

The Effects of Open and Closed Skills on Athletes' Attention Types

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Abstract

Background: Open and closed skills require different instructional training in regard to environment. Typical closed skills include diving, race swimming, and gymnastics, whereas open skills are those that are practiced in the changing world. Multiple cognitive processes are activated during both open and closed motor behavior, such as working memory, speed of information, and attention. Attention especially affects athletes' memory and cognitive processes.

Objectives: The aim of the present study was to investigate the effects of skill type (open and closed) and gender on two different attention types (selective and sustained) in athletes.

Methods: The study sample consisted of 40 subjects who were divided into three groups: 10 gymnasts (representing closed skills) purposely selected from the Jordan Gymnastics Federation; 10 non-athletes (representing open skills); and 20 fencers (also representing open skills). The Leiter International Performance Scale (Leiter-3) was used to evaluate the two attention types.

Results: The results indicated that athletes of both open and closed skills show greater ability in both attention types. Some differences were found regarding types of selective attention (Stroop effect), where the elite open-skills athletes (fencers) scored higher Stroop scores. Moreover, the study revealed gender differences, with females having significantly higher Stroop color congruent and color incongruent stimuli scores than males. However, males in closed skills recorded higher scores on sustained attention. Overall, it seems that skill type strongly influences cognitive function.

Keywords: open skills, closed skills, gender, selective attention, Stroop effect, sustained attention, athletes.

Introduction

Motor skills are classified according to how a sporting environment affects the skills needed for a given sport and its required movement skills and tasks. The sporting environment itself includes weather, surfaces, and players on both sides of the sporting event (Schmidt & Lee, 2001; Thorness, 2001). Using a movement tasks categorization system could influence the learning process (McCullagh & Davis, 2001). Numerous recent scientific publications have shown the positive impact of exercise on cognition and wellbeing (Booth, Roberts, & Laye, 2012; Cotman, Berchtold, & Christie, 2007; Erickson, Leckie, & Weinstein, 2014; Fernandes, Arida, & Gomez-Pinilla, 2017; Raz & Rodrigue, 2006; Westerterp, 2013). Notably, the benefits of sport exercises were found to protect against cognitive decline (Sofi et al., 2011), as sport performance and exercise influence brain maturation, including attention and cognitive functions (Hötting & Röder, 2013).

Attention is a basic but complex cognitive process that has multiple subprocesses specialized for different aspects of attentional processing, such as memory and cognitive processes (Riddle, 2007). It is one of the most popular contrasts in modern cognitive psychology, playing a critical role in the scientific analysis of various forms of information processing and behavior. There are several types of attention, notably selective, divided, and sustained attention. Selective attention refers to the ability to attend to some stimuli while disregarding others that are irrelevant to the task at hand. It also refers to the differential processing of simultaneous sources of information. For example, in a Stroop task, participants are asked to name the color of ink in which an incongruent color word is printed to measure the effects of interference on attention. Meanwhile, a divided attention task requires the processing of two or more information sources or the performance of two or more tasks at the same time, meaning participants may have to monitor stimuli at two different spatial locations (Riddle, 2007). Lastly, sustained attention is the ability to maintain concentration on a task, activity, or stimulus over an extended period of time. It is also a fundamental component of attention characterized by readiness to detect rarely and unpredictably occurring signals over prolonged periods of time (Drag & Bieliauskas, 2010; Sarter, Givens, & Bruno, 2001).

A difficult motor performance requires strong mental concentration to succeed. Such performances are based on motor programs stored in the central nervous system (Näätänen, 1992). Perception features of the task (open or closed) (Schmidt & Lee, 2001). The many motion changes require different plans of action and learner preparation.

With open skills, the critical factor is timing, as this determines the preparation for and execution of modified movement given open skills involve the rapid relocation of learners' attention to different aspects of the environment (Hassan, Dowling, & McConkey, 2014).

Gu, Zou, Loprinzi, Quan, & Huang (2019) found that open and closed motor skills have different effects on cognitive function. Skills performed in a variable and unpredictable environment are classified as open skills, such as driving in traffic, karate, taekwondo, and fencing, where it is difficult to predict an opponent's movement. Alternately, closed skills are performed in a stable and routine environment, with the task design requiring participants to repeat the same movement pattern; an example would be swimming or a gymnast performing a floor routine (Magill, 2017; Schmidt & Wrisberg, 2008). There are thus differences between open and closed sports regarding skill function (Cumming, Clark, McCullagh, Ste-Marie, & Hall, 2005). Researchers have used the Functions of Observational Learning Questionnaire to examine athletes' general observational learning use, as well as their differences according to gender, sport type, and competitive level; these researchers found that open skills lead to greater improvements in cognitive function in both children and older adults (Cumming et al., 2005; Gu et al., 2019; Law & Hall, 2009).

