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Review Paper

MOTOR LEARNING IN SPORT

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Abstract. *Motor learning is characterised by specific features and it incorporates laws that have to be observed throughout the various manifestations of an athlete's motor activity. It is the process of acquiring, completing and using motor information, knowledge, experience and motor programs. Performing a certain movement is only possible if a suitable motor programme for it exists. The motor process starts with a definition of the desired result and consists of three interconnected phases: the phase of basic movement coordination, the phase of accurate movement coordination and the phase of movement coordination stabilisation under changeable and difficult circumstances. A precondition for efficient motor learning is an optimally accurate notion of movement which is based on the visual followed by the kinesthetic processing of information.*

Key words: *motor learning, learning phases, motor programmes, motor memory, movement scheme.*

INTRODUCTION

The official definition of learning (UNESCO/ISCED 1993) reads as follows: "Learning is any permanent change in behaviour, acquaintance, knowledge, comprehension, viewpoints, skills or abilities that cannot be ascribed to physical growth or development of inherited behavioural patterns." Learning – in various forms and situations – is a part of man's everyday life. Learning changes our personality; it is a process of receiving, acquiring, recognising, developing and expanding our horizons. Questions such as: what is the essence of learning, what are the basic forms of learning, what are the necessary conditions for learning to take place, what are the most successful learning methods etc., have been dealt with by many psychologists in the past decades, during which time over fifty learning theories have evolved. The best known are: the associative, behaviourist,

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Gestalt, cognitive–constructivist, humanist, and cybernetic–information learning theories (according to Marentič Požarnik, 2000). Despite a myriad of theories, their common denominator is that they all face dilemmas about the ratio between the parts and the whole and about whether learning is a cognitive–rational process or an individual process with intertwined emotional and social elements. Among the various forms of learning, motor learning is characterised by those specific features and laws that have to be taken into account in the various manifestations of an athlete's motor activity.

THE MOTOR LEARNING PROCESS

Motor learning is a process of acquiring, completing and using motor information, knowledge, experience, and motor programmes (Adams, 1976). It is closely connected with mental abilities, motor abilities, foreknowledge, the cognitive and connative characteristics of an individual as well as his familiarity with the theoretical bases of movement technique. Based on Hay's biomechanical studies (1985), it may be ascertained that running, as the most elementary manifestation of human motor abilities, involves more than 80 muscle groups and 46 bones of the locomotor system. To facilitate the correct performance of a motor action, optimal coordination of movements is necessary. Abernethy et al. (1997) distinguished between three phases in the process of motor learning: the verbal-cognitive phase during which a new movement structure is first identified and then understood; the associative phase during which several elements of the movement structure are integrated and adapted to the changing circumstances; and the autonomous phase during which movement becomes automatic and results in few errors. During the first phase, a beginner executes a series of unnecessary movements, activates muscles that are not relevant and is unable to bring them into balance. Consequently, his starting position and movement rhythm are incorrect, while his posture is stiff. This phase of motor learning lasts from 15 to 30 hours. In the second, associative phase, the quality of movement improves substantially. Movements are already smoother and more relaxed, while superfluous movements gradually vanish. In the motor part of the central nervous system a notion appears as a motor stereotype. This phase lasts from 3 to 5 months. The third, autonomous phase is that of movement automation, where the individual kinematic and dynamic parameters of movement are optimally integrated. This lasts for several years and is never quite finished. The motor stereotype collapses only in extremely unpredictable circumstances such as fatigue, enormous pressure or stress.

Magill's (1993) definition of motor learning divides muscle activity into seven phases:

- The selection and innervation of those muscles necessary for the efficient execution of a movement;
- Sequencing (the correct sequence of muscle activation);
- Time structuring of the movement (the duration of the activity of an individual muscle during the entire movement);
- Gradation (varied application of the power of the engaged muscles);
- Timing (adapting the structure of the movement to external conditions);
- Alternative movements (selection of the optimal movement structure in view of the current situation);
- Movement control (movement automation and movement adaptation in non-standard circumstances).

Performing a certain movement is only possible if a suitable motor programme for it exists. Schmidt (1977) defined a motor programme as a multitude of commands that travel from the central nervous system to the muscles, and which are defined prior to the movement. The author distinguishes between short-term and long-term motor memory. Short-term motor memory registers visual, auditory, kinesthetic and other stimuli from the environment. It is useful for the current process of movement control. It is a working memory and only lasts for 30 seconds. The long-term motor memory stores well-mastered and automated motor tasks. Both memories are important in motor learning – the first one particularly duirng the initial stage of learning.

