Biology of Sport, Vol. 24 N°3, 2007

TIME AND SPATIAL ASPECTS OF MOVEMENT ANTICIPATION

Z. Borysiuk[1], J. Sadowski[2]
[1]Dept. of Physical Education and Physiotherapy, Technical University, Opole, Poland; [2]Dept. of Physical Education, Józef Piłsudski Academy of Physical Education, Warsaw, Poland

Abstract. Background: Anticipation is a mental process consisting in foreseeing future events and situations based on shortening the selection stage in the information phase of sensorimotor responses. Through anticipation it is possible to program proper technical actions in a sports fight and to correct them depending on the changing conditions of a contest. Methods: 14 physically fit students took part in the experiment. The EMG measurement system was used for detection of latency time marked RT (reaction time), movement time (MT), and EMG signal value. The research aim adopted was the evaluation of the influence of advance signals on the changeability of RT, MT and EMG signal parameters in consecutive tests. Results: The results of the time anticipation test: RT – 127 ms and MT – 88 ms showed that the latent reaction time was shortened by 99 ms and the movement time by 42 ms compared to the control test. Therefore it can be stated that an earlier knowledge of the time series of signals has a greater influence on information processes than on the movement speed expressed by the MT value. Conclusion: The research work proved that the factors anticipating motor activities significantly increase their effectiveness influencing the shortening of both the reaction time and the movement itself. This phenomenon refers especially to the sensor phase, mainly to the stage of motor program selection.

(Biol.Sport 24:285-295, 2007)

Key *words:* Movement anticipation - EMG system – Sensorimotor response - Reaction time

Introduction

Anticipation processes make basic influence on athletes' performances and behavior in real competitive situations. It is extremely important in combat sports and team games where athletes are exposed to visual stimuli and time aspects (timing anticipation).

Reprint request to: Dr Zbigniew Borysiuk, Technical University, Prószkowska 76, 45-758 Opole, Poland; E-mail: z .borysiuk@po.opole.pl

According to [1,3,6] anticipation consists of mental foreseeing a future event based on perception and picturing a future situation and (or) the aim of a given activity [9]. Through anticipation it is possible to program motor activities which are in line with the expected situations, to adjust them and correct before the occurrence of disturbances [15]. Anticipation process takes place both in space and time aspects [12]. The first kind of anticipation answers the question what will happen and the second kind (time anticipation) enables the perception of the moment in which the event is going to appear. The are situations in which the two aspects interfere and then the time aspect dominates and significantly influences on effectiveness of anticipation reactions [13]. Theoretical data of movement anticipation (Fig. 1) are connected with the concept of by-passes – a model of information processes presented by [5].

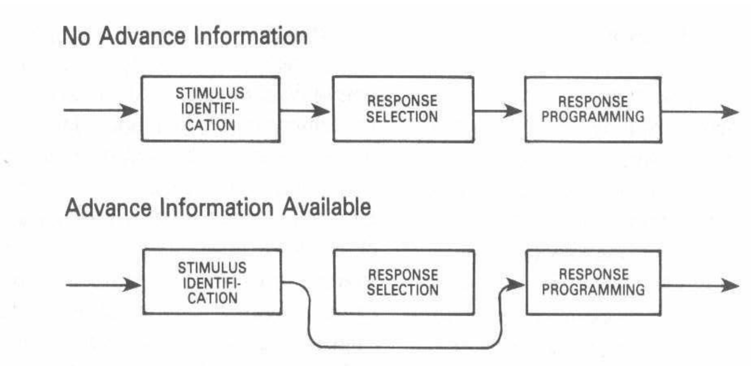

Fig. 1
Bypassing the response-selection stage by processing information in advance

According to this idea an accurate anticipation of the kind and time of a motor response makes it possible to 'avoid' the phase of response selection, which results in a significant shortening of the motor response time. Numerous research experiments carried out, among others by [18], have proved that advance information lead to the reduction of the reaction time of the persons participating in the tests from 100 to 150 ms. There is no doubt that the significant factor that can reduce the reaction time even more can be advance information of a time character (e.g. series signals every 2 s). Thanks to the application of modern technologies, including a properly constructed EMG apparatus, it is possible to determine precisely the influence of advance information on motor behavior of the test participants. In this paper a measurement system of the EMG signal, detection of the latency time marked RT (reaction time) and MT (movement time) were used.

The new idea of this system is based on project of algorithm of signal detection which allows the measurement of the sequences of movements [2]. Apart from that it enables detection of signal EMG during the extreme fluctuations of muscles tension. This possibility differs from the typical devices which have been used in the biomechanics field so far.

