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Self-perception of Students About the Practice of Exergames in the School Environment and Possible Influences on Their Learning Skills: A Preliminary Study

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A considerable number of students have learning disabilities in the first years of school, and a precoce intervention could minimize the financial, social, and personal costs of this problem. Ludomotor interventions have been shown good results as a neuropsychopedagogical intervention tool to improve motor and cognitive functions and consequently, academic performance. We developed a digital version, in Exergame (EXG) form, based on a set of Neuropsychopedagogical Ludomotor Interventions (NLI) called “Coordenando-se”, that was elaborated by Braga (2016). For this we use as the EXG console the Makey Makey kit, that can transform E.V.A. versions of the figures of the NLI in “keys” which when pressed fire events on the game. The presentation of the figures of this EXG on screen increases its velocity as the player increases his hit points. This study collected data utilizing Scale of Adherence to Digital Games in Education to analyze the self-perception of 30 students of Brazilian schools of Joinville, SC about the motivational and experiential aspects and learning capacity of the present EXG developed. The results point to a positive impression and promising preliminary results when it comes to improvement of learning capacity of the practitioners.

Keywords: neuropshycopedagogical intervention tool, ludomotor intervention, cognitive intervention, makey makey kit, exergames, learning academic performance

Introduction

Executive functions (EFs) are a family of complex mental skills responsible for self-management, reasoning, decision-making, planning, problem solving, attention management, among others (Fuentes et al., 2014; Krause, 2018). Therefore, they are directly related to academic, professional, and social success (Diamond, 2013; Zelazo et al., 2016).

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The role of EFs and motivation in supporting children's academic performance is well documented, although the vast majority of evidence comes from high-income countries (Diamond, 2013). The Brazilian school environment still tends to be focused on expository classes, providing mostly a verticalized learning experience, which ends up offering a series of extra challenges for children to remain involved with educational syllabus (Reis & Negrão, 2022). It is estimated that 15% to 20% of children in the first year of school have learning difficulty (Back et al., 2020). These difficulties are associated with pedagogical problems like literacy methods or with economic, emotional, social, or cultural issues (Capellini, Germano, & Cunha, 2010). Therefore, more studies are needed that emphasize the importance of indicators such as an emotionally comfortable environment, teacher skills in creating a good sense of community and the choice of theories and learning tools used to develop academic skills in children (Sanger, 2020; Kim, Raza, & Seidman, 2019). Nowadays, teaching is increasingly focused on children's own motivation and self-regulation skills, as they contribute to a greater engagement of these children during school activities (Saeed & Zyngier, 2012; Wigfield et al., 2015). These aspects can be associated with a possible improvement in the academic performance of children after a short period of systematic activities aimed at a greater development of Executive Functions (Habgood & Ainsworth, 2011), pleasure in solving problems and achieving goals (Blair & Razza, 2007; Pintrich & Schunk, 2002), and the development of metacognitive skills (Sawyer, 2017) carried out in the school environment itself (Habgood & Ainsworth, 2011).

Research indicates that children stimulated in a contextualized way, through ludo-motor programs can produce greater articulated neural networks and patterns of connections, as well as the presence of a greater number of branches (dendrites) responsible for the communication and formation of this network, which would provide a better ability to integrate proprioceptive information (Zeng, Pope, Lee, & Gao, 2017; Donnelly et al., 2016). Ludo-motor stimulation is an efficient way to promote improvement in procedural memory, which is fundamentally related to the potential increase in performance of the motor executive functions (Soares et al., 2015). Interventions aimed at learning mechanisms refer to qualitative influences of ludomotor activities, such as cognitive engagement during physical activity conceptualized as games or demands for motor coordination (Soares et al., 2021).

Exergame Stimulation

Schell (2014) says that Digital Games (DGs), which can be played using a computer or a video game console, are attractive in the challenge of solving a problem and practicing certain skills, often leading the player to a state of sustained attention related to fun and pleasure (Hira et al., 2016; Schell, 2014). The skills learned in the DG can be generalized to other activities of daily living, as suggested by Dunbar, Hill, and Lewis (2001). The children who performed better in the DG also were more attentive when, after the training session, they were going to cross the street.

