

MOTOR LEARNING IN SPORTS SCIENCE: DIFFERENT THEORETICAL FRAMEWORKS FOR DIFFERENT TEACHING METHODS

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Review paper

Abstract

Sport teaching methods are widely investigated by numerous scholars. The most widespread traditional teaching practices have their theoretical basis in the cognitive approach and in a prescriptive teaching vision. Cognitive approach implies specific psychological models of motor learning: Open Loop and Closed Loop motor control models and Generalized Motor Program theory. Other scholars study sport teaching methods from another point of view called the ecological approach. In this case, trainers focus on educational setting and interpret learning as the research for physical and motor solutions available in the environment. This approach has its psychological basis in Bernstein's degrees of freedom theories and in Motor Imagery. The discrete sequence Stimulus identification - Response Selection - Response programming, according to which the psychology describes the mechanism of perception - action, faithfully repeats the IPO model (input - processing - output). Information processing, however, is based on assumptions that knowledge is external to the learner. It does not take into account human experience and the ways in which perception is shaped by, and interacts with, the individual's life experiences. From this perspective, the ecological approach to teach sports appears to be more up to date concerning the evidences and elaborations from scientific research. Yet, in training methods, teaching practices appear to be more related to the cognitive approach, when they not directly descend from a behaviorist or cognitive framework. Methods of this study is to analyze the specific aspects of learning approach in sports science. The hypothesis is that the conceptual framework related to ecological approach to training methods could be more scientifically founded than the current training methods founded on tutorials tools.

Key words: loop, generalized motor program, ecological and cognitive approach, motor imagery.

Introduction

Trainers traditionally teach with orders and tutorials that have their theoretical basis in Cognitive approach. It means they simulate analytically with sequences and timings the global movement and use the tutorials following the cognitive approach. This approach has psychological basis on motor control theory articulated in Closed Loop Model, Open Loop Model and Generalized Motor Program. The teaching tools focus on order of movement executions (Partial practice, Varied practice, Randomized practice), on Mental Training and, finally, on the use of Feedback for error correction. On the other hand, trainers sometimes promote training methods that have their theoretical basis in Ecological-Dynamic approach. In this approach, coach or the teacher does not use the tutorials, but builds a learning setting aimed at variety of motor skills. This second approach has its basis in t Motor Imagery and Freedom Degrees Theory. Behaviorism and Cognitive theory have the mind in the focus of learning process. Vice versa, Gestalt and Phenomenology has the environment in the focus of learning process. Both of them has the main difference between the role of the mind and the role of the learning setting. Aim of this work is to study the issue of motor control theory and what is the correlation to learning process and motor skills. Methods of this study is to analyze the specific aspects of learning approach in physical activity and sport. This study highlights a significant

relationship among tutorials techniques such as order, demand, sequence and timing with prescriptive teaching method applied to motor skill. Furthermore, there is a significant relationship among focus on learning setting, and teaching strategies such as cooperative learning, role playing, circle time, brain storming, peer education, tutorship, focus group. Role of teacher is different in the two approaches, more invasive in cognitive approach than in ecological dynamic approach. Teaching method of cognitive approach is, traditionally, based on tutorials. Sport and physical activity is traditionally imparted by the coach or the teacher in illustration and simulation actions in details. The partial practice based training method consists in reducing a complex motor skill in a simplified form. Movements with a great level of difficulty and the high degrees of complexity, can be simplified by dividing the exercises in little part or reducing the need for speed precision. In this theoretical framework, fragmentation, segmentation and simplification do not adversely affect the deep structure of the generalized motor program. Despite, in the Ecological-Dynamic approach, the coach does not require tutorials but builds a learning environment, aims at spontaneous research of different solution to motor problems.. According to the ecological approach "to learn" means being able to progressively find the best motor solution for a given task in a given context.

Emblematic is the expression, coined by Bernstein, "repetition without repetition": practice does not mean to mechanically repeat the same solution to a given task, but to repeat over and over the process of solving the task itself. If learning movements means to optimize the process of solving motor tasks, this approach produces didactic implications different from prescriptive methods linked to cognitive approach. In heuristic learning the teacher must assist the student in research of autonomous motor solutions. If the learning task is too complex, teacher should not impose constraints to the learner (partial practice), but he has to apply constraints to the environment. Cognitive approach has the human mind in the focus of learning process. Vice versa, ecological approach has the environment in the focus of learning process.

