manner; an infant achieved head control before trunk and pelvic control, and refined hand function appeared only after proximal shoulder control was achieved. They postulated that the primary driver of these developmental sequences was the inhibition of subcortical centers of the brain as a result of the maturation of higher cortical centers. They suggested that the blueprint for the emergence and maturation of gross motor skills was predetermined or hardwired and dependent on cortical inhibition of lower brain centers. Accordingly, they hypothesized that the environment played a secondary role, if any.

Gesell (1945) and McGraw (1935) conducted longitudinal twin studies to evaluate the influence of the environment on motor skill acquisition. One twin received scheduled controlled environmental stimulation to enhance motor development while the other twin acted as a control subject. Both researchers concluded that the environment had a negligible or minimal impact on the development of an infant’s gross motor skills. Shirley (1931) sent assessors to observe 25 infants in their homes weekly in their first year of life and biweekly during their second year to document the appearance and maturation of their gross motor skills. She described the emergence of motor milestones as being orderly, that the sequence of skill development was...
similar across infants, and that although the speed of development may vary among infants, it had no relationship to parents’ stimulation.

Gesell, McGraw, and Shirley are considered the pioneers of the NMT theoretical framework and its application to infant gross motor development. A closer examination of their work reveals that all three investigators considered factors other than neurological maturation as having an influence on infant gross motor development. Although McGraw’s initial purpose in her longitudinal records of infants was, in the fashion of Coghll, “. . . determining the relationship between behavior development and maturation of neural tissues, particularly those of the brain” (McGraw, 1945, p. xi), she soon realized that this goal was not achievable due to limitations of the available technology; instead she focused on documenting the maturation of motor skills. She viewed motor development as an interaction between neuroanatomical structure and physiological functions such as growth, not merely the maturation of the nervous system. McGraw’s “bidirectional theory” suggested that infants and toddlers contributed to their own development by controlling how much conscious effort they made to combine alternative strategies. She also introduced the concept of “critical periods” of development, defined as a time when an infant may be most ready to explore a new motor skill.

Gesell (1945) also acknowledged the influence of physical growth on motor development. His concept of “reciprocal interweaving” suggests that some basic motor functions diverge from each other when under the influence of other traits such as growth and then recombine into a more mature motor function independent of cortical inhibition. In the same manner, Shirley (1931) kept records of children’s height, weight, and head circumference and postulated that critical ratios of height and weight may influence the emergence of independent walking. While all three investigators discussed the variability of the emergence of infant motor skills, these observations were often overlooked due to their focus on documenting the average age of attainment of motor milestones. Developmental milestones became their legacy, and as a result some of the depth of their discussions has been lost. However, even though their descriptions of the emergence of infant motor skills included how internal and external factors other than cortical maturation could influence motor skills, they never considered how environmental factors could initiate motor solutions. Contemporary theories of motor development introduced this concept.

**A SHIFT IN THEORETICAL THINKING**

The advancement of neonatal intensive care for preterm infants in the 1970s stimulated renewed interest in infant gross motor development and a reevaluation of some of the assumptions of NMT. Touwen (1978) questioned the emphasis on reflex responses. He preferred using the term reactions rather than reflexes and concluded that a healthy neonate can respond to the same stimulus with a variety of motor responses. He suggested that variability in motor responses was a characteristic of typical development and that stereotypical responses in a neonate could be an indicator of abnormality. Improved ultrasound technology in the 1980s allowed real-time observations of the elegant, complex movement capabilities of a fetus. Prechtl (1984) recorded the development and continuity of fetal movements from 7.5 to 8 weeks postmenstrual age to 6 months postterm and documented in detail the quantitative and qualitative changes in neonatal motor responses. These descriptions of the maturation of fetal movements did not align with the prescriptive reflex model put forward by the NMT. At the same time alternative theoretical frameworks to explain infant motor development appeared in the literature. Two theories that have had an important influence on contemporary motor assessment and intervention approaches for young infants are the DST and NGST.