The published literature showed that few studies, however, have compared attention types regarding sport type (representing skill type) and athletes and non-athletes' genders. The present study thus aimed to directly compare attention types regarding open and closed skill classification, athletes and non-athletes' genders, and their interactive effects. The researcher assumed there would be significant differences in attention type with regard to skill type and gender. Furthermore, the researcher predicted that elite athletes would record higher attention scores than non-elite athletes and that there would be an interactive effect between skill type and gender.

Study Objectives

This study had two primary objectives:

- 1- To compare attention types regarding open and closed sports skills and athletes and non-athletes' genders.
- 2- To determine the interactive effect of skill type and gender on attention type.

Methods

The study sample consisted of 40 subjects who were divided into three groups: 10 gymnasts (closed skills; 7 males and 3 females) purposely selected from the Jordan Gymnastics Federation, 20 fencers (open skills; 13 males and 7 females) selected from the Jordan Fencing Federation, and 10 non-athletes (open skills; 7 males and 3 females). Table (1) shows the demographic characteristics of the total sample. The Leiter International Performance Scale (Leiter-3) was used to evaluate attention types. The Leiter-3 is used to evaluate nonverbal cognitive, attentional, and neuropsychological abilities in typical and atypical children, adolescents, and adults. In this study, the researcher used SUBTEST 6: Attention Sustained, a subtest from Leiter-3 parts 5, 6, 7, and 8 that requires participants to select a target shape or pattern (e.g., Δ 0) within a complex array of different shapes and in a specified time of 30 or 60 seconds. Furthermore, SUBTEST 10 was used to assess selective attention by requiring the participants to select a Stroop color congruent

 or color incongruent  target within 45 seconds

Table (1) Demographic characteristics of the total sample (n = 40)

Categories	Open-skills Athletes n = 20		Closed-skills Athletes n = 10		Non-athletes n = 10		Sample n = 40		
	n	%	n	%	n	%	n	%	
	Gender								
	Male	13	65.0	7	70.0	7	70.0	27	67.5
	Female	7	35.0	3	30.0	3	30.0	13	32.5
	Total	20	100.0	10	100.0	10	100.0	40	100.0
Age									
	7–11 years	1	5.0	6	60.0	7	70.0	14	35.0
	> 11–16	19	95.0	4	40.0	3	30.0	26	65.0
	Total	20	100.0	10	100.0	10	100.0	40	100.0

Data Analysis

The data analyses were performed using the SPSS 21.0 software system. After compiling the subjects' descriptive statistics, a two-way ANOVA was used to differentiate the interactive effect between gender and skill type on attention type. A LSD post-hoc test identified which of the differences were significant.

Results

The descriptive results for the athletes and non-athletes’ attention scores are summarized in Table (2). The mean sustained attention score was 159.03 (SD = 22.24), whereas the mean for selective attention (Stroop effect) was 21.08 (SD = 5.69). For Stroop color congruent stimuli, the mean score was 29.83 (SD = 10.49) and for color incongruent stimuli, it was 8.75 (SD = 6.55). The closed-skills athletes reported higher scores in sustained attention with a mean of 161.70 (SD = 22.29), whereas selective attention (Stroop effect) was greater in the open-skills athletes. Overall, the athletes recorded higher scores than non-athletes in all attention types.

Table (2) Descriptive statistics for athletes, non-athletes, and skill type scoring according to attention type

Variables	Open-skills Athletes n = 10		Closed-skills Athletes n = 20		All Athletes n = 30		Non-athletes n = 10		Sample n = 40	
	M	SD	M	SD	M	SD	M	SD	M	SD
Sustained attention	158.30	23.40	161.70	22.29	159.43	22.71	157.80	21.89	159.03	22.24
Stroop color congruent	37.85	8.84	21.70	3.16	32.47	10.69	21.90	3.96	29.83	10.49
Stroop color incongruent	13.80	5.64	3.60	1.58	10.40	6.75	3.80	1.75	8.75	6.55
Selective attention (Stroop effect)	24.05	6.49	18.10	2.08	22.07	6.09	18.10	2.73	21.08	5.69