Motor control psychological models: a historical overview

William James (James, 1890) proposed one of the earliest descriptions of movement control, known as response-chaining or reflex-chaining hypothesis. The James hypothesis was an open-loop theory, in which attention is focused only on initiation of the first action of a movement. Each subsequent action was thought to be automatically triggered by response-produced feedback. In this hypothesis, ongoing movements cannot be modified according to unexpected changes occurring in the environment, and feedback is suitable only to regulate the movement chain (i.e. timing of subsequent actions) and is not compared to internally generated references for error checking.

The role of feedback is quite different in the motor control model proposed by Adams (Adams, 1971). Adams' closed loop motor control model has its focus in feedback-based error correction, throughout a continuous comparison between memory trace and perceptual trace. In this model, memory trace results from practice and feedback about movement outcome, while perceptual trace results in guidance to the correct position along a trajectory, by comparing feedback about actual position in space with desired position. Position is adjusted until the movement is appropriate to the goal of the action. The importance of this model has been historically remarkable, also by virtue of the attention bestowed to human information processing, but the model has two major weaknesses: 1) The described process is possible if the whole time lasts less of 200 milliseconds, otherwise the human brain is unable to process the data and transmit pulses in time below this threshold (time problem); 2) This theory could not explain how models for novel movements were acquired (novelty problem). Richard Schmidt (Schmidt, 1975) overcame closed-loop theories with a model resulting of open-loop control process and Generalized Motor Programs. Schmidt called Schema the structure containing generalized rules governing spatial and temporal patterns to produce a specified movement.

Schmidt's theory is precisely known as schema theory (Schmidt & Wrisberg, 2008). In this approach, motor learning means developing very articulated motor programs. As a result, teaching of motor activity will be prescriptive, by administering to the student exercises to stabilize the motor program and minimize the variability of execution. Blocked and random practices, as well as partial practice and feedback administration techniques are typical of this approach: "An important question confronting the learner or instructor is how to sequence the practice at these various tasks during the practice session so as to maximize learning. Two variations have powerful effects on learning: blocked and random practice. Suppose that your student has three tasks (tasks A, B, and C) to learn in a practice session and that these tasks are fundamentally different, such as tennis serves, volleys, and ground strokes. That is, tasks are chosen such that one cannot argue that any of them are in the same class or use the same GMP.

A common sense method of scheduling such tasks would be to practice all trials of one task before shifting to the second, then to finish practice on the second before switching to the third. This is called blocked practice, in which all the trials of a given task (for that day) are completed before moving on to the next task. Blocked practice is typical of some drills in which a skill is repeated over and over, with minimal interruption by other activities. This kind of practice seems to make sense in that it allows the learners to concentrate on one particular task at a time and refine and correct it. Another practice scheduling variation is called random (interleaved) practice; where the order of task presentation is mixed, or interleaved, across the practice period. Learners rotate among the three sample tasks so that, in the more extreme cases, they never (or rarely) practice the same task on two consecutive attempts. And from a common-sense perspective, the random method, with its high level of trial-to-trial variability, its high level of contextual interference would not seem optimal for learning" (Schmidt & Lee, 1988, 2013).

Otherwise, many scholars study the teaching methods of physical activity and sports from another point of view and suggest to train and teach taking into account environment in which performance happens. In the ecological-dynamic approach (Cornus & Marsault, 2003), the environment is the centre of educative process; trainers and teachers build a learning setting aimed at variety of stimuli and variables.

The role of teachers and trainers is to enhance the heuristic learning for athletes and students. They build an adequate educational setting using the structure and tools in order to suggest solutions to resolve motor problems. In this way, they use teaching methodologies such as circle time, role playing, cooperative learning, problem solving, brain storming, focus group, peer education, tutorship and utilize them to facilitate the dynamic relation among students.

