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The impact of playing video games on the attention function in middle adolescence

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Dictionary:

Cognitive performance – is associated with the development and enhancement of fundamental cognitive process. Performance is defined as the organism's ability to execute and organize specific activities. In this article, cognitive performance is conceptualized as a multidimensional construct that describes the organism's capacity to achieve learning objectives and solve problem by optimally utilizing mental resources [59, 60].
Generation Z – refers to individuals born approximately between the mid-to-late 1990s and the early 2010s, characterized by growing up in a highly digitalized world [1, 2].

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Abstract:

Background and Study Aim: Recent studies indicate that playing video games is currently one of the most popular interests and passions among young people around the world. In addition, modern researchers have emphasized the wide range of effects of this activity specifically on the efficiency of attentional processes. Current empirical data are often subject to many limitations. The cognitive goal of this research is knowledge on the impact of video games (in terms of type and frequency of use) on the efficiency of attention processes among representatives of Generation Z.

Material and Methods: Cross-sectional data were collected on a homogeneous group of secondary school students aged 14-16 years (n = 121; M = 15). There were 3 groups based on the declaration and frequency of playing video games: those who play regularly, sporadically and the group of people who do not play. Psychometric computer tools (SDP – system) and traditional tools (Children's Color Trails Test) were used.

Results: The results were statistically different. Adolescents who played video games regularly or sporadically performed better on tests measuring attention compared to schoolchildren who did not play video games. Higher scores were also achieved by students playing strategy, sports and action video games.

Conclusions: Playing a type of video game along with a specific frequency helps to improve the efficiency of the attention function. The current findings, indicating that not only the frequency but also the type of video games chosen (strategic, sport and action games) support cognitive performance among youth, shed new light on the possibilities of using video games, including cognitive training.

Keywords: cognitive performance, Generation Z, education

1. Introduction

Today's youth, among their most popular interests and passions, classifies playing video games in the second position, directly after sports. This activity is ahead of fields such as art, music, watching TV, or relaxing. In this aspect, there is a noticeable difference between Generation Z and the so-called Millennials – Generation Y [1, 2]. This seems reasonable, as playing video games is much more important for the younger generation [3]. Due to the ubiquity of smartphones, the availability of video games has become unlimited, making this activity an integral part of young people's lives. Representatives of Generation Z are people who feel the constant temptation to constantly access information, and they can turn on their portable smartphone or desktop computer more than fifty times a day [4]. An analysis of the current literature indicates a growing recognition of the potential of video games as a tool for influencing cognitive performance [5-7]. Nevertheless, these studies are still conducted by a small group of researchers and often focus on the risks of video games or their potential benefits, neglecting a comprehensive analysis [8-11].

Paraphrasing R. Bergonse [12], it can be stated, that *a video game is a type of interaction between the player and the apparatus with an audiovisual system and possibly other players, which is significantly mediated by a fictional context and which is sustained by the player's emotional attachment to the results of his actions*. This interaction has a wide area of impact on cognitive processes, including the elementary function, i.e. attention. This is indicated by studies showing differences between groups of people who play and do not play video games [13].

The modern classification of video games is characterized by the redundancy of genres in relation to what is necessary. Currently, there are dozens of specialized types of games, which are divided according to the form of temporary gameplay, the degree of imitation of the real world or the subject matter itself. Regardless of the genre, each of the games can directly or indirectly affect the efficiency of the attention processes of adolescents in late adolescence [14].

Adolescence is an important transition stage between childhood and adulthood, in terms of many developmental changes. In the 'period of second birth', as the state of adolescence is commonly described, we distinguish between the early and late phases. In the first stage, biological development predominates, while in the second stage, social competence prevails. Adolescence is described as one of the most difficult stages in a young person's life. Development involves changes in his psyche that have a huge impact on his future social life. It is during this period that a young person learns, how to to direct their attention and orient themselves in time and space [15-18].

Previous research in the area of cognitive development under the influence of video games has focused on a dichotomous approach: determining the negative effects of games as well as using positive effects for various practical benefits [19, 20]. The discussion about the impact of video games on cognitive functioning should not be reduced to just two attitudes, including only the good and the bad. This is supported by recent research findings on the relationship between video game play and cognitive performance [9, 21].

The efficiency of cognitive processes in the context of the use of video games is a significant and broad research area, which is why the adopted concept covers only the process of functioning of attention in adolescents of a similar age playing video games. The authors of the study tried to answer the question about the differences in the

cognitive functioning of adolescents playing video games in terms of attention, taking into account both the frequency of playing and the type of video game used by the respondents.

The Role and Importance of Attention Function Efficiency

According to E. Nęcka et al. [22] *Cognition is the ability of humans and other species to receive information from their environment and process it in order to effectively control their own actions, as well as to better adapt to environmental conditions.* Brain activities that are helpful in processing information are collectively called the mind. The process of cognition involves perception, imagination, attention, memory, and thinking [23-26]. Efficient cognitive functioning is synonymous with the optimal use of elementary cognitive processes, i.e. attention, perception, memory and cognitive control [22].

The adopted area of own research focused on the issue of the function of attention, which is a mechanism not only responsible for the selection of stimuli, but also determining the effectiveness of action in conditions requiring the performance of several activities at the same time [24]. The meaning and essence of the function of attention is selection, which is the choice of one object of perception as a topic of thought or a source of stimulation. In addition, the selection used by attention is concerned with perception, as well as advanced cognitive processes such as thinking. Thanks to attention choices, we can focus on the sensory stage, on the stimulus that is crucial for us in a given situation [27, 28].