A Ludo-motor form of stimulation that has been gaining prominence nowadays, thanks to advances in technology, is the Exergames (EXG), which comprehends activities that combine human movement with virtual reality provided by DGs. This may facilitate an anticipatory response and consequently improve the children's global development (Tore & Raiola, 2012). More studies have shown the benefits of EXGs for the performance of cognitive functions (Taylor & Griffin, 2015) such as memory, attention, visuospacial skills, and motor functions like balance and gait (Maillot, Perrot, & Hartley, 2012). Benzing and Schmidt (2018) state that EXGs can stimulate neuroplasticity by providing a rich environment with complex tasks (Bavelier & Neville, 2002; Carey, Bhatt, & Nagpal, 2005; Hötting & Röder, 2013; van Praag, Kempermann, & Gage, 2000). When it comes to the elderly, a combination of cognitive treatment and physical exercise seems to be more promising than interventions that focus on a single domain to induce improvement of different cognitive functions (Abbessa et al., 2022; Rahe et al., 2015). The possibility of adapting the training to the individual's needs in real time, in addition to the constant performance measurement and feedback to the therapist, is major advantage in favor of using EXGs in neurehabilitation (Staiano & Calvert, 2011). The physical and cognitive benefits are of paramount importance because they are related to an improvement in academic skills (Moreau & Conway, 2014; Vazou et al., 2019). According to Mishra, Anguera, and Gazzaley (2016), EXGs can also be used as a continuous diagnostic tool. As TOSTA I points out, the studies by Franceschini et al. (2013), Cress et al. (2010), Alzubi et al. (2018), Cancer et al. (2020) obtained preliminary results favorable to the use of exergames in the treatment of some Learning Disorders, although these results were not confirmed by the research by Luniewska et al. (2018) and Pedroli et al. (2017).

The "Coordenando-se" Ludomotor Interventions

"Coordenando-se" is a set of neuropsychopedagogical ludomotor interventions (NLI) proposed by Braga (2016) that consists of 24 activities based on the theory of motor development as a strong ally of the children's cognitive development (Gapin, Labban, & Etnier, 2011; Gomez-Pinilla, 2011). The "Coordenando-se" activities consist of associating figures with specific colors to body parts. The child should observe the exposed colored figure and position his associated body part according to the activity's rule Braga (2016). An experimental research by Cardoso et al. (2021) carried out with 102 children from schools of Joinville, Santa Catarina, Brazil, was conducted with control and experimental groups of children with and without learning difficulties, respectively, who were trained with "Coordenando-se" using the methodology's original figures made of E.V.A. This experimentation has obtained a positive result with regard to the effectiveness of the methodology.

Purpose of the Present Study

In the present study we investigated the self-perception of school-aged children about motivational, experiential, and learning development capacity of a EXG created for this research, which is based on "Coordenando-se" methodology. This analysis has used as EXG control an invention kit called Makey Makey®, which can use everyday objects as keys to activate the game's events (Silver, 2014). The purpose of this preliminary investigation was to analyze the viability of this EXG game as a possible alternative to the original application of the "Coordenando-se" methodology. This preliminary study paves the way for a more comprehensive further investigation that will analyze the effectiveness of this EXG as a neuropsychopedagogical or neurorehabilitative intervention tool for children with learning difficulties.

Method

Participants

It evaluated 30 children, aged between seven and eight years (average = 7.37 years) consisting of 16 girls and 14 boys, in second year of Brazilian Elementary School (the equivalent of Second Year of British's First Key Stage) of a public and a private school of Joinville's city, Santa Catarina, Brazil.

The inclusion and exclusion criteria of children's selection were:

- Present indications of proficient school performance proven by legal documents issued by the pedagogical team of the school in which they were enrolled;
- Have an estimated IQ (Wechsler Intelligence Scale for Children—WISC-IV) above 80;

- Do not use psychoactive medication;
- Do not show expressive symptoms of inattention, hyperactivity, or impulsivity through the SNAP-IV evaluation, proposed by Mattos et al. (2006);
- Do not have visual or auditory disorders, heart disease, orthopedic disorders, or behavioral disorders (according to medical evaluation throughout the study).

Proceedings

From August to November 2022, the children participating in the present study were invited to practice an electronic and interactive game aimed at helping the cognitive-motor development of children, during 20 sessions, twice a week for 10 minutes each session, that ran through the use of the interface Makey Makey® (MM), which is a kit containing a printed circuit board with an Atmega32u4 microcontroller that acts as an interface between the user and everyday objects that start to simulate "keys" of the computer keyboard. Keyboard and mouse events are generated by pressing everyday objects, such as a banana, and start to control the software running on the computer (Silver, 2014). It is possible to create Digital Gamess (DG) to be played with MM through the Scratch coding language, which has a visual interface, and allows you to create DGs and animations (Scratch-About, n.d.).

