The Mountain of Motor Development: A Metaphor

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ABSTRACT

Throughout history the field of motor development has employed a number of metaphors to explain how motor skills develop. These metaphors have typically described either the products or the processes of development, but few metaphors have provided an integrated framework to facilitate our understanding of both. Using Clark's characterization of six periods in motor skill development and concepts from the dynamic systems perspective, we present the metaphor of "the mountain" as an integrated framework to characterize both the products and processes of motor development. The metaphor of the mountain emphasizes the cumulative, sequential, and interactive nature of motor skill development as an emergent product of lifelong changes in multiple sources of constraint on behavior. Implications of selecting a developmental metaphor are discussed with regard to the utility of such descriptions for generating new insights and ultimately leading to formalized theories and models for a deeper understanding of the fundamental questions in motor skill development.

As infants, we all were once challenged to reach out for a toy we wanted or to walk independently across the living room carpet. Later in our lives, some of us may have become skilled basketball players, cellists, or dancers, while others were pleased to drive our cars safely or walk across the kitchen without spilling our coffee. Whether we become Olympians or not, across our lives, our motor skills will be dramatically transformed. Understanding how these transformations occur and what results from these transformations is the focus of motor development. That is, motor development has been defined as the changes in motor behavior over the lifespan *and* the process(es) which underlie these changes (Clark & Whitall, 1989, p. 194).

To understand motor development is no small challenge. Over the last century, researchers have discovered a vast catalogue of facts and relationships about when and in what order motor skills appear as well as the factors that influence these behaviors. But, how can we put all this information together to make sense of it? What is the relationship between the appearance of one motor skill and the disappearance of another? Why do some individuals develop skills and others do not? In science, we use several approaches for organizing what we know and what we might expect in the future. In general, these approaches come under the heading of "theory building." Theories take the facts we have discovered and provide a framework within which these facts can be systematically related.

Theories represent a formal system within which facts are connected and predictions are made about future events. Part of theory construction is the use of models and metaphors. Models too are formal systems. A model gives us a way of visualizing or representing concepts that are often difficult to grasp. For example, an inverted pendulum has been employed as a physical model of upright standing. We can "see" a pendulum (basically a ball atop a stick) standing on a surface. What forces, applied where, will push it over? Models can also be symbolic. Such symbolic representations usually take the form of mathematical equations depicting the phenomenon. In our upright standing example, an equation could be derived that would represent the behavior of the pendulum. If we changed parameters of the equation, for example, increasing the stiffness of the pendulum, we would predict specific outcomes such as increasing sway frequency. Would these predictions hold true for the behavior of a person standing quietly? By having a model of the behavior, we can generate and test formal hypotheses to help us understand the phenomenon better.

Another heuristic device that is used in science is the metaphor. As Snow writes, "models are scientific metaphors…" (1973, p. 82). A metaphor, like a model, is when one object or idea stands for another indicating a similarity or analogy between the two. Though the distinction between the two may be blurred, we will distinguish them on their level of formality. A model is a formal system that is usually connected to a set of empirical data, whereas a metaphor is often the first approximation of a representation and is therefore less formal and more speculative. Both are judged on their utility in conceptualizing difficult phenomena as well as their capacity to generate new and insightful ideas.

As we try to understand motor development, theories, models and metaphors are important tools that we use. In this chapter, we focus on metaphors that have been used for representing the "big picture" of how motor skills change across the lifespan. From conception to the end of life, how do our *purposeful, goal-directed* movements change? Our quest is to understand how individuals become skillful in their movement. Skillful movement is characterized by its efficiency, its adaptability, and its certainty of outcome (Clark, 1994; 1995). To be skillful, a performer must move with biomechanical, psychological and physiological efficiency. While being consistent, the skilled performer must also maintain the adaptability to adjust when conditions change. As we examine metaphors of motor development, we seek those that focus on representing the changing nature of motor behavior across the lifespan with a view to those behaviors that lead to motor skill.

SELECTING AN APPROPRIATE METAPHOR FOR MOTOR DEVELOPMENT

While it is not within the scope of this chapter to thoroughly discuss the use of metaphors in theory construction, it is important to address some dimensions for assessing the quality of a metaphor for conceptualizing the development of motor skills. In this section, we highlight key elements of a suitable metaphor and later follow with a brief critique of some metaphors that have previously been employed in our field. In the final section, we review a metaphor that we have used as a framework for teaching motor development and one that may help us better understand the relationship between the products and processes of lifespan motor development.

Two levels for assessing metaphors

The quality of a scientific metaphor should be considered on two levels. The first is at the level of the metaphor itself, or what we will call the level of *local application*. Local application refers to aspects of the metaphor that influence its quality and suitability with respect to the phenomena that the scientist wants to represent. Such factors include: how well the chosen representation fits with knowledge about the nature of the phenomena, simplicity, and the extent to which the metaphor aids in deployment and extension of knowledge of the phenomena. Evaluation of the metaphor at this level is based on the criteria of *usefulness*. As Reese & Overton (1970) discussed, theoretic characterizations in the form of metaphors "cannot be assessed as true or false…" rather, they can only be "…more or less useful" (p.120). In other words, the metaphor does not need to directly correspond to the phenomena; rather the metaphor should provide a framework for the development of adequate characterizations to assist in understanding the phenomena. An example of a question one would ask with respect to motor development, is "How similar is the metaphor to the process of change in skill development?" Does the metaphor accurately *represent* what is known about how motor skills change?

While the local application of the metaphor is critical to its usefulness, a metaphor must also fit with a broad view of how nature is organized. This level, the level of *global assumptions*, considers the metaphor with respect to fundamental assumptions regarding the *nature* of the process the scientist wishes to represent. When considering the global assumptions of a metaphor, we want to know whether or not it adequately reflects the organization of relations between elements of the metaphor as well as how it can be situated within the larger organization of nature. In developmental theory, global assumptions often appear at the level of the individual-environment relationship. The classic example of this is the dualist thinking that has led to the nature-nurture debate (Overton, 1998).

Assessing a developmental metaphor

At both levels, there are important issues to consider when selecting a metaphor that will help us understand developmental change. At the *global* level rests the issue of nature-nurture relations. While current thinking has moved away from questions of an "either-or" viewpoint and towards an adoption of the so-called interactionist position, many still address nature-nurture relations tacitly assuming that they are independent and distinct (Overton, 1998). Our position is that a metaphor is inadequate if it merely allots places for nature and nurture to separately exert influences on development in an additive fashion. An informed metaphor will recognize that heredity and environment are ends of the same continuum and the critical influence on development is their mutual, *inter*dependent interaction.