No motor learning is ideal or equally efficient at any time. Most motor structures need to be complemented and adjusted to new circumstances by motor control. Motor control distinguishes between an open circle system and a closed circle system (Schmidt, 1991). Movements lasting up to 200 milliseconds (reflex, ballistic movements) are centrally monitored (the open circle system) and require that the motor programme be defined beforehand, including all the details. Movement or its individual components are independent of the feedback information, since movement control is exerted subconsciously by higher centres of the central nervous system. Once this programme starts, corrections are no longer possible. Movements lasting longer than 200 milliseconds (the closed circle system) allow the correction of errors (Figure 1). Preparation of a programme, the programme itself and control over how it is implemented are important in the execution of movement. Each movement is realised in a closed system of spatial and temporal coordinates. Of particular importance are the kinesthetic receptors, synchronising movement by regulating muscle and tendon tonus (Golgi tendon receptors), Ruffini free nerve endings and Pacinian corpuscles located in joints and perarticular tissue (Enoka, 1998).

Motor learning of a given sports technique requires a plan which Schmidt (1977) defined as a "scheme" being stored in the motor memory. The movement scheme has four elements:

- Initial conditions such as information about the environment, the position of body parts, position of the tool (e.g. club, racquet, ball), the grip and balance of the body;
- Information about the speed, amplitude and force of the swing;
- Information about movement transmitted by kinesthetic receptors;
- Information about the reaction outcome in view of the set goal.

The motor process starts with a definition of the desired result of movement and establishment of the initial conditions. Implementation of the motor programme starts on the basis of stored information about previous movement experience. A precondition for efficient motor learning is an optimally accurate notion of movement. Notions of movements are formed on the basis of visual and motor perceptions combined with verbal and mental activity; at the same time the pre-existing notions are also activated (Tancig, 1996).

The concept of a motor programme is related to information processing in the time period during which a motor task is being performed. There is a great difference between a conscious execution of a motor task (verbal–cognitive phase) and an automated execution. In automated movements many intermediate stages disappear; the transition from sensory information to execution of the movement is direct and there is no symbolic interpretation such as was necessary at the very beginning. In the motor learning process two types of feedback are important: sensory feedback and indirect feedback. Sensory feedback enables motor control – particularly in the initial phase of motor learning. This information is transmitted by different receptors:

- exteroceptors (eye, ear),
- tactile receptors (receptors in the skin of the palm and fingers),
- proprioceptors (receptors in muscles, joints, tendons, epimysia).