It should be assumed that the efficiency of the attention function is the ability of the organism to perform and organize specific activities related to the selection of incoming stimuli. Efficient attention contributes to more effective control of one's own actions and adaptation to the conditions of the surrounding world. This is important, for example, for the learning process, because it is based on a series of operations, such as information recognition, information recall, and automation of activities [22, 29].

Attention function and video games

An efficient attention function means greater cognitive flexibility and more effective learning. Some studies to date suggest that playing video games helps improve the efficiency of attention control. In processes related to, for example, faster assimilation of material, an important role is played by increased attention control, exercised by accelerating the signal flow, while reducing noise and distractors [30].

Sattar et al. [9] conducted a study using *The Cognitive-Style Inventory* [31] and *Learning-Style Inventory* [32] on a group of 80 adolescents aged 15-17 years (M = 15.6) who were divided into two groups: those who played video games regularly (n = 40) and those who did not play regularly (n = 40). Studies have shown that participants who played video games regularly had significantly higher attention performance ($p = 0.000$).

The main limitation of the study was that the respondents' answers were included in a questionnaire, which is prone to many errors related to the standardization of the research procedure and burdens such as social desire. Secondly, the groups were divided into gamers and non-gamers, omitting categories such as casual gamers, non-gamers but past gamers, and problem users. In addition, too few psychometric tools were used – only one questionnaire [9].

Another study was conducted on 171 Pakistani students of both sexes between the ages of 15 and 23 (M = 18.9) using an online questionnaire. Participants were divided into two groups: 93 video game players (at least 2 hours per day) and 78 non-video game players (less than 2 hours per day). On the basis of the results obtained, it was found that the players show better results primarily in tasks related to attention span, processing speed, deductive reasoning and mathematical intelligence. The main disadvantage of the research was that it was conducted remotely. Therefore, their standardization is questionable, and the psychometric tool used has not been described in detail [33].

Interesting research was conducted using the 21-item *Gaming Addiction Scale for Children – GASC* [34] and the 36-item *Children's Memory Questionnaire CMQ* [35], which looked at the relationship between game use and cognitive abilities (mainly memory and attention). A study of 566 children aged 9 to 13 years showed differences in poorer visual attention function, poorer concentration, slower processing capabilities, poorer factual and working memory [8].

The type of video game and the attention function

The latest results of empirical research indicate that the *action video game* genre can be a tool for improving the span of visual attention and the shifting of attention functions, especially the aim of the study [36] was to investigate whether video game genres (*action game, sports and RPG*) can contribute to the improvement of attention function. The study involved 41 people between the ages of 18 and 40, who were divided according to the category of video games they used. Based on the results, it can be concluded that the distribution of visual attention and resource allocation during tasks were better in sports simulations and action video games than in *Multiplayer Online Battle Arena (MOBA)/Role Play Game (RPG)* and other video games. This is in support of previous research [39] suggesting that playing a particular genre of video game (action game) improves attention stores by allowing gamers to better distribute their attention both in space and time.

Another study used the *Attention Network Test (ANT)* [38] among action game players and non-gamers aged 7 to 22 years. The data suggests that action game players of all ages have developed attention skills that allow them to react more quickly to targets and leave additional processing resources.

The importance of the use of a specific genre of video games in relation to particular cognitive functions (including attention functions), in these studies has also been analysed and shown that the act of playing video games improves performance related to attention [39, 13]. Such conclusions are also confirmed by the latest research by Argiles et al. [36].

Video Playing Frequency vs. Attention Function. A study by a team led by S. Sattar [9] showed that participants who played regularly (at least an hour a day) achieved significantly better results in terms of attention function efficiency compared to those who did not play regularly.

Completely different results in the assessment of the impact of video games on cognitive functioning (mainly remarks) were presented by M. Özçetin et al. [40]. The study was conducted on a group of 77 adolescents. Some of them 46 were people who regularly played video games (at least 1 hour a day), the other part was a group of 31 teenagers who played games less often (less than 1 hour a day). Participants were given tests to assess cognitive function, incl. *The Wechsler Intelligence Scale for*

Children [41], *Verbal Fluency Test* [42], *Benton Visual Retention Test* [43] and *The Stroop Color and Word Test* [44]. The results obtained indicate that the difference between the two groups was related to the time spent playing video games. People who played more intensively made more mistakes in tests than those who played sporadically. A group of players reacted faster, but inaccurately. The main limitation of the study was the sample size, as it was cross-sectional, so it was impossible to determine the direction of the relationship between them.

Current Study

There is a lot of research in the literature on the relationship between playing video games and potential cognitive benefits. There is a small number of reliable studies with a relatively small number of methodological errors. If one selects studies on adolescents, in terms of the possible benefits or risks associated with the impact of video games on the performance of attention, there are only a few such experiments. They concern the relationship between video games and attention span and the ability to focus [30].

The study sought to expand on the existing literature by examining differences in cognitive functioning between adolescents who play video games and those who do not, taking into account variables in frequency and type of game used.

A hypothesis has been presented that *adolescents who play video games show higher efficiency of the attention function compared to their peers who do not play games.*

The above hypothesis was determined on the basis of the analysis of the literature on the subject and the results of pilot studies. Based on the aforementioned pilot studies, it was found that the group of people playing video games obtained better results compared to the control group in terms of the efficiency of the attention function. The players reacted more accurately and faster in psychometric tests implemented in computer diagnostic equipment, likewise in the *Simple Coordination Test* (SDP – system). It has been noted that the experience of playing video games and the preferred type of gameplay can be an important determinant of efficient cognitive functioning in terms of attention.

2. Materials and Methods

Pilot research

As part of the preparation of the study on the efficiency of the attention function of adolescents in late adolescence, pilot studies were carried out, the aim of which was to check the psychometric values of the selected research tools in the main study, the appropriate selection of study participants and the determination of the studied variables and their indicators.

