IT APPLICATIONS IN SPORT SESSION

SOFTWARE SOLUTIONS FOR STUDYING MENTAL FATIGUE

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Abstract:

The aim of this paper is to present possible softer solutions for research in the field of mental fatigue. For this purpose, the concept of mental fatigue was defined in the first step, a brief history of its research was presented, as were key results of current research. In the second step, the most commonly used software solutions for inducing mental fatigue have been identified, presented, and analyzed from the aspect of validity but the efficiency of their use.

Keywords:

Psychology, Physiology, Sport neuroscience, Sports performance, Methodology.

INTRODUCTION

Research and expertise within the domain of one scientific discipline and even the entire scientific field have long been insufficient to properly meet the basic goals of science and scientific knowledge, creating a comprehensive system of knowledge about man and the world. An integrative and interdisciplinary approach to the subject of study represents a logical response to the described challenge [1]. Sports neuroscience is an expression of the aspiration to try to answer the questions of the nature of the human movement, motor abilities and skills, information and physiological processes that govern them, and the possibilities of their systematic change in the training process through the integration of cognitive sports psychological and neurosciences [2], [3]. The results of this research, of course, have implications in the broader field of research on the human body and behavior.

In the modern society which is shaped by digital technology and new media play [4], all theoretical assumptions and concepts are in a permanent state of significant transformation [5], which has important methodological implications [6]. This turns out to, in addition to all the easily noticeable threats, represent a great potential [7], which can be seen in the field of research of the physiological basis of human performance as well.

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Increasing the range of theta waves in the prefrontal cortex is an indicator of the occurrence of mental fatigue [8]. Mental fatigue is thought to be associated with decreased prefrontal cortex activation due to increased ATP hydrolysis and brain adenosine concentration [9]. However, it was found that mentally exhausted athletes improved their score after caffeine intake that did not affect the change in activity in the prefrontal cortex [10] even in placebo sessions [9] say that the psychological component must be taken into account in explaining the phenomenon of inhibition of activity due to mental fatigue. In this place, we primarily refer to research in the field of mental fatigue, which through the use of digital technologies get the opportunity to systematically and validly engage in research into a very complex and multidimensional phenomenon. Phenomena on the volatile boundary between physiology and psychology studied primarily in the field of sports and human movement sciences.

The aim of this study is to present to the scientific and wider professional public in the domain of Psychology, Physiology, Sport, and human movement science software solutions for causing mental fatigue, which allows a new degree of validity in its research. The aim is also to acquaint professionals and researchers in the field of programming and information technology with the potential space for their greater involvement in the field of research in social sciences and human movement sciences.

For the purpose of reviewing the current research results of studies on software solutions for studying mental fatigue, the PubMed electronic base was searched for relevant scientific scores. The following keywords for database search were used: "mental fatigue sports performance", "mental fatigue induction", "mental fatigue software", and "e-sport". The search was performed for titles, as well as for abstracts. Initially, 785 results were found, ranging from the year 1968 until 2022. After filtering the irrelevant scores, which wouldn't fit under the subject of sports neuroscience, 46 scores were left. After further narrowing research results to systematic reviews, only 4 studies were left. Having in mind the exploratory nature of this paper, as well as the redundancy of the results found when it comes to the application of software solutions, we can conclude that this choice is justified.

2. DEFINITION OF MENTAL FATIGUE AND DEVELOPMENT OF RESEARCH CONCEPT

The role of psychological characteristics of athletes [4], i.e. their emotional [11], cognitive [12]) and conative [13] abilities and processes in achieving top sports results, has long been known. Highly developed motivation as well as stress resilience [14] can be just as important as physical ability [15] or morphological characteristics [16], [17] when it comes to achieving top sports results.

In the research of motivational characteristics, there is a lot of important and open research questions. Among them, these are questions of the limits of human endurance and what is the primary nature of fatigue that leads to the cancelation of physical activities. Of course, there are numerous studies that describe the physiological limits of the human body [18], [19], primarily related to muscle fatigue and limits [3]. However, recent research suggests that the study of this topic should primarily take into account the physiological exhaustion of the nervous system [20] at all levels from sensory input, through the spinal cord and brain to autonomic functions and effector output [21]. Such side effects of physical activity and fatigue are related to the concept of mental fatigue. Mental fatigue is defined as a mental state caused by prolonged demanding cognitive activity [22] and refers to both physiological changes caused by activity and psychological interpretation[23]. Movement control can also be considered a demanding cognitive task, which is crucial for understanding mental fatigue in a sports context.

