

## THE IMPACT OF COMPUTER ACTION GAMES ON THE COGNITIVE SYSTEM: A SHORT REVIEW

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**Abstract:** *The aim of this review is showing the impact of playing computer action games on the cognitive processes- mostly on attention. Firstly, we described results from behavioral research indicating that the influence of playing computer games on attention, working memory, short-term memory or cognitive flexibility is not consistent. Secondly, results checking the impact of training connected with computer action games on event-related potentials (such as: N1, P1, P2, P3) are mentioned. Additionally, we present longitudinal studies carried out to investigate the persistence of computer action game training on cognitive abilities. Finally, we give some critical view of factors such as: playing experience, kind of game, participants' sex and motivation which can affect the result of mentioned studies.*

**Keywords:** *action computer game, cognitive functions*

### 1. Introduction

The intensive development of new technologies has contributed to the fact that the computer has become part of human life and entertainment tool. More and more people spend their free time not only using the Internet or social networking capabilities, but also playing various games. Some of them are action games in which a person takes the role of a virtual character whose task is mostly to kill as many enemies as possible. However, hours of gaming are not without consequences for the player. It should be noted that 58% of the U.S. population plays video games, and the amount of players in the period from 2009 to 2011 increased by 241% (*The 2013 Essential Facts About the Computer and Video Game Industry, Trends in Digital Gaming: Free-to-Play, Social and Mobile Games*). In addition, 41% of players believe that computer games are more valuable than music or cinema. Besides 43.5% of the best-selling game console in 2012, are games of action and "shooters" (*The 2013 Essential Facts About the Computer and Video Game Industry*).

This new phenomenon, which replaces the earlier forms of entertainment, is the subject of many studies in psychology from the 80-ies of the XX century. In most of them the negative consequences for the social and emotional functioning of the individual are shown. However, research in the field of cognitive processes can show the positive effects of action computer games. After the Green's and Bavelier's article in Nature in 2003, there were established more and more studies on this subject [1].

### 2. Behavioral research

Most research on computer players focused on finding differences between players (*VGPs - video-games players*), and those who do not play at all in the games or who play occasionally (*NVGPs - non-video-games players*) and play in the other game types (e.g., *RPG - role playing games*).

The differences between these groups were sought in a variety of cognitive processes and using different research paradigms [1, 2]. It was noted that VGPs have a greater

range of visual attention than NVGPs in the study using the functional field of view task. In addition, researchers using attentional blink task paradigm demonstrated that VGPs have a greater ability to information processing over time than NVGPs [1]. Additionally, differences in the spatial attention and working memory using enumeration task paradigm were found [1, 3]. It should be mentioned however that other studies did not confirm these results [4,5]. Researchers have shown also differences between VGPs and NVGPs for visual short-term memory [4], working memory [6], visual searching [7, 8], attention switching [4, 9-12], and cognitive flexibility [13]. It was observed that the experience of action games can improve top-down control of attention processes (top-down), and may also modulate the negative effect of bottom-up attentional capture [14, 15]. However, there are discrepancies whether computer action games also have an impact on these processes [16]. In addition, the researchers also postulate that VGPs and NVGPs have similar control mechanisms of visual attention, but VGPs have a better ability to scan the field of view, which leads to a faster response in experimental tasks [7].

The studies mentioned above show that there are many differences between the two groups in cognitive processes and functions. Researchers often show the positive effects of playing computer action games. However, the results are not conclusive. Some studies indicate their existence [1-3], while in others, using an analogous paradigm those effects are not observed [4]. In addition, most research oscillates around the differences between VGPs and NVGPs focusing on different cognitive functions which are verified in different research paradigms [see 1-4, 7-11, 14, 15]. Moreover, within the same paradigm, the researchers use different test procedures [see 4, 9, 11].