At the *local* level, developmental issues may be organized as *product* and *process* issues. Product issues are those that relate the metaphoric object to the observations of developmental change. Does the metaphoric object "look like" a developing organism? Process issues, on the other hand, are those that relate the metaphor to theoretical characterizations regarding the underlying nature of developmental change and its mechanisms. What does the metaphor suggest about *how* development occurs?

From our perspective, there are a number of particularly important issues regarding the characterization of the products of motor development. A metaphor should consider developmental change as *age related but not age determined*. That is, when constructing a developmental metaphor, one must consider developmental progress itself as the most appropriate means of demarcating change rather than age. It is not that "Maria had her first birthday, so now she will be able to walk", rather "Maria was standing on her own last week, which means walking is on its way". Secondly, an appropriate metaphor will not represent the lifespan as an "inverted-U", such that birth to adulthood is an increase in development followed by a decline from adulthood to death. Rather, development is always progressive and is characterized by lifelong adaptation of what is learned to changes in the structure (or function) of the body as well as the environment (Smith & Baltes, 1999).

Last, we come to an assessment of what a metaphor connotes about the underlying process of developmental change. Development is *sequential* and *cumulative*. Previous accomplishments are the foundations on which later accomplishments are built. At the same time, owing to this progressive and cumulative process, individual differences become greater as development progresses. Previous experiences never disappear, but form the basis of the individual's *motor repertoire*. The process connoted by a metaphor must capture both the regularities and the individual differences seen in development.

From the preceding discussion it is clear that choosing an appropriate metaphor is not a task that should be taken lightly. Here we have provided a minimal set of considerations to assist in deciding on an appropriate analogy or metaphor for the developing human. In what follows, we assess a few of the metaphors that have been used throughout the study of motor development.

METAPHORS FOR MOTOR DEVELOPMENT

Watching children grow and change from infancy to adulthood is striking in the similarities and differences observed. Trying to understand what appears to be universal and yet individual, simple and yet exceedingly complex, has provoked scientists to employ a variety of metaphors in theorizing about development.

In motor development, like development in general, metaphors are abundant. These metaphors fall into three categories: those that focus on the developmental *product*, i.e., the descriptions of motor behaviors that are observed; those that focus mostly on the *process*, i.e., the explanations of change; and, *integrated* metaphors that focus on both product and process. It is the latter that would be most useful as a heuristic since it would not only seek to explain what behaviors occur when and in what order, but would also offer an explanation about why these changes occur and would be most consistent with our definition of motor development.

Metaphors as Descriptions of Behavior

Biology has provided a rich source for metaphors in development and indirectly for motor development. The use of biological metaphors dates back to Aristotle who compared the stages of the human fetus to steps in evolution (Gould, 1984). These ideas were introduced again in Haeckel's "biogenetic principle" (i.e. recapitulation) in which the embryonic stages repeat, in proper sequence, the evolutionary history of the species (Haeckel, 1866). Empirically, the early embryologists saw unfolding, stage-like changes driven primarily by genetic codes. These ideas influenced many of the developmentalists of the first half of the 20th century. In fact, the concept of "stages" as a metaphor has been one of the most enduring legacies of biology. Consider the butterfly that goes through dramatically different life stages. Life begins in the egg and proceeds to a caterpillar (larva) stage, which is followed by the dormant chrysalis stage (pupa) that precedes the adult (imago) stage.

In humans, stages are less radical, but nonetheless, developmentalists have found the stage metaphor compelling. For example, the human lifespan is often characterized by the stages of infancy, childhood, adolescence, middle age, and old age. Basically, the stage is a synonym or descriptor for behaviors in a particular age range. Thus, saying an individual is in the adolescent stage indicates which behaviors we expect to see in an individual in that stage, but says nothing about how the individual got to that stage. It is possible that the stage metaphor could become explanatory, i.e., address the issue of process, but according to Brainerd (1978), this would require that the metaphor include explanations of "how" an individual progresses from one stage to another. That is, to say that an infant walks because she is in stage *x* of motor development is merely descriptive. To be explanatory requires a process by which the infant got to stage *x* from a previous stage.

In cognitive development, the major stage metaphor comes from the work of Piaget (cf. 1952). In developmental psychology, stages, it is argued, follow lawful properties (Pinard & Laurendeau, 1969). First, all individuals pass through the stages, referred to as universality. Second, they pass through the stages in an invariant order – the property of intransitivity. Finally, an individual in a stage will exhibit predominantly behaviors characteristic of that stage – demonstrating stability.

In motor development, many seem to accept the notion of stages, but only Roberton (1977a, 1977b, 1978, 1982) explicitly wrote of 'stages' and how they could be tested. It was Roberton's notion that the sequential changes observed in the development of forceful overarm throwing could be characterized into stages. However, Wohlwill (1973) argued that stages are not about intratask development (such as development within throwing), but rather should characterize the individual at some stage of development across many tasks (i.e., intertask development). Indeed, in 1980 Roberton agreed with Wohlwill and characterized the changes in throwing as 'developmental steps' (Roberton & Langendorfer, 1980). Since then, no one in motor development has explicitly argued for a stage model or metaphor. Yet, several textbooks in the field continue to adopt "stage-like" depictions of the changes in motor behavior across the lifespan. Payne and Isaacs (1999) use the "age stages" of prenatal, infancy, early, middle, and late childhood, adolescence, early, middle and late adulthood. Gabbard (2000) describes the changes in motor behavior as a "developmental continuum". Using similar age-stage descriptions, Gabbard adds "phases" of motor development along side the stages to depict the overlap and complementary nature between motor behavior and the traditional age-stages.

Cratty (1970) offered a somewhat different descriptive metaphor. His metaphor, though not explicitly stated to be "tree-like" is pictorially similar to a tree. The trunk of the tree is comprised of four channels or attributes (cognitive, perceptual, motor and verbal). Each channel (or limb) grows out from the trunk toward more mature behavior. Limbs bifurcate and create more limbs. For example, in the motor channel "manipulating objects" splits into throwing, stacking and scribbling. Cratty suggested his model was not a "layer cake" (presumably of the age-stage variety) but rather a "latticework" whereby the tree limbs would 'connect' with each other.

Metaphors as Developmental Process

Some metaphors in development never address what behaviors might be seen or in what order they might appear. Instead, these metaphors attempt to capture the *process* by which change occurs. One of the oldest metaphors to address the process of development was proposed by Gesell (1946). He suggested the "loom" was a natural metaphor as it captured the interweaving of the threads to form designs or patterns. Processes of development, wrote Gesell, were like the intricate cross-stitching or interlacing that organizes the system into a pattern of behavior.