The purpose of this study was evaluation of the influence of advance signals on the changeability of the RT, MT and sEMG in the consecutive tests.

Two hypotheses were put forward, namely that advance spatial and time signals cause shortening of the RT and MT parameters and we assume that the variation of the signal sEMG during test trials will have the tendency to drop its value.

Materials and Methods

In the experiment 14 students-girls (the average age 22.4) studying physical education took part. The participants presented a considerable level of physical fitness as former contestants of combat sports (fencing, taekwondo, karate).

Taking into consideration the viewpoint of motor control area the research of muscles physiology and psychomotor reactions suggest that the most useful conception seems to be surface electromyography (s EMG). Starting from theory and implementing into scientific practice this idea was realized by [5,8]. The presented system is based on assumptions of above mentioned authors. The new approaches of this area is separation of reaction time (RT) which represents central processes from movement time (MT) which expresses peripheral phase of sensorimotor responses (Fig. 2).

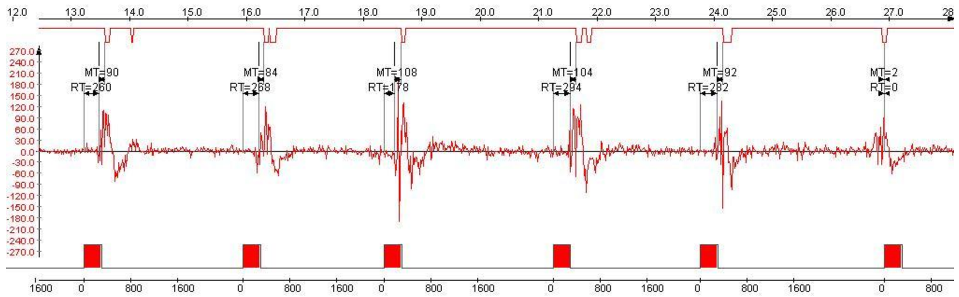

Fig. 2
Shows a curve of the EMG signal with RT and MT intervals marked

Measuring system: The measuring system consists of an analogue and a digital part. A block diagram is shown in Fig. 3. The analogue part enables initial amplification and filtration of the EMG signal. Such a signal is processed into a digital form and transmitted to the microprocessor system. To the microprocessor or input there are also attached switch-over buttons.

The proper software enables sampling synchronization of the measurement data, initial digital filtration and realization of the data transfer protocol to the computer. For transmission a serial USB 2.0 connection (Universal Serial Bus) was used. The digital signal representing the EMG tension measured is transferred to the computer. Proper software makes it possible to detect latency time, motor reaction time, synchronization with light pulses. Moreover, the computer makes it possible to store data and parameters determined in the base together with the characteristics of the object measured (a patient, a person under study). The measurement results can be put down in the form of a table or processed to the form of a graphic file

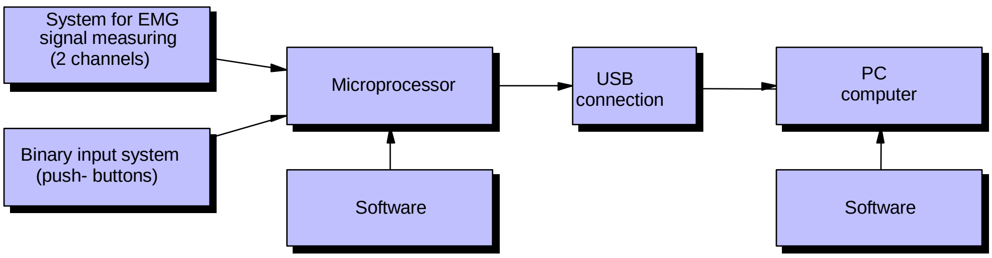

Fig. 3
A block diagram of the measuring system

The test participants had the electrodes of the EMG apparatus fastened to the more efficient hand. Their task was to press, depending on the type of the test, the button of the 35 mm-high test cockpit with the index finger on a light signal.

