Occupational therapy, since its inception, has been addressing human activity and performance, and therefore, motor control issues. At the same time, the scientific field of motor control has been developing. For occupational therapy to keep current with developments in the field of motor control, it must recognize and integrate the issues and developments pertinent to both occupational therapy and motor control. This paper investigates the history, contributions, and future importance of both fields.

Historical Review

In 1962, Ayres predicted that in 25 years a neurophysiological approach to treatment of patients with motor problems would be well developed and fairly well accepted. She also foresaw a new understanding of motor behavior that would address attention span, motivation, and emotions. Rood (as cited by Ayres, 1962) said, "Let us use our heads for more important business than running our muscles." These thoughts may suggest that human motor control and function involve both neuromuscular and neuro-psychological mechanisms—that there is a complex mind-body connection.

The multidisciplinary field of motor control was introduced to the Western world with a 1965 symposium entitled "Muscular Afferents and Motor Control" (Brooks, 1986). Brooks defined motor control as "the study of posture and movements that are controlled by central commands and spinal reflexes, and it is also the name given to the functions of mind and body that govern posture and movements" (p. 5). The field of motor control originated from two disciplines: (a) neuropsychology and its concern with the neural processes associated with movements and (b) psychology and its concern with high-level skills and behavior (Schmidt, 1982). Motor control and learning involve both biomechanics—the coordination of joints and muscles—and states of mind such as alertness, motivation, and concentration. Learning and doing are inescapably intertwined (Brooks). Throughout its history, occupational therapy has been concerned with doing—with how purposeful activity (occupation) influences adaptation, development, function, and physical and mental health. Purposeful activity involves motor control. This paper explores the relationship between the fields of occupational therapy and motor control and their past, present, and future roles.

During the 1950s and 1960s, occupational therapists who worked with patients with neuromuscular problems were realizing that although purposeful activity was necessary, purposeful activity alone was not sufficient. Normalization of motor state was usually a prerequisite to the performance of functional activity. Concurrently, the field of neuroscience was making great advances, due in part to knowledge gained from the aftermath of World War II. Various therapists, working independently with different age groups and diagnostic populations, began using neuromotor and neurobehavioral treatment approaches.

From the 1970s to the present, there has been a cross-fertilization and testing of ideas. Several occupational therapy authors attempted to digest and integrate information and to expand and apply concepts to various populations. Examples of work directed toward more fully integrated approaches include those by Banus, Kent, Norton, Sukinnicki, & Becker (1979), Farber (1982), Gilbert, Grady, and Moore (1981), and Knickerbocker (1980). Ayres (1972a, 1972b) introduced the concepts of sensory integration. Many of these approaches were initially developed for specific populations of children and were later adapted for various child and adult populations. Cognitive rehabilitation and cognitive-perceptual dysfunction had begun to receive more emphasis. Today, confusion still exists in relation to terms such as neuromotor, sensorimotor, perceptual-motor, and sensory-integrative—terms that imply either neuromotor or...
neurobehavioral treatment. This confusion with terminology may reflect the evolution of a developing knowledge base.

During the 1970s, many changes occurred in the fields of motor control and learning. There was movement away from the strict stimulus-response orientation and the conditioned reflex and mechanistic concepts of behavior initially investigated by Pavlov (Schmidt, 1982). Concepts from cognitive psychology became influential. Using an information-processing approach, the motor-control researchers began to study processes such as response selection, motor programming, movement schemas, and memory; they began to focus on the underlying mental and neural events that support or produce movements (Schmidt).

Another major influence on motor control studies was the work of the Russian physiologist Bernstein (1984). The research that Bernstein conducted in the 1930s and 1940s and Whiting (1984) reexamined integrated neural control, motor behavior, behaviorally based notions, and neurophysiology with fundamental theories of the interactions between the brain, the body, and the environment. Unfortunately, translations of this work did not reach American and English scientists until the late 1960s (Brooks, 1986; Schmidt, 1982). One of Bernstein's major contributions may have been the examination of problems raised by motor control within the perspective of the activity of human beings, who not only interact with but also act upon their environment. Bernstein was concerned with meaningful goal-directed acts (Whiting). Some of Bernstein's views have resurfaced and are currently being investigated by motor control scientists. These views incorporate ethology and ecology issues. For example, according to these views our motor system was created through evolution and interactions with the environment and we should attempt to understand the function of this motor system in natural settings. Related to these views are the ideas that perception and action are functionally inseparable and that an understanding of our motor system depends on an understanding of the physical principles underlying our actions and how these actions relate to our biological (including autonomic nervous system) functions (Schmidt; Whitting). Bernstein conceptualized a purposeful brain and suggested that the formulation of a motor problem and its solution required an act of some type of intelligence (Bernstein; Requin, Semjen, & Bonnet, 1984).

Schmidt (1982) suggested that Bernstein's ethological and ecological ideas represented a de-emphasis on cognitive-psychological and information-processing styles of inquiry. He suggested that this approach might contribute significantly to our understanding of motor behavior. Rock (1983), a cognitive scientist who studied perception, suggested that perception is sometimes the end result of problem solving. He proposed that perception may require the use of some type of nonverbal but intelligent thought-like operations. Ayres (1985) discussed praxis as a kind of intelligence or human competence. Edelman (1987), in his study of the evolution of functional systems and learning, stated that the single greatest development separating mammals from reptiles was not extensive thalamocortical reorganization, but the relation of the basal ganglia to the cortex. He considered the results of motor activity to be an integral part of original perceptual categorization and stated, "It would not be surprising if, to some extent, every perception were considered to be an act of creation and every memory an act of imagination" (p. 329).