In the late 20th century, the principal metaphor of developmental psychology was the "mind-as-computer". Simon (1962) offered this metaphor as he detailed an information processing theory of intellectual development. To Simon, computer programs governed performance at a particular level of development and change occurred when a computer program took an earlier ("younger") program and transformed it into an "older" program. One might see this transformation program as the "grower program". As computers became part of everyone's daily life, the metaphor became all the more compelling. Today such common expressions as "I need your input", "I can't retrieve that" or "I'm not a multi-tasker" are direct derivatives of the computer metaphor. While this is a powerful metaphor, it is not without its problems. A machine metaphor views development as static and dependent on outside agents to build and program the system (Thelen & Smith, 1998). However, development is dynamic, nonlinear and self-organizing (Thelen & Smith, 1994, 1998). Thus Thelen and Smith (1998) argue that a better metaphor would be a "mountain stream" – ever changing, dynamic, and influenced by many factors (constraints). In this same vein, picking up on the ecological metaphor used by Gibson (1966, 1979), van Geert (1991, 1993, 1994) sees an individual's growth and development much like an ecosystem that changes and develops as competing animals and plants change.

Although these metaphors may tell us "how" change occurs, they are mute as to when, in what order or what types of behaviors we might expect to see across the individual's lifespan.

Metaphors for both Developmental Process and Product

Metaphors that describe the product of development, such as the behaviors of a child during the preschool years, give us an important framework for characterizing or describing motor behavior across the lifespan. Metaphors that represent the process by which development occurs, such as "growing programs," represent notions about *how*, if not *why*, the developmental change occurs. While each of these types of metaphors is important, ideally we seek an *integrated* metaphor that characterizes both product and process.

Gallahue and Ozmun (1995) proposed an "hour glass" metaphor to represent both the process and product of development. As the sand falls through the hourglass (the *process*), layers build up creating the phases and stages of motor development (the *product*). The sand gets into the hourglass through two funnels, one from the "hereditary" container and the other from the "environment" container. The hereditary container has a lid on it, signifying that this sand is fixed in its contribution. The environmental container, on the other hand, is open and sand can be added across the lifespan. While the flowing sand represents how the various phases and stages are 'built', how the amount and timing of sand from each container is determined is never explained. Like the computer metaphor, the hourglass requires a 'builder' – an outside agent that would determine the amount of sand to flow, from which container sand would come, and when sand would flow. At some point, according to Gallahue and Ozmun, the hourglass turns over – around the late teens to early 20s. Again, an agent or "builder" is required for such an action. Why and how does this transformation occur? The inversion of the hourglass results in the top sand creating the periods of adulthood and old age. Interestingly, the metaphor includes heredity and lifestyle filters between the sand at the top and the empty glass below. These filters control the speed at which the sand passes.

No other metaphors could be found in the motor development literature that represent motor behaviors across the lifespan as well as the process(es) that account for these changing motor behaviors. The metaphor we propose in the following section, the "Mountain of Motor Development" is an attempt to provide such a metaphor.

THE MOUNTAIN OF MOTOR DEVELOPMENT

In this final section, we revisit Clark's (1994) characterization of six periods in lifespan motor development through the metaphor of learning to climb a mountain. Climbing the mountain of motor development (Figure 1) is an apt metaphor in that it takes years to learn, embodies an inherently sequential and cumulative process, and is influenced by individual skills and abilities as well as individual differences in context and practice. It is also representative of the ultimate accomplishment of motor development (the peak of the mountain), that is, the attainment of skilled motor action! Additionally, we expand Clark's developmental framework by extending the metaphor to characterize *both* the products and the process of motor skill development. Because our purpose is to discuss the metaphor we leave detailed discussion of the periods to Clark's earlier presentation (Clark, 1994).

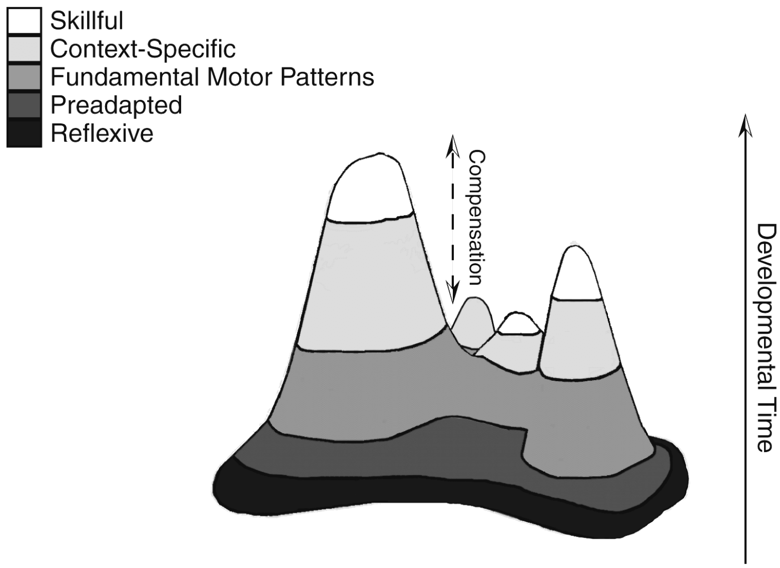

Fig. 1. One possible representation of the mountain of motor development. Developmental periods are demarcated by shading indicated in the legend at the top left. See text for details.

Global assumptions

In our discussion of the mountain, we hope to demonstrate that our chosen metaphor is consistent with our theoretical perspective namely, dynamical systems (c.f. Clark, 1995, 1997; Kelso, 1995; Thelen & Smith, 1994, 1998). In the language of dynamic systems, development is seen as an emergent product of a self-organizing process wherein changing constraints define the potentialities and behavioral options at each point in the lifespan. Such constraints, as well as their influence on development, have been identified as deriving from the organism, the environment, and the task at hand (Newell, 1986). Thus, as we will discuss at the end of this chapter, we view learning to climb the mountain as a nonlinear, self-organizing process that is driven by the goal of becoming an adaptive, autonomous actor in the world.

Importantly, it is the goals of the task that specify the *interaction* between the organism and the environment and this interaction is revealed as the behavioral products of developmental change. We see this as fitting in that the path up the mountain, as well as the level of success attained, are products of the characteristics of the mountain, environmental conditions on the mountain, and the individual skills and abilities of the mountaineer. In other words, in both cases (metaphoric and literal), the results emerge from the interaction amongst many changing constraints and are not pre-determined by either the mountaineer or the mountain alone.

