

Relationships of attention and arousal are responsible for action in sports

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Abstract

Study aim: The most important psychological mechanisms that are responsible for sports activity are arousal and attention. Study aim the relationships between the level of arousal and the level of attention, an attempt has been made to explain the mechanisms responsible for sportsman activity.

Material and method: The study was conducted in a group of sportsman-students (68 individuals) using the Vienna Test System: FLIM, a test of flicker/fusion frequency, which is a measurement procedure allowing to determine the functional readiness of the central nervous system in terms of arousal and COG (Cognitron), which is a test measuring the level of attention.

Results: The following in statistical analysis of the data were observed: inversely proportional relationships of image fusion frequency (FLIM1) during the recording of the level of arousal with: the correct acceptance of stimuli (COG1, $r = -0.287$), the correct rejection of stimuli (COG2, $r = -0.320$), the time of correctly accepted stimuli (COG3, $r = -0.299$), and with the time of correctly rejected stimuli (COG4, $r = -0.317$) in the attentional activity.

Conclusion: Fusion frequency indicates the level of fatigue and is inversely proportional to the correctly accepted stimuli in attentional activity, the correctly rejected stimuli in attentional activities, and the duration of the attentional actions.

Keywords: Attention – Arousal – Reaction time – Sport activities

Introduction

A sports action provides a relatively high level of personality integration in the realm of aspirations and sustains self-confidence. This perspective is grounded in psychological theories [4, 8, 9, 12]. These theories are used in psychology to describe all the mechanisms responsible for initiating, directing, sustaining, and terminating the action. The primary sources of actions include [9, 12] meeting basic needs, and the performance of tasks. Authors dealing with these problems interpret determination to act in many ways, but they all boil down to a consistent understanding. According to some [4], these are processes that organize, direct, and stimulate the activity of the nervous system (including mental processes) so that the activity controlled by these actions achieves certain goals, while according to others [8, 12], this means any experience that stimulates, restrains, promotes or hinders actions. Furthermore, other authors [9] suggest that it is a regulation process that performs the function of controlling actions so that they lead to the achievement of a particular outcome. However, no concepts are based on the important assumption that determination to act is a manifestation of the activation of

emotional (arousal) and cognitive mechanisms (attention). Arousal and attention relate to the intensity and accuracy of an action. The release of energy is reflected, for example, during skeletal muscle tone and bioelectrical activity of the brain. Arousal [3] is the most powerful and essential function of the brain, a continuous function that accounts for the ability of sportsman to respond to stimuli in the environment by producing muscular responses. This property provides speed and sensitivity and facilitates the transition of the system into different brain states. The activity of the ascending reticular activating system, responsible for the level of attention, can manifest itself in apathy, coma, or deep sleep when arousal is too low, while when arousal is too high, tension, fear, anger, or even anxiety may occur. This can be applied in many areas of psychology, e.g. clinical psychology, neuropsychology, sport psychology, and work psychology. Physiological examinations have found that activation and attention is controlled centrally. One criterion (in addition to e.g. EEG and electrodermal activity) that is an indicator of the readiness of the central nervous system for actions is the perception of the frequency of a point source of light [17, 18, 24], at which it is fused (flickering light source $\rightarrow$ steady light source) or flickers (steady light source $\rightarrow$ flickering light source). The flicker

frequency at which image perception occurs is referred to as the threshold frequency [25], whose value changes (decreases) as the individual's level of fatigue increases. A decrease in the perception of flicker fusion thresholds is considered an indicator of an increase in physiological fatigue of the body. One of the known symptoms of fatigue is a change in the perception of frequency thresholds of light flickering and fusion [5, 26]. In a study by Seitz [22], perception of flicker fusion thresholds is approached as measures of an individual's total information processing. The threshold values for flicker fusion frequency are considered the measures of the same phenomenon, and the results of the research by Curran and Hindmarch [7] indicate strong positive correlations between them.

As a neuronal mechanism for reducing perceptual information [13], attention is reduced to a contentless formal determinant of the course of mental processes. On the one hand, focusing or concentration of attention can increase the occurrence of desired and inhibit undesired frequencies that trigger neuronal activity in the brain (e.g., light frequency); on the other hand, neuronal activity in the involved brain areas can determine its level (e.g., reduction of undesired light frequency). To examine the abilities to sustain an action, it is essential that if a stimulus is frequently repeated, the constant focus of attention on this stimulus is becoming more difficult. The following attention mechanisms are most commonly enumerated [10, 11, 15, 16]: activation mechanism, used to maintain attention due to the performed actions, orientation mechanism, responsible for the direction of activation, and executive

mechanism, related to arbitrary, intentional, and planned actions. The degree of focus of attention is reflected by distinguishing a limited scope of objects to which it is oriented, and it is not distracted by reactions unrelated to the performed actions caused by secondary stimuli. The interdependence of arousal and attention (Figure 1) is responsible for the scope and depth of information processing and the amount of cognitive resources, and consequently, actions. On the one hand, attention can increase the occurrence of desired (e.g., in a relaxed state) and inhibit undesired frequencies of fusion and flickering (e.g., during fatigue); on the other hand, arousal can determine the level of attention.