Using a two-way ANOVA to assess sustained attention and selective attention (Stroop effect) with regard to skill type and gender, the results indicated that the Stroop effect differed significantly per skill type. Color congruent stimuli (0.000), color incongruent stimuli (0.000), and the total Stroop effect (0.001) were all statistically significant ($p < .05$; see Table 3). Open skills had greater scores in color congruent stimuli, color incongruent stimuli, and total Stroop effect, though sustained attention was not statistically significant for this group. The results further indicated that females have significantly higher Stroop color congruent ($M = 35.92, SD = 12.75$) and Stroop-color incongruent stimuli ($M = 11.85, SD = 7.90$) results than males ($M = 26.89, SD = 7.90$ and $M = 7.26, SD = 5.34$, respectively). Hence, there was a significant difference between males and females in terms of attention. Inspecting the significant results of the gender variable, the color congruent (0.002) and color incongruent (0.026) stimuli levels were < 0.05 , suggesting significant statistical differences according to gender. Females had higher selective attention scores in Stroop color congruent ($M = 35.92, SD = 12.75$) and Stroop color incongruent stimuli ($M = 11.85, SD = 7.90$), whereas the mean Stroop color congruent stimuli score for males was 26.89 (SD = 7.90) and the mean Stroop color incongruent stimuli score 7.26 (SD = 5.34). There were no significant differences revealed for sustained attention and total Stroop effect, as their levels of significance were > 0.05 unexplained variance between these variables.

Table (3) Two-way ANOVA (gender and skill type) for sustained attention and Stroop effect

Variables		SS	DF	MS	F	Sig
Skill type	Sustained attention	757.21	2	378.61	1.27	0.295
	Color congruent	2652.45	2	1326.23	49.88	0.000*
	Color incongruent	1018.81	2	509.40	38.11	0.000*
	Stroop effect	383.51	2	191.75	9.29	0.001*
	Sustained attention	559.46	1	559.46	1.87	0.180
Gender	Color congruent	301.13	1	301.13	11.33	0.002*
	Color incongruent	72.58	1	72.58	5.43	0.026*
	Stroop effect	78.04	1	78.04	3.78	0.060
	Sustained attention	10156.07	34	298.71		
Error	Color congruent	904.01	34	26.59		
	Color incongruent	454.47	34	13.37		
	Stroop effect	701.64	34	20.64		
	Sustained attention	19286.98	39			
Total	Color congruent	4291.78	39			
	Color incongruent	1675.50	39			
	Stroop effect	1260.78	39			

Table (4) Means and standard deviations for sustained attention and Stroop effect according to skill type

Variables	Open-skills Athletes		Closed-skills Athletes		Non-athletes	
	M	SD	M	SD	M	SD
	Sustained attention	158.30	23.40	161.70	22.29	157.80
Color congruent	37.85	8.84	21.70	3.16	21.90	3.96
Color incongruent	13.80	5.64	3.60	1.58	3.80	1.75
Stroop effect	24.05	6.49	18.10	2.08	18.10	2.73

Table (5) Difference in sources using the LSD post-hoc test for the Stroop effect according to skill type

Variables	Skill Types	Means	Open-skills Athletes	Closed-skills Athletes	Non-athletes
Color congruent	Open skills	37.85	-	0.000	0.000
	Closed skills	21.70	-	-	-
	Non-athlete	21.90	-	-	-
Color incongruent	Open skills	13.80	-	0.000	0.000
	Closed skills	3.60	-	-	-
	Non-athlete	3.80	-	-	-
Stoop effect	Open skills	24.05	-	0.003	0.005
	Closed skills	18.10	-	-	-
	Non-athlete	18.10	-	-	-

The LSD post-hoc results specified differences in location according to the skill type variable in the Stroop effect test. Concerning the color congruent stimuli, color incongruent stimuli, and Stroop effect results, the observed differences fell between open skills and the other two types such that the differences were in favor of open skills based on its greater mean.

Table (6) Means and standard deviations for sustained attention and Stroop effect according to gender

Variables	Male		Female	
	M	SD	M	SD
Sustained attention	158.07	19.82	161.00	27.39
Color congruent	26.89	7.90	35.92	12.75
Color incongruent	7.26	5.34	11.85	7.90
Stoop effect	19.63	4.32	24.08	7.09

The LSD post-hoc results for the Stroop effect according to gender indicated that females reported greater mean values compared to males.

Table (7) Difference specification using the LSD post-hoc test for the Stroop effect according to gender

Variables	Gender	M	Male	Female
Color congruent	Males	26.89	-	0.002
	Females	35.92	-	-
Color incongruent	Males	7.26	-	0.026
	Females	11.85	-	-

The last column in the table declares that the related mean differences were statistically significant at < 0.05.

