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Estimation of Selective Attention and Performance Accuracy Based on Working Memory in Young Girls

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Abstract

Background: Working memory is one of the important cognitive processes that underlie thinking and learning.
Objective: The aim of this study is to investigate the predictive role of working memory on selective attention and performance accuracy in young girls of the University of Tabriz.
Methods: This research was conducted in a descriptive – correlation method. The participants were 140 female students from the University of Tabriz aged 19 to 25 years. To measure research variables in this study, Working Memory Capacity Tests, Strop Test, and Standard Volleyball Test were used respectively. To analyze the data, the Pearson correlation coefficient and regression analysis were used.
Results: The results of the study illustrated that spatial working memory played a predictive role in selected attention (same color and font, and different color and font) and performance accuracy; Moreover, mathematical working memory played a predictive role in selected attention (same color and font, and different color and font). However, it did not have a predictive role in performance accuracy.
Conclusion: The regression analysis indicated that the working memory variable has a significant predictive ability for selected attention and performance accuracy in female students of the University of Tabriz. According to the results of this study, by raising the working memory, it can be helped reduce the reaction time, or increase the selected attention and the performance accuracy.

Introduction

People learn skills in different ways due to different cognitive or learning styles; one of the sources involved in information processing is working memory (1). Working memory is the process in which recent experience relates to stored schemas. This system is responsible for the temporary storage of information and keeps the input data to the cognitive system ready. Working memory is a part of high-level cognitive actions and refers to the ability to actively store and manipulate information in the brain. This system is responsible for temporarily keeping information entering the cognitive system; in addition, it selects and manipulates this information using the processing systems at its disposal (2). Short-term memory consists of memories that take seconds or minutes at most unless they turn into longer memories (3). Neuroscientists believe that the basis of our ability to think is complex; various theories have been proposed to introduce it, the most widely used and successful of which is Baddeley's multicomponent model (4). He considers working memory to consist of four components: The central executive component is a general supervisory domain that is used in allocating significant

resources and is involved in a range of regulatory functions, including cognitive coordination in performing multiple simultaneous activities, allocating resources to other parts of working memory and data retrieval from long-term memory (5). The fourth component also represents the event that is responsible for converting memory subsystems and information dimensions into integrated features (1). Working memory is one of the cognitive functions of the brain, which is defined as the ability to store information in the mind when performing complex tasks (6). Working memory refers to the function of short-term memory in encryption, maintenance, manipulation, and retrieval of information. So, it can be said that working memory refers to all the temporary information that a person has access to at any given moment. It is one of the critical cognitive processes that underlie thinking and learning (7). Physiologically, memory formation in the human brain is mediated by changes in the synaptic guidance from neurons to neurons due to previous neural activity, which in turn triggers new or facilitated pathways to send messages to the brain's neural circuits. Working memory is an old combination of attention, concentration, and short-term memory that can have a significant impact on the selective attention and accuracy of athletes' performance. Neuroimaging studies that identify memory processes in the brain have suggested the frontal cortex, especially the prefrontal one, as an important area involved in memory processes and deficiencies. On the other hand, the prefrontal cortex, the basal ganglia, and the cerebellum become active when people perform activities carefully (8).

Performance accuracy is an essential practice in many sports, and an elevation in performance accuracy can lead to success in performance. Due to the vitality of selective attention and performance accuracy, any factor that increases particular attention and performance accuracy leads to better performance in which speed is of crucial importance (9).

The content of the human mind is not entirely under the control of the surrounding environmental stimuli at any moment. Still, it selects some of the perceptual information available from the environment for more accurate processing and does not allow other information to enter the processing system. This active process of perceptual selection is called attention. Attention is one of the most important basic functions in the human brain, the components of which are the basis for other cognitive processes. Parallel with its unique functions in various fields, its apparent effect on changes in the intensity of different activities has attracted attention from researchers in this field. Although it is generally believed that attention is a general feature of the whole brain, neural imaging studies indicate the existence of specific networks in the neural regions involved in attention-related functions (10).

The first and most crucial function of attention is to choose from different visual perceptions that are considered as visual attention. Visual attention is the first significant event in the brain's ability to process information and allows a person to

selectively focus on specific areas of the visual environment (11). In addition to the importance of selective attention in athletes' performance, perceptual abilities are essential in the successful implementation of most athletes' activities. Also, the importance of these abilities under challenging sports conditions, especially at high speeds of the game or training, is necessary to prepare the motor responses carefully against the opponent's actions. Successful athletes must be able to accurately guess the opponent's movement behaviors in the same early stages of movement and show the appropriate reaction (12). One of the perceptual abilities that have been considered by researchers in recent years is the accuracy of athletes' performance. Evidence to support this claim is rooted in the link between working memory capacity and significant tasks; it seems likely that some athletes will benefit from their exercise by having high working memory capacity and considerable skills (13).