The test participants had 2 typical electrodes treated with chloride glued to their bodies which were connected with the EMG apparatus by means of low-noise electrical wires. As a measurement standard placing them on the neuromuscular points at the forearm (Fig. 4)

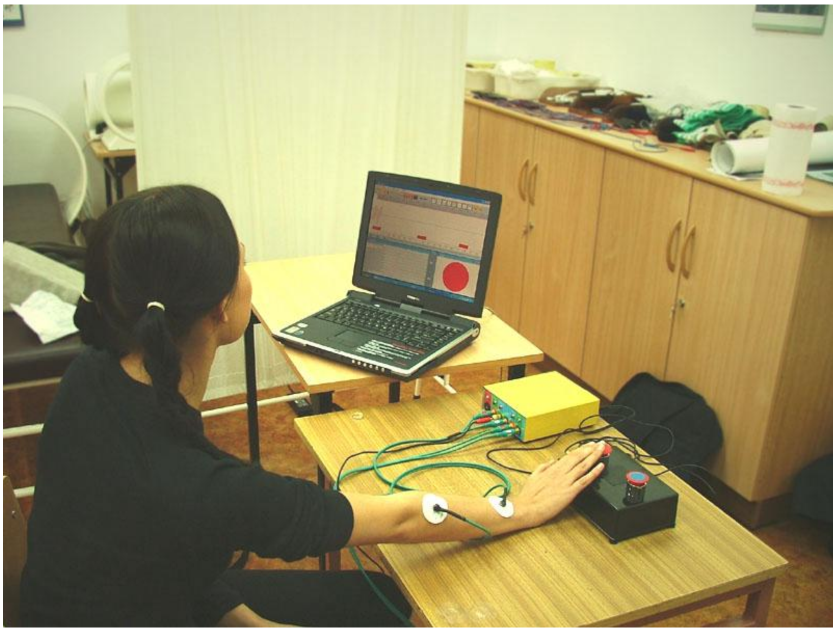

Fig. 4
Presents a view at the research display

Three test trials were used within the research methods:

1. It was adopted that the first test would be of a control character for diagnosing the RT(ms), MT(ms), EMG(μV) parameters in 'normal' conditions without the anticipation effect.

In this test the computer software of the EMG apparatus emitted 45 light signals in a random (from 1 s to 5 s) time series. The aim of the test was the evaluation of the information processes indicators (RT, MT, EMG) of the movement activities without the influence of advance factors.

2. In the second test time anticipation was introduced. The program emitted 45 signals always with the frequency of every 2 s. The RT, MT and EMG were registered.

3. In the third test the element of spatial anticipation was introduced. In order to reduce the time anticipation the emission of signals (45) was of a random character. The person tested could watch a curve of the EMG signal on the upper part of the computer screen during the test. Graphic representation of the curve running to the rectangles in the color of the emission of the light signals provided complete

advance information on the stimuli that were to appear. The parameters RT, MT, EMG were registered.

The computer software automatically registered the research results in all tests introducing averaged values of the particular parameters to the data base. Moreover, in the lower part of the screen the system presented on line the profiles of the curves visualizing RT, MT and EMG. This option enables instant comparison of the indexes under study with the reading of the muscle tension size in each phase of the test.

In the statistical analyses statistical measures of location and changeability (average values, minimum and maximum values, standard deviation, skewness factor and kurtosis) were used.

To evaluate the significance of differences between the average values of parameters a T test for dependent variables was used.

The research achieved a positive opinion of Bioethics Commissions of Opole Chamber of Medicine. All the participants took part in this undertaking voluntarily after a written consent.

Results

The results of the research are presented in Table 1. The visualization of data for parameters of reaction time and movement time is presented on the frame diagram (Fig. 5).

Symbol explanations;
RT1 – reaction time in control test,
MT1 – movement time in control test,
EMG1 – EMG signal in control test,
RT2 – reaction time in time anticipation test,
MT2 – movement time in time anticipation test,
EMG2 – EMG signal in time anticipation test,
RT3 – reaction time in spatial anticipation test,
MT3 – movement time in spatial anticipation test,
EMG3 – EMG signal in spatial anticipation test.

Table 1
Statistical measures of location and changeability of the variables under study (n=14)

Variables	Average	Minimum	Maximum	SD	Skewness	Kurtosis
RT1[ms]	226	178	219	35.12	0.42	-0.99
MT1[ms]	130	101	211	32.05	1.94	3.06
EMG1[μV]	816	412	1118	236.32	-0.54	-0.69
RT2[ms]	127	62	193	42.99	0.07	-1.19
MT2[ms]	88	63	119	15.66	0.81	0.29
EMG2[μV]	913	622	1380	216.21	0.80	0.30
RT3 [ms]	130	19	200	54.82	-0.72	-0.33
MT3[ms]	95	71	156	25.13	1.50	1.69
EMG3[μV]	583	449	988	150.26	1.89	3.46