The Mountain as a Description of Product

What are the products of motor development? Certainly, this seems to be a trivial question that would typically be met with an extensive list of motor milestones, fundamental behaviors, and specific skills that humans achieve throughout their lives. But, for our purpose of understanding motor development, such catalogue listings would be too extensive and unproductive. Humans are remarkably adaptive and exhibit a tremendous capacity to "solve" an almost infinite number of motor problems. With development, our motor repertoires become highly differentiated within and across individuals. The problem in a metaphor is that, to describe such complexity based on particular skills would either require (a) a metaphor that fails to meet the requirement of simplicity and thus be useless as a heuristic device, or (b) a general categorization of behaviors that would fail to illustrate the richness and versatility of human motor behavior.

Instead, we consider the products of motor development in a slightly more abstract sense. That is, becoming an adaptive, skilled and autonomous actor in the environment is the product of development. Once in the world, the infant's task, quite simply, is to adapt to and function in the new, complex, and ever changing environment. Thus, the mountain of motor development demarcates developmental periods, and the products associated with those periods, in terms of *adaptive developmental goals and the movements employed to meet those goals.*

Based on these developmental goals, Clark (1994) identified six major periods in motor skill development. Beginning around the third gestational month, these periods are (1) reflexive, (2) preadapted, (3) fundamental patterns, (4) context-specific, (5) skillful, and (6) compensation. Progression up the mountain is highly individualized while at the same time follows a cumulative, sequential process that characterizes most typically developing individuals. Skills and experiences from each period provide the basis for the extensions and refinements of the motor repertoire in subsequent periods. Importantly, age is not directly represented in the mountain. As with two climbers of different experience and skill levels, progress is determined by the specific constraints for each individual and not merely time spent on the mountain. In the following presentation of the mountain, some specific behaviors will be discussed, as will associated age ranges, however these are not to be seen as the primary concepts that define the mountain. They are presented more to illustrate the principles underlying the metaphor as well as to connect the metaphor to what is known about the typically developing child.

Prenatal development. When does the journey up the mountain of motor development begin? A likely "beginning" is when we have a body to move and muscles that are functional. Though this may be truthful, it is also relatively incomplete. What is important to remember is that all development is an emergent product of changing constraints. The mountain itself is a source of constraints and the developing individual is another source. We thus begin the climb as the constraints begin to interact.

A mountain's structure exists before the climber arrives at its foot, and so too are the constraints particular to an individual present long before the first cell divides. Before a child is conceived, his or her parents have been traveling their own individual journeys up the mountain. Their health and dietary habits (i.e. smoking, alcohol, caffeine use), the environmental conditions they experience (i.e. exposure to radiation or lead), and many other factors about their individual development will influence their physiological state and may be passed on to their child through the reproductive cells they contribute (Berk, 1994). This is not to say that the child's future is determined prior to birth. Rather, we consider the influence of genetics as the point at the base of the mountain that a climber chooses to begin. It could be a gentle and gradually rising foothill or a steep and rocky cliff. Either of the two is surmountable, but some starting points are more difficult than others. Further, it is not always the case that the starting point is indicative of future difficulties that may be encountered. The slowly rising foothill, after all, might lead to a deep gorge while the sheer cliff might give way to a well-traveled path. The point is that changing constraints drive development and lifelong motor development results from the interaction among many sources of constraint, some of which are interacting even before conception.

Reflexive period. Being delivered from the cramped, muffled, and warm environment of the womb into a cold, noisy and bright external environment is a traumatic introduction to the world. The first period on the mountain, the reflexive period, helps the neonate adapt to this major transition. Lasting from approximately the 3rd gestational month until 2 weeks after birth, the primary goals of this period are to: (1) facilitate survival and (2) "open a dialogue with the environment". Previously described as beginning at birth (Clark, 1994), the current notion of the reflexive period is that it can be subdivided into two similar, yet distinct portions defined as pre- and post-natal reflexive periods.

The subdivision of the reflexive period comes from the fact that the infants experience a major transition upon entrance into the external world. Environmental constraints are dramatically different in the world as compared to the infants' intrauterine experience. In addition to environmental changes are transformations within the infant's body. During birth, for example, infants produce large amount of stress hormones, causing increases in alertness, assisting in oxygenating blood to the brain and heart to compensate for constrictions and reductions in air flow during labor, and helping to absorb excess fluid in the lungs to prepare the newborn for his first gasps of air (Berk, 1994). Without a doubt, such tremendous changes produce what is likely to be one of the most difficult transitions in an individual's life. While prenatal movements could be considered a simple "turning on" of the neuromotor apparatus, it also seems that these movements serve a preparatory function in anticipation of the difficult first weeks of life during which the infant recovers from the birthing process.

During the reflexive period, actions fall into two general categories: spontaneous and reflexive movements. *Spontaneous movements* are movements, such as kicking, mouthing, or arm flailing, that do not appear to be elicited by a particular stimulus or environmental context. *Reflexive movements*, on the other hand, are relatively stereotyped motor responses to specific stimuli. Reflexive behaviors can be categorized into two broad types: primitive and postural. Primitive reflexes subserve basic functions necessary for survival, such as feeding (e.g. rooting and sucking) and protection from potentially harmful stimuli (e.g. moro and tongue protrusion). Postural reflexes are those that involve responses to changes in orientation relative to the environment. While both types of reflexes are present in some form both pre- and post-natally, due to the dramatically different environments, the repertoire of actions seen in prenatal life is much more limited than those observed after birth.

Though reflexes are advantageous for facilitating survival, a more subtle value of reflexes, as well as spontaneous movements, is that they "open a dialogue" with the external world. Indeed, all adaptive behaviors occur in response to sensory stimulation as well as produce sensory consequences. At birth, the infant is bombarded with a complex array of continuously changing sensory stimuli. How does the infant learn to make sense of such sensations? Many have argued that infants must exploit their actions to assign adaptive meaning to their sensory environment (E.J. Gibson, 1987, 1997; J.J. Gibson, 1979). As behaviors in the reflexive period result from and produce sensory stimuli, it seems reasonable to assume that the body has evolved to "teach" the system what sensations are coupled with which actions. This may be seen in reflexes that have no necessary survival value, yet have remained with our species through thousands of years of evolution. Take, for example, the asymmetric tonic neck reflex. This reflex occurs in response to a lateral turning of the head and is characterized by an extension of the arm in the direction of the turn as well as a flexion of the arm on the contralateral side. It is possible that this coupling of gaze direction with arm extension may serve less as a means for survival and more as a rudiment of visually-guided reaching (Fukuda, 1961).

The reflexive period is necessary to acquaint the infant with the mountain, but would be counter-productive if it lasted too long. For movement to be *adaptive* it needs to be flexibly tailored to task and context. Once the infant has recovered from the traumatic transition from pre- to postnatal life and begins to voluntarily initiate movements, we see the first major passage up the mountain of motor development. Metaphorically, the reflexive period marks the beginning of the journey, but to successfully proceed requires caregivers who will "carry" the infant along the first part of the path up the mountain.

