RHYTHM, A GESTALT OF HUMAN MOVEMENT?

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The questions raised in this paper are: Is it possible to consider rhythm as a Gestalt of human movement? Is it possible to start from this Gestalt to build up cognitive strategies to improve sport performance?

The study of human movement is one of the most interesting aspects of modern Gestalt research (MECHSNER 2003). In this work, we focus our attention on the relevance of rhythm for studying human motor action. We will show that specific mental strategies can be developed from the rhythm that is implied in most of the human actions.

Starting from an analysis of cognitive processes and from a practical and theoretical need to integrate cognition with complex motor activities, we believe that it is necessary to suscribe to an experimental psychology that considers the athlete as a psychomotor whole. It is therefore clear that, mutatis mutandis, as the whole is different from the sum of its parts, sport performance is a global act, and hence the whole act must be considered as a unit of analysis as well as a reference point for strategies formulation (BRENTANO 1874).

Research paradigms in the study of human movement

In essence, the task of experimental sport psychology is to provide guidelines that allow athletes to be aware of their mental resources, and to channel attentional energies into the more appropriate direction, trying to find in the environment the information that is more useful and that can be integrated in the perception and action process that is realized in sport practice.

Classification of movements

Classification of movements (not sharply differentiated), distinct on the basis of complexity and degree of cortical control

1. Voluntary movements: the most complex. These movements are intentional and can begin either in response to an external stimulus or voluntarily. These movements are directed to a goal, are largely learned, and the precision of the execution increases considerably with practice.

2. Reflex: the simplest, with the lower degree of voluntary control. These movements are fast, stereotyped, and largely involuntary, and usually evoked in a more or less graduated way by stimuli that evoke them.

3. Rhythmic motor activities: these share common features with the two previous classes. In general, only the beginning and the end of the sequence are voluntary, but once it starts, the sequence of repetitive movements, relatively stereotyped, can go on almost automatically, like a reflex.

The appropriate working of motor systems from one moment to the next depends on the continuous availability of sensorial information coming from sight, hearing, proprioceptors, and the vestibular apparatus, all of which provide information about objects in the environment and about spatial relationships between our body and objects; this information is fundamental for planning and refining movements during performance (see Figure 1).

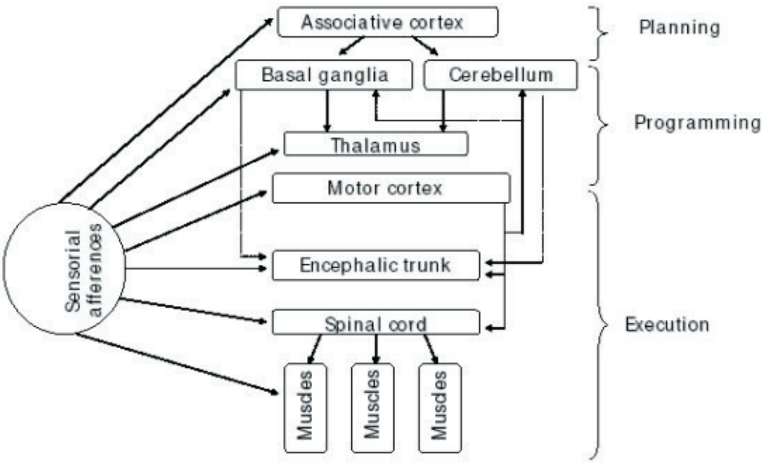

Figure 1: Schema of motor system connections, where neuroanatomical substratum of planning, programming and execution functions are represented, together with the main links among different brain centres and peripheral structures.

A large amount of experimental research about different types of locomotion, performed on both vertebrates and invertebrates, show that all organisms share the same general organizational principles: intrinsic nervous nets capable of generating oscillatory activities, activated and modulated both by afferent signals and signals coming from superior motor centers. Afferent information serves also to compensate perturbations caused by external interferences.

It seems that the first to relate motor activities to brain activity were Egyptians (Edwin Smith papyrus, 3000-2500 a. C.)who made observations about the relations between brain or spinal lesions and motor impairment.

The first systematic observations are dated 1870 (FRITSCH and HITZIG), whereas the first theory about brain localization of motor functions is that of JACKSON (1884).

BELL and MAGENDIE (1811, 1822) demonstrated that in the spinal cord there are two different and independent nervous routes, resulting from motor and sensory neurons.

Following these discoveries, SHERRINGTON (1906) formulated and described the functioning of reflexes.

At that time, maybe the only one to try to connect psychological and physiological research was BERNSTEIN, who in the '30-'40 integrated movement behavior observation to neurophysiologic and neuromuscular aspects (NICOLETTI 1992).

In fact, until very recently psychologists neglected the study of the integration between perception and action (GUASTELLO 2006; ROSENBAUM 2005, 2006).

At the end of the nineteenth century, things were different: Three chapters of JAMES' *Principles of Psychology* (1890) were dedicated to motor control. WOODWORTH wrote his Ph.D. dissertation on motor control (1899), later published also in French (Le Mouvement 1905). Also BINET, the author of the first intelligence questionnaire, studied movement, in particular in relation to writing.