The DG, of EXG type, developed to be used with MM was built using Scratch coding language, on the product's website. This EXG consisted of six colored figures (three squares and three circles) which represent different parts of the body, segmented into left side and right side, as proposed by Braga (2016). Body part's coding associated with the presented geometric figures followed the methodology, namely: blue circle—right hand, green circle—left hand, pink circle—two hands at the same time, blue square—right foot, green square—left foot, pink square—two feet. The participant needed to memorize this coding and press real geometric figures made of E.V.A. with their feet or hands, arranged on the floor and table, connected to the MM to simulate the keys. Every time the child pressed the key corresponding to the picture shown on the DG screen with the correct limb, the game increased the player's score by 10. The EXG's figures were displayed randomly on the screen every 0.7 seconds, however each time the player reached the mark of 150 points more than he had before, the interval between images decreased by 0.1 second. When the interval reached 0.2 seconds between the display of each figure on the screen, the EXG changed phase. With each new phase, the game scenario changed and the amount of images displayed simultaneously also changed. In phase 2, two figures were shown at the same time, and the practitioner had to press the corresponding keys simultaneously. In phase 3, three figures were displayed simultaneously and in phase 4, four figures. The game score and the amount of hits and misses is always displayed to the child and therapist.

After 24 hours of the last session of the aforementioned exergame, all children were gathered and instructed to respond individually to the Scale of Adherence to Digital Games in Education proposed by Savi et al. (2010), in order to evaluate the game in terms of its ludic aspects and possible impacts on the cognitive functioning and learning of these children. This scale consists of 22 items divided into three categories, namely: motivational aspects, aspects of the participant's experience, and ability to develop learning (influence of the exergame on academic performance). The scale score was as follows: each item marked with the frequency "strongly disagree" received two points less (-2); "disagree", minus one point (-1); "neither agree nor disagree", received zero points; "agree" one point (+1); "I fully agree", two points (2); Therefore, the maximum total score of the scale is 46 points. For the category motivational aspects, the maximum score is 18 points and for the categories aspects of experience and learning ability, it is 14 points for each category. Data analysis of this study was performed based on the comparison of statistical results using the statistics program GraphpadPrism 9.5.

The application of the aforementioned scale took place in a large, well-lit room in the children's own school environment and was only started after the children had no more doubts about the responsive process and conducted together with a duly trained evaluator from the team of researchers.

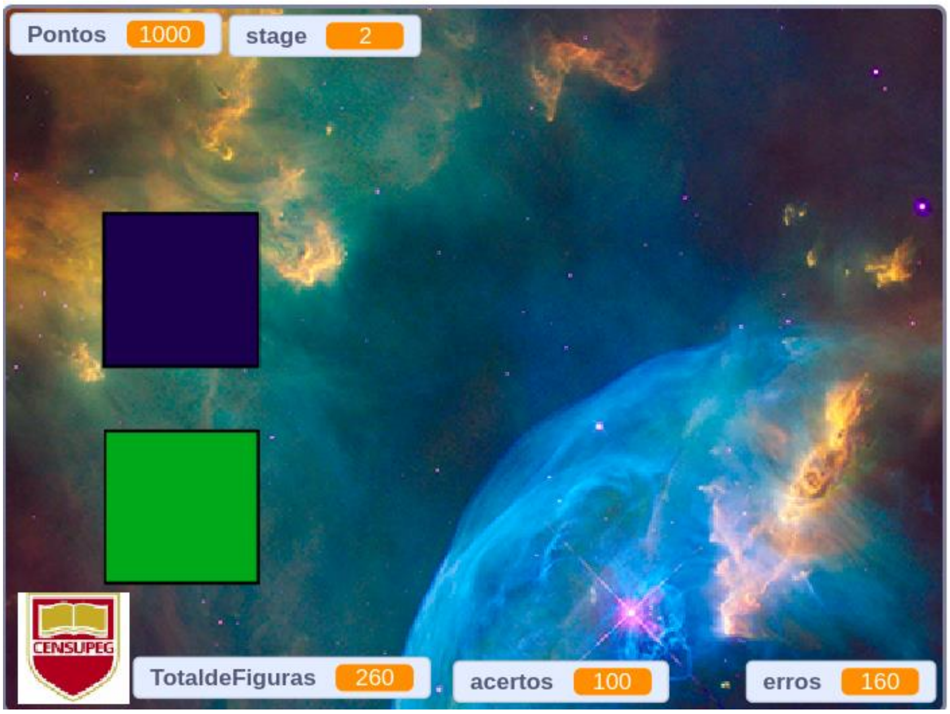

Figure 1. Print screen of game's second phase.

