Effect of mental fatigue on choice reaction time in male and female swimmers

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Abstract

The purpose of this study was to investigate the effect of mental fatigue on choice reaction time in male and female swimmers. 30 swimmers (15 male, 15 female) were participated voluntarily with average age of 22.1. The participants performed the task of choice reaction time in 51 minutes. In this task that included three periods of 17 minutes, with no break, the first 17 minutes was considered as pre-test and the next two periods as post-test. The results showed that mental fatigue to choice reaction time of male and female swimmers had a significant effect in different periods (P≤0.001) and participants had a better reaction time in first period than in second and third periods. The participants also had a better reaction time in second period than in third period. There was a significant difference between the choice reaction time of male and female swimmers in different stages of measurement (P≤0.001). The choice reaction time of females was better than males in all of three periods. These results support the perceptual narrowing theory such as parallel informative processing model and Easterbrook’s cues utilization theory.

Keywords: Mental fatigue, Choice reaction time, Time on task

Introduction

Nowadays, most of physical activities include mental and physical task. One of the purposes that coaches follow is to write an appropriate training program in order to omit the nuisance factors that decrease the learning and performance. One of these factors can be fatigue. Fatigue is a mental unpleasant symptom that includes the general feeling of tiredness to exhaustion and it interfere with natural capacity of doing tasks (Akuthota & Nadler, 2004). Mental fatigue is a psychophysiological state that is made in result of keeping the long-term efficiency in a cognitive hard task and is associated with a change in motivational state, information process, and mental state (Lorist, et al., 2000). The requirements of jobs have changed from great physical state to extensive mental states during past decades (Robinson & Tamir, 2005). This leads to constant increase of discomforts and complains arising from mental fatigue. One of the main characteristics of mental fatigue is a feeling of tiredness. The feeling of tiredness prevents the person from keeping efficiency and effort after a long term work. There are some reasons for tiredness including the time or the time period of duty, stress, heavy work, etc (Li, et al., 2004).

Reaction time is used to determine that what speed is used by athlete to react to sign or stimulus in sport situations. Although the reaction time is involved in most sport situations, the variety of information related to information process and decision making provided for athlete according to the type of reaction time. In simple reaction time, there is a stimulus and a response (Schmidt & Wrisberg, 2008). In choice reaction time, there are several stimuli and several responses and every
stimulus has its own special response. In discrimination reaction time, there are several stimuli that the person should respond just to one of them. The reaction time can be divided into two sections of pre-motor time and motor time (McMorris, 2014). "The pre-motor time" is the time distance between the stimulus show and the transfer of selected motor activity to muscles. "The motor time" is a period time that the muscles become active by efferent nervous or motor nervous. Although the reaction time is more influenced by inheritance (the simple reaction time is more influenced), the studies show that the internal and environmental factors such as fatigue, the number of stimulus and response, arousal level, exercise, etc. can have a great effect on the reaction time. For example, Langer, et al. (2011) showed when the intensity of the stimulus changes randomly in the tasks of the simple reaction time in result of mind fatigue, the speed of response improves after low-intensity trials. In the audio stimuli, this improvement was an asymmetric recognition and the speed of response was low in the low-intensity trials. The study of Langer, et al. (2010) as a mental fatigue and time preparation in the performance of simple reaction time was followed the answer of this question that whether the mental fatigue resulted from long time on task can destroy the time preparation for quick action in the simple reaction time. The result showed that when the pre-periods were different between the trials, the responses with longer pre-periods were quicker. This model has been attributed to voluntarily increase of automatic attention or learning of trial to trail. The increase was determined in all reaction times in the period of 51 minutes of performance. This increase showed that the time on task generally motivates the mental fatigue which decreases the cognitive efficiency, but it does not have any effect to time preparation in the uncertain conditions of presented stimulus. Boksem and Tops (2008) suggested a framework for mental fatigue including integrated assessment of expected benefits and decrease of energy for constant activity. The behavior is promoted in a way that the result of this assessment is in line with energy consumption. It is believed that the assessment of expected benefits and decrease of energy are among the key factors of mental fatigue phenomenon. In other words, if people understand that the decrease of energy for participating in an activity is more than its participation benefits in the activity so they don't have any motivation to participate in that activity. Boksem, et al. (2005) investigated the effects of mental fatigue to attention. The amount of mental fatigue and the power of alpha band of lower electroencephalography were increased. It is indicative of fatigue increase for 3 hours of training. The reaction time period, incorrect errors and alarms were increased along with exercise and it shows the decrease of performance efficiency in people with fatigue. The results show the different effects of mental fatigue to attention in the purposeful and automatic behavior. The mental fatigue decreases the purposeful attention and leads the people to automatic behavior. Finally, Lorist, et al. (2000) investigated the effect of mental fatigue to control task and made the participants tired by doing the long activity. The results showed that the involvement of brain areas that are related with administrative control is decreased by increase of performance time. Moreover, the mental fatigue leads to increase in number of errors and increase in reaction time. As movement has a fundamental role in physical education and sport science and mental preparation has a great effect among athletes, and also based on the review of literature it seems necessary to investigate the effect of mental fatigue to reaction time choice because the reaction time is considered as an important part of sports performance in the skill performance in the sport majors and it is influenced by mental fatigue.