In the decision-making theory it is important to measure the so-called inspection time, referred to as the speed of decision-making by the unit, completely excluding the execution time of the reaction itself when initially analyzing the visual perception drivers. Therefore, the likely high efficiency will be due to the high results achieved in a general test for the assessment of attention, which means that it depends on both correctness and speed of consideration and decision-making by the individual. With regard to the effect of emotional factors on human activity in a broad sense, the curvilinear relationship between the level of arousal and the level of attention should be noted (Figure 2). During the action, an optimal level of arousal accompanies the highest level of attention, whereas as the level of arousal decreases or increases, the level of attention decreases (which is the general pattern after the completion of the action).

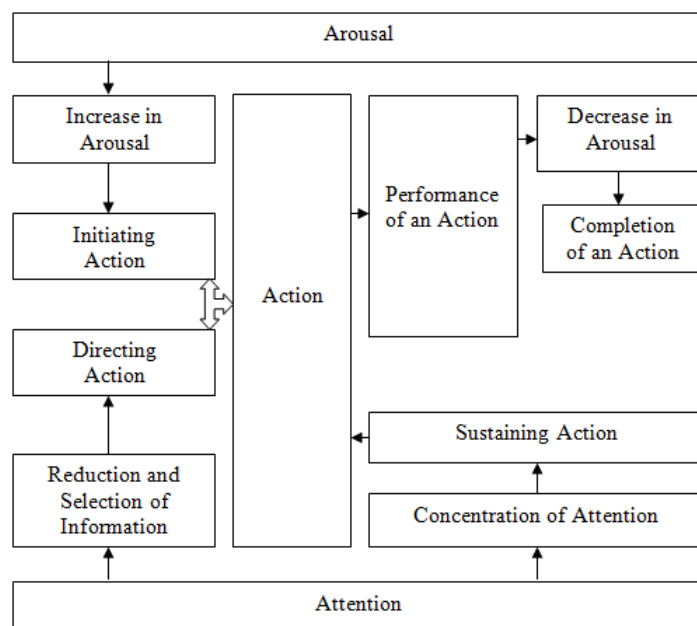


Figure 1. The mechanisms of arousal responsible for initiating action (increase in arousal) and its completion (decrease in arousal) and the attention responsible for directing action (reduction and selection of information) and sustaining action (concentration of attention)

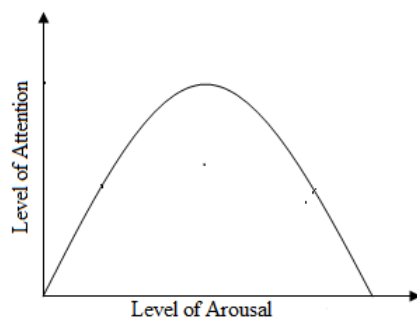


Figure 2. The relationship between the level of arousal and level of attention

To explain the mutual relationships between the processes of arousal and attention, an assumption is made about the anatomical and functional differentiation of the premotor cortex [2, 6], which is part of two functional neuronal circuits that control motor activity. This makes it possible to process exteroceptive sensory information captured in the spatial coordinates of the environment and to plan a course of action. The athlete must therefore use his or her cognitive abilities [14], to remember, evaluate, conclude and react immediately [19] under heavy physical exertion and high emotional tension. The sustained action can be controlled if feedback in the form of sensorimotor information regarding the level of readiness of a person is obtained. In research studied the above-mentioned performance indicators among sportsman students using the relevant tests of the Vienna Test System (VTS), provides a valid and reliable testing procedure that can identify the cognitive activities [21]. Study aim the relationships between the level of arousal and the level of attention, an attempt has been made to explain the mechanisms responsible for sportsman activity.

Material and methods

Participation in the study was anonymous and voluntary. The study group was comprised of 68 sports university students. The age of the participants ranged from 19 to 25 years. All participants gave written informed consent to participate in the study. All procedures were approved in accordance with the standards of the Senate's Research Bioethics Commission and the standards specified by the Declaration of Helsinki. Both arousal and attention levels were recorded and analyzed using computer tests. Two tests were used to record and analyze the level of arousal and level of attention: FLIM frequency test and COG general attention test from the Vienna Test System [21].