A total of 62 people took part in the pilot study. Two research groups were identified: non-gamers and video game players. The research work concerned the diagnosis of the level of cognitive functioning and psychomotor efficiency.

The research was carried out using the *Integrated System of Psychological Diagnosis, abbreviated as SDP system* [48]. As part of the study, 31 people who were partly members of the e-sports section of PWSZ Tarnów and high school students declaring themselves as gamers (including several people declared as e-sports gamers) were surveyed. The majority were boys and men (n = 27), and a minority were girls and women (n = 4), aged between 12 and 33 (M = 20.6 ±6.3). The control group of non-

players consisted of 31 people: boys/men (n = 28), girls/women (n = 3), where the youngest player was 12 years old and the oldest was 32 years old (M = 17.9 ±5.4). The group of non-players was tested in the same way as the group of players.

The collected results (Table 1) were statistically analysed using the IMB SPSS Statistics 27 package. Basic descriptive statistics were performed along with Shapiro-Wolf tests, Student's t-tests for independent samples, and Mann-Whitney U tests. The classic threshold of $\alpha = 0.05$ was considered to be the significance level.

On the basis of the results obtained, it can be concluded that the group of players obtained better results than the control group in the area of the efficiency of attention function and motor skills. The specificity of the correctness, adequacy of the response and the cognitive load constituted an interesting material for analysis. Players reacted faster, and their reactions were usually more accurate, made fewer mistakes, and learned the presented tasks faster.

Five significant statistical differences were noted in the pilot studies. Those in the gaming group often had lower reaction times on tests of memory functioning and hand-eye coordination. For example, the average reaction time in a task measuring simple coordination was lower in the group of players (M = 0.80 s) than in the group of non-gamers or those who played sporadically (M = 0.91 s).

On the basis of pilot studies, it was found that the functioning of attention processes should be enriched with a set of tools, incl. tests for measuring visual attention. The possibility of adding the so-called distractor should be used with a different method, a construction with a higher degree of difficulty. A conclusion was also drawn that it was necessary to add traditional paper-and-pencil tests in order to confirm the accuracy of the computer-based tests used. An important aspect of the conclusions from the pilot studies was the inclusion of people in the study in terms of the characteristics of their playing video games, with particular emphasis on the frequency of playing and the type of preferred game.

Table 1. Results of the Mann-Whitney U tests on individual test tasks measuring cognitive performance in the group of people who played and did not play video games (n = 62).

Variable	**M***	**SD†**	**M**	**SD**	**U‡**	**Z§**	**p-valueII**	**rs**
Number Location Test – Time [s]	6.29	1.62	5.38	1.00	312.5	−2.37	0.018	0.35
Simple coordination test W – Time [s]	0.91	0.13	0.81	0.08	213.0	−3.78	<0.001	0.58
Complex Coordination Test W – Time [s]	6.95	28.59	1.46	0.35	214.5	−3.62	<0.001	0.54
Supplementary Information	**Sporadical gamers (and not playing at all) (n = 31)**	**Sporadical gamers (and not playing at all) (n = 31)**	**Regular games (and very often playing gamers) (n = 31)**	**Regular games (and very often playing gamers) (n = 31)**	**Mann-Whitney's U test result**	**Standardized Value**	**Statistical significance**	**Effect Strength**

M* – medium; SD† – standard deviation; U‡ – Mann-Whitney's U test result; Z§ – Standardized Value; pII – Statistical significance; rs – Effect Strength.

Study Participants

Before the start of the work, about 20 schools from the Małopolskie and Podkarpackie provinces (southern Polish region) were informed about the possibility of conducting the research. General information was provided by telephone, followed by details of the study by e-mail. The request was approved by six public secondary schools. These schools were located in urban-rural and urban communes, in towns with a population ranging from 3,000 to 105,000. The study began in September 2022 and ended in February 2023. The subjects were students aged 14-16 (M = 15, SD = 1.0). In total, there were 121 people, including 60 girls and 61 boys, who were students of the first grade, in three high schools, two technical schools and one vocational school.

Secondary school authorities and parents of students were informed about the objectives of the study. School principals and class teachers received written consent from parents for their daughter or son to participate in the study. This type of document was presented to the student immediately before the examination, with the assistance of the teacher. The research was anonymous and fully voluntary (for those who were interested). Due to the fact that almost all students expressed their willingness to participate, the selection for the study was random. The examinations were carried out on an individual basis, but the teacher on duty (or school counsellor) received information about the standards and structure of the study immediately before the examination.

The students responded to the questions in the survey, which concerned the characteristics of playing video games. Based on the results: the most popular devices that were used as a gaming platform turned out to be a smartphone/mobile device (40.5%) and a PC/desktop computer (39.7%). Some of the users used several media on a daily basis. On the other hand, the majority of the respondents were students declaring themselves to play video games (76.9%). On the other hand, the largest group of gamers were those who had been doing this activity for 5 to 10 years (44.6%). Schoolchildren most often spent up to 1 hour a day (41.3%) or 1 to 4 hours (30.6%) playing digital games. The most popular video game genres were role-playing games (46.3%) and action video games (43.8%). Demographics and detailed characteristics of youth video game play are presented in Table 2.

Table 2. Data describing study participants (n = 121), including video game playing characteristics.