Materials and Methods

Research design

The design of present study is semi experimental and practical type. It is performed by pre-test and post-test.

Participant

The population of the study was composed of male and female swimmer students of Tehran University who take the swimming course in the second semester of 93-94 with average age of 20 to 23. The population sample of present study was based on Langner et al. (2010) consisted of 30 swimmers (15 males and 15 females) who participated voluntarily in the study. All the participants were right-handed and all had normal vision.

 Instruments and Task

Hardware: it includes one HP laptop, a FARASOO keyboard. Software: the software program was designed and built in widows. This software has three sections: the initial test section, the main test section, the results section. The initial test section: this section was designed to prepare the participant for the main test that is 51 minutes. The time of test is set based on second. The main test section: this section was the main and important part of the software; the time of the test was based on minute. The results section: in this section, the total result of the participant was demonstrated in three individual blocks and total average of the participant's performance for the calculation of the effect of mental fatigue to reaction time choice. The validity of instrument was confirmed by expert teachers of motor behavior. The reliability of
Instrument was done by test-posttest two times before doing the main study for 20 male and female students who all were right-handed in the same condition. The scores of two tests were compared. The reliability coefficient of test-posttest was gained that the regarded task had acceptable reliability.

The reliability coefficient of test-posttest was examined separately in male and female groups that it was gained in female group as (10 people) (ICC= 0.68) and male group as (10) (ICC=0.81). The VAS scale: it is an eye simulation scale this is considered as self-reported scale. What is used in this study is a simple linear analogue scale and the numbers from 0 to 10 are written on it. The 0 amount is indicative of the minimal level of tiredness and number 10 is indicative of the maximum level of mental fatigue. The participant was asked to determine the amount of mental fatigue according to this instrument Langner et al. (2010).

The participants of this study did a selective reaction time task as fast as they could by pressing button 1 with index finger of their right hand or pressing button 2 with middle finger. After pressing the start button by the researcher, first a 1000 Hz auditory stimulus presented to the subject via headphones and after 1000, 3000 or 5000 milliseconds which chosen randomly and was probably identical, one of the stimuli (1 or 2) programmed by computer completely at random presented on the screen and the subject should press the corresponding button under his/her finger as fast as possible and his/her time recorded with accuracy of 1/1000 of a Second (Langner et al. 2010).

This study uses foreperiods of 1000, 3000 and 5000 milliseconds chosen randomly and probably identical for every task. Visual stimulus (1 or 2) ended after responding (pressing button 1 or 2) or 2000 milliseconds after respond time ended. This study was conducted at 9 o’clock every morning during a month. Duration of task time for every subject was 51 minutes.

In this study, mental fatigue due to stay time on task (51 working minute) on every subject at the start and after the task was measured by Self-Expression VAS scale and the subject determined his/her mental fatigue using this measure.

**Procedure**

At the start of the study, the participants was briefed about all the experiment conditions including dangers and advantages of the study and informed consent was obtained from them. This experiment was conducted in a dim and quiet room and was under control by a standard personal computer with colored screen using a software developed by the researcher before the experiment. The subject sat directly in front of the computer screen at a distance of 60 centimeters and touched button 1 with his/her index finger and button 2 with his/her middle finger sitting at completely comfortable condition with closest distance to the Numpad. A dot was presented constantly on the screen and the subject should look at it at the time of presenting the stimuli.

All the stimuli were presented in black color on a white background. The touch of the finger on the corresponding button was emphasized during the experiment. For the sake of comfort and more concentration of the participant on the task, the participants were allowed to change the place of the Numpad and distance to screen whenever needed.

