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Motor Development: Core Curricular Concepts

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Motor developmentalists study the processes that underlie change in behavior. There are at least two fundamental ways in which theory and data emanating from motor development are critical components of what undergraduate kinesiology majors should know. First is an emphasis on the lifespan. We are very different organisms as we progress through life; understanding how and why a behavior developed into the pattern we see helps us understand it better at any unique point in time. Second is the emphasis on the interaction of multiple factors on emergent behaviors. Interdependency is fundamental, regardless of the subsystem or age group of interest. Incumbent upon us as teaching faculty is to reinforce within and across our subdisciplines that our content is interrelated and must be integrated in order to fully understand concepts, contextualize the information, and creatively solve problems, whether they are clinical, instructional, or purely scientific.

In the spring of 2006, Gil Reeve asked me to present a paper at the fall Academy meeting, addressing what kinesiology students need to learn from motor development. As straightforward as that request may seem, I admit to struggling with my precise goal. After considerable thought I interpreted my task to include the following: (a) to summarize the core content included in the curriculum for undergraduates in kinesiology; (b) to address how and why motor development is relevant to students in these programs, thus, to a kinesiologist; and (c) to identify some of the issues that are still emerging and important, but not clearly staples of this core. As I labored over this task it became clear to me that another relevant issue needed to be addressed: How do the existing categorical specialties called motor development, motor control, and motor learning intersect? Further, can this set of highly interrelated core areas have greater impact and set the standard for integrating content across subdisciplines by consolidating into one area, perhaps under the title, motor behavior? In the following pages I will address first, Gil's request, as I understand it, followed by a more speculative section on future possibilities.

To be as fair and comprehensive as possible in addressing parts (a), (b), and (c) above I surveyed colleagues around the U.S. It seemed reasonable to expect that what students in kinesiology should know about motor development should be reflected in what is taught in our motor development courses. Therefore, the questions I included in the survey addressed, primarily, the topics on course syllabi

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and the proportion of time spent on each. Respondents identified themselves as working primarily in Research 1 institutions whose students tended to pursue careers in teaching or were bound for graduate programs in health sciences (e.g., M.D., P.T., O.T., or research). The information presented below represents my synthesis of the feedback I received, with, of course, a dose of editorial license.

Motor Development, by Definition

As a Field of Study…

For those among the readership who are not motor developmentalists it may be useful to provide a definition of this area of study. Textbook authors and professors (as reflected in their course syllabi) tend to define this area in a relatively consistent way. With one small addition to a typical version of a definition noted in italics, I offer the following. Motor development is the study of change in motor behavior over time, *including typical trajectories of behavior across the lifespan*, the processes that underlie the changes we see, and factors that influence motor behavior.

Change over time reflects our interest in how people move over the lifespan, not only infants and children, but adults and the elderly too. We are interested in understanding the processes that explain how change happens. And we study factors that can impact significantly the behaviors that emerge—whether a particular behavior is evident at all, when it occurs, and what it looks like.

I have not seen the phrase I inserted in italics included in any recent textbooks or my colleagues' syllabi. Nevertheless, based on nearly all of these resources, this is content that is taught, and by association, must have been studied and published. I believe the omission may occur because some see it as unnecessary as part of a definition while others may fear that it is associated with simple, atheoretical, charting of behavior. To be sure, description adds knowledge but not theory. And I do not wish to promote description without purpose. Thoughtful studies of behavior over time are designed to uncover significant shifts in behavior, particularly qualitative changes in the ways people perform the same task. These discoveries identify fertile opportunities to probe the system and uncover the factors (control parameters) to which the system is sensitive; the data can contribute to the design of more theoretical studies. In a more clinical application, descriptions provide us with a barometer—reference points through which we put in perspective observations of behavior that depart from typical and signal when follow up screening or referral on the part of the observer may be prudent. Studies that involve description have value if designed with a problem worth solving in mind.

As a Global Process …

The term motor development is used to define a subdiscipline and by many scholars to define a process as well. In this use, for the organism, motor development is the ongoing process of exploring and matching one's intrinsic and extrinsic resources to one's goal. From this frame of reference behavior is always adaptive. One can study the degree to which individuals adapt their behavior, for example, from one set of conditions to another, or from relatively inaccurate to more precise and accurate.