Preadapted period. The passage to the preadapted period, while marked by the onset of voluntary movement, is not simply due to a disappearance or inhibition of reflexive behaviors. The beginning of the preadapted period is marked by the infant applying the rudimentary sensory-motor patterns from the reflexive period toward the goal of becoming an independent and adaptive actor in the world. The concept of preadaptation (Bruner, 1973) is chosen to represent the fact that movements in this period exhibit a *species-typical sequence* that characterize a progressive mastery of the body in a gravitational environment (Clark, 1994). Evolution has provided a set of genetic constraints that ensure a body structure as well as an arrangement of musculature that enables a functional motor repertoire. Though there is a nearly infinite range of possibilities for organizing the body's degrees of freedom (Bernstein, 1967), the reflexes help to define some of the fundamental sensory-motor relationships (Easton, 1972) that allow the infant to explore how her body works within our gravitational environment.

The primary goal of the preadapted period is the achievement of independent function. Two basic requirements of independent function are the ability to feed oneself and to move through the environment and seek out sources of nourishment. At birth, the pull of gravity proves to be too much for the infant to lift her head, much less support her body and move about. At the same time as gravity limits her movement, the objects and sounds of the world, as well as her own internal drives to find nourishment motivate the initiation of her struggle against gravity. First with the head on the trunk, followed later by the head and trunk on the hips and eventually with the whole body balanced over the small base provided by the feet, the infant progressively builds a sequence of behaviors that ultimately lead to independent stance and locomotion.

The emergence of manipulative skills also follows a sequence of preadapted movement patterns (Bushnell, 1985). Initial attempts at reaching, called pre-reaching, are characterized as "flinging" the arm towards a visually fixated object. With little coordination and driven largely by muscles around the shoulder, these early movements are rarely effective and never result in grasping the object. As improvements in posture continue, the infant stabilizes the trunk so as to increase control over prehensile movements. Over time, the primitive relationship between the eye and hand that was partially formed in the reflexive period (e.g. asymmetric tonic neck reflex) is exploited by the infant in the first visually-guided and successful reaches. These reaches, however, are far from the quality of the skilled and somewhat automatic reaches observed towards the end of the preadapted period (~9-12 months). Yet, with the onset of the successful reach comes refined hand-mouth coordination. Indeed, the infant does not eat every object that comes to his mouth, but when the coordination has developed to the point where an object can be efficiently obtained and placed in the mouth, the infant is clearly capable of self-feeding.

The passage out of the preadapted period, then, is marked by the joint accomplishment of self-feeding and walking behaviors. The preadapted period typically lasts from 2 weeks until the end of the first year of life and is rate-limited by the onset of independent walking. Importantly, the preadapted period is a time when infants learn how to work within the constraints defined by their body and the surrounding environment. Behaviors observed during this time are generalized actions aimed at one primary, adaptively necessary goal – to get off of the ground and find food. Nature and evolution have provided the general constraints for accomplishing this goal, but no detailed map has been included in the genes. The details of the path up the mountain are left up to a dynamic interaction between the constraints defined by the organism, environment and the developmental goal.

Fundamental patterns period. Equipped with the basic patterns of coordination for manipulation and locomotion, the infant climbs to a period during which these patterns are further elaborated into the "building blocks" of later context-specific motor skills. The overall goal of this period is to build a sufficiently diverse motor repertoire that will allow for later learning of adaptive, skilled actions that can be flexibly tailored to different and specific movement contexts. While the fundamental patterns period is entered during the child's infancy, it will last for most children until about 7 years where their fundamental patterns are applied to a specific context. From this "base camp", if you will, progress up the mountain becomes increasingly specific to the domain or context (e.g. throwing will become pitching). As seen in Figure 1, this is a time where individual constraints will lead to differentiation in the developmental trajectory (separate peaks of the mountain range). Though most typically developing children eventually achieve the fundamental patterns, considerable differences begin to emerge between those who have enriched and varied movement experiences as compared to those who do not.

There are three domains of motor behavior that emerge during this period on the mountain. First are the fundamental *locomotor* patterns. While the infant's first steps mark the passage into the fundamental patterns period, continued progress occurs *during* the fundamental patterns period. Three months after an infant takes her first steps, she demonstrates the leg movement patterns that have the adaptability and regularity of the mature adult. After about six months of walking experience the infant will run. Perhaps the more remarkable achievement occurs as infants and toddlers explore the various modes of locomotion, eventually producing asymmetric patterns such as galloping, sliding and hopping. These later emerging locomotor patterns provide an exquisite example of how meager beginnings, such as the symmetric pattern of walking, can be built upon and diversified to yield a range of coordination patterns that may flexibly be applied to a variety of task and environmental contexts.

Though adaptive locomotion is critical to an individual's ability to move through an environment, humans also need to develop a basis set of coordination patterns for interacting with the environment. Two categories of such interactive coordination patterns include *object projection* and *object interception*. For object projection patterns such as throwing, the individual initially has control of the object and projects it into the environment. Development of object projection skills involves changes in force-production as well as learning efficient whole-body coordination for appropriately applying force to the projected object. Object interception patterns, on the other hand, are those behaviors in which the object is moving within the environment and the individual wishes to intercept it. There are two forms of object interception, including *object reception* and *object deflection*. For object reception, such as catching, the goal is to control the object, taking it from its movement path. Object deflection, on the other hand, requires an interception, but rather than capturing the object – it is sent away (deflected). Striking and kicking are examples of object deflection. Important constraints for object interception are those involving perceptual judgments about the timing necessary to initiate the appropriate pattern of coordination. Further, object interception patterns require an ability to continuously update the movement pattern, using a coupled visual-proprioceptive feedback system to judge whether the trajectory of the movement is destined for success or failure. Again we see how an earlier accomplishment, visually-guided reaching, provides a basis for elaboration of the motor repertoire from visually guided arm movements to catching moving objects.

To complete the repertoire of fundamental movement patterns the human needs not only gross motor capabilities, but also must be able to manipulate objects in the environment. The fundamental *fine-motor manipulative patterns* are those which involve the use of the small muscles of the hands for a variety of behaviors ranging from communication to tool use. In the preadapted period the infant struggles with the ability to accurately and efficiently get the arm to an object and take hold of it. For example, grasping starts out as primarily whole-hand, undifferentiated movements (e.g. the power grip for writing) that, through the fundamental patterns period, become differentiated to the extent that the 5-year-old learns to write his name and draw pictures of his family (e.g. the adult, dynamic tripod grasp).

