Frontal Lobe Function in Chess Players

Majid Nejati[1] and Vahid Nejati[2]

[1] *Department of Anatomical Sciences Research Center, Kashan Univercity of Medical Sciences, Kashan, Iran*
[2] *Department of Cognitive Science, Shahid Beheshti University, Tehran, Iran*

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Abstract- Chess is considered as a cognitive game because of severe engagement of the mental resources during playing. The purpose of this study is evaluation of frontal lobe function of chess players with matched non-players. Wisconsin Card Sorting Test (WCST) data showed no difference between the player and non-player groups in preservation error and completed categories but surprisingly showed significantly lower grade of the player group in correct response. Our data reveal that chess players don't have any preference in any stage of Stroop test. Chess players don't have any preference in selective attention, inhibition and executive cognitive function. Chess players' have lower shifting abilities than non-players.

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Introduction

Chess is considered as a complex game with intellectual demand. Some researchers believe that there is correlation between chess success and intelligence (1-4). In contrast other researchers have failed to connect success at chess with any intellectual ability (5,6). Besides general intelligence in cognitive perspective, chess requires a high level of visuospatial ability (2,3) and calculating (7). Chess involves spatial problem solving in which participants often need to control as much space on the chessboard as possible in order to win the game. This requirement might be trained these cognitive functions. However, some researcher state that there is no correlation between chess skill and cognitive function such as memory (8)

Atherton *et al.* examined the neurological basis of chess playing using Positron Emission Tomography (PET) (9). Their results showed that all players displayed activation in the occipital lobe representing the processing of visual stimuli. Furthermore, the chess players displayed involvement of their parietal lobes for possible control of attention and spatial orientation. They concluded that the expert chess players tended to have higher levels of activation in their frontal lobe regions than the novice chess players suggested higher-order reasoning among the expert chess players.

Chen *et al.* in a functional MRI (fMRI) study confirmed this finding in the game of "Go" which is a complex Chinese board similar to chess (10).

In another fMRI study, Krawczyk *et al.* showed that bilateral posterior cingulate, left anterior temporal, left parietal and left orbitofrontal cortex are involved in chess playing(11).

None of the imaging studies in chess players has found activity in the prefrontal areas, especially the dorsolateral prefrontal areas that is involved in executive functions (EF). EF includes cognitive processing involved in goal-directed behavior and the control of complex cognition (12). The term executive function is the synonym with the term frontal lobe function (13-15).

These findings exited us to compare frontal lobe function in chess expertise and matched non-player with neuropsychological tests. If chess players have higher performance in executive functions, chess could be suggested as a game for training cognitive functions and chess players might be trained with cognitive rehabilitation.

Materials and Methods

Subjects

Thirty right-handed expert chess player whom were accepted in final national tournaments of the Iranian chess federation as chess players group, and thirty right-handed without history of chess playing as non players group participated in this study. Both groups were

Corresponding Author: Vahid Nejati
Department of Cognitive Science, Shahid Beheshti University, Tehran, Iran
Tel: +982129902339, Fax: +982129902339, E-mail: nejati@sbu.ac.ir

matched in age and education. None of the subjects were taking psychoactive medication, and they did not report any neurological or psychiatric impairment on a general health questionnaire.

Procedures

Wisconsin Card Sorting Test (WCST) and Stroop Color and Word Interference Test are used for evaluation of frontal lobe function of both groups.

The WCST is a neuropsychological test assumed to be sensitive to frontal lobe damage, (16) especially dorsolateral prefrontal cortex dysfunction (17). It was administered and scored according to Heaton's standardized criteria (16). In summary, subjects were given four stimulus cards with different color, form, and numbers of symbols, in front and were instructed to match 68 response cards with different color, shape, and number combinations to one of the stimulus cards according to a specific criterion (color, form, or number). Subjects were not informed of the criterion, but were told after each trial, whether the match was correct. The criterion was shifted in order of color, form, and number after 10 consecutive correct selections. This procedure was repeated until six criteria were passed. For our purpose, we considered only the total numbers of perseveration and the number of completed categories. These two variables on the WCST are generally the most sensitive to bilateral dorsolateral prefrontal cortex damage (16,18). Perseveration involves the subject sorting the cards consecutively in the same way or repeating the previous principle. The number of completed categories is the number of sorted categories with 10 consecutive correct responses. The Stroop Color-Word Test with three sets of stimuli was employed. Firstly, a set of four color names (e.g., red, green, blue, yellow) with the Same hue (e.g black) was presented on screen and participant should press corresponding colored key on keyboard. Time was registered by program that presented stimuli by milliseconds. In the second stage, a set of four color name, (e.g., red, blue, green, yellow) with own hue was presented and each hue was identified by the participant, who was timed. Third, a set of color words was presented wherein four color word with other hue (e.g., the word RED, was printed in blue; the word GREEN, was printed in yellow) and the color hues should be answered by the participant.

Analysis

Data were analyzed using SPSS16. Independent-Samples t-test was used to compare the findings in case and control groups.