Persons can adapt, that is, make adjustments in behavior based on their perceptions of previous attempts yet still fail to meet the intended goal, or, more often, fail if the goals imposed upon them are beyond their capacities and experience levels to achieve. I noted that *many scholars* use the term motor development to define a process. I also wish to note that implies disagreement; many *other scholars* view this as an inappropriate use of the term, which defines a field of study, only. As long as the secondary use does not become confused with the primary use, I believe both can function well for us.[1] By this secondary definition I would, for example, define my grandniece, Ellie's, process of spontaneously discovering a way to couple her body movements to the Latin rhythms pouring out of her parents' CD player in their backyard when she is 18 months old to that of mimicking her friends' movements (or inventing her own) on the dance floor at a wedding reception when she is 18 years old, as an example of the progression of her own motor development. The differences in her overt behavior at these two points in her life reflect the shift in her capacities as she responds to the same, or a similar at least, goal, with different capacities and a more extensive history of experiences.

Undergraduate Curricular Content Themes

Definitions provide the boundaries of an area, but the richness that lies within those boundaries is expressed by the types of and examples of knowledge that has been uncovered by scientists working in this field. The essence of this is depicted in the topical sequences of our courses. To organize the array of topics covered in motor development courses I settled on four major themes, based primarily on the consistency with which these areas or components of this subdiscipline appeared on syllabi, the relative amount of time spent on them, and the emphasis (either based on time or statements of importance) suggested by respondents. The thematic headings I use here seldom appeared on syllabi, with the exception of theory; in all other cases the content was organized under a host of different headings and subheadings. Further, specific content within these themes and the ways in which faculty organized or wove together the relations among them varied, to be sure. That said, I propose the consistent themes that emerge are: theory, developmental periods, developmental trajectories, and factors that affect motor behavior.

Theory

One could reasonably argue that a better way to describe this theme would be to call it perspectives on, or approaches to, explaining behavior. Certainly, the goal is to provide students with a framework(s) that explains why and how motor behaviors emerge and change. Built on scientifically controlled and significant amounts of observational and empirical data, theories move students beyond the lay use of "hunches" and "hypotheses" to broader frameworks or models that explain a set of phenomena—patterns of behavior.

My simple survey revealed approximately five theoretical approaches presented by at least several of the responders. For some, the list includes theories reflective of historical approaches but no longer reflective of contemporary thinking. These approaches, nevertheless, form the foundation upon which subsequent scientific approaches were built; by studying them students understand better why they are no longer deemed sufficient explanations. Some faculty members include multiple theories with a perspective that more than one is needed to explain aspects of the overarching picture of behavior and its change. Others focus largely on one theory as a state-of-the art contemporary and comprehensive explanation.

Table 1 lists the theories that dominated the undergraduate-level motor development syllabi. I will address only two here, for illustrative purposes, maturation theory and dynamic systems theory.

Maturation theory is both historical in that it provided the earliest explanation for why early behavior looks the way it does and emerges when it does, as well as a more contemporary view of innate factors that provide a range of probabilities for their impact on behavior. Recently interest in innate explanations for behavior has increased somewhat among developmentalists as scientists in related fields have been probing for genetic bases for a range of phenomena from diseases to personality traits. Maturation theory builds, fundamentally, on the observed growth and development of the nervous system, associated with change in other subsystems and with global behavior. Genetic explanations begin with biochemical substrates that code behavior by affecting the structure and function of a host of subsystems and, thus, contributing to more global physical and behavioral characteristics, to varying degrees of probability.

Dynamic systems theory emerged as an area of mathematics and physics used to describe the behavior of complex systems by employing differential and difference equations to develop models. Over time, this approach became associated with multiple disciplines and names, such as Complexity Theory, Chaos Theory, and Pattern Theory. The early efforts of Scott Kelso (Kelso, 1995) and his colleagues in motor control and Esther Thelen (Thelen & Smith, 1994) in motor development served to inspire significant growth of research in kinesiology. Among the theories cited by motor developmentalists, only dynamic systems appeared on all lists when more than one approach was proposed and, for some, this was the only theory

Table 1 Theories Most Often Covered in Undergraduate Motor Development Courses

Theory enables students to understand why and how new behaviors emerge and change. Theory prepares students to use scientifically sound principles to generate solutions to novel problems.