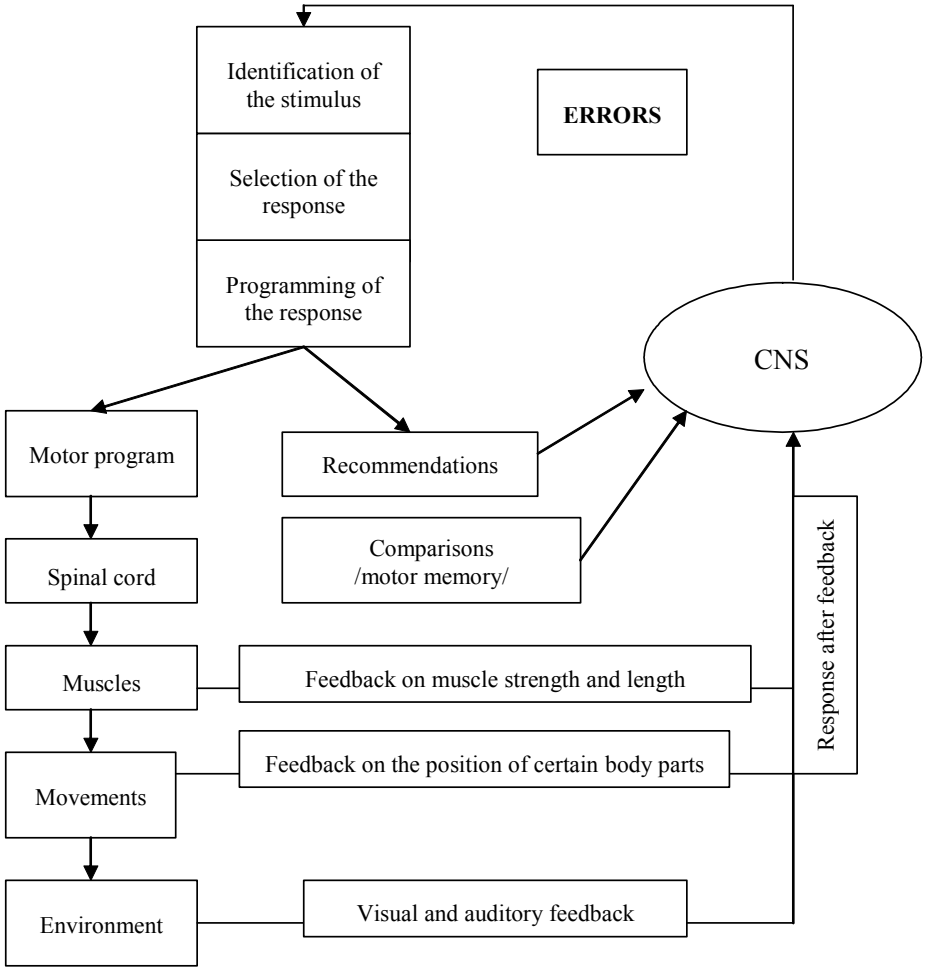

Fig. 1. Motor control based on the closed circle system (Schmidt, 1991)

Indirect feedback is more frequent in the second and third phases of motor learning and depends on knowledge of the result of the movement. Exact knowledge of movement execution, experience, highly differentiated tactile and kinesthetic sensations and anticipation of external circumstances are the factors that enable a player to apply the optimal technique in unpredictable conditions as well. The ability of motor learning may vary considerably in each individual. It depends on the perception of information, comparison and processing of information, age, motivation, motor experience as well as short-term (working) and long-term memory. Motor learning is a process of storing information in long-term memory through the exercise or repetition of motor tasks (Keele and Summers, 1976).

Figure 2 shows motor learning curves i.e. changes in learning effects due to learning. The abscissa shows the quantity of learning, while the ordinate shows the effects of learning. The learning quantity may be expressed through time or as the number of strokes, while the learning effect is expressed through the number of correct responses i.e. correct strokes. Motor learning curves may take various shapes. During the period of learning elementary movements the most common curve is the one with negative acceleration (curve A). Initially, the learning effect rises quickly (a), then slows down (b) and eventually reaches the plateau of motor learning (c). This curve shape is defined by different factors. A beginner first learns simple movements which are already known to him to some extent; the speed is low but the motivation for learning is high. Once the effect of these factors diminishes, the curve rises more slowly. Generally, it ends on a plateau i.e. the phase where there is no longer any progress in learning (Schmidt, 1976).

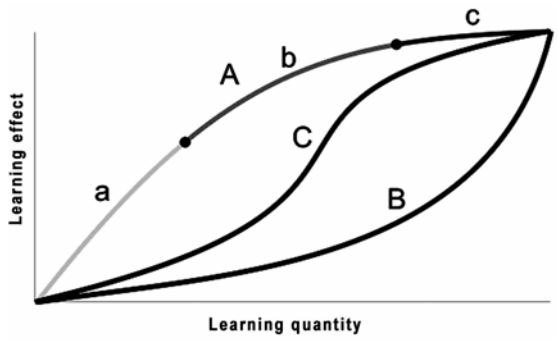

Fig. 2. Motor learning curves

The most frequent curve in motor learning is the C curve shaped like the letter "S", with negative and positive zones. This curve is typical for motor tasks that are usually executed for the first time and where there is no previous experience and motor programmes to support them. This group includes gymnastics, skiing, tennis, and golf. In the first phase progress is relatively poor, since a beginner has no adequate motor experience and notions. Progress is only possible when there is a higher frequency of exercises combined with appropriate motivation, concentration, understanding of movement and suitable motor abilities. The curve with positive acceleration (curve B) is less common in motor learning.

THE FUNCTION OF THE BRAIN HEMISPHERES AND MOTOR LEARNING

The neurophysiologic research conducted over the past decades has left a visible mark on the study of motor learning processes in various fields of sport. Namely, the brain is not a whole but consists of two separate halves, the left and the right hemisphere. The nervous system is an exceptionally highly organised and complex system. Which parts of the nervous system or the brain are responsible for efficient motor learning? Despite many research efforts in this field, no satisfactory answer has yet been given. We know that certain parts of the brain are responsible for certain functions. In the cerebral cortex there is a motor centre in charge of motor functions. Moreover, the left and the right