In addition to the investigation of the differences between VGPs and NVGPs, researchers wondered about the consequences of action games training – its impact on cognitive abilities and transfer these abilities to other tasks [17-19]. Studies were conducted in the corresponding paradigms as the research on VGPs and NVGPs [see 1-4,

11, 12]. For example, subjects (who have no experience in action games) after the training consisting of daily playing action games (e.g., *Metal of Honor: Pacific Assault*) revealed an increase in the accuracy and response time for tasks of recognizing the spatial and temporal aspects of attention [1-3, 11]. However, other studies using analogous procedure did not confirm these results [4]. In addition, the researchers observed differences in the results of training depending on the strategy type [20]. In this case, the differences were only in the three of twelve cognitive tasks used in the study. This study indicates that action games training improves cognitive functions, especially functions corresponding with attention. However, as in the case of investigation of the differences between VGPs and NVGPs, the results are inconclusive and require further verification.

## 2. Psychophysiological research

Previous studies have used behavioral indicators of differences between VGPs and NVGPs and differences between the state before and after the training based on the action computer game. These researches have used indicators such as reaction time, correctness answer, etc. However, the development of science and technology resulted in the use of eyetracking and EEG methods for exploration of the impact of computer action games on cognitive processes. [15, 21-24].

First of all, the psychophysiological studies showed an increase in the P3 component amplitude after action games training [23]. There was also a difference for the component amplitude between VGPs and NVGPs [21]. In addition, the P2 component revealed a similar dependency as the P3 component in the research using action games training. However, there were no changes in amplitudes of the P1 and N1 components and the latency of P2 or P3 component [23].

In this regard, it is considered the P1 and N1 components may be associated with the activity of neurons in the extrastriate pathway, which is associated with the area V1. Therefore, these components can be psychophysiological correlates of early visual information analysis [25]. Moreover, even if the amplitude of these two components may be modulated by selective attention, their character is mainly exogenous [26]. These results confirm the behavioral studies observations [see 14].

It was also observed that those who undergo action games training, despite the lack of differences in the accuracy of the task, differ with respect to the amplitude of the P2 and P3 components [23]. The increase in the P2 amplitude may reflect an adaptation to the requirements of the task for the selection and control of attention [27]. However, the component P2 can also be associated with distinctness stimulus [28]. These studies confirm previous behavioral results showing the impact of training on improvement of cognitive functions in a top-down process. On the other hand, the results show the ambiguity and possible other interpretations.

The P3 component is considered as an indicator of the allocation of attentional resources [29] This interpretation would suggest that the action game training gives greater

ability to allocate these resources in order to solve task [23]. The increase in the amplitude of this component was observed for the inhibition ability of the distractors impact [29]. Other research paradigms confirmed these observations. Greater inhibitory effect of distractors - in a situation of irrelevant stimuli exposure, caused greater suppression of the SSVEP amplitude in the group of VGPs than NVGPs [21]. In addition, in studies using fMRI less activation of visual motion-sensitive middle temporal area / medial superior temporal area was observed only for VGPs in the task with distractors [30]. However, research connected with The Dual Mechanisms of Cognitive Control Theory [31] indicated a negative relationship between the experience of playing action computer games and proactive control [32].

These findings are consistent with previous behavioral results and suggest better filtering of on the early stages of information selection by VGPs than NVGPs. However, it is difficult to formulate definite conclusions. There is little research on psychophysiological correlates of cognitive processes connected with playing computer action games. In addition, the use of different research paradigms significantly hinders the ability to compare these results. However, the results of experiments show that the differences between VGPs and NVGPs are associated with top-down cognitive processes. A similar relationship can be observed in researches on action games training. In both research streams exposes a greater ability to inhibit the effect of distractors, which may be associated with a higher allocation of attention resources in VGPs and subjects after the action game training. However, the deterioration of proactive control in VGPs [32] may be associated with top-down processes. The results are in contradiction with previously studies. This suggests that the issue of cognitive mechanisms connected with computer action games should be future explored.

## 3. Longitudinal research

As it was shown, playing computer action games contributes to the improvement of cognitive abilities. However, a significant question is whether this improvement maintains at a time or changes. Feng, Spence and Pratt [33] observed that ten-hour computer action game-based training results in better execution of correctness task and this effect mentions for five months. Other studies confirmed above results [34].