**Dynamic Systems Theory**

Dynamic systems principles emerged from the nonlinear dynamics of chaos theory (Gleick, 1987) described in the natural sciences literature of physics, mathematics, and biology. Researchers in these fields observed that when elements of a system work together, novel behaviors or patterns emerge that cannot be predicted from the individual contributing elements. Bernstein (1967) described a similar concept to explain adult movement by rejecting the belief that muscles were controlled individually by the central nervous system in a feedback manner. He suggested that motor choices in adults were determined by the self-organization of functional muscle synergies using information from neurological, muscular, and nonmuscular structures such as tendons and joints. He also postulated that muscle force information associated with the supporting surface could modulate the motor synergy used.

Esther Thelen, a psychologist, introduced the concepts of chaos theory and DST to the landscape of infant motor skills (Thelen et al., 1987). Her early work observing primary stepping in young infants questioned the assumption that primary stepping was a reflex integrated by cortical inhibition (Thelen et al., 1984). Her experiments revealed that the primary stepping reflex “disappeared” in infants by adding weights to their thighs and that the reflex “reappeared” in infants who no longer demonstrated the reflex when she altered the environment by holding them in a standing position in water. These findings challenged long-held beliefs about infant motor development in two important ways. First, Thelen postulated that the disappearance
of primary stepping was due to a critical fat: muscle ratio in the thighs of growing infants that made the leg too heavy to continue stepping. This hypothesis contradicted the belief that neurological maturation and reflex inhibition were solely responsible for the disappearance of reflex walking, thereby suggesting that other internal mechanisms or subsystems could affect motor output. Second, she demonstrated that an external change in environment could change the motor behavior of infants.

These two ideas have become tenets of contemporary descriptions of infant motor development. Her subsequent research on infant kicking and reaching (Thelen et al., 1993) supported her beliefs that motor skills emerged as a result of self-organization of an array of parameters within the child, the task, and the environment. No single subsystem can be considered the prime causal factor for the emergence of a new motor skill. Thelen also suggested that subsystems within the child do not mature at the same rate or in a linear fashion; a small change in an important subsystem or “control parameter” can result in a new motor behavior. Conversely, any subsystem within the child, task, or environment can act as a “rate-limiting factor,” impeding the emergence of a new motor skill. Infant motor solutions at any one point in time are flexible and the product of the dynamic interaction among many contributing factors within the child, the environment, and the specific task (Thelen et al., 1987). Thelen proposed that the functional task is the integral factor that shapes motor behavior. Interestingly, McGraw (1985), when reflecting on her academic research, wrote that in her twin study she had impeded the toddler’s ability to ride a tricycle by strapping his feet to the pedals. She concluded that by manipulating the task instead of permitting the child to craft his own solution, she had made it more difficult for the child to perform the task. As such, she adopted a dynamic systems perspective, suggesting that the characteristics of the task shape an infant’s motor solution.

Thelen continued to apply the tenets of DST to cognition (Thelen & Smith, 1994) and language (Thelen & Bates, 1994), and generated universal principles of development that could be applied across developmental domains. The first principle is the concept of nonlinear interactions of multiple internal and external subsystems influencing behaviors. The second principle is that the resultant behaviors are loosely assembled, allowing for variability of solutions over time and environments. The third principle is individuality, that children may choose different solutions for the same motor task. The fourth principle is described as embodiment, the suggestion that perception, action, and cognition are interrelated and cannot be partitioned into different developmental processes. Thelen constructed “a grand theory of dynamic systems” (Spencer et al., 2006) to explain changes in all developmental domains. Her research has challenged occupational and physical therapists to revisit a long-held belief system grounded in NMT that has guided clinical identification and intervention principles used with neonates and infants at risk for motor dysfunction for almost a century. One of the challenges of the DST framework is that it does not identify specific neural mechanisms responsible for the initiation of motor maturation—that is, how does the spiraling, interactive process begin (Sporns & Edelman, 1993)? Neuronal group selection theory draws attention to the neurological origins of motor maturation, while incorporating the influence of the environment and task.