hemispheres do not function symmetrically, as each of them has its own specialised functions. Learning is most efficient when the two hemispheres function in synchronisation. Communication between them is made possible by the neural bridge – the corpus callosum. The right hemisphere of most people controls movements and sensations of the left half of the body, and vice versa. There is no symmetrical division of functions and it is a known fact that 90% of all people are right-handed. Research conducted by Sperry (1971) established two ways of thinking, one manifesting itself through speech and the other not. The left hemisphere is "talkative"; the right is "silent". The educational system and the Western civilisation both give primacy to the functions controlled by the left hemisphere, at the same time neglecting those controlled by the right hemisphere. The functioning of the left hemisphere is connected with analytical thinking, logic, reading, writing, speaking, counting, and calculating. The functioning of the right hemisphere is connected with intuition, spatial processing, overall comprehension, movement, drawing, rhythm, feelings, creativity and dreams. In motor learning, both hemispheres jointly control movement; however, cognitively and rationally mediated functions originate more from the right one. The right hemisphere is responsible for overall spatial cognition, visual presentation of spatial depth, rhythm, recognition of movement patterns, and for concurrent processing of many pieces of incoming information (Bouchard et al., 1992). The left hemisphere is "smart", while the right one is "adept". The theory of the hemispheres' functions has not been altogether confirmed, yet it still offers interesting considerations regarding motor learning.

The optimal years for motor learning are around the age of 6 (Bompa, 1999; Marjanovič et al., 2004). During this period the two hemispheres are intertwined. The older we get, the more our brain hemispheres specialise. The educational system gives explicit priority to logical inference, learning by heart, mathematics, reading and language learning. At the same time there is less and less intuition, playing, rhythm, music and motor expression. Moulds, patterns and rules increasingly gain ground. In the opinion of Abraham (1985), elite sports creativity in any sport is a domain of the right hemisphere. According to some elite athletes, their top performance was characterised by a unique mood, almost like a trance. Their achievement was a result of serenity, absence of effort, a feeling of easiness and a crystal-clear mind.

To make use of these abilities in the process of motor learning, one has to activate the right hemisphere and thus facilitate and accelerate one's own learning. Only by activating the right hemisphere can one make full use of one's intellectual abilities and exploit their potentials. To increase the participation of the right hemisphere Abraham (1985) recommends the following:

- It is possible to achieve optimal results in motor learning as soon as the right hemisphere is activated in addition to the left one. Spontaneity and intuitiveness make exercising more fun. If one enjoys movement, one progresses much faster.
- Beginners make a big mistake trying to control their movements by focusing on inner consciousness. This way they activate their left i.e. analytical hemisphere, which triggers a series of commands in the body, generally disrupting the overall coordination of movement. That is the primary function of the right hemisphere.
- Too many commands will activate only the left half of the brain, resulting in the inhibition of the centre for movement analysis. Therefore, it is necessary to focus one's thoughts on the set goals.

- The overall comprehension of movement is the function of the right hemisphere of the brain. Learning a movement is easier if it is considered as a whole, not a jigsaw of many pieces.
- Mistakes are integral parts of learning, so allow yourself to make them. It is a normal part of the process and one should not harbour resentment towards it. Do not allow them to diminish your self-confidence and self-assurance. Immediate evaluation and analysis of the mistakes occupies the left half of the brain to a great extent, which in turn has a destructive effect on the execution of movement.
- Visualisation of movement and the notion of movement are prerequisites for efficient motor learning. A mental notion helps in the execution of a motor task. One has to learn how to observe a movement, its rhythm and coordination. A special type of such practice is the "observation" of one's own movement. In your mind, repeat the relevant movement several times (ideomotor training). Visualisation is not useful only as part of one's mental preparation, but also activates those muscles and muscular nerves that take part in real movement. Visualisation of exercises awakens the right hemisphere, reduces fear and increases self-confidence.

THE PHASES OF MOTOR LEARNING

The process of motor learning is long-lasting and, in terms of its effects, it consists of three basic phases: the phase of basic movement coordination, the phase of accurate movement coordination and the phase of movement coordination stabilisation under changeable and difficult circumstances.

The Phase of Basic Movement Coordination

In this phase of learning, an individual first learns about basic movements and is able to execute them only under favourable conditions and with sustained conscious concentration. The results are quite modest as the technique is poorly developed and uneconomical. The notion of movement and motor sensations are vague, dull, incomplete, sometimes even wrong and not in harmony with the dynamic and temporal components of then optimal movement. A beginner is unable to distinguish between essential and less essential elements and phases of movement. As a rule, the initial notion is formed on the basis of the instructor's demonstration, a photo or a video recording. The so-called external sensory signal system (sight) engages and provides optical information. During this phase of motor learning, verbal information (the instructor's explanation) is also important in addition to optical information, although it has to be clear, specific and comprehensible. A beginner builds his basic notion of movement from visual and verbal information and thus creates the foundations for the execution of movement. When a beginner starts executing a movement, his central nervous system engages the motor memory which stores specific motor programmes – motor foreknowledge (Harre, 1982; Piek, 1998). In the process of learning more demanding motor tasks (tennis, skiing, golf, gymnastics) these programmes are not very frequent in motor memory; therefore, one must not be disappointed if one's first attempts are not successful. Of course, there are great differences between beginners, due to differences in the level of their motor foreknowledge and experience, motor abilities, mental concentration, motivation and endeavours.

