

# *Serious Games to Improve Attention in Boys and Girls with Attention Deficit Hyperactivity Disorder (ADHD): A Pilot Study*

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## Abstract

**Background:** The objective of this study was to test a treatment program in Serious Games (SG) format to improve attention in children from Catalonia, Spain, with Attention Deficit Hyperactivity Disorder (ADHD). The activities adapted to the SG format consisted of (1) stimulus selection, (2) mark equal drawings, (3) eight differences, (4) hidden figures, (5) compare texts, (6) compare measures and shapes, (7) put model keys, (8) labyrinths and (9) memorization of drawings. **Method:** A pretest-posttest design was used with a cohort of 30 children between 8 and 10 years old diagnosed with ADHD, with 20% girls (n = 6) and 80% boys (n = 24) with a mean age of 9.4 years ( $SD = 0.63$ ; range of 8 to 10 years). Four schools and a clinical center from Catalonia, Spain participated in the sample composition. Half of the sample participated in an attention improvement program for nine sessions of 30-45 minutes each in Serious Games format. They were presented with a series of game challenges with various virtual scenarios through a monitor. The other half did the same attention improvement program in pencil and paper format. **Results:** The children in the Serious Games group progressed and improved more during treatment, as shown by the average number of errors of commission ( $p = .02$ ) than those in the pencil and paper group. Both groups also improved in the total score and concentration scale of the D2 test ( $p < .001$ ). **Conclusions:** Attentional training through programs in Serious Games format seems to have a more significant effect on commission errors than attentional training in pencil and paper format.

**Keywords:** ADHD, Serious Games, attention, treatment, cognitive disorder.

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# *Serious Games para mejorar la atención en niños y niñas con trastorno por déficit de atención e hiperactividad (TDAH): un estudio piloto*

## Resumen

**Antecedentes:** El objetivo del presente estudio ha sido poner a prueba un programa de tratamiento en formato *Serious Games* (SG) para mejorar la atención en niños de Cataluña, España, con Trastorno por Déficit de Atención/Hiperactividad (TDAH). Las actividades adaptadas al formato SG consistieron en (1) selección de estímulos, (2) marcar dibujos iguales, (3) ocho diferencias, (4) figuras ocultas, (5) comparar textos, (6) comparar medidas y formas, (7) poner llaves modelo, (8) laberintos y (9) memorización de dibujos.

**Método:** Se utilizó un diseño pretest-postest con una cohorte de 30 niños entre 8 y 10 años con diagnóstico de TDAH, con un 20% de niñas ( $n = 6$ ) y un 80% de niños ( $n = 24$ ) con una edad media de 9.4 años ( $DE = 0.63$ ; rango de 8 a 10 años). La mitad de la muestra participó en un programa de mejora de la atención durante 9 sesiones de entre 30-45 minutos cada una en formato de *Serious Games*. Se les presentó una serie de desafíos de juego con varios escenarios virtuales a través de un monitor. La otra mitad de la muestra hizo el mismo programa de mejora de la atención, pero en formato lápiz y papel. **Resultados:** Los niños del grupo de *Serious Games* progresaron y mejoraron más durante el tratamiento, como lo demuestra el promedio de errores de comisión ( $p = .02$ ), en comparación con los niños del grupo de lápiz y papel. Ambos grupos también mejoraron en la puntuación total y en la escala de concentración de la prueba D2 (ambos  $p < .001$ ). **Conclusiones:** El entrenamiento atencional a través de programas en formato *Serious Games* parece tener un mayor efecto que el entrenamiento atencional en formato lápiz y papel sobre los errores de comisión.

**Palabras clave:** TDAH, Serious Games, atención, tratamiento, desorden cognitivo.

## Introduction

The prevalence of Attention-deficit/Hyperactivity Disorder (ADHD) worldwide has been reported with significant variations among different studies, ranging from 8% to 18% among children and adolescents, with up to 65% continuing to have ADHD symptoms and neuropsychological impairments in adulthood (Luo et al., 2019; Polanczyk et al., 2015). The symptoms of ADHD carry a series of negative consequences in many aspects of the lives of individuals, families, and society, including, but not limited to, emotional and self-esteem problems, learning and coexistence problems at school, and increased spending in health system services.

Attention-deficit/hyperactivity disorder is characterized by three nuclear symptoms: inattention, impulsivity, and hyperactivity (Tehrani-Doost et al., 2017). It is hypothesized that neurocognitive deficiencies are a fundamental and widespread part of ADHD symptoms, including the domains of sustained attention or vigilance, working memory, and self-regulation, and executive function (EF) (Kofler et al., 2018).

Numerous studies support a multifactorial model in its etiology, arguing that genetic, biological, and environmental factors interact during early development to create a susceptibility to the disorder (Bélanger et al., 2018). This

etiological heterogeneity in biological and environmental factors is probably manifested in different neural correlations and, consequently, other cognitive and behavioral profiles and development trajectories of the disorder. Consequently, it is not possible to consider it as a homogeneous disorder (Luo et al., 2019).

Currently, the most widely used treatment for ADHD combines medication and cognitive-behavioral therapy (Cortese & Rosello-Miranda, 2017). However, the medium and long-term side and adverse effects of this disorder's medication are recognized (Yoo et al., 2020). The scientific community looks for alternatives that have fewer side effects and show greater or comparable improvement to traditional treatments.

