Schmidt's Schema Theory

In addition to the troublesome empirical findings outlined in the preceding discussion, Schmidt (1975) identified two further theoretical problems associated with Adams' closed-loop theory of motor learning. The first of these problems was related to storage. That is, how is it possible to store a mental representation for every movement ever performed? Surely we would exceed the capacity of human memory at some point. The second problem was related to an individual's ability to perform quite accurately what appear to be novel skills: movements not previously observed or physically attempted. Adams' theory provides no mechanism to explain how skills not previously experienced could be initially performed. These apparent shortcomings of Adams' theory inspired Schmidt to develop an alternative theory of learning. This new theory of motor learning came to be known as schema theory.

Hierarchical Philosophy

Although schema theory retained the need for two independent memory states, the recall and response recognition schemas proposed by Schmidt were less rigidly conceived and therefore better able to account for a learner's ability to acquire a broad range of movement skills. Like Adams' memory trace, Schmidt's recall schema was involved in producing a movement by being responsible for selection of the parameter values that specified that particular movement. Examples of these movements are throwing a ball using an overarm as opposed to underarm pattern or climbing a flight of stairs with different stair riser heights. Once these values were selected and the movement executed, it became the responsibility of the response recognition schema to evaluate the correctness of the completed movement in terms of both the amount and the direction of errors. Schmidt further hypothesized that as the learner continued to practice and receive feedback from his or her own sensory mechanisms and other external sources, the strength of both schemas would be enhanced.

open loop control

In addition to the two schemas, a core feature of Schmidt's theory was the generalized motor program (GMP), an abstract memory structure that could be prepared in advance of a movement. This mechanism provided the means by which a specific movement was executed. It was thought to contain the temporal and spatial patterns of muscle activity needed to accomplish a given movement. Thus, the GMP played a particularly important role in the execution of ballistic movements, where the opportunity to use feedback to guide the movement was limited or nonexistent. Although Adams argued that his memory trace was, in essence, a form of motor program, it operated only long enough to initiate the movement (e.g., a few milliseconds). In contrast, Schmidt's generalized motor program was capable of operating much longer (e.g., one

or more seconds) and therefore was not dependent on feedback or on the response recognition schema to complete certain movements.

Entry Generalized motor program

How were the recall and response recognition schemas thought to be developed? According to schema theory, their development was contingent on the learner's ability to extract four important pieces of information from every performance. These were the initial conditions associated with the movement (such as body position, characteristics of the object being thrown or held), the specific movement parameters or response specifications chosen (for example, force, velocity), the sensory consequences emerging from the actual performance of the movement (such as how the movement felt), and the movement's outcome. Once each individual piece of the movement puzzle was extracted from the performance, the learner would begin to put the pieces together, relating certain individual pieces to others. For example, the relationship between the initial conditions and the particular movement parameters selected was thought to contribute to the development of the recall schema, whereas the response recognition schema's development was assumed to be based more on the relationships among the initial conditions, the movement's outcome, and the sensory consequences generated (Schmidt, 1982b, 1988b). Once these relationships were abstracted, certain rules or principles of operation could be formulated and used to guide selection of the appropriate motor program for action.



The GMP is thought to contain the spatial and temporal patterns of muscle activity needed to perform a given movement.

Although interest in schema theory as an all-encompassing account of motor skill acquisition has largely waned, certain theoretical constructs emerging from the theory have endured. These constructs continue to be extensively studied by a number of motor learning researchers. Two of the more often investigated aspects of schema theory are the generalized motor program (Magill & Hall, 1990) and the variability-of-practice hypothesis (Bird & Rikli, 1983; Gabriele, Hall, & Buckholz, 1987). Schmidt argued that learning was not only dependent on how much a skill was practiced, but also how the skill being practiced was varied. The variability-of-practice hypothesis has received a considerable amount of research attention in the past 20 years. At this time, however, the predictions associated with the hypothesis have yet to be unequivocally supported.