	Number (%)	**Number (%)**
Number of participants	n = 121	n = 121
Girls	60 (49.6)	60 (49.6)
Boys	61 (50.4)	61 (50.4)
Age	Median MIN MAX	15 years old (55.4) 14 years old (22.3) 16 years old (22.3)
How long have you been playing video games?	n = 121 (%)	n = 121 (%)
I don't play and I've never played	9 (7.4)	9 (7.4)
I don't play, but I used to play	19 (15.7)	19 (15.7)
I've been playing for less than 1 year	4 (3.3)	4 (3.3)
I've been playing for 1 to 5 years	35 (28.9)	35 (28.9)
I've been playing for 5 to 10 years	54 (44.6)	54 (44.6)
What do you play video games on?	n = 121 (%)	n = 121 (%)
N/A I don't play video games	22 (18.2)	22 (18.2)
PC/Desktop computer	48 (39.7)	48 (39.7)
Video Game Console	29 (24)	29 (24)

Laptop/Tablet	28 (23.1)	28 (23.1)
Smartphone/ Mobile device	49 (40.5)	49 (40.5)
Video game usage time in hours	n = 121 (%)	n = 121 (%)
I don't play and I've never played	8 (6.6)	8 (6.6)
I don't play, but I used to play	21 (17.4)	21 (17.4)
I play sporadically (up to 1 hour a day)	50 (41.3)	50 (41.3)
I play regularly (1 to 4 hours a day)	37 (30.6)	37 (30.6)
I play a lot (over 4 hours a day)	5 (4.1)	5 (4.1)
Video games duration of use in years	n = 121 (%)	n = 121 (%)
I don't play and I've never played	9 (7.4)	9 (7.4)
I don't play, but I used to play	19 (15.7)	19 (15.7)
I've been playing for less than a year	4 (3.3)	4 (3.3)
I've been playing for 1 to 5 years	35 (28.9)	35 (28.9)
I've been playing for 5-10 years	54 (44,6)	54 (44,6)
Game genre	n = 121 (%)	n = 121 (%)
N/A I don't play video games	27 (22.3)	27 (22.3)
Action video games (e.g., Call of Duty: Warzone; Guitar Hero; Sprinter Cell)	53 (43.8)	53 (43.8)
Adventure (np. Life Is Strange 2)	23 (19)	23 (19)
RPG (np. GTA; World of Warcraft)	56 (46.3)	56 (46.3)
Simulation (np. The Sims)	36 (29.8)	36 (29.8)
Sports (np. FIFA)	47 (38.8)	47 (38.8)
Strategy (e.g. Forge of Empires; Commandos)	27 (22.3)	27 (22.3)
Logical (e.g,. Candy Crash Saga)	12 (9.9)	12 (9.9)
Educational (e.g., Minecraft Education Edition)	39 (32.2)	39 (32.2)

Test Procedure

The tests were carried out on an individual basis, in a sitting position, in favourable and ergonomic working conditions. The diagnosis took place during the lessons, always in the morning, in one of the empty classrooms and took the student about 15-20 minutes on average. The student, assisted by a diagnostician-psychologist, first completed a questionnaire on the characteristics of playing video games, which included information on the preferred medium, the genre of the video game and the frequency of play. The subject then performed a paper-and-pencil psychometric test (*Children's Color Trails Test*) [58], during which the time to complete the task was measured. After completing the sheets, the participant was asked to perform several tests contained in a computer application (SDP system) [48], where, in addition to instructions displayed on the screen, they also received verbal instructions from the researcher. At the end of the event, a short feedback was given on individual achievements (results). The data was recorded in the form of a code, which consisted of the first letters of the first and last name of the examined person and an ordinal number.

Measures

Five research methods were used to assess the efficiency of the attention function: computerized and traditional (paper-and-pencil) form. All participants were tested using SDP system computer tests. Earlier, they filled out their own questionnaire and a traditional paper test. Detailed descriptions of the test methods are presented below, starting with a description of the novel computer system used in the study.

Traditional Paper-and-Pencil Tests: Participant Survey Questionnaire in the form of a single A-4 paper page. The participant had unlimited time to complete it, worked independently, and informed the diagnostician after completion. The content

of the survey concerned, like basic demographic data of the respondent, gaming characteristics (e.g. frequency, choice of media) and the type of preferred gameplay. It was a multiple- and single-choice self-report questionnaire, the contents of which, after completion, were verified in an in-depth interview with a psychologist. In case of any ambiguities or discrepancies, the answers were corrected on an ongoing basis by a psychologist (e.g. it could refer to the type of video game used).

Children's Color Trails Test – CCTT-1 i CCTT-2 [58]. Version for children and teenagers (up to 17 years of age). It is a simple, short eye-motor test, of the paper-and-pencil type. The tool measures the efficiency of attention processes and executive functions. The first part of the test (CTT-1) begins with the instructions on the first page, where the subject is asked to connect a string of numbers as quickly as possible (from 1 to 8, ascending). The subject then turns the paper over to connect the numbers from 1 to 15 in the same way. The second part (CTT-2) also begins with instructions, after which the person performing the task connects a sequence of numbers (from 1 to 8), taking into account the alternation of colours (once yellow, once pink). After completing the instructions, the subject turns the paper over to connect the numbers from 1 to 15 in the same way. The result is interpreted by specifying the time of task completion and the number of mistakes made by the participant. The Polish version of the test is currently under development, but the author of the study has been granted permission by the Testing Laboratory of the Polish Psychological Association to use the CCTT for research purposes.

Computer tests: SDP system (Figure 1) is a device based on an integrated computer system with an executive module for displaying and receiving stimuli (test tasks), used to measure the efficiency of cognitive functioning, psychomotor efficiency and selected personality traits. The device is a patented invention of the Psychotronics Group from Tychy [45]. Its design and functionality can be compared to the popular Vienna Test System [46].

Figure 1. SDP system.

Source: own materials

Line Test – distractor version. A tool used as a method to measure the efficiency of visual attention and perception. It allows you to determine the possibility of selecting perception by concentrating your gaze on the detail of the presented image. It requires a concentration of attention. In addition, a distractor was used to check the subject's reaction to cognitive (external) load. The goal of the test subject was to count the horizontal lines appearing on the screen very close to each other as quickly as

possible, and then, in order to confirm, to press the button specified in the instructions. The task consisted of nine tasks.