Furley and Memmert (2012) (14) found that individual differences in working memory capacity show themselves in athletes' behaviors in interference situations in which it is not sensible to rely on automatic reflection behaviors. Volleyball is defined as one of the most dynamic ball sports, which has a wide variety of stimuli and falls, which, along with the high speed, make the game challenging and complicated. Therefore, the key to success in volleyball is to quickly and accurately gather information from different stimuli, player positions, balls, and make the right decisions. Making the right decision can only be achieved by paying attention to the vital environmental signs and also to areas that are rich in the relevant information. Given the importance of the subject of working memory alone and the role of predictors in selective attention and the accuracy of athletes' performance in many ball and fast sports, including volleyball, the opportunity to respond puts pressure on the athlete to choose and perform quickly; therefore, it is necessary to pay attention to the topics related to practicing the appropriate answers about what should be done (tactics) and how to implement it (technique). Despite all that has been said, there is little information about the development of memory capacity in sports, and most research has been enough to describe it among different groups. Despite the value of such descriptive research, the need for intervention research to identify the best conditions for the expansion and predictive role of working memory among different groups seems essential.

Method

The present research is applied in terms of purpose and descriptive in terms of method. The population of the present study consisted of 140 young girls aged 19 to 25 years who were students of Tabriz University and were selected by purposefully (among those who were almost familiar with volleyball service). Inclusion criteria of the study were not having at least 3-5 years of sports experience or regular exercise training, not having an injury or neurological diseases, voluntary consent of the subjects to participate in the research, and not using drugs that affect the central nervous system. Subjects then participated

in a survey of research variables that included working memory, selective attention, and performance accuracy. The research included memory capacity, strop, and rapid volleyball tests, respectively.

The working memory test, published by Turner and Engle (2004) (15) to measure working memory, has two steps that are performed on a computer. Two types of efforts (mathematical and memorization of the order in which words appear) are placed in a square and shown one after the other. In the first step, the person checks the mathematical relation (problem) on the monitor; if the answer is correct, he chooses one of the two options, yes or no, with the mouse, and enters the next step, which includes displaying a word on the monitor screen. The "Next" button leads the subject through the steps. In the next step, a mathematical problem is displayed on the monitor again; finally, a word appears on the monitor, and the subject remembers the order of priority of the displayed words and determines them in the square by clicking on them. This set is presented in the form of 18 training efforts. The correct answer and the wrong answer (which includes choosing the wrong options in the math problem or in the wrong choices in the priority of the appearance of the words) were counted for each person. It should be noted that participants could not change their answers. After completing the results, they will be summarized separately and converted in percentage values in a table that includes test scores for spatial and mathematical working memory. The validity and reliability coefficients are 0.78 and 0.82, respectively (16).

A strop test was also used to measure the selective attention of young female students of Tabriz University. The test was invented by Ridley Strop in 1935 to measure selective attention and cognitive flexibility. This test provides a scale of cognitive inhibition or the ability to inhibit something that has already been learned a lot (dominant response) in favor of an unusual response. In the present study, the computer type of test was used. The test consists of three stages; in the first stage, which is the stage of coordinated efforts, the names of the four primary colors appear in black in the center of the screen, and the participant must, as soon as possible, press on of the keys based on the names of the colors blue, red, yellow or green. In the second step, the names of the four main colors appear in the center of the page with their colored font, and the participant must press the appropriate key for each color as soon as possible. In the third stage, called the stage of uncoordinated efforts or interference, the names of the four primary colors appear on the screen with a color other than their own; and participants were asked to press the key according to the color of the word as soon as possible. For example, the word red is written in a different color, such as green, and the participant must determine the color of the ink instead of the meaning of the word.

Measurable indicators in this test are accuracy (number of correct answers) and speed (reaction time of correct responses to the stimulus based on one-thousandth of a second). The average

reliability coefficient for the three attempts was reported to be more than 0.75, and Ghadiri, Jazayeri, Ashayeriand Qazi Tabatabai (2006) reported the reliability of the retest of all three attempts at 0.60, 0.83, and 0.90, respectively (17).

A quick volleyball test was also used to measure performance accuracy. Designed to measure skill and accuracy in volleyball service, this test has acceptable validity and reliability of 80%. The scores of this test, which can be applied to both sexes (male and female) according to the marking of the volleyball court, are given a way that the score of each ball is equal to the area in which the ball lands. The maximum score is a total of ten times of service, and the ball that does not cross the net does not score (18). For statistical analysis, the research data were analyzed using a regression test in SPSS statistical software version 25 and at a significance level of $P< 0.05$.