Listed in order of appearance, historically:

1. Maturation
   — Linked, today, to Genetics
2. Information Processing
3. Ecological Psychology (a.k.a., Perception-Action Theory)
4. Dynamic Systems (a.k.a., Complexity Theory, Chaos Theory, Pattern Theory, etc.)

presented. In quite simple terms, the behavior of a dynamic or complex system emerges from the confluence of multiple highly interactive subsystems, rather than being prescribed a priori. Behavior changes over time as subsystems change and change is often non-linear, shifting from one pattern to another when the level of a particularly relevant subsystem, or control parameter, reaches a sufficient level. New behaviors emerge via the system's exploration of (thus generating instability within and between repetitions) and ultimate discovery of more effective solutions to movement problems or goals.

Most important to this course in motor development, I would argue, is that students learn to understand why and how behaviors emerge and change. They need to recognize the interaction of multiple factors, consider the relative impact of intrinsic and extrinsic factors, and the processes by which these variables contribute to behavior. Theory can prepare them with scientifically sound principles they can use to generate solutions to problems not previously encountered. Theory enables all of us to move beyond recipes for our actions, to question the "way it has always been done" and move forward more confidently when we conclude it is best to retain old methods or to try new ones. Continued study within this aspect of motor development, theory/perspectives/approaches, call it what you wish, forms an absolutely essential core of this area of scientific study and, thus, application.

Developmental Periods

With some reticence I use the term periods here because our lifespan is a continuum with distinct stages but without crisp-edged boundaries, particularly for individuals. Nevertheless, there are ways in which behaviors over time tend to cluster into similar patterns with similar sets of issues, from form, to function, to subsystem development and performance context. Our focus in motor development on the entire life spectrum is one of the ways we bring unique value to kinesiology. We emphasize the change that occurs in organisms over time, which is relevant for all of our subdisciplines, from physiology to biomechanics, to pedagogy, and so on. I would argue that one understands better the issues surrounding behavior at any point in time by understanding both how it "got there" and where it "may go next." The value is not simply in the description of behaviors, but in understanding the processes that underlie change. The processes themselves are not unique to any period in time, although the factors that impact behavior, such as basal metabolic rate, relative lengths and mass of body segments, and so on, contribute in uniquely different ways at different times because they have their own developmental trajectory. Many of our kinesiology students will work with age groups other than young adults, yet, young adults in the prime of their physical/physiological lives seem to be the focus for many of the topics taught and examples used in kinesiology. For not all, but surely the majority of the careers to which our kinesiology students aspire, as well as their future roles as parents and community leaders, understanding the developmental aspects of kinesiology seems to me to provide a critical piece of our field.

In order to put the lifespan into a manageable organization and meaningful order, developmentalists categorize this continuum into periods. Table 2 provides a list of general categories. Students need to be able to characterize these to build reference points or anchors for conceiving what is possible and probable at vari-

Table 2 Developmental Periods of the Lifespan

We become very different organisms as we progress through life because many factors, intrinsic and extrinsic, each with their own developmental trajectories, affect the probability that humans will exhibit particular behaviors and characteristics.

General Periods: Each with Distinct Subperiods

1. Prenatal (conception to birth) embryonic, fetal
2. Infancy (birth to 2 years) neonatal, infancy, toddlerhood
3. Childhood (2 to 11-13 years) early childhood, middle childhood, late childhood
4. Adolescence (11-13 to 18-21)
5. Adulthood (21 to 85) young adulthood, middle adulthood, older adulthood
6. Elderly (85 and older)

ous points in life. For the researcher, understanding in more detail and depth the differences among these periods is critical to designing appropriate and reasonable experiments. To illustrate these categories and the relevant similarities of members of these groupings, I sketch below some relevant aspects of just two of life's periods, prenatal and adolescence.

Prenatal. During the first 2 months post conception (embryonic period) all of the major systems of the body emerge, including the nervous system. The embryo is quite sensitive to biochemical imbalances in the uterus and circulation; neural tube defects occur within the first 8 weeks. The fetal period begins with the onset of ossification centers in the cartilage; the body grows rapidly, neurons proliferate, migrate, building connections/organization impacted by sensory input; muscles begin to fire; movement patterns, rhythmicities, and reflexes are observed; evidence that learning occurs and memories are established that persist post birth.