• COG (Cognitrone) General Attention test

The test analyses attention and concentration and measures a general ability to be alert. The program displays

four squares constituting one row (display field) and one field below (task field). As regards the subtests not limited by time, the subject is supposed to determine whether an abstract figure presented at the bottom is of the same shape as that of the figures presented in the top row and press the appropriate button. Participants had to judge the congruence of a geometrical figure to four reference figures. Mean time of the correct rejections is the mean time that the subject needed for a correct rejection when the figure did not match one of the reference figures. The result in COG tests is the number of tasks solved correctly in a limited time, which means that it depends on both correctness and speed of consideration and decision-making by the individual. "Mean time correct rejections" is the mean time the subject needed for a correct rejection when the figure did not match with one of the reference figures (VST handbook).

The test evaluates the following indices:

- the sum of correctly accepted answers (COG1),
- the sum of correctly rejected answers (COG2),
- mean time of correctly accepted answers (COG3),
- mean time of correctly rejected answers (COG4).

• FLIM arousal test

In the Vienna Test System, the examination (measurement of flicker fusion frequency) is performed under stable conditions by placing the light source in a darkened body tube. The tube is applied tightly to the eyes of the subject. There is a light source with backlighting that provides adequate contrast. During the test, the flicker fusion frequency is automatically changed, and the participant's task is to determine the threshold of fusion or flickering by pressing the appropriate button. The FLIM testing procedure makes it possible to determine the functional readiness of the central nervous system in terms of arousal. In the "increasing" version of the test, the frequency of the flickering light source is gradually increased until the light appears to be steady (continuous). In the "decreasing" version, the frequency of the light source, initially so high that the participant recognizes the light as steady (non-flickering), gradually decreases until the subjective sensation of flickering. The participant should accept any change in the nature of the light (flickering → steady or vice versa) by pressing the button. This critical frequency is stored. The mean value of the critical frequency for the "increasing" and "decreasing" versions is the critical value and is called the fusion or flickering frequency, respectively.

The empirical indicators are as follows:

- fusion frequency (FLIM1): subjective perception of the transition from flickering to steady light,
- flicker frequency (FLIM2) – subjective perception of the transition from steady to flickering light.

The subject should accept any observed change in the light frequency (flickering → steady or vice versa) by pressing a button [Vienna Tests].

Statistical analysis of the data

After a series of measurements after sports training 68 students, the frequency thresholds are determined statistically. Mean threshold frequencies are assumed to range between 40 Hz and 60 Hz [21]. It should be noted that frequencies above 75 Hz are perceived by the vast majority of people only as a steady light. Descriptive statistics were performed, and the means, standard deviations, and minimum and maximum values were calculated. The research problem was verified using Spearman's correlation coefficient analysis between variables. The significance tests two-sided.

Results

The fusion frequency (FLIM 1) and flicker frequency (FLIM 2) indicate the level of arousal while the sum of correctly accepted answers (COG1), the sum of correctly rejected answers (COG2), mean time of correctly accepted answers (COG3), and mean time of correctly rejected answers (COG4) indicate the accuracy and speed of attentional actions (see Method). Table 1 shows the mean, minimum and maximum values for all the variables studied with their measurement error. The measurement error ($\pm$ standard deviation) of the mean value M (FLIM1 and FLIM2) is a control value that allows for the evaluation of the accuracy of the determination of the critical threshold of the transition between steady and flickering light

Table 1. Level of arousal and level of attention. The test power is 0,42; N = 68

Variables	Mean $\pm$ SD	Min	Max
COG 1	74.28 $\pm$ 3.48	63.00	79.00
COG 2	113.75 $\pm$ 4.75	99.00	120.00
COG 3	1.86 $\pm$ 0.38	1.16	2.93
COG 4	1.90 $\pm$ 0.37	1.20	2.80
FLIM 1	39.47 $\pm$ 5.01	33.13	59.90
FLIM 2	38.50 $\pm$ 3.96	25.10	48.96

Table 2. Correlation coefficients of attention and level of arousal; N = 68

Variables	COG 2	COG 3	COG 4	FLIM 1	FLIM 2
COG 1	0.447*	0.461*	0.469*	-0.287*	0.220
COG 2		0.386*	0.328*	-0.320*	0.151
COG 3			0.871*	-0.299*	0.113
COG 4				-0.317*	0.032
FLIM 1					-0.132

* correlation coefficient $p < 0.050$.

and vice versa, i.e. the determinants of the level of fatigue. The measurement error ($\pm$ standard deviation) of the mean value M (COG 1, COG2, COG3, and COG4) represents estimates of the sum of correct acceptance and rejection of the stimuli and reaction time.