Studies of the effects of direct transcranial stimulation (tDCS) represent a new experimental method that should shed light on the neuroanatomical and neurophysiological basis of conative abilities and processes as well as causal links between them and athletic achievement [3]. After anodic stimulation of the primary motor cortex in experimental conditions, a significant increase in endurance was obtained associated with increased corticospinal excitability of the knee extensor muscles and decreased effort perception [24]. The research potential of the use of the method of direct transcranial stimulation in experimental research of conative processes and abilities in sports, but also its application in diagnostics, selection, and training, has yet to be fully used.

One of the important methodological issues in these studies is the cause of mental fatigue. How to provoke it, how to induce it, how to control its intensity and whether the results of studies that use different experimental treatments for this purpose can be compared? The use of information technology, as well as software solutions, are one of the possible answers to these challenges.

3. SOFTWARE SOLUTIONS

The usage of software solutions for mental fatigue induction is very popular since it is easily applicable, cheap, or free and shows adequate results. Some of the most popular software solutions used in research are AX Continuous Performance Test (AX-CPT) [25], Stroop Task [26], and some often used is Wisconsin Card Sorting Test (WCST) [27], [28]. What is characteristic about all these tests whose main goal is to induce mental fatigue is that they need to be performed for a longer period of time (at least 30-45 minutes) as previously mentioned. What is even more important is that all participants should be in a similar psychological state in order to obtain valid results [29].

In AX-CPT, participants have the objective to respond by pressing a particular button when a target is presented, and a different button when any other stimulus is presented. Typically, the target is represented as letter X, but only when it is preceded by the letter A. When a participant sees A-X-A-X, both X's are targets, but if it sees A-X-B-X, only the first X is a target (Figure 1). This is very convenient because the researchers have the ability to manipulate how often the target will appear and in which circumstances. If only A-X and B-X combinations are shown, the participant would soon have the assumption that when A appears on the screen, the X would follow. That is where the other part of this test comes in, which is the inclusion of Y. So, showing an A-Y combination would not be a target and the participant would give the wrong answer if only focusing on the first letter. This way AX-CPT has a dual-task, first it measures a person's ability to focus on a goal (X should be connected to A in order to be a target), and second, the person's ability to process context (if B is presented, the next letter will certainly not be a target, and if A is presented, the next letter is likely to be a target).

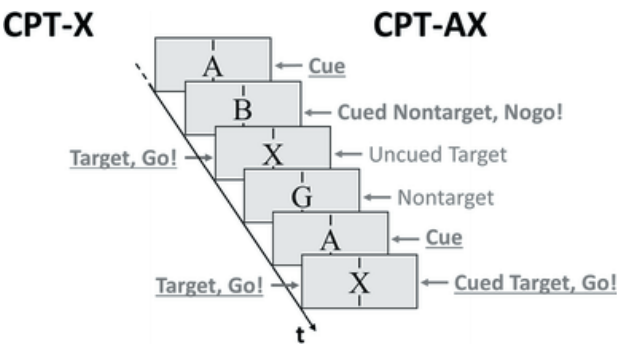

Figure 1 – An example of AX – CPT targeting

The Stroop task is one of the most used and best-known psychological tests. The test consists of words appearing on the screen in different colors. The goal is to state the color of the ink in which the letters are written. In this way, the word "GREEN" appears but is written in red ink (Figure 2). The software version measures the time needed to answer and accuracy. The Stroop phenomenon shows that it is difficult to name the ink color of a color word if there is a mismatch between them. It also shows that there is a delay in the reaction time between matching and mismatching stimuli.