Table (8) Two-way ANOVA (gender and skill type) for interaction between gender and skill type in sustained attention and Stroop effect

	Attention Type	SS	DF	MS	S	SIG
Skill type *	Sustained attention	8954.17	2	4477.09	14.99	0.000*
Gender	Color congruent	231.36	2	115.68	4.35	0.021*
	Color incongruent	59.13	2	29.56	2.21	0.125
	Stoop effect	56.58	2	28.29	1.37	0.268
	Sustained attention	10156.07	34	298.71		
Error	Color congruent	904.01	34	26.59		
	Color incongruent	454.47	34	13.37		
	Stoop effect	701.64	34	20.64		
	Sustained attention	19286.98	39			
Total	Color congruent	4291.78	39			
	Color incongruent	1675.50	39			
	Stoop effect	1260.78	39			

The results in Table (8) indicate differences in the interactions between skill type and gender, revealing that sustained attention and color congruent stimuli scores reflected significant differences (0.000 and 0.021, respectively).

Table (9) Different sources using the LSD post-hoc test for the Stroop effect according to gender

Variables	Skill Type	Gender	Sig
Sustained attention	Open skills	Males 146.85 Females 179.57	.000
	Closed skills	Males 174.00 Females 133.00	.002
Color congruent	Non-athlete	Males 163.00 Females 145.67	.155
	Open skills	Males 33.31 Females 37.85	.000
	Closed skills	Males 21.29 Females 22.67	.700
	Non-athlete	Males 20.57 Females 25.00	.222

Table (9) explains how the skill type variable interacted with the gender variable over the sustained attention and color congruent stimuli variables. In sustained attention, the observed differences fell between males and females such that females recorded greater means in open skills and that males recorded greater means in closed skills. For the color congruent stimuli variable, the significant values in Table (9)'s last column indicate that there was one difference between males and females in the open skill type such that females reported a greater mean.

Discussion

The aim of the current research was to investigate the effects of skill type (open and closed) and gender on different types of attention (selective and sustained), and to determine the interactive effects of skill type and gender on attention type. The results illustrate that both open- and closed-skills athletes recorded greater scores (Gu et al., 2019; Crova et al., 2014; Hötting & Röder, 2013; Schmidt, Jager, Egger, Roebbers, & Conzelmann, 2015; Westerterp, 2013; Becker, McClelland, Geldhof, Gunter, & MacDonald, 2018) suggested that the cognitive benefits of open versus closed skills may vary across the developmental period and influence brain maturation. Previous studies have further determined that open-skills participants show greater cognitive flexibility, such as in information processing speed and working memory, than those who perform closed skills (Di Russo et al., 2010; Gu et al., 2019; Hung et al., 2018; Tsai, Pan, Chen, & Tseng, 2017).

The current results revealed that the open-skills participants recorded higher scores in selective attention (Stroop effect), which indicated that their abilities to attend to some stimuli while disregarding others that are irrelevant to the task at hand were high, as open skills are performed in an environment that is unpredictable or in motion and involves the rapid relocation of learners' attention to different environmental aspects, such as changes in walking speed and cognition (Hassan et al., 2014).

Regarding sustained attention, the closed-skills participants (gymnasts) yielded higher scores, as the researcher understood that they could maintain concentration on a task over an extended period of time more proficiently. According to these results, elite closed-skills athletes use sustained attention to concentrate on the skill components, as closed skills are trained in a set pattern that needs less cognitive guidance to accomplish a challenging goal or coordinate the body to execute complex movements (Di Russo et al., 2010; Gu et al., 2019; Tsai et al., 2017).

The present results were similar to previous work in this field with regard to gender differences. The current study found a significant difference between males and females in terms of selective attention, with females having significantly higher Stroop color congruent stimuli and Stroop color incongruent stimuli results than males. A study cited by Lee et al. (2012) found that males performed generally faster in selective attention. Other studies using Stroop effect tasks reported that women showed less interference than men in these tasks (Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2006). In contrast, Christakou et al. (2009) did not observe gender differences in selective attention.

Furthermore, there was indeed an interactive effect between skill type and gender in the current study. The researcher observed a significant difference between males and females in terms of sustained attention with regard to skill type. Specifically, females with open skills recorded higher scores in sustained attention, whereas males with closed skills recorded higher scores in sustained attention (see Figure 1). On the other hand, concerning the selective attention results of color congruent stimuli, color incongruent stimuli, and overall Stroop effect, the observed differences fell between gender and selective attention such that the differences were in favor of females with open skills (see Figure 2).