Adolescence. Females enter and complete adolescence an average of 2 years earlier than males, who may not finish physical growth until 20 or 21 years of age. During this period growth is rapid but differentiated, with the trunk growing more than the legs, gender differences in relative shoulder and hip width and muscle and fat tissue distribution and proportion emerge due to changes in levels of circulating hormones. Capacities to thermoregulate change, as do basal metabolic rates. Activity contexts expand into after-school jobs, clubs, and community service. New motor skills continue to emerge (e.g., driving a car, activities of daily living), sport-specific skills continue to become more refined for some who continue to participate in sport but, overall, organized sport participation has already passed its peak in terms of percent of the population. Movement and reaction times have not yet reached peak performance.

Trajectories of Typical Behavior Over Time

Over developmental time we acquire new movement goals, some of which persist throughout the remainder of our lives, such as locomoting, others of which we acquire and then abandon as we lose interest in performing them, such as throwing a Frisbee or riding a "sit and spin" toy. For many movement goals we demonstrate sequential changes in coordination pattern as we practice, learn to control, and become more powerful or energy efficient. And, we tend to demonstrate similarities in the sequence of emergence of a variety of skills over time, such as during the first year when infants learn to hold up their heads before learning to push up with their arms when prone, before learning to roll over, and to sit alone. Table 3 reflects a small selection of some of the developmental trajectories of behavior over time that have been widely studied.

In many cases, the specific coordination pattern and specific order of emergence are less critical than understanding why and how such trajectories emerge with such similarity. Kinesiology students may be asked to learn the typical order of behavioral sequences and their relative timing, such as what to expect to see a neonate do when lying on his tummy on a mat versus what a 6-month old would

Table 3 Developmental Trajectories—Changes in Coordination Patterns Used to Perform the Same Task *and* Sequences of Behaviors Across Tasks

Examples

1. Object projection and reception skills, locomotor gaits (e.g., throw, catch, kick, strike, walk, jump, skip, gallop)

Over developmental time, children, in particular, tend to demonstrate in a relatively predictable order the emergence of the capacity to perform skills of this nature. Within each skill they tend to demonstrate distinct shifts in patterns of coordination to accomplish the same task.

2. Coordination patterns used to move through space during the first year

During the first year of life infants discover a variety of coordination patterns that allow them to move from one point to another, including but not limited to: rolling over, making forward progress in prone, creeping, scooting, cruising, walking.

3. Stair ascent/decent

Early in life: toddlers demonstrate a sequence of coordination patterns to ascend and descend stairs that reflect their increasing strength and body control.

Late in life: elderly adults may also demonstrate a shift to new coordination patterns to adapt to their diminishing subsystems, such as strength, body control, vision.

4. Walking patterns

Later in life walking patterns begin to change, showing reductions in stride length (absolute and normalized to height), velocity, and increased time spent in double support. Interestingly, changes in these same parameters are demonstrated during early walking in toddlers, but in the opposite direction over time.

do, or how a young versus frail elderly person might ascend a set of stairs. More important is to explore the reasons these behaviors appear as they do at that point in time and change, over time. Is practice the key, or strength, or neural maturation, or motivation, and so on.

For example, when a very young child is asked to throw a grip-sized ball as hard as possible at a large target on the wall, she is likely to do so without moving her feet, but she will extend her trunk and flex her shoulder to "wind up" before forcefully flexing her trunk and extending her shoulder to project the ball forward. To have stepped would have meant losing control of her center of mass and perhaps falling over. As she continues to practice moving and throwing she increases her body control and shifts from keeping her feet stationary to transferring her weight forward, initially with the ipsilateral leg and later with the contralateral leg. This developmental trajectory and change in coordination pattern is common and has been well documented. Nevertheless, it is important to understand the impact of context here. By changing ball or target size, distance to the target, etc., her coordination patterns spontaneously shift to adapt to new task constraints.