Results

The results obtained initially in relation to the scale of adherence to the use of games in children's context, proposed by Savi et al. (2010), were calculated using descriptive statistics, mean, and standard deviation. For a comparison and intergroup analysis for gender and age, the data initially obtained were tested for verification of their normality by the Shapiro-Wilk test, being classified as parametric. Thus, the *t*-test for two unpaired samples was used for comparison and to verify which of the three factors had the greatest influence on the total score of the referred scale, Pearson's Correlation was used.

Table 1

Description of the Values Per Category in the Scale of Adherence to Digital Games in Education

Categories	Motivational aspects	Experiential aspects	Learning aspects
Minimum	12.00	8.00	9.00
Maximum	18.00	12.00	14.00
Media	16.28	10.06	11.66
Standard deviation	1.373	0.9817	1.096

When observing Table 1, it is possible to notice that in relation to the motivational aspects category, the scores obtained among all participants ranged between 12 and 18 points with an average value equal to 16.28

points. The values related to the aspects of experiences when practicing the referred game presented their scores varying between 8 and 12 points with an average performance equal to 10.06. Regarding the learning aspects, the scores varied between 9 and 14 points with an average performance equal to 11.66 points. When establishing an individual analysis on the scores obtained on each of the factors of the aforementioned scale with the maximum possible score for each of them (Figure 2), it can be seen that in relation to the motivational aspects 3.12 of the children presented their scores below out of 75% of the possible points, 56.25% of the children presented their scores between 75% and 89% of the possible points and 40.62% of the children presented their scores above or equal to 90% of the possible points.

When analyzing the individual scores obtained in relation to the experience of each child in relation to their interaction with the referred game, 28.12% of the children presented a score below 75% of the possible points and 71.87% of the children presented a score around of 75% and 89% of possible points. Regarding the individual values related to aspects of influence of the referred game on their learning, 3.12% of the children had a score below 75% of the possible points, 81.25% of the children had a score between 75% and 89% of the points possible and 15.62% of the children had a score around 90% or more of the possible points.