The indices of the sum of correctly accepted stimuli, correctly rejected stimuli, time of correctly accepted stimuli, and time of correctly rejected visual stimuli are significantly directly proportionally related to each other, which may indicate a high level of attention in terms of accuracy and reaction time. In contrast, the negative relationship between the fusion frequency (FLIM 1) and flicker frequency (FLIM 2) is inversely proportional and may indicate a regularity concerning the optimal level of arousal. What is very relevant to the main research problem concerning arousal and attention, a negative correlation was observed ($p < 0.050$) for arousal with all attention indices. The flicker frequency (FLIM1) is associated with the sum of correctly accepted visual stimuli (COG1) at the correlation level ($r = -0.287$, $F = 5.939$, $P = 0.017$), the sum of correctly rejected visual stimuli (COG2) at the correlation level ($r = -0.320$, $F = 7.533$, $P = 0.007$), time of correctly accepted stimuli (COG3) at the correlation level ($r = -0.299$, $F = 6.470$, $P = 0.013$), and time of correctly rejected visual stimuli (COG4) is associated at the correlation level ($r = -0.317$, $F = 7.362$, $P = 0.008$). This inversely proportional correlation between the level of arousal and attention indicates a psychological regularity with respect to the perception of the flicker fusion threshold, the accuracy of determining the critical threshold of transition between steady and flickering light, and vice versa, i.e. determinants of the level of fatigue.

Figure 3 shows that the perception of threshold fusion frequency, i.e., the subjective perception of the transition from flickering to steady light, is significantly related to the level of attention indices. The negative relationship of the fusion frequency (FLIM 1) during the recording of the level of arousal with the high result of correctly accepted stimuli (COG 1, Figure 3A), and with the high result of correctly rejected stimuli (COG 2, Figure 3B) in