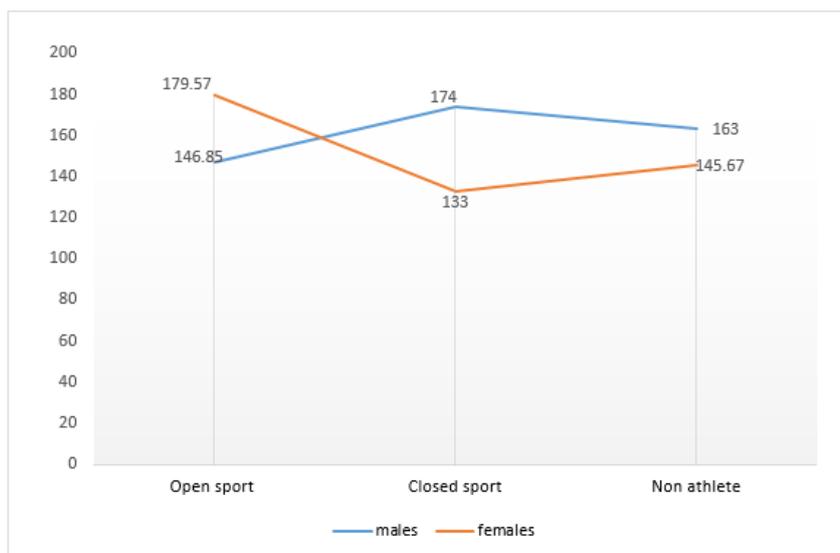


Figure 1: Sustained attention according to gender and skill type

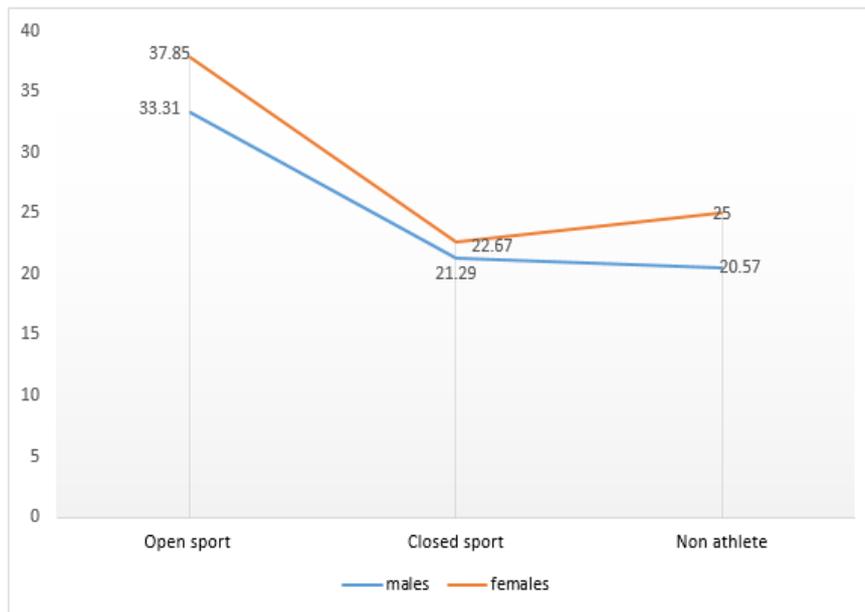


Figure 2: Interactive effect of skill type and gender on selective attention (Stroop effect)

Conclusion

In summary, the current study's results have provided evidence of the positive impact of exercise on cognition, as the athlete participants with both open and closed skills showed greater scores in different attention types (selective and sustained). It could be concluded that both the skill type and gender variables show a significant effect on the different attention types. The open-skills athlete participants yielded greater scores in selective attention (Stroop effect) with favor to females. Meanwhile, the closed-skills athletes had higher scores in sustained attention with favor to males.

A deep understanding about the effects of motor skills training in terms of outcomes and based on the current literature shows that movement skills are influenced by individuals, tasks, and environmental factors. Understanding different types of skills and attention helps analyze and improve athletes' cognition and performance level. Coaches, athletes, and practitioners could prescribe general attention type principles with regard to motor skill training approaches to help athletes achieve peak performance. Lastly, future research should concentrate further on the effects of skill type (open and closed) and measure different aspects of cognition using larger sample sizes and different open skills, such as those in soccer, karate, football, basketball, and baseball, or in closed skills, such as in swimming and golf.

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