### Neuronal Group Selection Theory

NGST has been described as a “bridge” between the NMT and DST frameworks (Hadders-Algra, 2000) because it acknowledges the influence of both nature (genetics) and nurture (environment and task) on the emergence and refinement of infant gross motor skills. Edelman (1987) proposed NGST as an overarching theory to explain how the maturational processes that occur in the brain and nervous system affect all areas of development. Sporns and Edelman (1993) applied this theory specifically to sensory motor development. Working from Bernstein’s premise that movement occurs in synergies, not through individual muscle actions, they suggested that maturation of movement results from coordination among the musculoskeletal and neurological systems and afferent stimulation from the environment. Their specific interest was how changes in the brain were related to both muscle coordination and environmental influences.

NGST proposes that movement variability is a critical component of infant motor development. At birth, movement is organized through diffuse, disorganized neuronal circuits in cortical and subcortical areas of the brain. Interconnected neurons that fire in a temporally coordinated manner form neuronal groups that produce more organized movement patterns. These primary movement repertoires are not hardwired or stereotyped across all infants; their variability is a product of genetic information that provides general movement constraints for movement choices. While primary movement repertoires do not provide specific solutions to environmental situations or tasks, these movements are more organized than those at birth.

As an infant matures and practices primary movement repertoires, the brain receives increased afferent information from the environment, resulting in the emergence of secondary movement patterns linked to specific tasks and environmental situations. Although both primary and secondary movement patterns exhibit variability, the source of variability differs. Primary movement variability is a
product of genetics and internal afferent information, while secondary movement patterns are a result of added external afferent information from environmental experience. These secondary movement choices are situational and task specific, appearing at different ages for different tasks.

The most mature form of secondary movement patterns evolves from one motor solution for a specific task to the emergence of multiple motor solutions for a specific motor task. This mature form of multiple solutions for one task may begin to appear for certain motor tasks as early as 2 years of age but may not appear for other more complex tasks until mature adolescence (Hadders-Algra, 2000). NGST synthesizes the interaction between neurological maturity and environmental influences; it views both as malleable and responsive. Motor maturation is not preprogrammed or hardwired; it is accomplished by initial diffuse interconnected neurons that eventually are directed to specific motor tasks as a result of afferent feedback from the environment.

The common intent of all three theories presented in this chapter is to understand and describe the process of emergence of typical infant motor skills. They differ in their explanations of the initiation of developmental changes. NMT describes inhibition of subcortical areas of the nervous system by the motor cortex as the primary instigator of change. DST views the demands of the task as the process that shapes motor behavior. NGST views diffuse epigenetic coding as the precursor of purposeful infant motor behavior. DST and NGST acknowledge that the final motor solution for any given motor task reflects an interaction of factors represented by the child, the task, and the environment. In both of these theoretical frameworks, motor development is fluid and variable, with no one preferred motor solution that may be applied across different circumstances. While McGraw and Gesell also recognized some variability in the timing and pattern of emerging motor skills both within a child and across children, their unremitting focus on the documentation of the rate and order of the emergence of universal motor milestones rather than on individual variability resulted in their adherence to the NMT.

Movement variability, both within an infant (intraindividual) and across infants (interindividual), defines typical motor development. Historically, variability in both the pattern and age of appearance of motor milestones was considered to represent measurement error (Vereijken, 2010); it was assumed that motor skills should emerge in a smooth linear fashion. The tenets of both DST and NGST suggest that infant motor skills emerge in a nonlinear manner. Nonlinear, unique individual patterns in the development of infants’ growth rates of height and weight have been reported (Lampl et al., 2001; Mei et al., 2004).

In the same manner, the appearance of infant motor skills can be episodic with many skills appearing in a short time coupled with periods of consolidation when no new motor skills emerge. Longitudinal studies of typically developing infants’ scores on gross motor, fine motor, and language developmental scales have revealed variability both in an individual infant’s score over time and among infants’ scores at one time (Darrah et al., 1998, 2003). Infants do not maintain the same percentile score at all sampling ages, and there is not one universal pattern of the emergence of infant motor skills. Previous studies of emerging motor milestones may have failed to capture these patterns of intraindividual and interindividual variability because the time interval between assessments in most longitudinal studies of infant development is long and thus may fail to capture the discontinuous shape of development (Adolph et al., 2008). Factors that affect variability can be intrinsic to the infant such as anthropometric change (height, weight, strength), behavioral characteristics (temperament, curiosity), and cognitive abilities. External factors associated with the environment or the demands of the task can also affect an infant’s movement solution. For example, an infant with a mature gait may revert to a high guard pattern when walking on uneven surfaces, or an infant may creep to move in her home but decides to bear-walk on hands and knees when outside on an unfamiliar surface.