In addition, it was observed that the strengthening of contrast sensitivity function remained even over a year after completing the action computer game training [35]. It should be noted that these conclusions [33, 34] are based only on the results of the correctness task and do not include other measures, such as speed of response or psychophysiological response. In addition, there are some uncertainties which can affect the results. In the study by Feng, Spence and Pratt [33] the two men from the experimental group continued to playing in computer action games in the period from the end of training to the test time 5 months later [33]. Moreover, in the case of one woman there was a decrease of accuracy of 14% [34]. In addition, participants were playing up to 4h/month in other

types of games in the last 3 years, which also may have influenced the results [34].

On the other hand the studies by Li et al. [35] considering differences between the measurement of after a training session and after the adjournment, reported an decrease in accuracy of the task execution by 15%, but the result was still significantly higher than in a situation before training [35]. However, in both experimental and control group, postponement ranged from about five months to two years. Therefore, it is difficult to determine whether after a break of more than five months the results would still be clearly higher than before training. The effect of action game-based training may persist over several months afterwards. It should be therefore mentioned that this effect has been shown only in the paradigm of functional field of view task for correctness of the task.

An important question still remains whether the observed persistence of the effects of training also applies to other cognitive processes than just associated with the expansion of the field of view. An important issue to be resolved is the question of what is the base of the observed effect. In addition, we should consider the impact of memory and cognitive control on the results.

#### 4. Critical comments

Because of the various research paradigms and different procedures the interpretation and comparison of the results poses some problems. The text below highlights a few more differences between the studies, which can explain differences in the results obtained.

Firstly, the disparity in the results can be caused inter alia by heterogeneity of the group of subjects. The minimum experience in playing action games ranges from about 3-5 hours / week for 6 months [1-3, 11, 15] to 7h/week for two years [4]. In addition, NVGPs are considered as those who did not have any experience with action games or the experience was minimal. Moreover, in the case of training, the time ranged from 10 hours [see 1-3, 21] by 21.5 hours [4] and ending with 50 hours [see 11]. These differences hinder a clear interpretation of the results, in particular for assessing the impact of action games training on cognitive function.

Secondly, VGPs are considered as players playing action games with both first and third-person perspective (e.g., *Auto 3*, *Halo*, *Counter-Strike (CS)*, *Crazy Taxi*, *Rogue Spear*) [1-4, 11] or as players playing games only with first-person perspective [5, 6, 13, 24]. In addition, in the case of training different types of action games were used [see 1-4, 11, 22]. This inconsistency may be important, because other studies suggest different brain activity during the playing action games using avatar first-person view, compared with the third-person view [36]. Moreover, the difference in brain activity during passive situations, associated with a lack of movement, and the situation when the character moved has been observed [36]. To sum up, omitting the importance of the game type may contribute to different results despite of using similar research paradigms.

Thirdly, most of the subjects in the study of differences between VGPs and NVGPs were male. However, in the

studies focused on the impact of training gender was balanced [1-3] or women were the majority of the respondents [4]. In this regard, Feng, Spence and Pratt noted that women achieve greater benefit from the workouts in the functional field of view task and the mental rotation tasks than men [33]. It should be noted that these differences may hinder comparisons between disparate studies, and thus also their unique interpretation. However, studies on the same group have shown a similar procedure, the lack of gender differences in the accuracy of before and after training based action games [34]. This suggests the issue of gender differences is still unclear in studies of the impact of computer action games on cognitive system.

Finally, it should be indicated that VGPs may be more motivated to complete a task than NVGPs. The experience in action games may give more motivation to achieve better results. What is more VGPs may have knowledge about the positive impact of games on cognitive performance because of their playing experience [37].

Problems and methodological errors described above may contribute to the difficulty of comparing results from different studies. Similarly, analyzing the impact of video-games-based exercise on the functions and cognitive processes, in particular, the attention should be paid to the possibility of subsequent draw firm conclusions from the conducted research. Without strict testing procedure it is difficult or even impossible.

We can find some ambiguities in studies of cognitive processes connected with playing action computer games which should be an area of further exploration. In addition, an issue that requires an examination is the problem of persistence of the effect of training on the functions and cognitive processes [see 1-4, 11, 23].

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