Results

To estimate the selective attention and accuracy of performance based on working memory, the regression test was used by the input method. In this method, all variables are entered into the model. Table 1 provides descriptive information about the variables.

After observing the test assumptions, including the residuals, were normal, the residual variance assumed to be constant, and the assumption that the residues were random, the regression test was used. For the first step, the correlation coefficient was used to see if the predictor variable is related to the criterion variable. The results are shown in Table 2.

Table 1. Average and Standard Deviation of Variables.

Variable	Number	Average	Standard Deviation
Spatial Working Memory	140	34.39	14.57
Mathematical Working Memory	140	97.23	2.58
Selective Attention (Similar Color and Font)	140	646.94	102.20
Selective Attention (Different Color and Font)	140	676.34	129.71
Performance Accuracy	140	19.71	8.05

Table 2. Pearson Correlation Coefficient Test Results Between Memory, Work and Attention Scores, Selection and Performance Accuracy.

Variables	Selective Attention (Similar Color and Font)		Selective Attention (Different Color and Font)		Performance Accuracy	
Spatial Working Memory	- 0.76 **	0.001	- 0.77 **	0.001	0.74 **	0.001
Mathematical Working Memory	- 0.47 **	0.001	- 0.40 **	0.001	0.12	0.15

As shown in Table 2, the variables are significantly related to each other, which means that as the amount of memory-work increases, the amount of selective attention and performance accuracy will also increase. Mathematical memory alone does not have a significant relationship with performance accuracy. Table 3 summarizes the models, which is in the table of the study of the square of R or the coefficient of determination. This

number represents the amount of variance in the criterion variables (selective attention and performance accuracy), which is explained by the predictor variable (working memory).

According to the coefficient of determination, it can be stated that working memory explains 71% of the selected attention rate (same color and font), 68% of selective attention (different color and font) as well as 55% of performance accuracy. Variance analysis was used to determine whether the model was appropriate. Then, the regression coefficients and the regression equation were extracted, the results of which can be seen in Table 4.

Table 3. Summary of Regression Model of Factors Affecting Selective Attention and Performance Accuracy.

+Models	R	R Square (Determination Coefficient)	Escalated Factor	Standard Error of the Estimation
Selective Attention (Similar Color and Font)	0.84	0.71	0.71	54.76
Selective Attention (Different Color and Font)	0.83	0.68	0.68	72.95
Performance Accuracy	0.74	0.55	0.54	5.4

Table 4. Results of Regression Analysis of Predictive Variable (Working Memory) on Criterion Variables (Selective Attention and Performance Accuracy).

Significance Level	t	Standardized Beta Coefficient	Standard Error	Non-standard Beta Coefficient	Model	
0.001	12.69	----	175.38	225.88	constant value	Selective Attention (Similar Color and Font)
0.001	-15.38	-0.70	0.32	-4.96	Spatial working memory	
0.001	-7.96	-0.36	1.81	-14.48	Mathematical working memory	
0.001	9.01	----	233.62	2313.98	constant value	Selective Attention (Different Color and Font)
0.001	-15.18	-0.73	0.43	-6.52	Spatial working memory	
0.001	-6.01	-0.29	2.42	-14.53	Mathematical working memory	
0.82	0.21	----	17.36	3.79	constant value	Performance Accuracy
0.001	12.83	0.74	0.032	0.41	Spatial working memory	
0.91	-0.103	0.006	0.18	-0.019	Mathematical working memory	

Examining the results of the standardized beta values, it can be stated that if the standard deviation in the predictor variable of a unit changes, the amount of change in the standard

deviation of the criterion variable can be determined. For example, if we increase the standard deviation of spatial memory by one unit, the standard deviation of the selective attention (similar color and font) will increase for -0.70.

According to Table 4, the regression function of selective attention in terms of mathematical working memory and spatial working memory is as follows:

Y1= 2225/88 + (-4/96X1) + 2225/88 + (-14/48X2)
Y2= 2313/98 + (-6/52X1) + 2313/98 + (-14/53X2)
Y3= 3/79 + (0/41X1)

Y1: Selective attention with a similar color and font,
Y2: Selective attention with different color and font,
Y3: Performance accuracy,
X1: Spatial working memory,
X2: Mathematical working memory,

Significance in the interpretation of the regression function states that the share of spatial working memory and mathematical working memory in predicting selective attention with the same color and font was -4.96 and -14.48, respectively. The share of spatial working memory and mathematical working memory in selective attention with different colors and fonts is -6.52, -34.53, respectively. Besides, the share of spatial working memory in the performance accuracy is 0.41. Mathematical working memory has not been significant in terms of performance accuracy.