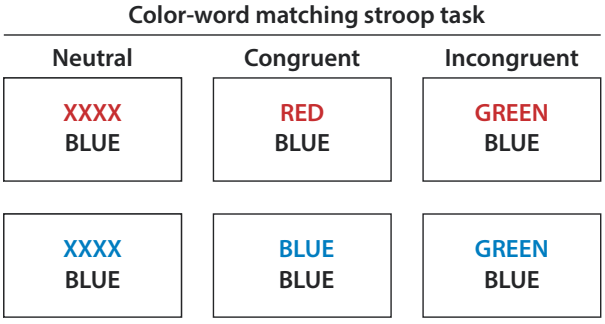

Figure 2 – An example of Stroop task

The WCST is maybe less conventional in research than the previous two but is a very significant tool when it comes to mental fatigue induction. In this test, the participant has 4 cards shown on the screen. Each card has a different symbol (e.g. circle, triangle, star, etc.), a different number of symbols shown on them (1, 2, 3, 4), and each symbol has a different color (red, blue, green, yellow). When the test starts, another card with a random number of symbols with random colors appears. The participant has the objective to match the shown card with one of the previously mentioned. When he chooses one of the cards, the sound indicates a right or wrong answer. The goal is to find out the indicated pattern.

There are three patterns where the participant should follow the number of symbols, their type, or their color. After a certain period of time, the pattern switches during the test, and the participant has the objective once again to find out the pattern type. This way, the person needs to be aware and focused during the whole process in order to perform the test right.

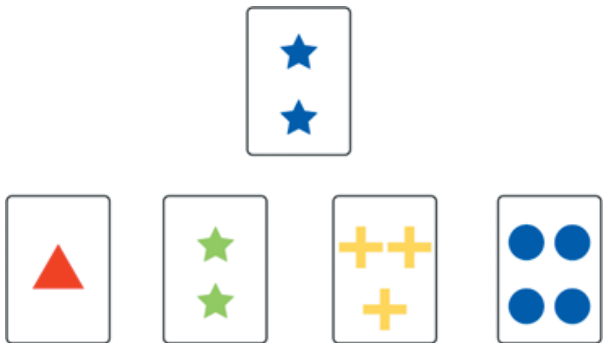

Figure 3 – an example of Wisconsin Card Sorting Test

4. DISCUSSION AND CONCLUSION

In this paper, we sought to outline the current importance and potential of using software solutions in studying mental fatigue. The significance of research findings in this area is widely used in clinical psychology [29], physiology [8], [9], and especially in sports science [12], [13], [15]. What is even more interesting to note is that specific branches in sports science, such as motor control deal with this phenomenon in terms of time reaction. It is well known that in all sports with a direct opponent, time reaction plays the key role [30]. On the other hand, mental fatigue shows different effects on physical fatigue, impairing endurance performance, decreasing time to exhaustion and self-selected power output, or increased completion time [22]. Further, some studies [29] show that neither cognitive flexibility nor attention to detail is associated with the level of eating disorder symptomatology, depression, anxiety, or OCD symptomatology. This leads to another trail when it comes to the connection between mental fatigue and physiology.

When it comes to experimental control of mental fatigue induction, all studies were mainly focused on time duration of the tests/objectives in which participants were included [26], [31]. There is also a significant difference in test type used in the experiment, but in general, most of the researchers agree that specific time duration plays a key role in the experimental control. On the other hand, depending on the sports expertise or job profession, it depends on which level the aforementioned tests would induce mental fatigue. This is very important for highly-stressful surroundings, where people tend to maintain focus under pressure, to perform and achieve high standards in similar situations. In sport, this is very significant, especially in sports branches where focus plays the main role [32].

Finally, the usage of the mentioned tests can be further upgraded by adding additional contents, making their validity even stronger when it comes to mental fatigue induction. Taking into account that today people's attention is much more stimulated than it was in the past [33], creating more complex tests would probably improve the validity of further research in this field.

There are also limitations in this paper, regarding the tests presented. First, there is a great number of tests that can be used for inducing mental fatigue, and the authors presented only a few of the most common ones. Second, there are multiple ways to induce mental fatigue, such as audio or electrodermal [34], depending on the research methodology and desired results. In this paper, only online solutions were presented, since it is the most simple and affordable way to implement them. Third, in specific sports situations, additional content including physical activation can be used by coaches and sports scientists to further induce mental fatigue, creating an environment where multiple answers are possible.

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