Motor learning from an ecological perspective

Apart from the obvious references to Gibsonian psychology (Gibson, 1986), the ecological approach has its theoretical roots in Degrees of Freedom theory (Bernstein, 1967) and in Motor Imagery (Jeannerod, 1994). The motor imagery is defined as a dynamic state in which an individual mentally simulates an action; he experiences a reactivation of kinesthetic memory allowing to relive the motor experience (Decety, 1996). On the neuroanatomical level, physically performing or imagining an action implies overlapping of involved brain areas (with a limited activation in imaginative practice).

According to Jeannerod (Jeannerod, 1994), a fundamental distinction must be made between a dynamic type of visual image, that allows to imagine scenes with objects and people moving, and the motor imagery. The motor imagery is more properly an internal image: it is the representation of ourselves in action, with the feelings that the implementation of the action involves, whether it involves the whole body, whether it be part of it.

If it refers to a simple motor behavior, the internal motor image represents the more strictly effectors aspects, such as stress, motion duration, direction and speed. If we assume a more complex situation, such as the execution of a technical act in an official match, then the internal motor image will be enriched with all the feelings of stress, emotion and regulating arousal levels, that this situation entails.

It is well known that athletes use mental imagery to lower or raise their levels of activation in order to better control the distractions and the possible anxiety-inducing factors (Jones & Stuth, 1997). We can therefore distinguish two strategies prevalent in the representation of body movement: 1) A strategy based on the observation and on the formation of a visual model of movement to be performed (modeling), most used by beginners or by young athletes (Bandura, 1997); 2) a strategy based on internal representation of movement (motor imagery), more common in elite athletes and more closely connected to motor execution quality.

Many scholars, anyway, consider that the cognitive processes that underlie these two strategies are super-imposable and only differ with regard to the initial nature of the information from which the representation arises (SooHoo, Takemoto, & McCullagh, 2004). The Degrees of Freedom theory consists in external observation and analysis of movement. Bernstein (1967) stated that motor learning consisted in the voluntary control of the extreme freedom of movement in an indefinite variety of execution the so-called theory of degrees of freedom. No movement made up of several actions can be performed several times in exactly the same way; it differs by virtue of the many possibilities of execution. According to Bernstein, motor learning occurs through three consecutive stages:

- reduction of degrees of freedom
- exploration of degrees of freedom
- capitalization of degrees of freedom

The reduction of degrees of freedom is the motor learning initial stage, from the first run of the movement with the minimum functional freedom to achieve the desired result. Since a beginner student is probably unable to properly control the huge amount of degrees of freedom in the neuromuscular system and in the environment, it is useful to reduce them in order to facilitate the motor task solution with available resources (Vereijken & Bongardt, 1999).

Reducing degrees of freedom is the process that helps the person to find the solution for the motor task using the available resources. The teaching practices in this phase relate directly to locking some general movements in order to immediately reduce the range of motion executions. Locking the articulations can be effective if the movement to be learned is made up of many single actions and engages more articulations at the same time. The second stage of learning, according to Bernstein, is the exploration of degrees of freedom (Bernstein, 1967; Vereijken & Bongardt, 1999). This is the opposite to the previous process: when the student is able to perform the movement in simplified form, additional degrees of freedom can be introduced by coordinating the movement of a progressively larger number of articulations. The third stage is the capitalization of degrees of freedom.

Capitalization, in this case, means optimizing degrees of freedom, by exploiting all available resources, in order to economize the movement. In this approach, motor learning means to govern the degrees of freedom, namely to identify the most effective motor solution to a given task in a given context. Teaching strategies to enhance motor learning revolve around one key concept: to stimulate the emergence of spontaneous solutions to motor problems. This sheds new light both on the teaching methods (it is clear that, to foster the emergence of spontaneous solutions, I cannot adopt a prescriptive approach, and therefore I have to intervene on the environment) and on evaluation methods (if, in cognitive approach, execution variability is symptom of an error, in the ecological approach variability is an indication of effectiveness; the perspective is reversed). In the cognitive approach, in fact, "motor learning is an internal process that reflects the level of individual ability and performance and could be evaluated according to the relative stability of the executions of a task" (Schmidt & Wrisberg, 2008).