Developmental sequences emerge later in life as well. Throughout much of our lives we ascend stairs by placing one foot on each riser in alternation and we don't bother to hold onto the railing. As we age, as factors such as strength, or body control, or proprioception/sensation, or eyesight, perhaps, wane, we may shift to holding onto the rail and later to stepping on each riser with both feet to minimize the challenge of remaining upright.

Factors That Affect Motor Behavior

At some level one could state reasonably that all factors affect motor behavior, given that motor outcomes emerge from the confluence of multiple related factors intrinsic to the organism (e.g., muscle strength, neural integrity and organization, arousal level, experience) the context (e.g., playing field, backyard, compliant versus rigid surface, implements to be manipulated) and the particular goal (e.g., moving from one location to another, choosing to optimize on power or precision or both, climbing a jungle gym, ladder, or rock wall, striking a baseball, tennis ball, or golf ball). Yet the difference between whether a person is able or unable to produce the intended goal may be limited by one or more particular factors, at any point in time. It is factors thought of in this way to which we turn now. These represent, as well, factors that those who wish to intervene or to facilitate the acquisition of skill may find to be recurring limitations or opportunities for inducing change.

Note also that, just as organisms may be characterized by non-linear developmental trajectories (new skills emerge at different times, the qualitative performance changes over time), constraints tend to have their own unique developmental trajectories. Their role as potential constraints on performance, or the reason that a new skill or coordination pattern has not emerged, waxes and wanes over time as well.

Again, because my goal in this paper is only to illustrate, rather than to deal with this topic in more breadth and depth, I will expand a bit on only two examples. Table 4 provides a more comprehensive list of categories into which we can organize a wider landscape of variables.

Table 4 Factors That Impact Motor Behaviors

Some factors seem to form relatively distinct categories. In reality, most do not simply co-exist, rather they are intertwined. We are complex organisms, perpetually active and interactive, thus changing both how we move and view the world and how the world behaves toward and views us.

Examples:

1. Morphological/Physiological/Biochemical: muscle properties, cardiovascular and thermo-regulation capacities, BMR, body size and proportions, joint structures, hormonal levels

2. Experiential: history of skills practiced and used, learning contexts, quality of instruction

3. Environmental (physical): support surfaces, implement's scale relative to performer, weather conditions

4. Neural (motor, sensory): speed of processing, levels of development of aspects of the nervous system—organization within and among areas, plasticity

5. Perceptual: development of optimal use of abundant sources or information (e.g., visual, auditory, tactile, etc.), learning to use sensory input to guide action decisions

6. Cognitive: language skills, memory levels and strategies, knowledge—factual and procedural, use of egocentric versus allocentric perspectives

7. Psychological/Sociological/Cultural: motivation, perceived competence, fear, peer pressures, value, gender neutral versus gender-associated choices

Mophological/Physiological/Biochemical Factors. Over the first 18–21 years of life, growth in segment lengths and muscle mass enable humans to generate more and more force at faster and faster speeds, and thus, new movement options. Prior to adolescence, as a group, morphological and physiological differences between boys and girls are too small to account for performance differences. With adolescence and the accompanying changes in hip and shoulder proportions, along with greater muscle mass in males, arise gender differences in capacity to generate force and speed, although overlap between groups continues to exist. During adolescence the significant size differences among children of the same chronological age due to early and late maturation levels can produce high variability among performers on tasks for which power and speed trump skill and finesse.

The dynamics of bone tissue allow it to be modified and shaped, to some extent, by functional forces. For example, the shallow acetabulum of infancy deepens as the head of the femur pushes against it when infants learn to crawl and walk, thus contributing to increased joint stability when upright. This natural process can be delayed in infants with particularly lax joints—which seem to contribute to delayed onset of walking (presumably due to the infant's perception of instability when upright) and to the use of less-common modes of locomotion prior to walking, such as scooting on one's bottom, thus maintaining a larger base of support while at least one hand is free to manipulate or hold objects.