Oral explanation along with practical presentation of the way the experiment would be done was presented to the participants before the experiment. The participants demonstrated a 45 seconds test (three 15 seconds block) for a full acquaintance and resolving any probable ambiguities regarding the experiment, then the main experiment began.

A 1000 Hz sound was presented as an auditory stimuli via headphones to indicate the participants to be ready.

**Statistical design**

Shapiro Wilkes and Levene test statistics were used for evaluating the normal distribution of the data and homogenizing the variance respectively, then mixed variance analysis (2x3) was used for determining the differences in control and experimental groups at different stages of measurement. Analysis of variance with repeated measurements was used for evaluating in-group change process. Bonferroni post hoc test was used for evaluating the place of differences, and for evaluating the differences between groups at every stage of the measurement the independent t-test was used and finally, the data was analyzed by SPSS version 21. Statistical tests were analyzed at a significant level of 5%.
Results

![Graph](image_url)

Figure 1. Mean of reaction time in different times

Analysis of variance with repeated measurements was used for evaluating the effect of mental fatigue on reaction time. As for the significance of Mauchly's sphericity test \((P=0.001)\), indexes \((F)\) of The Greenhouse-Geisser was reported. The results of Analysis of variance with repeated measurements test on time interval factor showed that mental fatigue has significant effect on male swimmer reaction time at \((F_{1,12,173}=128.445, \text{sig}=0.025)\) and on female swimmer reaction time at \((F_{1,12,173}=197.597)\) at different time intervals. The results of Bonferroni post hoc test showed that there is a significant difference between first and second time intervals \((P<0.001)\), between first and third time intervals \((P<0.001)\) and between second and third time intervals \((P<0.001)\) which means that subjects had less (better) reaction time at first time interval than at second and third time intervals. Subjects had less (better) reaction time at second time interval than the third.

Discussion and conclusion

The goal of this study was to evaluate the effect of mental fatigue on selective reaction time of male and female swimmers. For this end the subjects of the study did a 51 minute protocol test and the results of analyzing the compound variance showed that mental fatigue has a significant effect on male and female swimmers’ selective reaction time. The results also revealed that this negative effect increases with the passage of time. The subject’s reaction time at first time interval is better than the second and third and the second time interval is better than the third interval, this shows that mental fatigue has increasingly negative effect with the passage of time on swimmers’ reaction time. The results of this study corresponds to the results of Langner, et al. (2010), Wright, et al. (2007), Boksem, et al. (2008), Boksem, et al. (2005) and Langner, et al. (2011). The results showed that mental fatigue disarranges to a great extent the performance and action. Generally, it seems that the effect of mental fatigue on behavior is largely the result of a person incapable of allocating attention efficiently. Increasing of fatigue during the exercise with the pass of time relates to the limiting data processing capacity and accordingly attention to the fatigue due to staying on the task stops the subject from attending simultaneously to performing effective task. This model is known as parallel data processing (Langner, et al., 2010). Moreover the results of this study confirms the Easterbrook’s hypothesis of Perceptual narrowing according to which, attending to mental fatigue stops attending simultaneously to effective task performance so it is expected that mental fatigue resulted from performing a task reduces the attention to effective performance of the task and finally disarranges the performing of the task (Boksem, et al, 2005).

According to recent decades’ studies, increasing in the rate of Serotonin (Dihydroxytryptamine) to dopamine in brain is known as the major fatigue factor of the cortex. Probably part of this result should be related to the effects of mental fatigue on increasing secretion of serotonin in brain. From neuromuscular perspective, the effect of mental fatigue on weak capability of firing motor units and reduction of potential at the time of failure can be evaluated (Taylor & Gandevia, 2008; Kosinski,
As it is revealed, rate of firing of alpha motor neuron and maximum potential in it increases before failure and decreases on failure state. Accordingly, if an external factor stimulates cortex, and alpha motor neuron in corresponding muscles prompts the decreasing of frequency, it will reduce the rate of performed task, in this study the external factor was mental fatigue (Enoka & Stuart, 1992; Taylor & Gandevia, 2008).

Generally, mental fatigue can be one of the effective factors on motor performance and it is suggested to instructors that while teaching motor skills attend to mental fatigue more than physical fatigue so that it prevents injuries and increases motor harmony.

Conflict of interest
The authors declare no conflict of interest

References