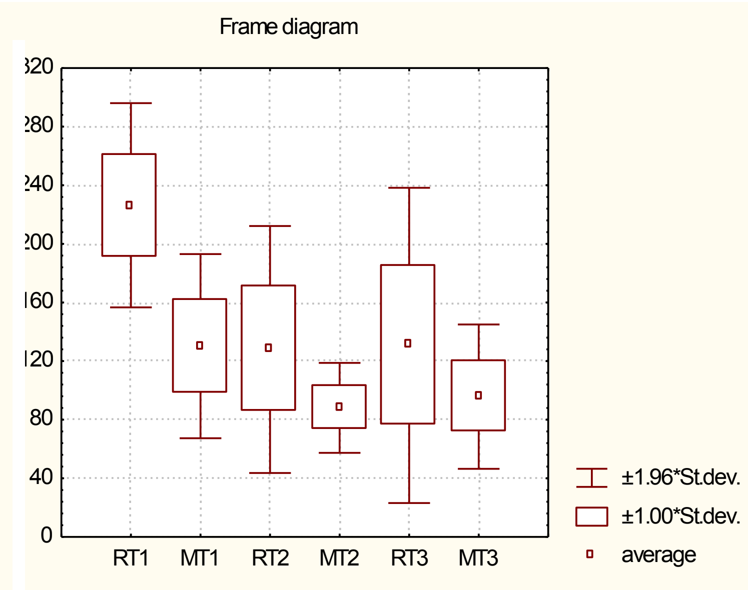

Fig. 5
Shows duration time [ms] of the RT and MT phases in three consecutive tests

The average values in the first case were 226 ms for reaction time and 130 ms for movement time. The time interval that passed from the time of the appearance of a stimulus to the end of the movement was 356 ms, out of which 2/3 of the time were the information processes, i.e. the latent reaction time. The average value of the sEMG was 816 μV. It was adopted that the parameters of the first test were reference points for further comparison with the time and spatial anticipation tests.

The results of the second test (time anticipation) do prove that the latent reaction time was shortened by 99 ms ($p<0.001$) and the movement time by 42 ms ($p<0.001$). Therefore it can be stated that an earlier knowledge of the time series of signals has a greater influence on information processes than on the movement speed expressed by the MT value.

The third test (spatial anticipation), as assumed, was to bring a further shortening of RT and MT; however, the results did not confirm the suppositions on the spatial anticipation influence on the reaction effectiveness. RT and MT results were significantly better than the results of the first comparative test ($p<0.001$), but in comparison with the time anticipation test, they did not indicate significant differences**;** RT2 vis RT3 ($p<0.882$) and MT2 vis MT3 ($p<0.343$). It should be stressed that the test participants were bereft of the time rhythm factor. Although watching the EMG curve running to the colorful rectangles they had the time orientation of the light stimulus occurrence the random selection of time intervals made a fuller anticipation more difficult.

The issue of the EMG signal (μV) during the tests requires a separate treatment. Three characteristic tendencies have been observed. First of all, in all tests the participants needed a kind of a 'warm-up' and a few first reactions were characteristic of a more considerable signal EMG values than the others. No significant differences in signal values were observed between the control test and the time anticipation test ($p<0.268$). The interesting observation refers to a significant drop in signal values of about 300 μV in the spatial anticipation test ($p<0.004$). This fact can be the proof that visual aspects of the movement anticipation can reduce substantially muscles tension expressed by EMG signal.

Discussion

In the light of the research carried out it should be concluded that the factors anticipating motor activities significantly improve their effectiveness, which has influence on shortening both the reaction time and the movement itself. In the context of the research work presented the conclusion can be drawn that it especially concerns the latent reaction time, almost twice as short. Also, although smaller but statistically significant drop in the movement time was observed. This proves that anticipating signals accelerate not only information processes occurring in CNS but also clearly shorten duration time of the motor phase of the movement response. The results are similar to the data given by Schmidt and Gordon [11], Kelso [7], Wood and Abernethy [17], Williams and Grant [16].

This conclusion refers both to time and spatial aspects of the movement anticipation alike as the research results did not show any statistically significant difference between time and spatial parameters of the movement anticipation and the first control test. Therefore it can be observed that time factors compared with spatial factors cause equally strong anticipation effects. It should be stressed, which results from the step-by-step analysis of all tests, that in each test there were registered 2-3 false tests on the average caused by too early reactions which took place still before the occurrence of the light signal. This fact is worth stressing because the experiment excluded intuitive reactions often used in high-qualified sport, e.g. reactions of fencers which make an action parry-riposte or karateka's blocking the kick from their opponents. In the research tests presented false reactions were registered as errors.