Importantly, the motor patterns developed during this period will provide the basis for later *motor skillfulness*. Games and sport, such as baseball, soccer, and basketball involve running, jumping, catching and throwing skills. Artistic endeavors, such as painting and playing the piano are context-specific applications of fine-motor manipulative skills such as writing and utensil use. Even everyday behaviors, such as typing, eating, or crossing a busy intersection will require competence in the fundamental motor patterns from these three domains. Indeed, these fundamental motor patterns form a base camp to which the individual may always return as he attempts to climb the various peaks (skills) on the mountain of motor development.

Context-specific period. As the child establishes his basic motor repertoire, he eventually begins to apply the fundamental patterns towards a variety of task and environmental contexts. The passage into the context-specific period occurs when the child no longer runs for the sake of running but instead begins to impose additional task constraints on how, where and why he is running. Keeping in mind that the goal of motor development is to become an adaptive, skilled and autonomous actor in the environment, the goal of the context-specific period is to learn how to adaptively apply fundamental movement patterns to a variety of constrained situations. Certainly, humans require a protracted period of development as compared to other members of the animal kingdom. In the context-specific period, we begin to see the advantage of this long-term process. That is, this is a time when the human learns the range and versatility of his motor repertoire and how his actions can be adapted to a number of specific situations. In the metaphor of the mountain (Figure 1), context-specific development is shown as multiple and specific peaks of varying heights. In some cases, the context-specific peak is seen as an end in itself; meaning that the ability to adapt a movement to an environment, as opposed to skilled movement, is the only goal the actor may have.

Generally speaking, with sufficient experience within a particular context, a child may pass into the context-specific period as early as 4 or 5 years of age. Take for example Tiger Woods, the professional golfer, who was clearly beyond the fundamental patterns period at a very early age. One can think of many similar examples in which early experience has accelerated the progress towards a specific peak on the mountain. Yet, a more typically developing child would be expected to make the passage into the context-specific period around the age of 7.

Because humans encounter new movement contexts throughout their life, they will continuously return to the base camp of the fundamental patterns period, followed by a new passage onto another peak (context-specific period) of the mountain. Consider, for example, the adult attempting to learn the guitar when having no previous experience with stringed instruments. In order to climb this new peak on the mountain, he will have to return, however briefly, to the fundamental fine-motor manipulative patterns before being able to adaptively make the appropriate finger placements for chords, or flexibly differentiate the fingers to sound a melodic arpeggio. This is an important reminder that lifelong development, while being age-related, is not determined by the time spent on the mountain (getting older). Individual experience is certainly a large influence over the developmental changes that occur during the context-specific period.

Related to this is the fact that, from the context-specific period onward, development of motor skills becomes increasingly individualized. The preadapted and fundamental patterns periods are the primary times when species-typical behaviors develop that are common to all humans. After the fundamental motor repertoire has been established, however, motor skill development becomes influenced more by cultural, familial, and social constraints. A boy who is raised in the town that holds the state-championship for football will likely be encouraged to apply his fundamental patterns to the task constraints of football. Yet, if that boy comes from a family of carpenters, he will likely be raised in an environment where tool use and craftsmanship are considered more important than being a sports hero. Further, if that boy were raised in South America or Europe, cultural influences might result in his becoming a soccer player rather than a quarterback. These and other environmental factors will provide strong influences on the specific applications of fundamental patterns during the context-specific period.

Because development in the context-specific period is driven by particular tasks and experiences, another important rate-limiter is the development of perceptual-cognitive capabilities. If fundamental patterns are to conform to a particular task, such as a sport or game, the child needs to perceive and understand the *rules* and *context-specific knowledges* associated with those tasks. For example, while the child may know how to throw a ball, in a baseball game knowing when, where and to whom she should throw the ball becomes a critical aspect of being successful. Because of the specificity of knowledge required for context-specific adaptation, *experience* with the particular task and environment also takes on a critical role in this period on the mountain.

The context-specific period is an important time in the life of the developing child. It is a time that can either stifle or facilitate progress towards becoming an adaptive, autonomous actor in our complex world. Though all typically developing humans enter the context-specific period, it is again important to recognize that experience and environmental influences are major determinants of how fast and how far the individual will ascend the mountain of motor development. As with climbing a mountain, progress becomes more difficult the further one climbs. In addition to a well-developed fundamental motor repertoire, dedicated practice and experience become major factors in the level of skillfulness that an individual will reach. Thus, the passage between the context-specific and the skillful period is driven primarily by the individual's motivation to excel as well as the opportunities they have to devote to sharpening their particular skill.

Skillful period. With enough dedicated practice and experience, the individual soon will pass from context-specific competence to skill. The goal of this period is the achievement of skillful behavior. Motor skill is characterized as being voluntary, efficient and adaptive (Clark, 1994; 1995). Once true skill is achieved, the performer can apply their behavior with maximum certainty in a variety of contexts and situations. Psychological efficiency is demonstrated by the performer's ability to focus on strategy, rather than maintaining attention on the performance of the skill (Hatfield & Hillman, 2001). Physiological and mechanical efficiency are seen in the ability of the individual to maximize work output while, at the same time, keeping physical effort to a minimum. Take a skilled basketball player, for example, who can gracefully weave her way through 3 opponents whilst at the same time feigning a shot at the goal and executing a “no-look” pass to her teammate.

Certainly, no individual becomes skillful across a wide range of behaviors and contexts. Rather, attainment of skill is largely specific to a particular sub-domain of motor behavior. The first passage into the skillful period generally coincides with two general achievements. First and foremost, the individual must have significant context-specific experience with the particular behavior. The importance of dedicated practice and experience cannot be stressed enough. Without the proper opportunities and support, as well as explicit guidance from other experienced individuals (such as parents, peers or coaches), achievement of skill would likely not occur. Secondly, the passage into skillfulness tends to coincide with the onset of puberty and the adolescent growth spurt, at approximately 11-13 years of age. The dramatic increases in body size, strength and cognitive-emotional capabilities that coincide with adolescence are important constraints that allow differentiation between competent and skilled movers.

Of course, many examples may be discussed in which skill is evident at young ages. One has only to watch Olympic gymnasts to realize that the young can demonstrate very high-level performances. Yet, as no two mountain peaks are the same, skill in one sub-domain does not necessarily imply skill in any other. An individual’s skills are dependent upon their own particular constraints and are specific to those behaviors with which she or he has had significant practice and experience. Of course, certain competencies that are common between skills may influence the rate at which the individual may achieve skillfulness in a new behavior. For example, a skilled wrestler may decide to study judo. While the specific postures and techniques may be different between the two sports, certain abilities such as balance control, timing, and knowledge of how to upset the opponents balance may provide the wrestler an advantage over the complete novice.