An important role is played by motor foreknowledge (motor programmes) which is indirectly connected to the elements of the technique in a given sport. According to Bernstein (in Latash, 1998), there is a strong transfer (transmission of motor knowledge and abilities) between related motor situations. For example, motor knowledge of gymnastics, track-and-field and tennis very positively affects the efficiency in learning to ski, play basketball and football, and vice versa. The more motor knowledge, experience and programmes a beginner has, the easier it will be for him to learn new movement techniques in other sports.

In this phase a beginner often thinks that he is executing the task correctly, while in fact he is doing it perfunctorily or completely wrong. Why? Because control over his movement is very weak. He is capable of controlling movement only through his visual signal system. The eyes may be the most important optical analyser but they are not enough. The most important function in the coordination of movement is that of the kinesthetic receptors (Schmidt, 1991). These are sensory bodies that are scattered over joints, ligaments and tendons and monitor body part position and movement, joint angles and muscle tension. In the case of beginners, the function of kinesthetic analysers is substantially less prominent, as they depend on experience and the already mastered motor programmes and motor memory. Therefore, the feedback information flow is very weak, the information is incomplete, imprecise and untimely. If one wants a beginner to understand verbal information (an explanation), one has to help him with optical control. The instructor has to clearly demonstrate technical elements, repeat them several times at a lower speed, if needed, emphasise the key elements of execution and furnish a suitable explanation. As far as the explanation is concerned, care should be taken that the beginner is provided only with the information that is indispensable for the execution of a specific movement. An abundance of initial information may negatively affect an individual's concentration and motivation.

The main characteristic of this phase of motor learning is rigidity of movement, manifested in the inability to distinguish between correct and incorrect movements, inadequate movement amplitude, stiffness and tension, inappropriate execution tempo and poor movement coordination. The main reason lies in the phenomenon of "irradiation" in the motor cortex of the central nervous system (according to Bernstein, in Latash, 1998). The result is the uncontrolled activation of those muscles that are not engaged in specific movements. The engaged muscles and muscle groups work against each other and mutually hinder their performance. Furthermore, practising leads to psychological and physical fatigue which eventually diminishes the learner's ability to concentrate on practising. Another element is often a fear of failure, which may additionally block the functions of the learning process. An enthusiastic beginner must not feel pressured to achieve success at any cost and to immediately attain his often unrealistic goals and ambitions. In this phase the instructor must not be overcritical; he should contribute positive energy and encourage the learner while correcting only critical errors. He must not "bomb" the learner with too much information. It is a known fact that a beginner may only control one or a maximum of two elements in an individual attempt at a movement.

In order to enjoy initial success in motor learning, the instructor has to take extenuating circumstances into consideration by offering assistance and reducing speed or force. At the same time, analysis of the playing technique has to be made in view of each individual's motor abilities. In many cases, errors stem from unsuitable motor abilities. Last but not least, a successful take off in the learning process largely depends on a favourable

working atmosphere that is manifested in mutual trust, motivation, a suitable environment, a favourable climate and temperature as well as the proper tools.

The Phase of Accurate Movement Coordination

During this phase an individual is capable of executing high-quality movement in regards to optimal technique pattern, provided that the circumstances are normal. Errors still occur but they are less obvious and less frequent. As the player repeats the movement, his results improve. Movement becomes more coordinated, individual motor phases are interconnected, leading to a good and refined movement coordination. Progress in learning the technique is not continuous and depends on the characteristics and abilities of an individual. After many very successful executions of a technique, a momentary standstill may occur that is usually of short duration. Performing incorrect repetitions may have long-term consequences such as an unwanted consolidation of errors. The greater the number of error repetitions, the more the error becomes automatic and the harder it is to eradicate it. This is why many "self-taught" tennis players, skiers, swimmers and golf players face great difficulties when learning with a professional instructor, as their motor memory stores incorrect notions of movement, incorrect motor programmes and resulting errors. In this situation, interference occurs (according to Bernstein, Latash, 1998), when seemingly similar but essentially different programmes thwart each other and cause disturbances that hinder the correct execution of the technique.