Number Localization Test – A tool consisting of two arrays divided into square fields, inside which two-digit numbers are placed. Similar in structure to the popular pencil paper test: Couve's test [47] – measuring attention and perceptiveness. The task was to first memorize the numbers from the first array and then find them as quickly as possible among the numbers on the second board. To do this, the subject changes the position (using the keyboard buttons) of the frame to the field containing the stored number. Concentration and perceptiveness play an essential role in this task. The task ends when the participant finds it of all the designated numbers.

PiM Indicator (Precision and Thinking) – It is the sum of correct answers (reactions) in test tasks for simple and complex coordination, at a forced pace. The results show an overall level of hand-eye coordination, requiring mainly attention function. In the simple coordination test: numbers from 0-9 are randomly shown on the screen for 1 minute, the test subject's task is to select the appropriate key marked with a number that corresponds to the one shown on the monitor screen. In the complex coordination test: one of the characteristics of the test is the ability to test the efficiency of the so-called cognitive inhibition in the test subject. Within 1 minute, stimuli are exposed, which are simple mathematical problems, based on the addition or subtraction of single numbers. The reaction consists in typing the result of the presented action (e.g. 3+4) using the keyboard. The test lasts one minute and is carried out in the so-called forced mode. In both tests, the overall result is the number of correct reactions [48].

Analytical plan of research methods

The data obtained by means of questionnaire surveys were appropriately encoded in a spreadsheet after collecting 121 results from the respondents. The material obtained on the basis of paper-and-pencil tests and psychometric tests included in the SDP computer set - the system was also collected in separate spreadsheets. The obtained records were included in a database, where the students' results in relation to the efficiency of the attention function were taken into account. The whole thing was imported into the database of the statistical program in order to properly encode it, as well as to perform descriptive statistics and normality tests for variables. The next step was to make comparisons and correlation analyses, along with the presentation of percentage distributions and indicators relevant to the research.

The analyses were carried out using the IBM SPSS Statistics 26 package and concerned the explication of data from the SPSS (Statistical Package for Social Sciences) database [49].

IBM SPSS was used to perform the analysis of basic descriptive statistics along with the Kolmogorov-Smirnov test, the Kruskal-Wallis ANOVA test, the Mann-Whitney U test, crosstabs with the chi squared test of independence and the rho Spearman correlation analysis. The significance level (p) in the statistical analysis of the results was considered to be $\alpha = 0.05$.

3. Results

The following are basic descriptive statistics along with the Kolmogorov-Smirnov test. In the first step of the analysis, the dispersions of quantitative variables were checked, hence the calculation of basic descriptive statistics together with the

Kolmogorov-Smirnov test, responsible for checking the normality of the distribution. The results of the analysis are presented in Table 3.

Table 3. Basic statistics on the Kolmogorov-Smirnov test.

Variable	M*	Me†	SD‡	Sk.II	Kurt.ś	Min.**	Maks.§	D††	P‡‡
Line Test – Response Time	8.13	7.76	1.91	0.77	1.17	3.66	15.26	0.10	<0.001
Line Test – Correct Reactions	6.59	7.00	1.96	−0.57	−0.54	2.00	9.00	0.16	<0.001
Number Localization Test – Response Time	6.25	6.21	1.11	0.54	0.25	3.93	9.81	0.07	0.168
PiM Factor – number of points	99.97	98.00	13.14	0.32	−0.14	71.00	135.00	0.07	0.093
CCTT-1 – task execution time (min)	0.19	0.19	0.07	1.68	7.01	0.09	0.56	0.11	<0.001
CCTT-1 – number of mistakes	0.26	0.00	0.46	1.39	0.64	0.00	2.00	0.46	<0.001
CCTT-2 – task execution time (min)	0.37	0.34	0.16	3.35	14.17	0.18	1.28	0.18	<0.001
CCTT-2 – number of mistakes	0.44	0.00	0.66	1.58	2.68	0.00	3.00	0.38	<0.001

M* – medium, Me† – Median, SD‡ – standard deviation, Sk.II – skewness, Kurt.ś – kurtosis, Min.** – minimal score, Maks.§ – maximal score, D†† – medium deviation, p‡‡ – significance level

Interpretation of the distributions of the test results showed that more than half of them deviated significantly from the normal one – the Kolmogorov-Smirnov test turned out to be statistically significant in their case. Therefore, as well as due to the occurrence of outliers, the use of non-parametric tests was justified.

The above summaries of results are presented as an introduction to the attempt to obtain an answer to the research question posed and as a verification of the hypothesis. In the next part, statistical analyses are presented, along with a description, concerning the differences in the functioning of attentional processes that occur in adolescents who play and do not play video games. In order to obtain a full answer to the research question, the discussed cognitive function was compared as two correlations of results in psychometric tests, measuring cognitive performance, with the frequency of playing video games and the genre of the video game used.

The frequency of playing video games and the attention function. Further analysis of the results of the study was aimed at checking whether the level of cognitive functioning of the students in terms of attention efficiency was differentiated by the frequency of playing video games. For this purpose, the Kruskal-Wallis ANOVA test (Table 4) was performed for dependent variables whose measurement level was at least ordinal. The data obtained from this area are presented in Table 4.