Finally, it is important to acknowledge that skillfulness occurs on its own continuum. Different individuals may be climbing different peaks of the mountain. Not everyone becomes an Olympic athlete or a world-renown musician. However, for some individuals, skill eventually becomes *expertise*. Expertise is exceptionally skilled motor performance that occurs due to an optimal interaction of biological and environmental constraints as well as years of dedicated practice and experience (Ericsson, Krampe & Tesch-Romer, 1993; Ericsson & Lehmann, 1996). Certainly no one becomes an expert performer over night. Those who become experts often began the context-specific application of their skill very early in life, but professional athletes, Olympians, and concert-musicians alike do not generally achieve the rewards for their years of practice until well into their 20's.

To enter the skillful period on the mountain may take years of practice and experience with specific motor skills. Nearly all typically developing people will obtain some motor competence within their lifetime. Consider the average person navigating through their home to get a glass of water in the dark of night. Clearly, such ability represents skillful locomotor control in that, in an impoverished visual environment, the task is easily accomplished. At the same time, such ability also comes from years of walking through a vast range of environments from dry, well-lit pavement to an uneven, slippery lawn at dusk. The skillful period, as with all other periods on the mountain, comes from a progressive building and refinement of the motor repertoire. From the meager beginnings of the infant who cannot lift his head at birth, comes the ability to drive a manual transmission car, dance a polka at a wedding, or even perform a triple axle on ice skates in the Olympics. Although skillfulness is metaphorically at the peaks of the mountain, it is not the end of the process of motor development.

Compensation period. Throughout the discussion of the mountain of motor development, two major themes have been discussed. First, the mountain presents a story of development as lifelong, cumulative, and progressive adaptation. Second, the changes seen across the lifespan are due to changing constraints from the organism, environment and task. As these constraints change, so do the behaviors that we observe. From the newborn to the skilled adult, motor development represents an emergent process of progressive adaptation. As with all of the previous periods on the mountain, this holds true for the final period of motor development, the compensation period.

The word "compensate" is defined as "to make up for" or "to counterbalance". Compensation implies that a part of a system is not performing up to standard and the rest of the system must adapt in order to accomplish the goal. In the case of motor development, this can be thought of as a change in the constraints that produce a behavior and a subsequent behavioral reorganization to afford continued function. Clark (1994) defined the compensation period as a time when the system adapts, or compensates for detrimental changes in organism constraints. There are two ways in which the compensation period can be brought about, including *injury-induced*: a change in organism constraints associated with an injury and *aging-associated*: the typical changes in organism constraints that are associated with the process of aging.

The difference between the two types of compensation has to do with the typical developmental directionality associate with each.

Injury-induced compensations are generally considered bi-directional in that, throughout life, all individuals have setbacks in their progress up the mountain. Occasionally these are permanent changes, such as in the case of a traumatic accident leading to changes in the structural or functional features of the body. However, most often these are discrete injuries that lead to a temporary need to return to a previous fundamental base camp in order to adapt the behavior for continued function in everyday life. In some cases, because of this discrete return to the fundamental patterns period, the injury-induced compensation may lead to an expansion of the motor repertoire. An example of this is in the case where an individual is forced to learn how to write with the non-dominant hand while the dominant arm is recovering from a broken bone. Aging-associated compensation, on the other hand, is generally considered to have a progressive developmental direction. This is because, despite the fact that the system remains adaptive during aging, there are certain organism constraints that will progressively undergo reduced function with continued development.

The important commonality between the two types of compensation, however, has to do with the fact that compensation implies a fundamental capability of the system to adaptively reorganize to maintain function within the external world. Indeed, many theories exist regarding the aging body. Unfortunately, most of these theories focus on aging as a regressive state in which the body deteriorates. To consider aging as an adaptive process, rather than as a regressive one, seems a more powerful and optimistic means of characterizing the nature of change across the lifespan. Aging is not merely an overturning of the process of development. Rather, we consider aging as a compensatory state in which the body may maintain most of its function throughout the end of the lifespan.

Depending on the physiological system as well as the individual’s life history and level of activity, different developmental courses can be seen within the aging-associated compensation period. For example, it is relatively well established that normal, healthy older adults can maintain cardiac and muscular function through routine exercise (Spirduso, 1995). At the same time, other systems such as skeletal bone density and macular degeneration in the visual system seem to be influenced very little by maintaining an active, healthy lifestyle. Clearly, there are declines associated with old age. However, increases in pathology and decreased activity or disuse also seem to be major contributing factors to these changes. Yet, the aging body retains its capacity to respond to activity across many physiological systems and thus, aging is not simply process of progressive decline.

From infant to older adult, development is driven by progressive adaptation. The primary goal of a mover in the world is to be an adaptive and autonomous actor in the environment. Whether learning motor behaviors for the first time or compensating for detrimental changes in organism constraints, development continues through the process of adaptation. While, through the majority of the lifespan, motor abilities improve with experience in the external world, it is important to remember that adaptive function is the goal of motor development. Though one may or may not return to a previous level of skillfulness following a compensation period, one can typically manage to meet the goal of maintaining adaptive function.

Atypical development and the mountain. Although our presentation of the mountain has primarily discussed the typically developing human, it is important to note that this framework can be used with those who follow a different path. The process embodied by the mountain applies to any human, typical or atypical. While some may have to climb a different mountain than most, their path up that mountain will be the result of the same process. That is, the constraints may differ and the limitations may be harder to circumvent, but the developmental products will result from interaction between the individual, environment and the task.

Further, in the language of the mountain, the products (developmental goals) will also be similar. The atypically developing child will have reflexive, preadapted, fundamental, and context-specific periods. Yet, these periods will be tailored to their own organismic constraints. For example, the child born with cerebral palsy will have a preadapted period in which they learn to walk. According to Holt, however, the child with cerebral palsy has to learn to manage a system with a fundamentally different functional architechture and thus, will have different criteria in choosing an appropriate gait pattern (Holt & Jeng, 1992). Therefore, instead of walking with the energy-efficient gait pattern of the typically developing individual, the pattern of locomotion used by the child with cerebral palsy is one that emphasizes postural stability.

This is not to say that the atypically developing child should be treated or considered in the same manner as those who do develop normally. What this does say is that, when attempting to understand atypical development as well as design developmental interventions, it is critical to consider all sources of constraint. Typically, those who work with developmentally challenged populations focus on “making the atypical child look typical”. Often, this may result in surgical or pharmaceutical interventions that have minimal, if any, positive outcomes. Perhaps, instead of attempting to impose normality on atypical individuals, it would be more fruitful to work within the constraints that are unique to that person.