Nevertheless, it is typical at this phase of motor learning that motor programmes are substantially more accurate and are connected primarily to kinesthetic receptors. All three signal systems, namely verbal, sensory and kinesthetic, are interconnected more efficiently. As a whole they form precise notions of movement in harmony with the external spatial and temporal coordinates. Movement is executed on the basis of a close coordination between what is desired and what is real. During this phase, anticipation of a movement distinctly improves, based on internal and external factors. The conscious control of movement subsides. The movement is executed "subconsciously" and subjectively with greater ease and relaxation. In addition to feedback, kinesthetic and sensory control, an adequate cognitive and symbolic system is also set up at this phase. An athlete translates concrete movements into ideas, terms or phrases, helping him to rationally control the movements and communicate better with the instructor. He may be able to give minute descriptions of his own movements, individual phases and key moments. Kinesthetic sensations become increasingly sharper and depend on changes in the environment and the tools. At this point, the methodology should focus on practising the technique in normal circumstances. Generally, a player scores good results in favourable conditions. Errors start appearing in difficult, unpredictable and changeable circumstances and cause the technique to collapse, possibly even producing long-term negative consequences on the game. The player and the instructor have to set a goal: execute the technique correctly, consistently and under standard circumstances.

The Phase of Stabilising Movement Coordination under Changeable and Difficult Circumstances

A learner is able to execute the optimal technique in changeable and difficult circumstances with a high level of stability. During this phase, the motor programme is com-

pletely automated and constant. Very subtle kinesthetic sensations of the player are combined with verbal and sensory information. The level of the movement technique's applicability in a competitive environment is high. The motor programme is adapted to the player's abilities and characteristics and involves a high level of anticipation of movement and the possibility of correction. In addition to reliability and constancy, such a motor programme can easily be adapted to various unpredictable external and internal circumstances. The player may execute the technique correctly despite some "distracting noises" such as psychological pressure, physical or psychological fatigue, competitive stress, wind, bad weather and the like. If the athlete's technique cannot adapt to such changes, it is completely useless. Therefore, methodology includes the execution of movements under difficult and changeable circumstances, constant control and correction. A high level of movement coordination has to be achieved through a flexible programme that adapts to external and internal changes. Only this kind of technique guarantees that the set goals will be achieved. Experts have established that it takes from 40,000 to 50,000 repetitions of a certain motor task to achieve the complete stabilisation and automation of one's technique (tennis, skiing, golf). In this phase the method of practising the technique turns into a "training match" in which the simulation of competition circumstances and tactics is aimed at achieving the desired result.

One of the most important components of learning and executing one's technique in competitive circumstances is concentration. In fact, concentration is a process which may last anywhere from only a few minutes to a few hours. An athlete has to focus on the execution of the movement and concentrate his thoughts in a pre-defined direction. He should repeat the movement scheme in his mind several times (ideomotor training). In this way the movement pattern and motor memory will be consolidated (Singer, 1981). He should create conditions for positive thinking and a positive notion of the correct movement. Errors from the past have to be extracted from memory. "Bad movement patterns" have to be forgotten as soon as possible, as they reduce the player's self-assurance and confidence in his own abilities. Immediately before executing a motor task the athlete has to focus on one thing and remove all other thoughts. "There is no future and no past, there is only the present and myself." (Bernhard Langer – one of the world's best professional golf players). High concentration consumes a lot of mental energy which at a certain level of a player's fitness is limited. Players who are fitter are able to maintain high-powered concentration more easily and for longer periods of time (Glyn, 1992). As is the case with other skills, this one has to be trained for seriously and systematically.

LEARNING METHODS

Learning methods are conventional procedures or sequences of procedures used for acquiring knowledge (Marentič Požarnik, 1980). In motor learning methodology various learning methods are used and combined, depending on the exactness and character of the motor task and on the learner's age and stage of motor learning. The most important characteristic of a motor task in terms of choosing the learning method is its integration. The more the individual parts intertwine, the more significant the synthetic and combined methods are. If an individual is completely unfamiliar with the components of movement and considers them very demanding, the method of learning part by part is more appropriate.

The Method of Instruction

Verbal instruction is one of the most elementary forms of human expression and communication. It is important during the initial phase of motor learning, when an individual is becoming familiarized with the basic movements. It may include descriptions of the basic characteristics of movement, explanations of concepts, rules, inferences, definitions of models and the like. An instruction may be in the form of a conversation, where questions and answers are not determined beforehand. It may also be a discussion, a debate or an argument where different opinions, viewpoints, attitudes, arguments and counter-arguments are put forward. When giving instructions, the instructor should present objective facts, adhere to the principle of gradual progress from the easy to the more difficult, from the familiar to the unknown, from the relevant and vital to the less important. Good instruction is the cornerstone of successful motor learning.