The little consideration that movement studies received in the past century is reflected in two clichés: It is commonly believed both that motor control is studied by ergonomics, and not by psychology, and that movement has just an executive function: there is no intelligence in body movement. The decline of studies on body movement and action coincided with the establishment of behaviorism, that, paradoxically, identified the object of psychological studies just with body movement, the observable behavior (STUCCHI and MARINO 2006).

Nowadays, there is a growing connection between psychology and neurophysiology, so that over the last years the study on human movement and motor control is becoming more and more an autonomous and interdisciplinary identity, as it already happened for neurosciences (NICOLETTI 1992).

The relationships that exist between perception and movement are a crucial fact for understanding and controlling motor activity, so that both perception and action should be faced as a single functional system (LEE and YOUNG 1986; ARBIB 1987; KELSO and KAY 1987, WARREN 1988; KELSO, DEL COLLE and SCHONER 1990).

Movement is, on the one hand, a way to adapt the external world to an internal goal.On the other hand, the environment can drastically influence the performance of the motor act, by asking an essential adaptation as a function of external parameters; the correct perception of the external world is therefore necessary to an appropriate performance of any movement.

In organizing and controlling movement, even when there are no disturbances in the different sensorial perceptions afferents to the central system, usually visual perception is overriding (e.g., POSNER et al. 1976).

In actual fact, in some sport activities, like swimming, visual information is of little help; indeed, it has been demonstrated that when it is more useful to the motor task an analysis based on a temporal coding (e.g., GIBSON 1966) instead of one based on spatial parameters (i.e., mainly visual), acoustic perception is better than visual perception (WALKER and SCOTT 1981).

Visual and acoustical models in motor learning

SCULLY and NEWELL (1985) underline the relevance of watching visual representations of the sequence of movements to learn: it provides subjects with basic information about the dynamic succession of movements.

The use of acoustic models has been systematically studied in the domain of the development of musical abilities (see Suzuki learning method – PRONKO 1969).

According to DOODY et al. (1985), an acoustic model of the action that has to be performed can provide subjects with information about execution time, acting as a prototype for the execution itself.

KOHL and SHEA (1995) found that when an acoustic model is provided in the learning phase of a movement, compared to the absence of a reference criterion that can guide motor performance, there is less variability in the performance of the learned movement, therefore it seems that it occurs an adherence to a standardized motor execution program.

SHEA et al. (2001) tested the effect of the use of an acoustic model on the production of simple movements, finding that the advantage of the prototype listened to by subjects is reflected in the acquisition of an execution time cognition both in absolute and in relative terms. A significant difference between these two aspects of the representation of a physical movement can be found in the degree of exposition to the model that is necessary to obtain the maximum advantage: as regards absolute execution time cognition, there is the need to replicate practically the listened model, while the acoustic presentation itself assured the same result as a practical motor application of the model.

Even if there is a common belief, both among athletes and trainers, about the importance of acoustic information available during performance, it is not systematically used in the implementation of strategies directed to being successful within sport domain.

Our approach

Our research is framed within experimental sport psychology. We think that the use of the experimental method can be an effective approach to the study of the cognitive aspects of sport performance. In his studies on sensory-motor intelligence, one of the first to propose the idea that the physical movement of a human being is an interesting topic for cognitive sciences was PIAGET (1926). At that time, however, a large majority of cognitive psychologists didn't share PIAGET's interest. Rather than exploring the whole process starting from perception and ending to action, they restricted their investigation on the analysis of perception processes and of the external information acquisition.

More recently, the "Perception and Action" approach is stressing the relevance of human movement as the final product of manifold cognitive mechanisms (KELSO 1977).

To develop an experimental approach to the study of human movement and sport performance, it is necessary to identify the units of analysis that can be considered significant for both the final result of a motor action and the mental work for the action control.

Within sport sciences, biomechanics is an important approach (BART 1997), and sport psychology must recognize the high standards of this kind of research (ROBERTSON et al. 2004).

Its model of human motor action is based on the study of how each element of the body moves during sport performance; it resolves high-level performances into its components, to find out how each body part must move to "guarantee" a good result.

Researchers usually focus their attention only on the motor action analysis, not offering to trainers any kind of strategic advice.

However, the effect of biomechanics on training is quite evident in the setting up of a specific part of the whole performance. Most of the trainers prefer to use a few of these partial aspects of the motor action to help the athletes to correct their gesture.

But, is the biomechanical analysis sufficient to explain different performances by the same athlete or equivalent performances by different athletes?

The ultimate purpose of our approach is to help the athletes to improve their performances by making them aware of their own psychological resources that can be used to develop adequate mental strategies.

Our first researches in experimental sport psychology stress the hypothesis of the analysis of athletes' cognitive resources with the aim of improving their psychomotor organization, in particular, in reference to the timing of the motor action (AGOSTINI et al. 2005).