Results

Table 1 shows demographic data of chess player and non-player groups. Table 2 shows findings of study in WCST and Stroop task. For WCST mean and standard deviation of correct response, preservation errors and completed categories in both chess player and non-player are shown in table 2.

Table 1. Demographic data.

	Player Mean (SD) (n=30)	Non-Player Mean (SD) (n=30)
Age (yr)	22.87 ± 3.24	23.37 ± 2.42
Education (yr)	14.06 (2.59)	14.13 (4.21)
Gender (Male- Female)	6M /24 F	4M/26 F

Table 2. WCST and Stroop test findings in chess players and non-players.

Variable	Player Mean (SD) (n=30)	Non-Player Mean (SD) (n=30)	t-Ratio	*P*-value
WCST				
Correct responses	36.97(10.23)	42.93(8.77)	2.42	0.018
Perseverative errors	30(8.83)	11.40(5.53)	1.82	0.073
Completed Categories	3.57(1.3)	4(0.83)	1.15	0.136
Stroop test				
Color	29.70(0.53)	29.30(2.05)	1.03	0.306
Color-word	29.63(0.615)	29.53(1.04)	0.45	0.652
Interference	28.63(2.55)	29.23(1.07)	0.36	0.405

For Stroop test mean and standard deviation of reaction time in color stage, color-word stage and interference stage in both player and non-player are shown. Moreover table 2 contains results of independent sample t-test.

In WCST as a central task of frontal lobe function data showed no difference between the player and non-player groups in preservation error and completed categories but surprisingly show significantly lower grade of the player group in correct response.

Our data reveal that chess players don't have any preference in any stage of the Stroop test.

Discussion

Based on our findings in the Stroop test, chess players don't have any preference in selective attention and inhibition. If we consider chess as a cognitive game that engaged attention, chess players should have more capabilities in neuropsychological tests.

Most attention process training programs are based on the notion that attentional abilities can be improved by providing opportunities for stimulating a particular aspect of attention. These aspects of attention depend upon the model of attention that drives a particular program. Training usually involves having users engage in a series of repetitive drills or exercises that are designed to provide opportunities for practice on tasks with increasing attentional demands. Repeated activation and stimulation of attentional systems are hypothesized to facilitate changes in cognitive capacity. For these reasons, the present study claim, that chess did not involve executive function.

Our data are confirmed by fMRI study of Atherton *et al.* that showed the paucity of activation in the frontal lobes in chess player during playing (19). They found the same lack of frontal activations in Go game.

The researchers found that, the areas of activation associated with the game condition were similar in both chess and Go, with bilateral activation of the parietal and the occipital lobes. In general, these are areas engaged in spatial perception, imagery and mental rotation. Compared with these robust findings, activation in the frontal lobes was scattered and inconsistent, and did not involve the lateral prefrontal 'intelligence area' to any significant extent, suggesting that both games primarily involve spatial cognition, rather than logical and computational skills (10).

Our findings are confirmed by other researchers in other cognitive domains. Waters *et al.* found no association between chess skill and the Shape Memory test, as a measure of visual memory ability (8). Similarly, Grabner *et al.* found no association between chess rating and intelligence (20). In another study (5), found no association between chess skill and the scores on the Raven's Progressive Matrices, Digit Span, and Corsi block-tapping test in chess players.

In contrast, Gobet *et al.* stated in their article that they were not aware of a single study that has shown that more skilled chess players outperform less-skilled chess players on any psychometric test (21). Some of the studies in this matter testing chess player with general intelligence tests and report different finding. As a sample Frydman and Lynn tested 33 child tournament players with the Wechsler Intelligence Scale for Children (WISC), and reported that scores significantly above average for general intelligence (mean IQ=121) and the performance IQ (mean IQ=129) but not for verbal intelligence (mean IQ=109), and concluded that high-level chess playing requires a good general intelligence and strong visuospatial abilities (22). Bilalic *et al.* highlights this unambiguous association between intelligence and chess skill (23). They show that when consider whole samples of children, some of whom had just recently started to play chess, found a moderately positive correlation between intelligence and chess skill. However, when they examined the role of intelligence among highly skilled young chess players found not only the same absence of the association between intelligence and chess skill but also that smarter children had actually achieved a lower level of chess skill. This unexpected negative association between intelligence and chess skill is partly the consequence of the different chess skill measures used for the whole sample, and the elite sub sample.

Our finding in WCST confirms this finding so that non-player had a higher grade in correct response. Chess is a game with fixed rule, and player should consider and obey this rule in all situations of playing. This factor does not match with mental flexibility that is evaluated by WCST as a main function of frontal lobe.

This finding can be discussed in problem of experts in chess. An expert chess player can play several games simultaneously without sight of the boards. However, paradoxically, it has been argued that experts may fail on problems that novices solve. When a novel approach is required, the experts' knowledge can make them unable to adapt to the new task demands. This can be summarized as inflexibility of experts (24).

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