Theoretical frameworks and teaching methods

The cognitive approach is consistent with a theoretical model of Human Information Processing that includes discrete and non-overlapping stages (Di Tore, Discepolo, & Di Tore, 2013; Di Tore, 2015).

The discrete sequence *Stimulus identification - Response Selection - Response programming*, according to which the cognitive psychology describes the mechanism of perception – action (Schmidt & Wrisberg, 2008), faithfully repeats, in fact, the IPO model (input - processing - output). “In essence, this model is functional in an interaction that considers space and time as separate elements, consistent with a conception of time as something moving with respect to a static observer, a linear path from A to B in which to place our body” (Di Tore et al., 2013). “The idea of inputting information and then processing it before acting upon it is easy to follow and makes learning in games look relatively straightforward. Information processing, however, is based on assumptions that knowledge is external to the learner. It does not take into account human experience and the ways in which perception is shaped by, and interacts with, the individual’s life experiences. Information processing assumes knowledge as a given object independent of human experience” (Light, 2008). Perception, instead, is more than merely a biological function of the body.

Processes of perception involve interpretation shaped by experience (Varela, Thompson, & Rosch, 1992). The preschool child learns through his or her eyes, ears, tactile sensations and combinations of senses (including thinking), and nonverbal social interaction well before the development of language. This learning involves the use of “organs of the process of doing something from which meaning results” (Dewey, 1916). Recent literature has shown how the action does not just react to the event, but anticipates it through simulation or emulation (Decety & Jackson, 2004; Jeannerod, 1994; R.R. Llinás, 2009; Prinz & Hommel, 2002; Di Tore, Di Tore, Mangione, Corona & Conesa Caralt, 2014).

The model of Human Information Processing, in fact, falters: “the brain does not actually compute anything, not in the sense of the algorithmic handling of ones and zeros that characterizes Alan Turing’s digital “universal computer” (R. R. Llinás, 2002). In such vision, there is no reason to find the boundaries between mind and environment. Human brain is not a computer, rather it’s an emulator (a reality emulator, according to Llinás) which is at the origin of perception – action process (that is, an intentional, goal-oriented process), recalling an intuition from Merleau-Ponty: “the world cannot be separated from the perceiver” (Merleau-Ponty, 1962). The French phenomenologist suggests that perception is an interpretative act that involves, not passive reception of information, but active projection of the agent’s experience. What is perceived and how it is interpreted varies according to the agent’s accumulated experiences. The world does not exist in some pure form completely separate from us but instead exists as we perceive it (Light, 2008; Merleau-Ponty, 1962) or, in other words, What happens in perception can be understood in terms of action (Leman, 2008).

In such an approach, motor learning is a question of the adaptability of the movement, matching the diversity of the environment and the specificity of the individual (Carnus, 2010). From this perspective, the ecological approach to teaching of movement and sport appears to be more up to date concerning the evidences and reflections from scientific research. Yet, in schools, from kindergarten to high school, teaching practices appear to be more related to the cognitive approach, when they not directly descend from a behaviorist framework. Our hypothesis is that the conceptual framework related to ecological approach to movement, as more scientifically founded, finds it hard to translate into classroom practice because it offers less ready-made solutions to the teachers. It is important to emphasize how theories of knowledge (especially the behaviorist and cognitivist theories, borrowed from the psychology domain), have shown, historically, a good contiguity with the practical problems of educators (Davis & Sumara, 2003).

In movement education, behaviorist idea of teaching is immediately understandable because it focuses its attention to the relationship between teaching and observable performance, and suggests teaching strategies capable of replicating or improving performance. In the same way, cognitive perspective promote an instructional design based on the individual characteristics and on the personal dimension. These two models share an idea of immediately observable performance, and produce a continuity in teaching practices (Raiola, 2015, 2011; Raiola & Tafuri, 2015; D’Isanto et al, 2017, D’Isanto 2016, D’Isanto & Di Tore, 2016, Altavilla & Di Tore 2016; Cirillo et al., 2016, Raiola, 2012).