During the last 2 decades, there has been increasing collaboration between the neural-control and motor-behavior scientists. The field of motor control has attained its own identity, complete with its own journals, methods, and theories (Schmidt, 1982).

Integration of the history and issues in the fields of occupational therapy and of motor control involves developmental parallels and commonalities. Because of the nature of the work, occupational therapists may have had more firsthand knowledge and a more holistic view of the totality of human performance than have scientists. Now, the motor control field validates many therapeutic observations and may have valuable information and practical tools to assist occupational therapists. The motor control field's contributions to the understanding of neuromuscular mechanisms and motor behavior may also assist with therapeutic role definition. It is interesting to note that in 1918, at the beginning of the current rehabilitation fields, the Army established training programs for two groups of reconstruction aides. Class 1 aides, physiotherapy aides, were to "give massage and exercise and other remedial treatments" (Hopkins & Smith, 1983, p. 10). Class 2 aides, occupational therapy aides, were to "furnish forms of occupation . . . and . . . the therapeutic benefits of activity" (Hopkins & Smith, p. 10). The Army perceived a need to address complementary but different aspects of human movement and function. There has been considerable role confusion ever since. The field of motor control, with its related but separate issues of neural muscular mechanisms and motor behavior mechanisms, could be used to define and defend the related but different roles and professional identities of occupational therapists, physical therapists, and others interested in human performance.

Present and Future Roles of Occupational Therapy and Motor Control

The neuroscience information explosion has provided a foundation on which occupational therapists can build and substantiate their theories and performance and motor control treatment approaches. Today's exciting frontiers have gone beyond the analysis of brain circuit mapping and have expanded into the study of neuropsychology, recovery of function, and neuropsychology. The development of prosthetic devices is converging with neuroscience and robotics. Clinical pharmacology is expanding. Emerging from within the field of motor control is a multidisciplinary study of movement and motor behavior, which has tremendous therapeutic potential (Brooks, 1986; Moore, 1986).

Within the past 30 years the merging of science and technology has introduced us to the fields of in-
formation theory, communications and telecommunications, and cognitive science. A high-tech society has been born, and new environmental worlds of instant communication have been created (Lerner, 1987). Although the future role of high technology in occupational therapy is not known, the demand for occupational therapy professionals skilled in motor control issues is assured. However, there will also be significant competition among professionals regarding the issues of motor control. Occupational therapy must develop a plan to incorporate motor control findings into treatment programs. For example, Rosenzweig, Bennett, and Diamond (1972) and Rosenzweig, Bennett, and Krech (1964) demonstrated that the environment of infant or adult rats substantially influenced cortex thickness and weight (Greenough, 1987; Rosenzweig et al., 1972). Studies have since demonstrated in a variety of mammalian species that environmental opportunities and experience have differential effects on brain structure and chemistry and on performance and learning potential in both the developing and mature brain. New synapses have been shown to form in response to experimental demands for information storage (Greenough). Environmental opportunity and active experience are familiar domains for occupational therapy. Occupational therapists could use such information on activity-dependent neuronal plasticity to treat patients, but to do so requires familiarity with the motor control literature.

High technology offers promise for new prosthetic aids, communication systems, and environmental manipulation. For occupational therapists to help mold this technology to the needs of patients, knowledge of the available technology is essential. If occupational therapy is to help optimize the possibilities these advances in motor control and technology offer for the benefit of patients, it must carefully choose and define its roles within the field of motor control. For example, occupational therapists will have to clarify their involvement with neuromuscular mechanisms, neuro-psychological mechanisms, motor behavior, learning and information processing, and technology-assisted function. Commitment to the chosen role will necessitate a critical examination of educational preparation on every level, from entry level competencies to graduate curricula, continuing education, and the professional levels of clinical specialists.

A danger in times of transition and rapid change is distraction from basic principles. It is important that with the availability of state-of-the-art equipment and treatments, occupational therapists not lose sight of critical treatment reasoning. When faced with a choice between conventional and new approaches, the occupational therapist should consider the following questions:

- Is this treatment really effective?
- How does it work and on what principles is it based?
- Is it accomplishing what is needed for this patient?
- Are some of the older treatment methods more solidly based, more effective, or cheaper?
- Are there other better ways to meet this patient’s needs?

Summary

Human motor behavior continues to evolve and, therefore, may never be fully understood. Still, occupational therapy treatment approaches that are based on neurophysiological principles are fairly well accepted, and there is much potential for the development of treatments that will facilitate recovery of function. Occupational therapy must face and confront its roles in relation to the field of motor control; a health care profession involved with performance and motor control issues cannot afford to ignore the rapid advances in neuroscience information and the parallel developments in the field of motor control. Rood (1980) stated that many people want a “womb with a view,” so that they remain protected and yet passively observe the outside world. However, if occupational therapy is to remain current with new developments in the field of motor control, it cannot afford to be passive.

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