Digital Games and the Exercise of Attention: Interventions in Small Groups in School

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Abstract

Digital games can improve cognitive skills in schools since they have rules, goals, challenges and propose actions that require the player's attention, problem-solving capacity, involving the planning of actions, keeping the goals and objectives in mind. Therefore, this article aims to investigate indicators on the effects of digital cognitive games in interventions carried out in small groups in the school context on attention capacity. Therefore, a quasi-experimental study was conducted with 30 subjects, aged 7 to 11, divided into two groups, participant and control. Both were evaluated before and after the intervention through the application of a concentrated attention test. The results obtained indicated that the participant group had a significantly superior performance concerning the quality of the attention because of more minor mistakes in the second application than the control group. The differences found in test variables that indicate the speed of discrimination of stimuli and attention more broadly were not significant.

Keywords: learning, computer games, attention, elementary school, cognition.

1. Introduction

The development process is marked by substantial and constant changes that happen at certain times, causing significant changes in the functioning of memory, perception, emotion, and attention. Each period of human development is marked by biological changes and cultural acquisitions that will determine how the individual acts and relates in the world (Lima, 2009).

Thus, the executive functions stand out, which allow the individual to interact with the world in different contexts and situations and are essential to ensure the success of our actions on day-to-day, in routine tasks, the decisions and planning, for example. These functions are part of a range of cognitive abilities, including cognitive flexibility, working memory, inhibitory control and self-regulation, and direct

the individual to achieve objectives, setting behaviour strategies for the action to be completed, objectively and flexibly (Lent, 2005; Diamond & Lee, 2011).

Among the executive functions' dimensions, inhibitory control stands out, which involves the ability to control attention, behaviour, thoughts, and emotions to do what is appropriate or necessary, containing impulses and changing habits (Diamond, 2013). According to Diamond, attention related to the inhibitory control of attention allows the human being to be more selective to intentionally focus attention, suppressing attention to other stimuli. This attentional control allows the human being to voluntarily ignore or attend to certain stimuli and attend to others, considering their objectives, goals, or intentions.

The executive functions are fundamental to the learning processes, including those taking place in the school context. However, there are recurrent teacher complaints about some students with difficulties on these functions, standing out attention, or the lack of attention and the difficulty for the student to remain focused on achieving a goal related to a school activity. Considering the importance of attention and the need for an intervention to contribute to its improvement, this work is guided by investigating the effects of the use of digital games in the school context on students' attention. Therefore, one guided intervention was proposed to use digital cognitive games that can be defined as "a set of different games working cognitive aspects, proposing the intersection between games concepts, fun and cognition" (Ramos, 2013, p. 1).

Cognitive games receive this name because they present, in essence, an alternative to the exercise of cognitive skills. Despite having common characteristics with games, "cognitive games can exercise different and simultaneously cognitive skills. Depending on the challenge and objectives of the game, the exercise of a specific skill may be privileged, minimizing the exercise of others." (Ramos, 2013, p. 123). These games can have different formats, reproducing board or challenge games, but in general, they are simple games, presenting increasing levels of difficulty and using the digital medium.

The proposition of using these games as an intervention assumes, systematized by Diamond (2013), that environmental factors are essential in the development of executive functions because they heavily influence the changes in the nervous system resulting from these interactions. In turn, Lima (2009) reinforces the importance of the individual experience to understand students' learning paths when considering that the brain reorganizes itself based on the circumstances of life.

In addition, research indicates that interaction with digital games can have effects on cognitive skills (Eichenbaum et al., 2014), such as making the activation of executive attention networks faster and more efficient (Rueda et al., 2012); improve different cognitive aspects, which when exercised in a digital game can improve performance in tasks that share similar characteristics (Oei & Patterson, 2013); train the inhibitory control (Lopez-Rosenfeld et al., 2013; Homer et al., 2018), diminish the players' reaction time, improve coordination visuomotor and attention (Griffiths, 2002; Palaus et al., 2017); and improve air performance related to basic visual skills and attention (Li et al., 2010).