The Demonstration Method

The initial notion of motor learning is primarily based on a sensory signal system which provides optical information (sight). The demonstration method has to be combined with other learning methods, especially the method of instruction. The demonstration must be absolutely correct, clear and suitable to the learner's age and level of maturity. The instructor must always evaluate the effect of the demonstration and its applicative value. The demonstration must be in line with the learner's mental and motor abilities, and suitable for practical application. The demonstration of only one ideal movement is not desirable. Movement technique mirrors the concrete effects of a learner's motor abilities and morphological characteristic with wide variety. The demonstration of a technique should reflect the general rules of movement and the comments should be based on the individual learner's limitations and particularities. The basic precondition for motor learning is a good mental and visual notion of movement, the activation of psychic processes and working muscles. The ability to create a notion of a motor task is primarily the function of the right hemisphere of the brain (Horst, 1985).

The Situational Method (Synthetic Method)

It is one of the most frequent and most natural methods of motor learning, which is usually used for less demanding movements. The method is more suitable and effective for beginners, as they have a higher ability of understanding movement as a whole rather than its individual parts. The concept of learning movement as a whole is not to be understood literally, since learning is demanding and in the case of complex movements one should not start with all the details right away. In terms of difficulty and composition, not all movements are the same; nevertheless, each movement has inherent basic and vital elements. Beginners have to learn these very basic elements as soon as possible. The situational method enables athletes to display their abilities and characteristics on two levels. The first consists of replication – repeating the motor task which has been demonstrated in its entirety. The second level is the execution of a simple version of the motor task (a kind of imitation), while still considering the task as a whole. In both cases the instructor has to look for deficient movements and any gross errors. Minor errors may be "tolerated", and an extensive verbalisation is not recommended. In the case of beginners whose

movement patterns (motor stereotypes) have not yet taken shape, the information is received and processed in an undifferentiated manner and at a lower level. However, it has to be emphasised that the emotional effects of such focused exercising are far greater, which may be a deciding factor – particularly at the beginning of the learning process. Strong inclination and an interest in exercising have a positive effect on learners' attention and motivation.

The Analytical Method

The essence of this method is to divide the movement technique into individual fractions, teach these fractions one by one, and in the last phase, gradually combine the learned fractions with the basic movement. It is generally used for very complex movements, which cannot be learned as a whole. In this method, difficulties occur due to the long-term learning of certain fractions, and problems arise in the process of combining the learned fractions into a whole. The overly repeated fractions, which sooner or later become automatic, may completely alter the overall movement scheme and rhythm. Therefore, the order of learning individual fractions is important. The basic movement scheme has to be preserved throughout the process. Experience teaches that it is reasonable to teach individual elements in the same order in which they appear in the kinematic and dynamic structures of the basic technique. Mastery of certain elements does not imply mastery of the entire movement. In principle, beginners are rarely taught only by this method; it is usually combined with some other method and the emphasis is put alternately on one or the other, depending on the learner's development, abilities and the degree of difficulty of the exercise. In practice, the analytical method is used during the initial phase of motor learning and then each well-mastered element is incorporated into the basic movement as soon as possible.

The Complex Method

This method is a combination of the situational and analytical methods. In motor learning both methods intertwine and complement each other. First, individual elements are practised, then there is a gradual shift to practising the entire technique and, finally, some elements are practised again to perfection. In the case of beginners, a stronger emphasis is placed on the situational exercise, while the analytical exercise is merely complementary. Irrespective of the applied method, care should be taken throughout the process that the incorrect notions of movement do not consolidate and produce errors. Only a sufficient quantity of movements may produce an adequate quality of movements. It should be noted that there is no universal method to be applied under any circumstances and by anyone. When applying any of the methods, the following has to be considered:

- The application of a learning method depends on biological and calendar age, foreknowledge, movement experience and information regarding movement;
- Attention has to be focused on the causes of incorrect movements, instead of their consequences;
- Causes of incorrect movements may be: incorrect notions, a lack of motor abilities (agility, strength, coordination), an unfavourable morphological constitution;
- First, gross errors have to be eliminated, as the minor ones often stem from them;

- The sooner the errors are corrected, the lesser the chance of them becoming automatised;
- One-time errors should never be corrected if they occur by coincidence;
- Errors and shortcomings should be rectified in the order in which they appeared;
- The correction process should not emphasise only the shortcomings, but also positive thinking, progress and trust;
- Instructions have to be in tune with the learners' motor sensations;
- Instructions have to be adapted to the learners' age and maturity;
- A variety of words, codes, illustrations, demonstrations, imitational exercises should be used to influence the movement patterns;
- The instructor should commend successful technique execution;
- The instructor should evaluate the technique from various angles and perspectives;
- When correcting errors, the instructor should protect the learner's privacy and should never admonish a learner in front of his colleagues.