According to us, the basic features for an experimental sport psychology are:

- Holistic view of the motor act
- Ecological perspective
- Reference to needs emerging from athletes/trainers
- No problems "treatment" but "extraction" of athletes' talent
- Uniqueness of offered strategies
- Centrality of rhythmic hypothesis

The sound and, in general, the acoustic stimulation, is an important sensorial input for synchronizing human body movement (EFFENBERG 1996). We think that it is possible to systematically use this information in order to develop mental strategies helping the athlete to optimize and standardize her/his performance (KOHL and SHEA 1995; AGOSTINI et al 2005).

FRAISSE is the most representative experimental psychologist that studied rhythm. In his work "Psychologie du ritme" (1974), he investigated several aspects of rhythm such as the rhythmic patterns produced spontaneously by human beings, the integration between rhythm and music, and the correlation between rhythm and poetry. Within human motor action studies, FRAISSE's researches on sensory-motor synchronization demonstrated that sound affects the timing of simple movements (FRAISSE 1982). In the literature, several studies on perception and reproduction of rhythm can be found (SUETOMI and NAKAJIMA 1998); it must be noticed that, in one of his first works, KOFFKA (1909) investigated the influence of rhythm on movement.

We have considered the possibility of using acoustic rhythmical structures to develop strategies to improve sport performance. Rhythm is a natural outcome of the human movement andcan be considered as a way to guide human action. In order to build up an efficient training strategy for athletes, we assume that it is necessary to start from their phenomenal experience. In fact, each athlete has different kinds of awareness about her/his movement and, therefore, of her/his performance. For this reason, it is necessary to find a specific way to translate this personal phenomenal experience in a cognitive strategy aimed to improve performance.

In agreement with the aforementioned literature, we think that an acoustic rhythmical representation could be an effective representation of a given movement and that it can be also considered as phenomenally relevant for the athlete since it reproduces in a direct way the timing of the performance.

Probably the best way to obtain a veridical representation of the movement timing is to record the sound produced by the human body engaged in some kind of physical activity. When an athlete is asked to listen to the acoustic track associated to her/his performance, she/he is able to recognize her/his own performance amongst others' ones; moreover, from the acoustic track, the athlete is also capable to identify the technical features of the performance itself.

Therefore, by recording the acoustic information produced by human actions, it is possible to represent the movement in a way in which it is easy to detect the overall temporal duration of the action, the length, and the sequence of movements within the series. It is also possible to analyze the relation between the temporal duration and the intensity of the sequences of movement.

We have successfully applied our rhythmical model to several sports as track and field, swimming, and road racing (AGOSTINI et al. 2004; GALMONTE, RIGHI, AGOSTINI 2004)

Conclusions

To summarize, the operational proposal of our work is to try to build up cognitive strategies based on the acoustic representation of human movement which , if used in an appropriate and systematic way, can lead to a better and more standardized performance.

The rhythmical hypothesis is based on the idea that, in collaboration with the athlete, an "ideal" performance can be extrapolated from the acoustic model of his/her athletic action. This modified "ideal" acoustic model can be used to improve and standardize the performance itself. Therefore, the experimental intervention consists in proposing a rhythmical model to be followed during the real performance.

The strategic hypothesis is that rhythmic scanning of the acoustic representation can highlight the speed progression of the movement.

In conclusion, auditory information can provide athletes with the timing of their motor performance.

By a gestaltic viewpoint, the analysis of the movement timing has two very important aspects:

1) the whole time of the motor action; 2) the temporal relationships among the different phases of the whole action.

The whole time of the motor action results from the sum of the time of its different phases, but a good motor performance results from a specific pattern of temporal relationships among all the phases. The structure of this pattern is strictly individual for each athlete, in fact, for instance, even if different sprinters can have exactly the same best performance on the 100 m race, their pace number, length, and, therefore, timing can be quite different. Therefore, the timing can provide athletes with a strictly individual model of a standard performance.

We think that the timing of a motor action can be considered as a Gestalt of an athlete's own performance; auditory information can provide her/him with a stronger Gestalt of her/his best performance or even, and this is the challenge for every sport scientist, a Gestalt of a new, higher level, sport result.

Abstract

In this work, we offer a new model based on rhythmical acoustic stimulation in improving sport performance. We hypothesize that rhythm is relevant information to guide human movement and it is possible to use it as unit of analysis in sport science. In general, we propose to consider rhythm as a Gestalt of human movement.

Zusammenfassung

Wir präsentieren in dieser Arbeit ein neues Modell zur Verbesserung sportlicher Leistungen durch akustische, rhythmische Stimulation. Wir stellen die Hypothese auf, dass Rhythmus wichtige Informationen bereitstellt, um menschliche Bewegungen zu leiten, und dass rhythmische Einheiten als Ausgangspunkt von sportwissenschaftlichen Analysen geeignet sind. Allgemein schlagen wir vor, Rhythmus als eine Gestaltqualität menschlicher Bewegung zu betrachten.

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