One can assume, then, that the application of digital cognitive games in school aids in the exercise and the development of cognitive skills, making the student more competent through the proposition of challenges involving cognitive aspects such as memory, logical reasoning, creativity, problem solving and attention, building the bridge between fun and cognitive development and, thus, contributing to greater involvement of students, due to the motivational factor that awakens, in addition to inserting information

and communication technologies in the school context (Ramos, 2013).

Among executive functions, we focus on attention due to its importance for learning and recurring complaints among teachers. Thus, it is highlighted that studies on attention are concerned, above all, with the way "the brain selects which sensory stimuli to discard and which to transmit to higher levels of processing" (Gazzaniga & Heatherton, 2005, p. 175).

Attention helps to monitor the subject's interactions with the environment, to establish a relationship with the past and the present, giving a sense of continuity of the experience, to control and plan future actions, linking the monitoring information with the memories' past and present sensations (Sternberg, 2016).

It also stands out the fundamental role of attention in the learning process. Lima (2009) refers to attention as a fundamental ingredient for learning since the process of learning knowledge requires observation, categorization, and analysis, being permeated by attention. Attentional capacity also influences the applicability of these skills in everyday life, decision-making, planning, and developing strategies for solving problems.

Therefore, this study aims to investigate indicators of the use effects of digital cognitive games on the ability of attention in the context of focal care, which refers to extracurricular interventions held in small groups in school.

2. Methodology

The research is characterized as a quasi-experimental study with a quantitative approach, as it proposes the intervention in small groups based on the use of digital cognitive games in the school context as an independent variable, aiming to analyze the contributions to the improvement of the attention capacity, measured from the application of a psychological test taken as an indicator of improvement in this dependent variable. It is delimited as a quasi-experimental study, as it recognizes the complexity of the research context and the difficulty in controlling and isolating the variables. According to Cozby (2001), one can classify the study as applied research, which seeks to infer whether a given treatment may result in the desired effect but occurs in situations where it is impossible to have the same degree of control as in an experimental design.

To isolate the effects of other variables, the research worked with a sample organized into two groups. The participant group was evaluated and participated in the intervention, and the control group was evaluated but did not participate.

In compliance with the ethical aspects of the research, it was submitted to and approved by the Ethics Committee of the Federal University of Santa Catarina (Brazil), and all participating children had the Free and Informed Consent Term signed by the parents or guardians.

2.1 Participants

The proposition of the focal care sessions was held in a municipal elementary school in Florianopolis. This school works with an integral education project from the 1st to the 4th year. Thus, in

one period, part of the children attends regular education, and in the other, they receive specific pedagogical assistance and extracurricular classes in the evening, such as dance, indoor soccer, and arts.

The survey's sample was defined by nonrandom convenience that comprised indication of children entitled to the aid proposed by the educational coordinator and teachers. Observing the ethical procedures, the informed consent form was sent to parents and guardians for signature. It should also be noted that the research was submitted to and approved by the Ethics Committee for involving children.

The sample consisted of thirty children aged 7 to 11 from the comprehensive education project, with an average age of 8.96 years old (SD = 0.94). The participating children comprised two distinct groups: the participant group and the control group.

The first group participated in the activities carried out in the evening of the regular class period, with an extracurricular characteristic and without the obligation to participate. The second was only evaluated with the same instruments, without participating in the activities.

Of the fifteen children indicated to compose the participant group, five attended the 2nd year (three boys and two girls), six the 3rd year (six boys), and four the 4th year (four boys). The control group was composed of four 2nd year students (two boys and two girls), six third-year students (five boys and one girl), and five 4th year students (three boys and two girls), totalizing fifteen children.

2.2 Materials

The interventions in focal care were based on the use of the Brain School (*Escola do Cérebro*), which is an application developed through research carried out at the Federal University of Santa Catarina and activities developed at the LabLudens (*Cognoteca*) of the Application School (*Colégio de Aplicação*).

This system aims to integrate cognitive games into a database that allows both the exercise of cognitive skills and the monitoring and guidance on players' performance and cognitive characteristics (Ramos et al., 2014).