The third research option registered in the whole procedure were average values of the EMG signal in all tests calculated in [μV]. The analysis of this factor points to an entirely different regularity compared with the above-presented conclusions. It occurred that only the spatial aspect of the movement anticipation differed significantly from the level of the signal EMG values in the control test. It means that watching the EMG curve running to colorful rectangles – illustrations of the anticipated light signals by the test participants has a good effect on the decrease of the sEMG signal values. The opposite tendency took place in the case of time anticipation. It is likely that focusing attention on controlling time intervals is not conductive to muscle relaxation.

The initial efforts in each tests were characteristic of more considerable muscles tension [μV] values, after which the signal EMG values stabilized to achieve the values close to average ones.

Therefore it can be observed that the anticipation of signals in the time aspect when the so-called fore period is constants and the intervals are short - of hardly 2 seconds, causes that the signal values (muscle tension) is relatively high all the time. Similarly, in the control test significant signal values was observed. In this case the cause was a random changeability of the duration time of intervals between the signals from 1 to 5 s., which significantly attracted the attention of a test participant leading to the increase of the signal EMG values.

Summing up the research results presented in this paper it can be stated that they confirmed the initial idea about a significant shortening of motor activities due to the occurrence of fore period-anticipation information. This phenomenon refers mostly to the latency phase (latent reaction time) reflecting the stage of a signal selection in the whole process of receiving information [4]. Comparing presented results with other authors' findings [10,14] testing students, the high effectiveness of anticipation reactions was the sequence of previous experiences. All of them practiced comet (combat) sports and martial arts.

References

1. Abernethy B., J.M.Wood, S.Parks (1999) Can the anticipatory skills of experts be learned by novices? *Res.Q.Exerc.Sport* 70:313-318

2. Borysiuk Z., D.Zmarzły (2005) Surface electromyography (sEMG) as a research tool of psychomotor reactions. *Ann.Univ.Mariae Curie-Skłodowska Lublin-Polonia* 60, (Suppl. 16):188-192

3. Czajkowski Z. (2001) About the specificity of energy and coordination abilities. *Sport Wyczyn.* 11/12:37-43 (in Polish; English abstract)

4. Davids K., K.Williams (1999) Visual search strategy, selective attention, and expertise in soccer. *Res.Q.Exerc.Sport* 69:111-128

5. De Luca C.J. (1997) The use of surface electromyography in biomechanics. *J.Appl.Biomech.* 13:135-163

6. Haywood K.M., N.Getchell (2001) Life Span Motor Development. Human Kinetics, Champaign, IL., 390 pp.

7. Kelso J. (1995) Dynamic Patterns: The Self-organization of Brain Behavior. MIT Press, Cambridge

8. Portney L.G., M.P.Watkins (2000) Foundations of Clinical Research: Application to Practice. Prentice Hall,.

9. Rosenbaum D. (1991) Human Motor Control. Academic Press, San Diego

10. Sadowski J. (1999) Coordinative training of highly qualified taekwon-do athletes. In: Proc. of the 3rd International Scientific Congress on Modern Olympic Sport. 43(Suppl. 1):S 261-262

11. Schmidt G. (1977) Errors in motor responding, „rapid" corrections, and false anticipations. *J.Motor Behav.* 9:101-111

12. Schmidt R., C.Wrisberg (2004) Motor Learning and Performance. 3rd Ed. Human Kinetics, Champaign, IL.

13. Starkes J.L., K.A.Ericsson (2003) Expert Performance in Sports. Human Kinetics, Champaign, IL.

14. Tyshler D, G.Tyshler (1995) Fencing. Physical Education and Science Press, Moscow, 151 pp.

15. Ward P., A.M.Williams, S.J.Bennett (2002) Visual search and biological motion perception in tennis. *Res.Q.Exerc.Sport* 73:107-112

16. Williams A.M., A.Grant (1999) Training perceptual skill in sport. *Int.J.Sport Psychol.* 30:194-220

17. Wood J., B.Abernethy (1997) An assessment of the efficacy of sports vision training programs. *Optometry Vision Sci.* 74:646-659

18. Zelaznik H.N., R.Hahn (1985) Reaction time methods in the study of motor programming: The precuing of hand, digit and duration. *J.Motor Behav.* 17:190-218

Accepted for publication 08.06.2007