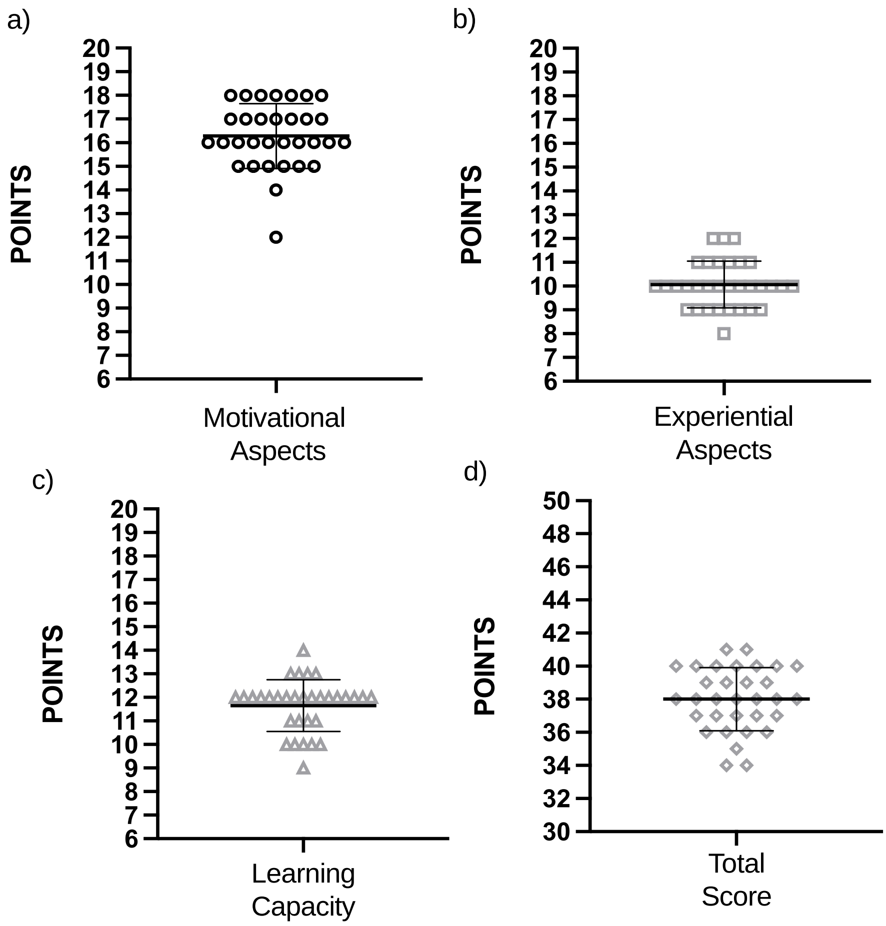

Figure 2. Scatter dot plot depicting the individual results of children in the scale of adherence to digital games in education. (a) children's performance in the motivational aspects category; (b) children's performance in the aspects related to experience categories; (c) children's performance in the learning ability category; (d) children' performance in relation to the total score obtained. Data expressed as mean and standard deviation (n = 32).

Still looking at Figure 1, it is possible to see that in relation to the total value, 93.75% of the children presented their total scores between 75% and 89% of the points possible and 6.25% of the children presented their total scores around 90% of the possible points. When carrying out a statistical treatment through the use of the *t*-Test, a *p*-value < 0.01, of significance, was obtained, thus defining, statistically, the profile of the impressions of the children participating in the referred study in relation to the aspects of playful activities and possible benefits of the game in their cognitive and academic performance.

Aiming to verify the interrelationships between the total score on the Scale of Adherence to Digital Games in Educational and its three subtests, Pearson correlation analyses were conducted, considering the scores obtained in each one. By observing Table 2, it can be observed that all correlations were positive and significant and that the test that most influenced the total score was the motivational aspects, since it was the subtest that presented the highest Pearson correlation value.

Table 2
Correlation Matrix Between the Total Score and the Subtests of the Scale of Adherence to Digital Games in Education

Explicative variables	Pearson coefficient (*r*)	Value of (*p*)
Motivational aspects	0.897	< 0.01
Experiential aspects	0.824	< 0.01
Learning capacity	0.738	< 0.01

As can be seen in Table 2, the three aspects that make up the Scale of Adherence to Digital Games in Education showed high correlations with the total score obtained on the scale of the children participating in the present study. This fact reveals that the three aspects are measuring the same construct, that is, the systematized practice of EXGs shows strong adherence by children. The test that most influenced the total score was that of motivational aspects, since it was the subtest that presented the highest Pearson correlation value.

Discussion

The present study shows results that corroborate with previous studies which show that gamified activities provide a sense of increased motivation in their participants (Alves, 2014; Barreto, Vasconcelos, & Orey, 2017; Miller et al., 2019). Video games draw people of almost all ages into virtual world environments, making them work effectively to achieve meaningful goals, persevere in the face of multiple failures, celebrating the rare moments of triumph after successfully completing tasks.

It should be noted that the results presented in the scale used in this investigation corroborate the results found by Júnior and Sales (2012) who concluded that DGs can be used as a resource to facilitate school learning by providing playfulness and leisure. Therefore, educational professionals need to reflect on changes in the forms of communication and knowledge production for the learning of this generation that lives immersed in digital culture (Berbel, 2012; Barbosa & Moura, 2013; Fardo, 2013).

Regarding the students’ feeling of having improved their learning abilities after the systematic practice of exergames, the results corroborate with previous evidence regarding an improvement in cognitive functions after the practice of physical exercises and the training of fundamental motor skills (Jaffery, Edwards, & Loprinzi, 2018; van der Fels et al., 2019; Park et al, 2022). The high index regarding the improvement of their learning capacity, and the experience of the participants when playing the exergame developed for this research is similar to the result of Lai, Wang, and Yang (2012) and seems promising in view of the findings by Diamond (2015) and Mossmann et al. (2016), Cardoso et al (2021) on better performance of cognitive skills through systematized ludomotor practices.

The positive results about an improvement in student's learning skills may be due to the genre of the game, because it is a game that requires the decoding and encoding of information, which means that the practitioner has to mentally manipulate a series of information during practice, thus stimulating the attentional systems and Executive Functions.

Conclusion

The present study obtained good results regarding the experience and motivation during the game perceived by the students, as well as the perception of positive influences on academic learning. Therefore, it justifies the need for further experimental research to assess the effectiveness of the game in question as a neuropsychopedagogical and neurorehabilitative intervention tool in students of the same age group.

From the results presented, it can be considered that the practice of physical exercises in a systematic way through the use of exergames, may be an effective and beneficial educational tool for the development of important cognitive skills for a good academic performance.

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