These Brain School games have three levels of difficulty, ranging from easy, medium, and difficult, making it possible to play indefinitely without the need to complete one level to pass to the other. The games highlight the development of three cognitive skills: memory, problem-solving and attention.

Another instrument used was the D2 Concentrated Attention Test, whose results offered the attention indicators. D2 aims to assess concentrated visual attention, its fluctuation, and the ability to concentrate in a broader sense. It is aimed at individuals between 9 and 25 years old. This test is carried out for a highly objective diagnosis and requires the examinees to differentiate between analogous details quickly and safely (Brickenkamp, 1998).

According to the manual, it is a cancellation test that provides results that make it possible to assess the speed, accuracy, quality of attention and fluctuation in performance. Initially, a training exercise is carried out. Then the examiner explains which signs should have been marked for the subject to correct, then proceeds with the test application that lasts about five minutes and can be individual or collective (Brickenkamp, 1998).

Furthermore, according to the authors, the total number of signs examined refers to the Raw Score (RS). The RS subtracts the Total Number of Errors (TE) and, finally, the Net Score (NS).

In the context of this research, this instrument was used only as an indicator without purposes of

evaluation or diagnosis, analyzing the results recorded in the used instrument and observing the same application conditions before and after the intervention.

2.3 Procedures

The study carried out observed three distinct moments: 1) the initial assessment of the participants of both groups, through the application of the D2 test; 2) weekly interventions carried out in groups of 3 to 4 students, based on the use of the Brain School and previously defined procedures; and 3) the final assessment of participants in both groups, through the application of the D2 test.

The intervention procedures used in focal care were inspired by the structure of the cognitive therapy session, geared, however, to the school context. The service follows this structure:

a) registration of attention: through the painting of smiles (attention faces), the child registers the perception of his/her attentional state;

b) review of the week's challenges: the child is invited to solve small challenges at home, such as crossword puzzles and labyrinth, among others, and at this moment, he/she talks about the difficulties he/she had or not to accomplish them;

c) establishment of the agenda: despite prior planning, this is the time to discuss with the child what will be done, explaining the games to be used;

d) content of attention with games: develop what was planned using the games and watching the child playing and interacting;

e) challenges of the week: presentation and explanation of the challenges that the child will do during the week, in printed activities or digital games;

f) feedback: first, the child is asked about his performance, his/her opinion about the game and his/her level of attention;

g) afterwards, the behavioural categories of attitude, attention, commitment and interaction are evaluated together in the reinforcement table;

h) at the end of this process, a green face is assigned when the behaviour met the category, yellow when it met partly, and red when it did not meet it adequately (Ramos, 2014).

During the attendance of approximately 40 minutes, each student is identified by a badge and uses an individual tablet, connecting him/her to the Brain School with login and password, so he/she can use the combined game of the week and choose the difficulty level.

2.4 Data Analysis

For analysis, the following dependent variables were considered: the Raw Score (RS) refers to the total of points without considering the errors, which can be taken as an indicator of the speed in the discrimination of stimuli; the Errors that account for both the omitted; and the wrongly marked stimuli and the Net Score (NS) that considers the raw score minus the mistakes, which can be taken as an indication of the quality of the attention.

After typing the results obtained in the test in the Excel software, they were converted into a database for analysis in EpiData Analysis. As they have a normal distribution, the numerical variables were described using the mean, standard deviation, and confidence interval. The results obtained before and after

the test were analyzed based on the paired t-test; considering the difference between after and before, the level of statistical significance used was 5% ($p < 0.05$).

5. Results

In this research, the tests were used without making a diagnosis, but as a consistent and already validated indicator to assess whether the intervention carried out has caused changes in attention.

Table 1 features the descriptive and inferential analysis of the results obtained in the D2 application, both in the participant and the control group, and the difference obtained between the raw score, the sum of errors and omissions and the net scores of the application of the D2 test. In the latter, the median (Md) and the interquartile range (q25 and q75) are recorded, as the variable is nonparametric.