Table 4. Results of the Kruskall-Wallis test, which compares the level of attention function performance among adolescents depending on the frequency of playing video games

Dependent variable	Choice option	Medium rank	Mdn*	IQR†	H(2) ‡	P§	η² II
Line Test (+Distractor) – Reaction Time	1ś	79.31 a. b	8.65	2.56	11.09	11.09	11.09
	2**	52.43 a	7.40	2.18			
	3††	58.56 b	7.68	2.36			
Number Localization Test – Response Time	1	78.41 a. b	6.70	1.47	9.82	9.82	9.82
	2	57.68 a	6.09	1.80			
	3	52.923 b	5.96	1.32			
PiM Indicator – number of points	1	43.26 a. b	93.00	12.00	9.80	9.80	9.80
	2	66.00 a	102.00	19.25			
	3	67.30 b	100.50	16.00			
CTT-1 – task execution time (min)	1	67.88	0.21	0.08	2.19	2.19	2.19
	2	61.66	0.19	0.09			
	3	55.46	0.17	0.09			
CTT-1 – number of mistakes	1	68.76	0.00	1.00	3.47	3.47	3,47
	2	59.50	0.00	0.00			
	3	57.43	0.00	0.00			
CTT-2 – task execution time (min)	1	76.03 a	0.39	0.15	7.28	7.28	7.28
	2	57.96	0.33	0.11			
	3	54.24 a	0.33	0.10			
CTT-2 – number of mistakes	1	54.72	0.00	1.00	1.75	1.75	1.75
	2	63.55	0.00	1.00			
	3	62.30	0.00	1.00			

Mdn* – median, IQR† – interquartile range, H(2)‡ – independence test, P§ – statistical significance, η²II – effect strength, 1ś – I don't play, 2** – I play sporadically, 3†† – I play regularly

The analysis of the obtained data showed statistically significant differences between the studied groups in terms of the adopted indicators i.e. *PiM indicator* – number of points, line test (+distractor) – response time, *Number Localization Test* – response time. The calculated value of the strength of the eta squared effect (η^2) indicates that the obtained differences were moderately strong in the cases of psychometric test results.

In order to obtain an answer as to which of the study results differ statistically significantly, post-hoc tests (Dunn-Bonferroni pair comparison tests) were performed, the contents of which are presented in Table 5.

Table 5. Results of Dunn-Bonferroni pair comparisons for dimensions of cognitive functioning of students' attention function, due to the frequency of playing video games.

Dependent variable			
Test type	**Pairs compared**	**Test statistics**	**Corrected significance**
Line test (+distractor) – response time	I play sporadically-I play regularly	−6.13	1
	I play sporadically-I don't play	26.88	0.003
	I play regularly-I don't play	20.751	0.043

Number localization test – response time	I play regularly-I play sporadically	4.751	1
	I play regularly-I don't play	25.485	0.008
	I play sporadically-I don't play	20.734	0.034
Simple coordination test – response time	I play sporadically-I play regularly	−0.747	1
	I play sporadically-I don't play	23.493	0.012
	I play regularly-I don't play	22.746	0.022
Simple coordination test– number of correct answers	I don't play-I play regularly	−21.701	0.031
	I don't play-I play sporadically	−22.619	0.017
	I play regularly-I play sporadically	0.919	1
Complex coordination test – response time	I play regularly-I play sporadically	2.437	1
	I play regularly-I don't play	19.443	0.065
	I play sporadically-I don't play	17.006	0.113
PiM indicator – number of points	I don't play-I play sporadically	−22.741	0.016
	I don't play-I play regularly	−24.039	0.014
	I play sporadically-I play regularly	−1.298	1
CTT-2 – task execution time (min)	I play regularly-I play sporadically	3.722	1
	I play regularly-I don't play	21.796	0.03
	I play sporadically-I don't play	18.074	0.081

The results also indicate that people who played sporadically or regularly had faster reaction times in these tests, so there were noticeable differences between the group of gamers and non-gamers. In addition, it should be stated that single outliers and extreme results were observed in the results, worse than the others in the area of longer reaction time. It can be assumed that video game players had greater attention control.

Thus, people who played games were characterized by higher cognitive performance in terms of attention function. On the other hand, the difference between adolescents who played occasionally and adolescents who played regularly was statistically insignificant. Thus, an answer to the research question concerning the differences in cognitive functioning among students playing video games was obtained. People who play video games show higher attention skills compared to their peers (non-gamers).

The type of video game used and the processes of attention. In the next stage of the analysis of the results of the study, it was checked whether the level of cognitive functioning (attention function) was differentiated by the fact of playing a specific type of game. To this end, Mann-Whitney U tests were performed for each of the eight types of games. Table 6 presents the results of only those categories of games that turned out to be statistically significant on the basis of the analysis.

Table 6. Results of the Mann-Whitney test, which compares the level of attention function performance among adolescents, depending on the category of video games used.