Environmental (Physical). This area provides a particularly interesting set of factors because it allows us to consider how the environment informs us about its impact on typical behaviors and to explore options for changing the task demands, and thus, shifting patterns or enabling new patterns to emerge. For example, for humans, the typical means of locomotion on earth is upright and bipedal, with alternation among the limbs. But, the environment in which we exist is critical to the emergence of this pattern, as universal as it may seem. Were infants to learn to locomote in zero gravity (e.g., in space) walking might not emerge at all, in favor of jumping, hopping, or pushing; infants might not creep or crawl at all and rolling over would necessitate a very different synergy among muscles and joints. In therapeutic settings we reduce the challenge of opposing gravity when we design water activity classes for people who are obese or have arthritis; we put treadmills in water or suspend performers over a treadmill in a harness to encourage stepping in individuals who have difficulty supporting their own weight.

Equipment that is scaled to the user's body dimensions and strength levels increase the likelihood of success and certainly change the coordination patterns used. Consider the changes in body segment coordination you might observe when children attempt to throw a junior basketball into an 8-foot-high net compared to a regulation ball and standard height hoop. Persons with poor vision may move their fingers more quickly and accurately across a keyboard or touch pad on their telephone if the targets (keys and letters) are larger.

Motor Development: Collateral Yet Important Content in Undergraduate Curriculum

Assessment Instruments

One topic that emerged less frequently in the undergraduate motor development syllabi is assessment. I propose that this is an important addition for two reasons. First, for motor development students, studying and particularly attempting to administer a developmental assessment instrument can serve as a capstone experience if students are encouraged to discuss reasons underlying the behaviors observed. Such an activity can illustrate and contextualize developmental periods, developmental trajectories, factors that influence performance, and show where and how performers deviate from expected behavior. With a theoretical foundation, the processes by which these issues contribute to behavior may become clearer. Kinesiology students need to understand, generally, the importance of and criteria for valid and reliable assessment tools. But these topics are hard for students to grasp;

concrete examples engage students and make the information more meaningful. Illustrations that can span infancy, young adulthood, and the elderly can provide excellent illustrations and motivate as well. The number of assessment instruments that have been validated and proven reliable for use in motor development research and clinical applications is high. The point is not necessarily for students to develop reliable skills in any of these instruments within this course, rather to know why professionals and researchers use them, the merits and limitations of example instruments, the difference between screening and diagnostic tools, and the difference between outcome and process measures.

For example, by studying the Bayley Scales of Infant Development (Bayley, 2006) students apply their knowledge of population differences, age differences and ranges, parallels between cognitive, motor, and social skills. By administering or observing the administration of an assessment instrument they begin to understand how arousal levels, social skills and fears, distractions, and so on, can significantly affect behavior. This can lead to discussions of the stability of behaviors and the fact that behavior is always "in context." By administering the Berg Scale (Berg, Wood-Dauphinee, Williams & Gayton, 1989) students can discover the ways in which deficits in maintaining the body upright manifest. Some people earn low scores even when they can perform the required tasks but they move slowly on timed items. Others have a difficult time sequencing tasks, or when vision is occluded and fail to perform these tasks.

Atypical Development

One can ask reasonably if atypical development should be part of the motor development core content. I propose that in the same way that we embrace the continuum of time we must also consider seriously the continuum from typical to atypical, which is, in fact, a matter of degree and probabilities. But I would add that the point of this is to focus on how various factors impact behavior and that the level of development or integrity of relevant subsystems impacts the outcome. For example, an infant with Down syndrome (DS) is likely to exhibit the onset of walking about 1 year later than an infant with typical development (TD). Factors that affect the onset of this skill include motivation, the ability to control one's body upright as the center of mass shifts from one foot to the other, and muscle strength, among other things. Infants with DS tend to be less motivated to explore than ones with TD. This may reduce the frequency with which they explore and attempt to walk. They have significant ligamentous laxity, making their joints more wobbly than their peers with TD. Thus, controlling their multi-segmented systems upright over such a small base of support is particularly challenging. Their muscle strength and tone tends to be lower than their peers. All in all, they have the same problem to solve as infants with TD—to organize their resources to walk independently—yet the solutions are different (increased stiffness and impulse at walking onset with wider base of support) and require more time to perfect this solution, or at least to master it sufficiently to use it successfully (Kubo & Ulrich, 2006). The factors that contribute to the differences in performance and delays are also potential areas on which to focus attempts, if needed, to intervene. One could, of course, illustrate the point with examples from many other populations with atypical development, such as spina bifida, cerebral palsy, skeletal dysplasia, rheumatoid arthritis, Parkinson's disease, and stroke. The point is, factors such as morphology, physiology, and cognition matter, not just incidentally, but fundamentally.