Table 1

Gross results, sum of errors and omissions, net obtained D2 test per group.

GROSS RESULTS							
		Before	**After**	**Difference**			**P-value***
Group	**N**	**(DP)**	**(DP)**	**Md**	**q25**	**q75**	
Participant	15	281.27 (50.32)	292.00 (54.51)	13	-34	57	> 0.05
Control	15	259.47 (65.88)	275.93 (57.84)	23	-22	47	
SUMMARY ERRORS AND OMISSIONS							
		Before	**After**	**Difference**			**P-value ***
Group	**N**	**(DP)**	**(DP)**	**Md**	**q25**	**q75**	
Participant	15	63.20 (47.34)	20.93 (17.92)	-33	-67	-11	< 0.05
Control	15	38.00 (23.89)	27.87 (23.28)	-8	-31	-3	
NET RESULTS							
		Before	**After**	**Difference**			**P-value ***
Group	**N**	**(DP)**	**(DP)**	**Md**	**q25**	**q75**	
Participant	15	218.07 (27.74)	271.07 (59.63)	47	12	89	> 0.05
Control	15	221.47 (50.77)	248.07 (60.6)	31	-7	78	

Note. * Paired student t-test

The raw score is obtained in D2 through the total count of markings made in the test; however, it

does not consider errors and omissions. It can be taken as a quantitative indicator of the speed of discrimination of stimuli by the subject. The results, according to Table 1, reveal an improvement in this result, both in the participant group, which in the first application scored an average of 281.27 points and in the second, 292.00, and in the control group, which scored an average of 259.47 points in the first and 275.93 points in the second application. These data were used to calculate the difference between the second and the first performance, which resulted in a median of 13 in the participant group and 23 in the control group. Despite the difference, the paired Student t-test did not indicate that this difference was statistically significant ($p > 0.05$).

Another aspect that was analyzed in the application of D2 was the total number of errors, whose value corresponds to the sum of the incorrectly marked stimuli and the omissions. This value is a strong indication of the quality of the attention.

By analyzing the results described in Table 1, one can note an improvement in the quality of the attention in both groups, as the participant decreased from 63.20 to 20.93 the number of errors recorded, and the control group decreased from 38.00 to 27.87. These data allow us to say that the difference was greater in the participant group, and the p-value ($p < 0.05$) indicates that this value was significant, that is, the training of attention with the use of digital cognitive games in the participant group revealed significant improvement in the quality of the attention.

Another indicator analyzed was the Net Score calculated based on the external data. In Table 1, one can observe the results obtained in the D2 test, which refer to the raw score minus the number of errors.

The data in Table 1 shows an improvement of 53 points in the second application of D2 in the participant group and 26.6 points in the control group. These data indicate that the participant group had a better performance, as it obtained an average difference of 26.4, almost double the control group. However, the statistical analysis based on the application of the paired student t-test reveals that the difference in the evolution of performance between the two groups is not statistically significant.