Test	Line Test (+distractor) – response time	Line Test (+distractor) – correct reactions	Number localization – response time	PiM – number of points	CTT-1 – task execution time (min)	CTT-1 – number of mistakes	CTT-2 – task execution time (min)	CTT-2 – number of mistakes	Variable
Game genre									
Action games- no (n = 68)	64.41	55.01	65.58	55.21	63.06	59.24	65.46	60.76	x*
	8.1	6	6.26	97	0.19	0	0.35	0	Mdn†
	2.4	3	1.49	19	0.09	0	0.16	1	IQR‡
Action games- yes (n = 53)	56.62	68.68	55.12	68.42	58.36	63.26	55.27	61.3	x
	7.66	8	5.96	102	0.19	0	0.33	0	Mdn
	2.66	2.5	1.52	16.5	0,08	1	0.11	1	IQR
	−1.21	−2.16	−1.63	−2.06	−0.73	−0.84	−1.59	−0.1	Z§
	0.225	0.031	0.104	0.04	0.464	0.403	0.112	0.921	pII
	0.11	0.2	0.15	0.19	0.07	0.08	0.14	<0.01	rś
Strategy games- no (n = 74)	67.46	61.7	68.2	55.7	62.16	63.23	63.03	58.39	x̄
	8.14	7	6.32	97	0.19	0	0.36	0	Mdn
	2.46	2.25	1.33	18	0.1	1	0.16	1	IQR
Sports games- yes (n = 7)	50.83	59.9	49.66	69.34	59.17	57.49	57.8	65.12	x
	7.46	7	5.7	100	0.19	0	0.33	0	Mdn
	2.28	3	1.58	17	0.07	0	0.1	1	IQR
	−2.54	−0.28	−2.83	−2.09	−0.46	−1.17	−0.8	−1.22	Z
	0.011	0.781	0.005	0.037	0.647	0.241	0.423	0.223	p
	0.23	0.03	0.26	0.19	0.04	0.11	0.07	0.11	r
Strategy games- no (n = 94)	65.5	58.44	64.88	58.31	64.51	62.12	65.56	60.43	x
	8.12	7	6.29	98	0.19	0	0.35	0	Mdn
	3.02	3	1.54	19	0.09	1	0.13	1	IQR
Strategy games- yes (n = 27)	45.33	69.93	47.5	70.37	48.78	57.11	45.11	63	x
	7.14	7	5.77	102	0.17	0	0.3	0	Mdn
	1.78	3	1.14	16	0.06	0	0.07	1	IQR
	−2.63	−1.52	−2.27	−1.58	−2.06	−0.87	−2.67	−0.4	Z
	0.008	0.128	0.023	0.115	0.04	0.383	0.008	0.691	p
	0.24	0.14	0.21	0.14	0.19	0.08	0.24	0.04	r

x* – medium, Mdn† – median, IQR‡ – interquartile range, Z§ – standardized value, pII – Statistical significance, rś – effect strength.

In the case of playing arcade games, the analysis showed statistically significant differences between the groups in terms of two indicators: line test (+distractor) – correct reactions and *PiM indicator* – number of points. In both cases, people playing action games performed better. The values of the strength factor of the r-effect indicate that both of these differences were weak.

The analysis of sports games showed statistically significant differences in three indicators: *line test* (+distractor) – response time, *number localization time* – response time, *PiM indicator* – number of points. In each case, people who played this type of game had better results.

In terms of strategy games, there were significant differences between the groups in terms of several indicators of cognitive functioning (attention function), incl. *Line test* (+distractor) – response time, *number localization time* – response time and also measuring the efficiency of attention: CCTT-1 – task execution time (min), CCTT-2 – task execution time (min). In each case, better results were achieved by people who played strategy games.

The results of the study allow us to conclude that adolescents playing specific genres of games: strategy games, sports games and action video games are characterized by higher efficiency in the field of attention. These research results are in many respects higher than those of players of other types of games. The obtained results constitute an additional argument for confirming the hypothesis and complement the answer to the research question posed regarding the differences in cognitive functioning among adolescents playing video games.

Pupils playing specific categories of games (strategy games, sports games and action games) focus on visual information while playing, performing tasks like logical and tactical tasks, which in turn can lead to improved cognitive performance in terms of attention. This is confirmed by higher results in studies obtained by adolescents who play certain types of games.

In the presented categories of games, dynamics and competition are important. For example, in turn-based strategy games, the player constantly performs tasks that require his or her concentration, alternating moves with another player or the computer. Sports games, on the other hand, require dexterity and logical thinking from the player, which is closely related to efficient selection and shifting of attention. The experience of playing action video games, which require reflexes and perceptiveness, lead to a more efficient information processing function and thus attention selection.

4. Discussion

Interpreting the results obtained on the basis of the selected indicators, i.e. PiM indicator – number of points, line test (+distractor) – response time and number localization test – response time, It was shown that the group of adolescents who played video games (sporadically or regularly) had higher reaction times, fewer false results and higher scores compared to adolescents who did not play video games. Thus, people who played games were characterized by higher cognitive performance in terms of attention function. The results confirmed the research hypothesis. The differences between players who played sporadically and players who played regularly in terms of the examined attention were statistically insignificant in each case (no differences between these groups were observed). Thus, an answer to the research

question concerning the differences in cognitive functioning among adolescents playing video games was obtained.

In addition, on the basis of the results of the study, the following conclusion was drawn: higher efficiency in the attention function is characterized by adolescents playing specific genres of games, i.e. strategy games, sports games and action video games. These results are higher than those of players of other game genres.

An efficient attention function has a significant relationship with the quality of functioning in various areas of life, with the learning process, by amplifying the signal in relation to information noise. Choosing the right strategy for choosing the right game and frequency of play can be beneficial for the player.

It is assumed, based on the results of our own research, that people who play video games regularly or sporadically show more efficient functioning of attention. The role of efficient attention seems to be crucial, for example, in the daily acquisition and selection of information. Analysing the existing literature on the subject, similar results can be found in the research of P. Cardoso-Leite and D. Bavelier [30]. The authors noted that video games can improve attention function, particularly in terms of selectivity. However, the results of the above-mentioned study emphasize that not all types of video games are equal in terms of influencing the efficiency of elementary cognitive processes. Similarly, the studies presented above highlight the beneficial impact of specific types of games (e.g. strategy games). However, it should be noted that there are also studies in the literature showing that video games cause indirect attention deficits, which is associated with a sedentary lifestyle in people who play video games [50]. In our own research, other video game genres did not have a significant effect on the performance of attention functions or this effect can be assessed as neutral.