Controversies

As in all fields there are topics that remain controversial and yet need to be discussed. As our science progresses the strength of empirical and theoretical arguments may enable one to emerge as the generally accepted view. In the meantime, both because of the importance of the issue and the dynamics of the intellectual disagreements themselves we hold to the value of engaging students in the discussion of such issues. Table 5 lists a subset of some of the issues that fall into this category.

For the purpose of illustration, let's consider the issues of "nature versus nurture," because it is not limited to motor development but spans many subdisciplines, from cognitive to social to physiological, and so on. At its simplest level, the polar arguments are that the reasons we see particular behaviors are that they are built into the human versus they must be learned or acquired over time. One could posit that innate means there is a "code" for universal behaviors inherent in the genetic makeup and thus, they simply appear at predictable and relatively consistent points in time—the "nature" position. From the nurture polar end one might propose that one responds to experiences and external influences by exploring and learning new behaviors, matching behavioral output to the input received. Contemporary approaches are somewhere in between, of course. And, in a related and popular approach, nature and nurture are inextricably linked by their inherent influence on each other, thus the arguments for either as primary become moot.

Another issue that clearly spans, but is not limited to, motor development, learning, and control is that of defining skill. At first blush this term begs definition by any layperson. My friend Allison has the skill to water ski and I do not. But is skill simply a matter of success? Then how do we define success? I can zip my down jacket—sometimes (well, usually), though it may require several tries. Is

Table 5 Controversies: Important, Yet Unsettled Issues

Examples
1. Nature versus Nurture (a.k.a., innate versus acquired)
2. Critical Periods versus Sensitive Periods
3. Skill: How Do We Define This? Adaptability, variability, stability—how do these "qualities" reflect our understanding of skill and how important are they to our assessments of skill or indicative of the need to impact level of skill?
4. Balance versus Postural Control versus Motor Control?
5. Static versus Dynamic Postural Control? Is there any such thing as static postural control or is there only a small subset of tasks for which we attempt to maintain our bodies in a state of minimal movement?

my skill stable/variable, is it adaptable? If a person can stand up from an armchair but not from the middle of a sofa, does he possess this skill? What is acceptable for a researcher may be different from that which we look for in therapeutic or instructional applications. Is there an underlying neural control pattern that is the hallmark of skill?

Last, but not least, a factor that should, I humbly suggest, appear in each of our core content courses is "emerging issues in research." I believe it is critical that we include some examples of the latest research coming from our own laboratories or those of others in each of the foundational core courses in kinesiology. We must assume learning is lifelong and we have a responsibility to fan the flames of interest that we kindle during our classes so that, when students leave our classrooms they will be looking for and know how to find more up-to-date information on this subject. As scholars, we know the excitement of discovery and should be able to transmit this enthusiasm to our students. What a wonderful way to put the finishing touches on any of our courses.

Motor Development + Motor Control + Motor Learning = Motor Behavior, OR, Is the Whole Greater Than the Sum of Its Parts?

In a paper Gil Reeve and I wrote for the 75th anniversary edition of the *Research Quarterly for Exercise and Sport* (Ulrich & Reeve, 2005) we argued that there is significant common ground across the traditionally separate subdisciplines of motor development, motor learning, and motor control to unite under a shared title, called motor behavior. We were, essentially, taking a position in a debate with a history, rather than identifying a unique issue. Each of these areas of study is clearly strong enough to stand on its own. That is not the question. The reality is that scholarship in motor development, control, and learning crosses each other's boundaries naturally and frequently and it is even unclear, at times, to which specific subdiscipline a particular line of questioning "belongs." Ultimately, the whole is greater than the sum of its parts. As a unified area, motor behavior, we add impact by creating more integrated approaches to solving problems.

For the same reasons we cross boundaries and sometimes the boundaries blur, we can, I believe, for our undergraduate kinesiology students encourage a deeper, richer understanding of related issues and their application by presenting them in a more complementary manner. Knowledge about how various areas of the brain communicate with each other and the periphery is understood better by recognizing that this is dynamic; the organization emerges over time and experience and is impacted in real time by practice and multiple sources of input.