“Although physical education teachers may not necessarily articulate clear beliefs about it, their practice invariably rests upon basic, unquestioned beliefs about learning. Their practice is typically based upon assumptions about learning that are deeply embedded in Western culture (Davis, Sumara, & Luce-Kapler, 2000) and that assume it to be an explicit linear and measurable process of internalizing knowledge.

From this perspective, knowledge is conceived of as a pre-existing, “out there” entity and learning as being a process of internally representing this reality in the mind of the learner (Varela et al., 1992). In physical education, this is evident in the teaching of predetermined “fundamental” motor skills seen as being a prerequisite for playing games and sport” (Light, 2008).

Table 1. Relationship between categories.

Approach	Cognitive	Ecological
Teaching method	Prescriptive	Heuristic
Teacher role	Invasive	Non invasive
Scope	Performance	Education
Context	Sport association	School

Table 2. Relationship between educational aspects.

Approach	Cognitive	Ecological
Motor control	Closed loop Open loop Generalized motor program	Freedom degrees Motor Imagery
Motor learning	Skills	Abilities
Teacher Tools	Tutorials	Educative setting
Type of proposal	Blocked practice, varied practice, random practice, feedback-based error correction	Role play, cooperative learning, focus group, peer education

Conclusion

The moving body and the process of perception - action have been object, in recent decades, of

attention that goes beyond the disciplinary boundaries of Physical Education and sports sciences. However, the teaching practices common in schools, from kindergarten to high school, are still bound to a theoretical framework that looks outdated or appear related to personal epistemology of teachers and educators. This is not surprising. The new transdisciplinary framework that acknowledges the centrality of the body and of the movement cannot be taken without mediation in teaching practices and, in this particular case, involves all the traditional educational system, from didactic methods to assessment. However, we reiterate that some practices destitute of scientific basis must be abandoned as soon as possible, by relocating to the center of the teaching activity the unitary structure perception / action, postulated within the ecological approach.

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MOTORIČKO UČENJE U SPORTSKOJ ZNANOSTI: RAZLIČITI TEORIJSKI OKVIRI ZA RAZLIČITE METODE POUČAVANJA

Sažetak

Metode poučavanja o sportu naširoko istražuju brojni znanstvenici. Najraširenija tradicionalna praksa poučavanja ima svoju teorijsku osnovu u kognitivnom pristupu i u predznanju tj. viziji. Kognitivni pristup podrazumijeva specifične psihološke modele učenja motorike: Nadzor s otvorenom petljom i zatvorenim petljama te Generaliziranu teoriju motoričkog programa. Drugi znanstvenici proučavaju metode učenja sportova iz druge perspektive zvane ekološki pristup. U ovom slučaju treneri se usredotočuju na obrazovno okruženje i tumače učenje kao istraživanje za fizička i motorička rješenja dostupna u okruženju. Ovaj pristup ima svoju psihološku osnovu u Bernsteinovim teorijama stupnjeva slobode i motoričkim slikama. Diskretna sekvenca Identifikacija poticaja - odabir odgovora - programiranje odgovora, prema kojem psihologija opisuje mehanizam percepcije - akciju, vjerno ponavlja IPO model (ulazno - procesno - izlaz). Obrada informacija, međutim, temelji se na pretpostavkama da je znanje izvan učenika. Ne uzima u obzir ljudsko iskustvo i način na koji percepcija oblikuje i interakcionira s životnim iskustvima pojedinca. Iz te perspektive, čini se da je ekološki pristup poučavanju sportova više aktualan u odnosu na dokaze i razrade iz znanstvenih istraživanja. Ipak, u metodama treninga čini se da su prakse poučavanja više povezane s kognitivnim pristupom, kada se ne izravno proizlaze iz biheviorističkog ili kognitivnog okvira. Metode ove studije su analizirale specifične aspekte pristupa učenju u sportskoj znanosti. Pretpostavka je da bi konceptualni okvir povezan s ekološkim pristupom trenažnim metodama mogao biti znanstveno utemeljeniji od trenažnih metoda utemeljenih na tutorialnim alatima.

Ključne riječi: petlja, generalizirani motorički program, ekološki i kognitivni pristup, motoričke slike.

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