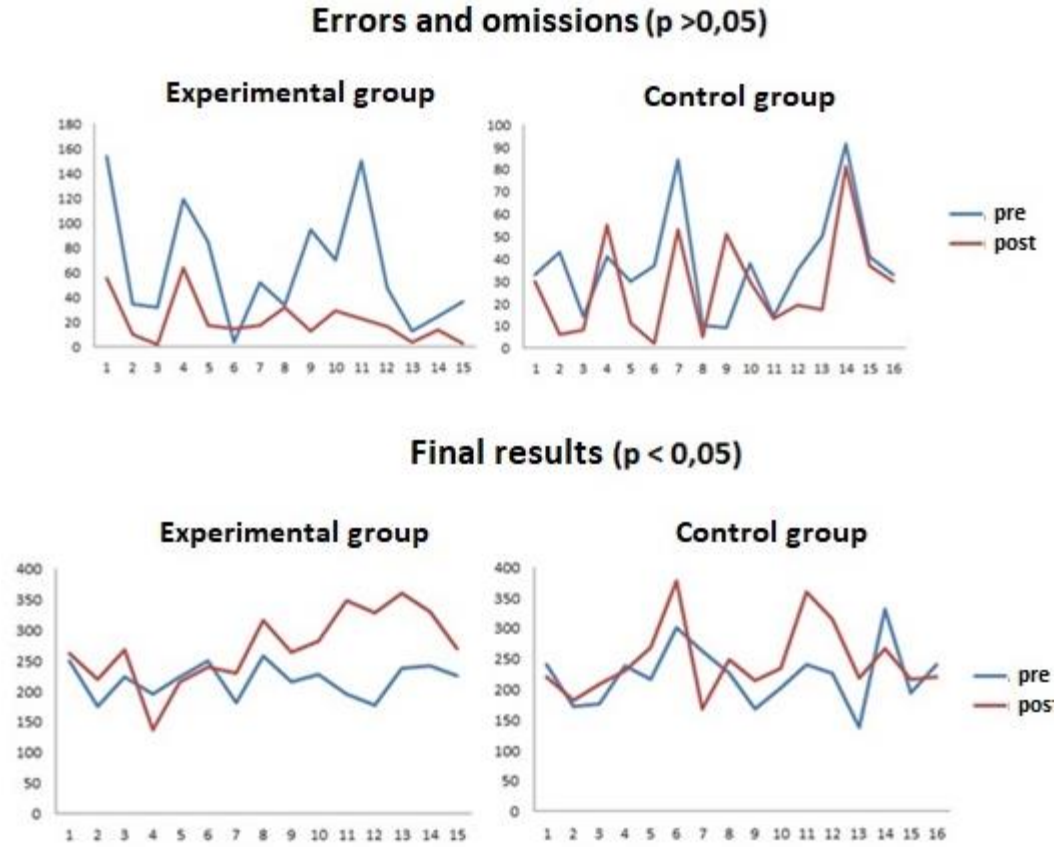
The results obtained by each participant in the two groups, before and after, related to the errors made in the test can be seen in Figure 1, in which it is visible that the behaviour of the line in the participant group is more stable and it can be noticed that in the first application the participants made more mistakes, except for one child. The lines of the control group, on the other hand, are more irregular and present a behaviour very close to each other, not allowing to observe an apparent difference between the first and the second application.

In Figure 1, one can see the results obtained by each participant in the two applications (before and after) in both groups:

Analyzing the lines of the two groups, it can be noted that the line of the participant group presents a more typical behaviour and allows us to realize an improvement in performance in the second application, except for three participants. There is a gap between the two lines from subject seven on, indicating a difference between the initial and final performance. On the other hand, the lines of the control group are more irregular and closer, and one can identify that five participants performed worse in the second application.

Figure 1

Comparison of errors and net score before and after in both groups.



In the evaluation of the quantitative data D2 test, one notes a performance increase between the first and second test in the participant group and a decrease in responses involving errors and omissions. These data can be corroborated with the observation of the behaviours manifested by the children during the second test when it was possible to identify greater control of impulses, planning in action, greater capacity for concentration and perseverance to achieve the greatest possible number of responses. These behavioural gains were observed in the performance of focal care and the teachers' report after using the games.

In the evaluation of the reinforcement table of the focal care protocol between the before and after the use of games, it was noted a significant improvement in the categories of attitude and interaction involving greater patience, persistence and use of planned actions, which were observed in the second application of the D2 test. In the attention category, although the results show little difference between before and after, information reported by teachers indicated behavioural improvements related to attention, observed in the classroom, in manifest behaviours, such as following guidelines, calmer attitudes and planned to carry out the tasks, and greater perseverance, which may be directly related to the significant improvement in performance found in the second assessment of attention in the D2 Test.

The improvement obtained in the analysis of D2 can be taken as an indication that the training of attention, using digital cognitive games, can be transferred to other activities that involve attention, such as the test used.

5. Discussion

The results obtained with the test application before and after the intervention indicate a significant improvement related to the quality of the attention, which resulted in fewer mistakes made in the execution of the proposed task. Despite the improvement in attention, the participants did not become significantly faster in discriminating the stimuli in relation to the control group, any aspect related to the task proposed in the used test.