One of the reasons to address the theme of relevance of each of our content areas to kinesiology as a whole for the undergraduate student is to assure that we, as instructors, enable students to understand, integrate, and apply the information to solve problems. We are kidding ourselves if we believe this just happens without our direct facilitation. Just as important is our effort to integrate our own unique content with knowledge emanating from other subdisciplines that comprise kinesiology. Our students must understand the human as a whole integrated system, even if we address our research questions with more or less restrictive approaches.

Within this larger entity, all of kinesiology, motor development, learning, and control seem to offer an ideal subset to establish a role model of how this integration could be accomplished. Pedagogically speaking, that could not be accomplished by compressing the content from all three specialties into one course; too much would be lost. Synthesis and problem solving must be built on a sufficient foundation of scientific information that is rich and varied. The content of each of our multi-credit courses should be laid on the table by the experts to be reorganized into a sequence of perhaps two 4-credit courses. The topics could be organized into clusters of relevant content, sculpted to enable students to understand more of the puzzle at each step of the way than just small pieces of information that may not, for them, link easily to real-world problems.

Consider for a moment organizing parts of the courses with a problem-based learning approach. One example of a problem to be solved might be the following. A parcours was created for adults in a local park that includes a series of tasks, designed to stress muscle strength/power, body control, agility, and endurance. Signs and arrows identify what to do at each station and where to go next. Identify any aspects about this course that might cause “failure” for a 6-year-old child or an elderly adult. The tasks include, in sequence: (a) warm-ups: sit and reach, jumping jacks: (b) walking on a log, balance-beam style; (c) jogging, agility-run-style, in and out of a series of trees; (d) jumping over each log in a series of logs, each 30 cm in diameter, laid perpendicular to the path; (e) stepping from one tree stump to another positioned in the ground 60 cm apart and 60 cm in diameter; and (f) jog along a trail 0.75 km long, around the edge of a pond. To identify potential failure points would require students to explore the capacities of people at these two very different points in the lifespan, their performance limits, body sizes, cognitive abilities, interests, and motivational characteristics. By working in groups, students may start by sharing ideas based on their experiences with family members, friends, and activities similar to these. But they would be challenged to verify their preconceived expectations with data gleaned from class readings and information they could gather from other scholarly sources. This would require them to integrate many factors that could affect performance, but that might have differential effects over time.

Conclusions

Motor development has unique contributions to a kinesiology that is concerned with humans as whole, integrated beings and with the lifespan of humans. Kinesiology not only should not be bounded by any age period, it is incumbent upon us to address the content of our subdisciplines to relevant changes that occur over the lifespan, or at least address examples of developmental differences that occur beyond the healthy young adult period. Ultimately, the reason what we study is important is because it has the power to affect change. Basic science is important because it leads to understanding and explanation. Understanding leads to principled tests of interventions, when needed, to improve the quality of life for society. Understanding how multiple factors interact (e.g., our biomechanical characteristics, neural capacities, physiological limitations) to affect motor performance, injuries, and diseases, has been part of our scholarly approach in motor development historically (see the section “Factors That Affect Motor Behavior,” above). More recently, an approach embraced by many motor developmentalists and scientists from disparate disciplines and subdisciplines as well, dynamic systems (a.k.a., Complexity Theory, Chaos Theory, Pattern Theory) helps formalize some principles of organization and change and offers a level of unification across areas, at least for some issues. I propose that motor development, given its lifespan approach and emphasis on explaining the processes that underlie organization among components in a system and change in behavior over time, forms a critical thread that helps bind subdisciplines of kinesiology into a cohesive whole. Students, surely, need a knowledge base of information, vocabulary, and scientific facts (as best we know them today). But they also need to put this information into context, to problem solve, and to recognize and value the changes within and among subsystems that interact to drive the system's behaviors we observe. If we are to solve important problems, we must be multidisciplinary, we must be collaborative, learning from each other in order to progress as a discipline.

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Endnote

1. What motor development scholars agree on is that motor development is NOT synonymous with elementary physical education. Although a significant amount of empirical data collected over the years by motor development researchers may have direct application in such a setting, these data represent only one piece of a much broader array of empirical and theoretical work.