In summary, contemporary theories of infant motor development reject the premise that motor skills are hardwired and dependent solely on cortical maturation. In addition to neurological integrity, many other physiologic and behavioral characteristics within an infant can influence motor behavior. Characteristics of the task and the environment also contribute to an infant’s motor solutions. How have these new principles and beliefs changed the assessment and intervention approaches of therapists?

**CHANGING THEORIES, CHANGING PRACTICE**

NMT dominated the landscape of infant motor development for over 50 years; as such, the theory informed and defined infant motor assessments and intervention principles during this time. Approaches to assessment were prescriptive and followed a reflex to voluntary movement pattern. Accordingly, therapists evaluated the integration of primitive reflexes, the emergence of righting and equilibrium reactions, and changes in muscle tone and resting postures, with little or no consideration of environmental influences. This assessment approach required extensive handling of the infant by the therapist, who often placed the infant in unnatural positions such as vertical and vertical suspension. Infants were expected to follow a similar course of motor development both in terms of the sequence...
of appearance of motor skills and the rate of appearance. Interindividual or intraindividual variability in patterns of movement were viewed as error or “noise” rather than an integral feature of emerging motor skills.

Traditional intervention programs for infants with motor disorders also were based on the assumptions underlying NMT. Extensive handling of an infant by the therapist attempted to inhibit “abnormal” patterns of movement and to facilitate “normal” patterns of movement. Treatment approaches included suppressing primitive reflexes, encouraging head control before trunk control, developing proximal shoulder control before voluntary hand control, and practicing sitting and four-point kneeling before standing. An infant’s movement was controlled by the therapist, and the therapist determined the optimal movement solution for an activity. For example, infants with increased muscle tone who were able to pull to stand using bilateral hip and knee extension may have been discouraged from standing until they could master a more “mature” dissociated pattern of movement through half-kneeling.

Interactionist theories such as DST and NGST have modified therapists’ perspectives of assessment and intervention approaches for infants at risk for motor delay and those with identified motor dysfunction. The tenets of these theories encourage therapists to consider the spontaneous motor solutions of infants as innovative rather than abnormal. Infant assessment tools have evolved from therapist-initiated testing of primitive reflexes, righting reactions, and equilibrium reactions to more hands-off approaches that entail observing the spontaneous movements of infants. The quality and variability of infant movements are considered important indicators of typical motor maturation. Motor milestones continue to provide a window into an infant’s motor progress but with the understanding that they represent the outcome of development, not the process of development (Adolph et al., 2008).

Intervention approaches based on DST and NGST frameworks are now occurring in clinical practice (Akhbari Ziegler et al., 2019; Law et al., 2007; Löwing et al., 2009; Morgan et al., 2016). These approaches focus on the achievement of child- and parent-identified functional goals rather than therapist-identified goals. The interventions are multifaceted and consider an array of factors within the child, the task, and the environment that may act as either barriers or facilitators to the achievement of the identified goal. There is an appreciation for child-initiated exploration of movement. Opportunities for practice are important; innovative movement solutions and environmental modifications are valued. Therapists no longer assume that there is one “best” motor solution that applies to all infants; rather they may provide opportunities for an infant to explore a variety of motor solutions to achieve the same functional task.

Similarly, traditional models of intervention are not supported using DST or NGST principles. The following clinical example highlights some of the assessment and intervention differences based on the NMT and contemporary theoretical models.

Amy is 8 months old with a diagnosis of mild spastic hemiplegia on her right side. She is curious and enjoys exploring her environment by rolling. She can maintain sitting when placed in the position. She recently learned a new way to move in sitting by “scooting” on her buttocks (bottom shuffling). Her parents are very proud that she has learned this new skill and want to share her achievement with her therapist.