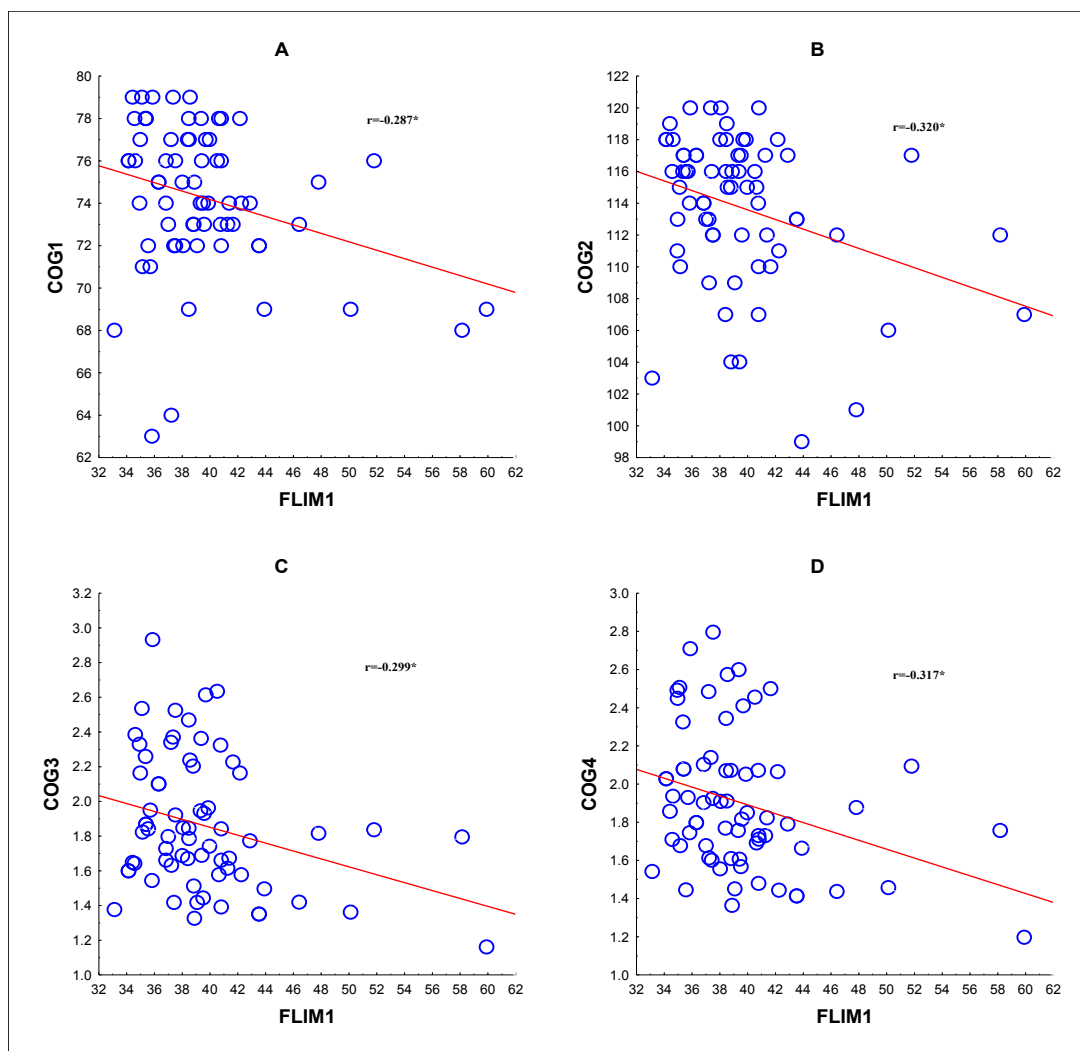


Figure 3. The relationship of the fusion frequency (FLIM 1) during the recording of the level of arousal with the result of the correctly accepted stimuli (COG1, Figure 3A), the result of the correctly rejected stimuli (COG2, Figure 3B), the time of correctly accepted stimuli (COG 3, Figure 3C), and the time of correctly rejected stimuli (COG 4, Figure 3D) in the attentional action; $N = 68$

the attentional action indicates that the action is performed better when the perception of the threshold of transition to the fusion frequency occurs more slowly. Shortening of the time of correctly accepted stimuli (COG 3, Figure 3C) and the time of correctly rejected stimuli (COG 4, Figure 3D) occurs when the perception of the threshold for the transition to the fusion frequency occurs later. This may mean that a low level of fatigue (no fatigue) allows the subject to perform the action correctly.

Discussion

In studying the relationships between the level of arousal and the level of attention, an attempt has been made to explain the mechanisms responsible for sportsman activity. Measuring arousal through the perception

of flicker fusion threshold frequencies has a long tradition in experimental psychology [22]. Its exact cerebral location is not fully understood, but there is considerable scientific evidence that the mechanism responsible for the perception of flicker fusion threshold is located in the cortex [7]. On the one hand, it reflects the level of arousal of the sportsman central nervous system, the level of attention, and the individual's ability to process information; on the other hand, attention is responsible for determining the critical point between steady and flickering light or vice versa. Too high or too low arousal and a decline in the level of attention lead to fluctuations in levels of activity [23]. It also appears that this ability can change through repeated training, as it was demonstrated [1] that the critical values of the perception of flicker fusion frequencies increased in participants who were subjected to light flickering training. Data analysis indicates that with

optimal arousal and a high level of attention, the sportsman performs best, whereas, with too high or too low arousal and a low level of attention, both accuracy and rate of performing actions may increase or decrease. It was found that the time it takes for an individual to correctly perform an attentional action (correctly accepting stimuli and correctly rejecting stimuli in a short period of time) may indicate abilities to match working rate while maintaining attention during performing the action. The results of the experiment concerning the level of arousal and the level of attention prove these findings. Fusion frequency indicates the level of fatigue and is inversely proportional to the correctly accepted stimuli in attentional actions, the correctly rejected stimuli in attentional actions, and the duration of the attentional actions. This is consistent with the findings published by Rózanowski [20], who revealed a clear downward tendency for the perception of flicker fusion threshold frequencies while driving a car in real traffic conditions. This decrease in the perception of threshold frequencies is explained by the increase of symptoms of fatigue in drivers. The results of my research indicate a large variation in the level of arousal and in the level of attention during an attentional action, which may suggest the varying levels of fatigue. Such results encourage further research in this area, including controlling the mechanism of inferring the degree of fatigue of the subjects based on the results of measurements of this variation. This could verify knowledge of the relationship between the level of fatigue and the mechanisms responsible for actions. Knowledge of specific indicators of these mechanisms can provide support for the individualization of sports actions.

Conclusion

The interdependence of arousal and attention is significant during actions, it refers to the change in perception of flicker fusion threshold frequencies as indicators of fatigue. With optimal arousal and a high level of attention, the individual performs best, whereas, with too high or too low arousal and a low level of attention, both accuracy and rate of performing the actions may increase or decrease. Fusion frequency indicates the level of fatigue and is inversely proportional to the correctly accepted stimuli in attentional activity, the correctly rejected stimuli in attentional activities, and the duration of the attentional actions. Knowledge of specific indicators of these mechanisms can provide support for the individualization of the activity.

Conflict of interest: Authors state no conflict of interest.

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