One of the conclusions of our own research is the fact that video games have a beneficial effect on the efficiency of the attention function, regardless of the amount (an hour or more) of time spent playing games per day. A team led by S. Sattar [9] came to slightly different results, showing that participants who regularly played video games (at least an hour a day) achieved significantly better results in terms of the efficiency of attention functions compared to people who did not play regularly (who played once in a while). The study did not show which types of video games have a beneficial effect on cognitive performance. These results are somewhat complemented by the conclusions reached by the team of Y. Farchakh [8], who, based on the results of research on the relationship between problematic use of games and the efficiency of cognitive functions. He found that students who played video games very often showed significantly worse cognitive abilities in terms of attention function, which in turn was reflected in poorer learning outcomes. In the presented study, a small group of people who play very often (4.1%) was classified as a group of people who played video games for whom the activity of playing video games had a beneficial effect on the efficiency of the attention function. Similar conclusions as the team of Y. Farchakh were presented by M. Ozcetin [40] and his team, focusing in their research on the role of playing video games in the cognitive functioning of school adolescents. The obtained results indicated a correlation between the time spent on digital gaming and the results in psychometric tests. The group of people who played intensively made more mistakes than the group of people who played sporadically. On the other hand, the group of sporadic players reacted faster but less accurately.

Analysing the literature on the subject, studies that have analysed the importance of the use of a specific genre of video games in relation to particular cognitive functions are worth emphasizing (e.g. attention function), including B. Chaarani [39] and F. Alsaad et al. [13] works. In the current state of research, action games was the category of games indicated as most strongly related to the improvement of attention functions [37]. However, it is worth mentioning that some researchers [51], without pointing to the predominance of any video game genre, have often emphasized that playing video games improves performance related to attention. The results of our own research also indicated a beneficial effect of playing action video games, but the category of games used that correlated most strongly with the greater efficiency of the attention function were strategy games.

Numerous studies, e.g. R-Y. Zhang [52] highlight the beneficial effects of video game use, e.g. in the form of an increase in cognitive abilities. Emphasis is placed on the fact that training, e.g. in action games, increases the rate of information selection [53]. A similar conclusion was reached by M. Dye's [54] team, suggesting that action game players, regardless of age, have developed attention skills that allow them to react more quickly to targets and leave additional processing resources. Similar conclusions were presented by the team of M. Argiles [36], emphasizing that visual attention is more efficient in people who play sports games and games of skill. The last of the research results are identical to the results of our own research. The results of the study highlight the importance and impact of the use of strategy games.

Higher efficiency of the attention function means better selection of the source of information, better searching of the field of perception, prolonged concentration, greater possibility of divisibility and shifting of this function. In order to understand a piece of information, it must first be recognized and then recalled [22, 26, 55, 56]. The function of attention, on the example of own research (school youth), is an important element in learning based on elementary cognitive functions. Its efficiency is visible already in the initial phase, not only in the posture itself, but also in the attitude, i.e. the state of readiness, e.g. to listen [57].

Based on our own research, it has been proven that playing certain genres of video games on a regular or sporadical basis can have a beneficial effect on attention functions. By conducting our own research, we were able to avoid several limitations that characterized previous studies. First of all, the focus was on the standards of the examination, which were carried out individually, face to face, in ergonomic conditions. Questionnaires, self-report questionnaires, computer and paper-and-pencil tests presented to the respondents were verified at every stage of the study in the form of an in-depth interview and observation. A large group of people of similar age and cognitive abilities were included in the study. On the basis of the analyses, m.in groups of people who do not play, do not play (but play in the past), play sporadically, play regularly and play a lot. In addition, data on the type of video game used was extracted and verified, submitting eight game genres for multiple choice with examples given. The entire study was voluntary and anonymous, and the research was approved by school management, students' guardians and the students themselves. An additional value was the use of a novel computer system for the diagnosis of cognitive functions.

Limitations and future directions

The research carried out for the purposes of the discussed issues was burdened with at least a few limitations. The first concerns the tools used. Although the computerized apparatus for psychological diagnosis of the SDP – system has various tests, the psychometric value of which has been confirmed, their verification is not characterized by such 'achievements' as traditional paper-and-pencil tests. Only one such test was used in the studies carried out (CCTT). Another limitation concerns the size of the group of students surveyed, especially those who declared that they do not use video games and have not done so in the past. This fact, as well as the fact that the research took place in a specific region of the country (southern Poland) allows us to draw the conclusion that the number of young people is insufficient to be able to generalize the results to the entire population of young people playing in Poland. The third limitation is related to the subjectively formulated positions in surveys on the use of video games. Just talking to a student about playing games is not enough. This type of information should be confirmed, m.in. by interviewing the student's parent or tutor. Most of the results obtained on the basis of statistical analysis of the study turned out to be significant, but it is worth emphasizing that among them there were also significant results of low intensity.

The limitations mentioned above do not undermine the significance of the obtained relationships between the studied variables. However, it is suggested to be cautious in interpreting them, especially when generalizing the results to the entire population of adolescents in Poland. This research sets out numerous directions of research work that should be undertaken. Future exploration should take into account, like a larger sample size, the use of more traditional tools, and, if possible, steps should be taken to obtain information on how to play specific genres of video games in a more objective way. For example, which strategy games have such a beneficial effect on the efficiency of the attention function should be answered?

5. Conclusions

It was proven that the group of adolescents who played video games occasionally or regularly was characterized by better reaction times, a higher number of correct results and a higher number of points compared to the group of adolescents who did not play. People who played games had higher efficiency in the attention function. This correlation was evident in the results carried out, with the help of *Precision and Thinking Indicator, line test* (+distractor) and *Children's Color Trails Test*, which emphasised above all the efficiency of the attentional function. In addition, it has been proven that school children with higher attention skills use specific genres of games: strategy, sports and action video games. In addition, it has been found that people who do not play video games, regardless of whether they have played them in the past or not, are characterized by poorer efficiency in the functioning of elementary cognitive functions, including attention.

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