Using the concepts of NMT, therapists might advise the parents to discourage “bottom shuffling” because of concern that it would promote further asymmetry. To achieve more symmetric motor behavior they might place Amy in a four-point kneeling position and encourage creeping to replace bottom shuffling. In contrast, using the concept of DST or NGST, therapists would respect, even celebrate, Amy’s new motor skill achievement with her parents and let Amy continue practicing her new skill. They also might ensure that Amy had opportunities to experience movement symmetry by modifying her environment and her motor tasks. For example, they might suggest toys that encourage the use of both hands and suggest that the parents place toys on a higher surface so that Amy can experience symmetry in standing. They would encourage opportunities for Amy to explore a variety of movement strategies but would not restrict Amy’s spontaneous movement solutions.

Therapy approaches derived from DST and NGST are not congruent with treatment principles based on tenets of the NMT. Even though DST and NGST frameworks are prevalent in the literature and are taught in entry-level professional programs, clinical interventions continue to incorporate many NMT-derived practices such as infant movement that is controlled by the therapist, preferred movement solutions, and the assumption that motor control should follow a cephalocaudal, proximal-to-distal sequence. A disconnect between contemporary theoretical frameworks and clinical decision making and interventions is still present (Rahlin et al., 2019).

**FUTURE CHALLENGES**

McGraw (1985) wrote an essay confessing six personal “blunders” of her career. Her fifth blunder was labeled “Theories.” She reflected:
Over the years colleagues have commented that I never attempted to formulate a McGraw Theory of early behavior development. . . . An explanation for my failure to do so is quite simple. At the time I was not qualified with an understanding of the artistry and techniques of theory formation, nor did I have the mathematical skill to do so. Perhaps therein lies my blunder. My concept was of multisystems developmental processes emerging and advancing at different times and different rates, but finally interacting, integrating and synthesizing for the creation of new performances or traits. I preferred to present my findings as observed and to allow future researchers to make use of them as they saw fit. Had I attempted to formulate a theory for such a complex of processes then decorated it with a catchy acronym, the chances are that it would soon have been challenged by some current or future investigator and then we would have another troublesome dichotomy to deal with. . . . Perhaps some future or present-day investigator can formulate a comprehensive theory of development that can withstand dichotomies. The subtle complex processes deserve a reliable, workable theory. (p. 170)

Perhaps if McGraw had ventured to develop a theoretical framework from her observations, it would have resembled the concepts of DST and NGST. Contemporary interactionist theorists suggest, as McGraw did, that development is an interactive, integrated, and synthesized process characterized by variability rather than uniformity. Has her vision of a reliable, workable theory been reached? At present the process of infant motor development is not explained by one universally accepted theory. Tenets of different theories overlap, making it confusing to disentangle the terminology and specific premises of each theory. Unfortunately, the efficacy of the emerging therapeutic programs based on these theories has not yet been confirmed (Morgan et al., 2016). More research is needed to evaluate whether the theories can, indeed, be supported by clinical interventions based on a unified therapy approach.

Perhaps one unified therapy approach to the assessment and intervention of infants at risk for motor disorders is not reasonable considering the complexity of infant motor maturation and the new understanding of the variability in motor solutions. Instead a “menu” of clinical assessment and intervention options based on theory and research may better guide therapists in making informed clinical choices tailored to the characteristics of an individual infant and a specific functional goal. There may be an array of intervention solutions to achieve a functional goal with the most effective solution differing for each infant. Such diversity of both individual motor solutions and therapy approaches makes evaluation of the effectiveness of interventions more challenging. New research evaluation methods may also need to be developed, as the gold standard randomized controlled trial may not prove to be the best method to use when evaluating the efficacy of new intervention approaches.

Infant motor development theory has evolved from prescriptive brain-controlled beliefs to contemporary frameworks that consider the role of numerous interacting variables within the infant, the task, and the environment that shape an infant’s motor solution. Contemporary theories of infant motor control have made the understanding of infant motor development more complex and hence more challenging to translate easily into practice. The challenge for physical and occupational therapists is to avoid repeating the error of blindly accepting the new theories, as was done with NMT, as truth. Theories are not truth; rather they are a set of assumptions to describe observations and as such need to be systematically evaluated. Occupational and physical therapists are well positioned, using innovative research methods, to evaluate assessment and intervention protocols based on the new theoretical paradigms, thereby linking practice to the underlying theory.

REFERENCES


CHAPTER 1  Theories of Motor Development