Discussion

The aim of this study was to investigate the predictive role of working memory on selective attention and performance accuracy in young girls. The findings of this study showed that working memory has the ability to predict the selective attention and performance accuracy of trainable beginner athletes. This finding is consistent with the results of the findings of Posner (2011) (19), Conway et al. (2001) (20), and Habibi and Khosroshahi (2016) (1). They showed that working memory has a positive relationship with the time of selective attention and performance accuracy (1). If we accept this hypothesis that working memory is a general attention source, working memory training should show its effects on the capacity of working memory and attention control (21). Based on the three-component working memory model of Baddeley and Hitch, and the theory of controlled attention in working memory (23,24), the predictive role of this memory can be considered a convincing justification. Engle and Kane (2004) (25) suggested that people with high working memory capacity are able to better control aspects of their attention for actively maintaining goal-oriented information to position themselves in the task at hand. It can be said that working memory capacity is closely related to selective attention. However, some research suggests that working memory function cannot determine the relationship between selective attention and performance accuracy. Rather, memory-based abilities are important predictors of working memory and play an important role in the predictive power of

working memory. Colcombe et al. (2006) (26), in their study, concluded that when the common short-term variance of memory storage and executive memory is removed from the executive memory variance, the remaining memory variance cannot predict selective attention. Therefore, they concluded that working memory could not play a fundamental role concerning selective attention and that what underpins this relationship is short-term storage. A possible explanation for these findings is that what certainly clarifies the importance of psychological skills, such as working memory capacity and attention, is the nature of the exercise situation. In general, the right decision in sports situations is based on the information about the stimulus requirements provided by the opponent, because relying on conventional responses, if not in line with the requirements of the situation, will be to the detriment of the player. Controlled processes result from the central executive memory component and occur when attention is used purposefully or endogenously. Without sufficient resources (working memory capacity), controlled processing is disrupted, and an unintended or inappropriate response emerges. Working memory is related to various aspects of life and is vital to all aspects of information processing, which is why we value good memory in adulthood and beyond. Considering the importance of memory and, according to the theory of controlled attention in working memory capacity, which expresses working memory capacity can control attention in keeping the information in an active state. With the ability to recover quickly (10), it can be said that evidence to support this claim is rooted in the link between working memory capacity and the importance of the tasks. It seems likely that some athletes will benefit from their sport by having high working memory capacity and considerable skills (12). Regarding the relationship between working memory and selective attention, it can be noted that attention can be directed to memory representations and produce a flexible model of active visual memory content (27). Encryption of information within working memory is influenced by selective attention; this attention plays a role in storing information within working memory (28). Working memory is a mental desk that allows us to access and gather information to understand written and oral language, decision making, and problem-solving. In another explanation, it can be said that improving memory will have a positive effect on learning and performance; because memory supports learning. In other words, memory leads to increased selective attention and performance accuracy, facilitating learning. Therefore, increasing accuracy and attention to task and memory and adjusting images and calculations due to the cognitive role will increase students' working memory (29). Furley and Memmert (2010) (13) found that individual differences in working memory capacity had an effect on athletes' behaviors and reactions in interfering situations that did not rely on automated reflexive behaviors. Accordingly, working memory is the core of the most complex human cognitive and executive functions. Impairment in

this memory causes a decline in selective attention and performance accuracy in athletes; because athletes' cognitive functions are a set of mental processes that retrieve and store information through working memory. The results of Ghotbi et al. (2010) (30) showed that there is a relationship between dart-throwing accuracy and numerical memory. In addition, they show that there is a correlation between working memory scores and dart-throwing accuracy. Also, it has been shown that spatial visual function, central executive system, selective attention, and performance accuracy are related to working memory capacity and are an important variable in the acquisition of skill performance (31).

Conclusion

In general, individuals with high working memory capacity have a better performance in controlling their attention to keep target information active than those with low working memory capacity. Working memory has limited capacity, and its proper use requires the use of maximum available capacity and prevention of intrusive stimuli and unrelated information. In this regard, selective attention plays an important role and causes faster and better information to be stored in working memory. Bandura emphasizes that the initial stage of any learning begins with attention, and if there is not enough working memory, attention does not occur, and as a result, a person's learning is impaired. Therefore, working memory is one of the most important functions of the mind and, by itself, is one of the main aspects of cognitive structure, playing an important role in the structure of intelligence, selective attention, perception, and accuracy of performance (10).

However, this research has some limitations. Since no interventions were performed on the subjects, it is recommended that a training program be developed to examine memory and its role in selective attention and performance accuracy. On the other hand, this research has been done on young female, and the results of this study could not be generalized to males.

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