The Ideomotor Method

The basis of successful motor learning is a good notion of movement. When it comes to beginners, the notion of movement is vague, incomplete, sometimes even wrong and not in harmony with the real dynamic and temporal parameters of movement technique. A correct notion is formed on the basis of the instructor's explanation and demonstration. By means of visual and verbal information, a beginner can easily form a basic notion of movement and enhance it by the already existing motor programmes stored in his motor memory. In the ideomotor method, movement is performed inside one's mind, which makes it an example of mental learning. Only the motor cortex is activated and is responsible for the planning of motor structures. The athlete "executes" the movement technique in his mind, particularly the key elements of the technique. This method may be used in different situations. In the concentration phase, the athlete may take a mental leap and seemingly perform certain movement phases. The ideomotor method may help consolidate the movement pattern, as the number of imaginary repetitions is greater than the real movement frequency. Thus, the movement pattern consolidates because the memory traces before the next repetition are fresher and stronger. This method is highly effective, even when the athlete is injured, does not train and cannot execute the movement technique. Ideomotor training may help the athlete to concentrate on the crucial moments of his performance. An athlete should be capable of "getting rid" of stress and competitive pressure and should prepare himself for the decisive moments of a competition.

The Iterative Method

During the phase of automated and highly adaptable movement, when the athlete is able to execute optimal technique in changeable circumstances, the iterative method (Latin *iteratio* from *iterum* – repetition, doing anew) is one of the most common exercise methods. It involves repetition of a movement in a series over a period of short intervals. Each execution leaves a trace in the motor memory and paves the way for another trace. The effect of this method depends on the degree of technique automation, the athlete's motor abilities, movement complexity, the number of repetitions, concentration and mo-

tivation. When applying this method attention has to be paid to the correct technical execution of movement, otherwise the incorrect movements will become automated. The method is all the more successful when the movements are most similar to competitive technique elements. In the repetition process, breaks between the repetitions are highly important. If a break is too short, it can lead to mental and physical exhaustion or the learner might start getting tired of that exercise. The pitfall of using this method is that it primarily activates the left hemisphere of the brain, which inhibits motivation and creativity. During this phase, feedback information about the correct execution of a motor task is of great importance. The instructor has to present the learner with as much criteria as possible so that the latter may evaluate his own performance independently. The control of movement is thus transferred from the instructor to the learner, where the latter develops a subtle feeling for execution accuracy. At this level, and by using this method, the instructor leaves the control of movement technique to the athlete, who has to rely on his inner feelings and feedback information. Of course it is recommendable that the athlete compares his inner feelings with an objective recording of the technique e.g. video recording. The instructor's intervention in this phase is only necessary when serious errors in movement are identified. Errors may occur unexpectedly, owing to fatigue, lack of concentration, a hidden injury or the athlete's getting tired of training. This is why the instructor has to have professional knowledge, practical experience and the ability to analyse movement, while at the same time giving the athlete the right information at the right time and in the right place.

CONCLUSION

Motor learning is a complex and continuous process consisting of several phases. The margins between the phases are usually not clear. The basis of motor learning is a specific motor programme, which is created by the motor cortex based on external and internal information. The essence of efficient motor learning in sport is a correct notion of movement. In the case of beginners, the notion of movement is vague, incomplete, sometimes even wrong and not in harmony with the real dynamic and temporal parameters of movement technique. The use of motor learning methods depends on the athlete's biological and calendar age, foreknowledge, motor experience, and the information he has on movement. Attention has to be focused primarily on the causes of incorrect movement, and not their consequences. The most common causes of irrational movement are incorrect notions, a lack of motor abilities and an unfavourable morphological constitution of the athlete.

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MOTORIČKO UČENJE U SPORTU

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Motoričko učenje ima specifični značaj i zakonitosti, koje moramo poštovati u raznim pojavnim oblicima motoričke aktivnosti sportiste. To je process usvajanja, upotpunjavanja i upotrebe motoričkih informacija, znanja, iskustva i motoričkih programa. Pokrete je moguće izvesti kada za njih postoji odgovarajući motorički program. Proces kretanja počinje određivanjem poželjnog rezultata pokreta i proizilazi u tri međusobno povezane faze: Faza osnovne koordinacije pokreta, faza precizne koordinacije pokreta i faza stabilizacije pokreta u promenljivim i otežanim okolnostima. Preduslov uspešnog motoričkog učenja je precizno izvedeni pokret, koji je ustaljen na vizuelnom i samim tim na kinestetičkom procesiranju informacija.

Ključne reči: *motoričko učenje, motorički programi, motoričko pamćenje, shema pokreta.*