The improvement in the quality of the attention recorded in the study enhances the effects of the use of digital games, which has been disclosed in other research, as in the study by Rueda et al. (2012) with 37 preschool children aged five divided into two groups - control and participant, confirming with the ability to improve attention through training. The participant group held ten computerized attention training sessions. Moreover, both groups were evaluated through a series of tasks before, after and two months after training and also the brain function was examined with an electroencephalogram system of high density. The results showed that trained children activated the executive attention network faster and more efficiently than untrained children.

Rivero et al. (2012) reinforce that digital games can promote improvements in players' performance in different tasks of visual perception and attention and also provide improvements in basic cognitive functions, which can be generalized to tasks and new stimuli, suggesting that the skills learned within the game can be transferred to the individual's daily activities. Griffiths (2002) also indicates that the continuous use of digital games produces changes in the players' reaction time, improves visuomotor coordination, increases self-esteem, and inferring the state of attention.

In this sense, the data obtained in this study corroborate with other research that has been conducted, which results showed improvements in various cognitive and indicate that training specific cognitive skills, often exercised in a digital game, improves performance on tasks that share characteristics and similar skills (Oei & Patterson, 2013).

Digital games and aerobic activities, martial arts or yoga, can improve executive functions in children, especially when they involve repeated practice and the progressive increase of challenges (Diamond & Lee, 2011).

Those aspects reinforce that the development process is influenced by the environment, which can contribute to bringing about significant changes in the functioning of cognitive abilities (Lima, 2009), at the same time that it highlights the potential of digital games for the improvement of cognitive skills, supporting the use of the cognitive adjective proposed by Ramos (2013) for games that favour the exercise of cognitive skills to achieve goals and have a good performance.

Thus, the use of cognitive games in interventions in the school context is guided by the notion that skill development is directly related to the involvement of various mental functions such as attention, memory, perception, reasoning, language, among others, in the interaction of students with the games used.

Among the functions, attention stands out, which is heavily involved in the players' actions to maintain the game and the actions necessary to achieve that are configured as a focus for which attention is concentrated. According to Rivero et al. (2012, p. 40), "the players need to manage different tasks in the game, at the same time they need to maintain the central goal of the game, alternating between different

tasks".

Attention is how a certain amount of information is processed from a large amount through the senses, memories and various cognitive processes. Through this function, the focus is directed to the stimuli that matter, responding more quickly and accurately (Sternberg, 2016). Thus, the improvement in the quality of attention tends to have an impact on the learning process.

Despite indications that there are positive effects obtained from the interaction with digital games, Miller and Robertson (2010), through a review of studies conducted to investigate the use of learning games, show that this intersection still has limited and contradictory results in the scientific literature, highlighting how found contributions are most strongly related to the faster processing of information, greater interest and involvement in the learning process and selection of relevant material.

Based on the results described, it is reinforced that digital games can be used to improve cognitive skills in the school context, as they present rules, goals, challenges and propose actions that require the player's attention, the use of problem-solving, involving the planning of actions, keeping in mind the goals and objectives.

These aspects that are further explored in some games allow us to call them cognitive games, especially if they are developed to provide feedback to the player. The potential of using games to improve cognitive skills was reinforced by the study since the effect measured was the improvement in the quality of attention of the participants who, after the interventions, made significantly fewer errors than the participants in the control group.

A validated test obtained the results taken as indicators of improvement in attention, but it is known that other factors such as the motivation and physical disposition of the assessed subject, for example, can influence the results. This aspect can be taken as a limitation of the study. In addition, although a control group is foreseen to isolate the effect of using games, other factors can influence the obtained results, such as the participants' maturation and many other variables present in the school environment.

We reinforce the importance of studies investigating the effects of digital games, especially in children, as they are part of the environment of many children for prolonged periods, which tends to affect their development.

Finally, digital games are attractive and use advanced resources to capture and involve the player, which can also enhance the learning processes through the insertion of their use in the school context.

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