The Mountain as Description of Developmental Process

Throughout this presentation of the mountain of motor development, our focus has been primarily on relating the products of development metaphorically through the various periods on the mountain. However, a close read of this presentation also reveals a few themes that are indicative of how the mountain may relate to the process of development. These themes are important enough that they merit a more explicit discussion. Specifically, these themes involve: the goal of development, the importance of development as a cumulative and history-dependent process, and the consequences of the interactional nature of development.

Autonomy as a goal of development

Perhaps one of the most critical questions for developmental theory is the question of "why". That is, why climb the mountain of motor development? Is there a goal towards which development progresses? The field of developmental psychology has been characterized as divided, at the level of the root metaphor, by the question of whether or not development is goal directed (Reese & Overton, 1970). Even the current conception of development adopted by those working from the dynamic systems perspective is that there is no necessary teleology, or goal-directed nature, to development. As stated by Thelen & Smith (1998), "The mountain stream metaphor depicts behavioral development as an *epigenetic process*, that is, truly constructed by its own history and systemwide activity" (p. 569). While we find this metaphor agreeable at one level, it does not provide an intuitive means of understanding the species-typical regularities seen in human development.

Rather than adopting a split, "either-or" position, we choose to consider development as a process that has a non-specific goal, which organizes the epigenetic process in such a way as to produce species-typical behaviors. This non-specific goal is to become an adaptive, skilled and autonomous actor in the environment. In order to achieve this goal, the developing organism must seek out adaptive solutions by *actively* interacting with the environment. The motor repertoire is formed as the actions of the system are exploited to select the most adaptive solutions from the array of possible choices given by the current constraints. A particular solution becomes adaptive when it facilitates progress towards the goal of autonomous function given the current set of constraints. Thus, as with the mountain stream metaphor, developmental products "fall out" of the systemwide, active interactions with the environment. Concisely, development is inherent in the system and therefore, the process itself becomes the goal of development. Indeed, if the mountaineer's goal was merely to "get to the top", a helicopter would suffice. The reason for climbing the mountain is *to climb the mountain*. That is, learning to climb the mountain is inherently rewarding since it provides the climber an increased array of choices for adaptive and skilled behavior.

History dependence and developmental process

Given that the process of selectively seeking adaptive solutions is the goal of motor development, we must also recognize the importance of history as a major factor. Development is not a stage-like process in which previous states are disconnected from current and future states. Development is cumulative. When climbing a mountain, the choices made at a lower elevation will influence the nature and range of choices that may be made higher up. The path up the mountain builds upon itself, forming a foundation for continued progress towards the peak. Likewise, in motor development, both physiological maturity and experience are parts of the history of the developing system that provide a functional basis for later elaboration of the motor repertoire.

Of course, motor development is not necessarily a one-way path to the top of the mountain. As Lerner (1998) discusses, human development is characterized by *relative plasticity* that exists over the lifespan. What this means is that a certain amount of flexibility exists that affords the *potential* to learn motor skills throughout the lifespan. One may always move up and down the mountain range within reasonable limits. Yet, this plasticity is relative in the sense that it interacts with the individual's current developmental level. Because development is history-dependent and cumulative, the available motor repertoire changes along with development. Again, analogous to climbing a mountain, once a certain point is reached it may not be possible to "start over". Rather, depending on where on the mountain the individual is, it might be more efficient to select the most adaptive behavior from the current motor repertoire instead of attempting to re-learn at the level of the fundamental patterns. Alternatively, at some point the climber may have to "retrace" her steps, returning to a fundamental base camp, in order to attempt an alternate route towards other peaks (context-specific and skillful behaviors); particularly if the current path is not passable.

The interactive nature of development

The final theme represents a return to the global assumption that underlies our conception of motor development. That is, fundamentally, the metaphor of the mountain assumes that the most important influence on development is the interaction between nature and nurture. Further, we do not consider nature as fundamentally distinct from nurture. Indeed, the structure of a mountain is not static. Environmental conditions such as precipitation and wind lead to erosion and rock falls, which, over millions of years alter the structure of the mountain. Similarly, genetic constitution both within a species as well as within a family is an emergent property of the experiences and constraints of each individual in the lineage. Current evidence suggests that even within an organism, genetic materials are not static "on-off" entities that determine an individual's fate. Rather, genetic expression, observed as a phenotype, is determined by the interaction between the DNA code, biophysical laws and the environmental milieu within which that code is to be expressed (Elman et al, 1996).

More explicitly, the development of motor skills results from the *interaction between the constraints* (organismic, environmental, and task) that are specific to each individual. To the extent that the constraints are similar across individuals, such as in the reflexive and preadapted periods, regularity and stereotypy will be observed. However, the further up the mountain an individual climbs, due to the cumulative nature of development, the more specific the constraints will become to that individual.

Finally, development is a nonlinear process. Throughout the lifespan and across different time-scales, the rate of development can appear linear, nonlinear (i.e. exponential), discontinuous, at a plateau, or even regressive. Certainly, for development to show such a diverse range of trajectories, it must result from a dynamically interactive rather than a linearly additive process. As seen in Figure 1, the process of development occurs over a range of "peaks" in the mountain. The level of skill attained is known to vary across individuals, as well as across behaviors within an individual. Indeed, development cannot be described as the result of a stage-like process in which *all* skills progress at the same rate. Considering behavior as an emergent property due to the interaction between constraints that are specific to individuals, as well as to particular skills, allows for a ubiquitous description and characterization of the *how* and *why* of motor development.

BEYOND THE METAPHOR: SUMMARY AND CONCLUSIONS

In this chapter, we have discussed the utility of the metaphor as a tool to provide a framework for understanding complex phenomena such as the development of motor skills. After discussion of metaphors as process, product, and integrated (process-product) descriptions, we forwarded our own integrated metaphor in an attempt to provide a simple, yet relatively complete picture of critical features and principles of the developing motor system. In this metaphor, which we call "the mountain of motor development"; developmental progress is seen as the result of a process in which changing constraints interact and self-organize yielding a cumulative and sequential pattern of developing motor skills.

While this metaphor is useful as a heuristic device to facilitate an understanding of motor development, it is important to remember that metaphors are not to be ends unto themselves. Metaphors are first steps in building towards more formalized models and theoretical frameworks. In the first section of this chapter, we argued that metaphors are to be assessed on the criteria of usefulness. Certainly, if the mountain provides an intuitive and accurate means to communicate knowledge about motor development and thus, facilitates teaching and learning, then on one level we have been successful in our intent. At the same time, we present the mountain to inspire new ways of understanding for both the researcher and the teacher of motor development. The challenge for the future, then, is: "How will we, as motor developmentalists, move beyond the metaphor?" (van der Maas, 1995).

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