One of the most widely used conventional treatments that does not have the adverse effects of medication is cognitive training in pencil and paper format, which includes activities to improve attention, self-instructions, and relaxation exercises. Children who have received cognitive training have been observed to improve attention and efficiency in academic tasks (Chacko et al., 2014; Cortese et al., 2015; Dosis et al., 2015; Johnstone et al., 2017; Kerns et al., 1999; Pahlevanian et al., 2017; Rapport et al., 2013; 2017; Robinson et al., 2014; Shinaver et al., 2014; Tamm et al., 2014; Tangul et al., 2013; ).

Other studies have shown that self-control techniques improve behavior and academic productivity in some children with ADHD (Shapiro & Cole, 1994) and decrease aggressive behavior in children with ADHD (Miranda et al., 2000). However, some of these activities can be tedious and generate some resistance in the continued application among children. The application of Serious Games (SGs) in training using cognitive-behavioral techniques has been shown to improve attention and impulsivity in children with ADHD (Dovis et al., 2012; Lim et al., 2010).

Some research has gone further, showing that the use of SG could improve motivation and adherence to treatment (Dovis et al., 2012). Hence, the inclusion SGs in the health field presents the potential to be considered due to its intrinsically motivating nature (Giunti et al., 2015). Based on a recent review of research evidence, Zheng (2021) has established that SGs are a relevant tool in diagnosing and treating ADHD. It is relevant to strengthening attention, supporting executive functions, and enriching social communication skills. In this way, electronic games of this type have significant effects on ADHD and can be a complement or alternative to conventional treatments.

Following this, the objective of this study was to test a treatment program in Serious Games format to improve care in children from Catalonia, Spain, with ADHD. The developed SG program is based on and replicates cognitive training in pencil and paper format, which includes activities to improve attention, self-instructions, and relaxation exercises, but an electronic game mode. A second objective was to compare the results of the application of the SG program and a conventional program (pencil and paper) for attention training in children with ADHD. The experimental group (SG) and the control group (pencil and paper) perform the same activities to improve attention, self-instructions, and relaxation exercises, but in a different format.

We hypothesize there were statistically significant differences between serious digital game programs versus the paper-and-pencil intervention in treating children with ADHD. Specifically, the experimental group will present a greater increase in sustained attention than the control group, and the participants in the experimental group will obtain better scores in selective attention than the control group.

### *Serious Games*

A Serious Games is an interactive game, attractive, but not necessarily fun, that promotes implicit or explicit learning, that does not have a unique pedagogical approach and whose learning results depend on the use of an appropriate didactic method, mechanics of underlying game, and content integration, situating learning as an intrinsic behavior of the game. They also present motivational and affective effects, help the acquisition of knowledge and understanding of concepts, favor the development of motor and social skills (Valverde, 2015). SGs should be defined as games that involve a pedagogical dimension and motivate the user to achieve defined purposes instead of focusing on pure entertainment (Zhonggen, 2019).

Wattanasoontorn et al. (2013) divide the tools used into three groups to design SGs: database (player information, score, animation, etc.), game engine (controls game operation), and software applications of design. The format can be both 2D and 3D. The content is the information with which the game will be developed; this is analyzed by experts and will focus on the game's objective. The technology used can be virtual reality or increased. The video game genre is an adventure, sports, action, strategy, simulation, role, or others. Typically, the goal of SGs is aimed at the field of education, training, or dissemination of information (Laamarti et al., 2014).

Within the SG in the psychological field, we find the programs developed for the psychological treatment of different disorders. Some of the technologies used are telemedicine, internet or virtual reality (Botella et al., 2010). They have been applied in different disorders such as schizophrenia (Francillette et al., 2021), addictive disorders (Gamito et al., 2014), attention deficit (Peñuelas-Calvo et al., 2020), autism education and treatment (Grossard et al., 2020), prevention of sexual abuse (Stieler-Hunt et al., 2014), post-traumatic stress disorder (Radkowski et al., 2011) and social skills training (Bahiss, 2021).

An example of this type of SG is PlayMancer, which has been applied to therapy for addictive behaviors, eating disorders, and impulsivity (Fernández-Aranda et al., 2012). The game introduces the player to an interactive scenario called Islands, where the challenge is to increase skills in emotional control and self-control of impulsive behaviors. Islands is made up of several islands; in each of them,

different activities occur with varying degrees of difficulty. The player will be faced with various situations in which they will have to strengthen their skills in problem-solving, impulse control, frustration, and emotion management.

In the last decade there has been a growing interest in investigating the application of SG in the therapeutic setting, one of the areas of interest has been the impact of these games on ADHD, where it is possible to notice a series of favorable repercussions.

#### *Serious Games (SG) as Treatments for ADHD*

Serious Games (SG) treatments can be used as complementary tools in combination with conventional treatments (Fleming et al., 2017). The possibilities offered are very wide, especially in mental health, because they can be used for preventive, psychoeducational, and therapeutic purposes (Alchalabi et al., 2018; Dankbaar et al., 2017).

Studies have been conducted to assess Serious Games' effectiveness as a treatment for ADHD, observing that children with ADHD who have received treatment show improvements in various aspects such as: selective attention, divided attention, and inhibitory control (Kerns et al., 1999; Shalev et al., 2007). This type of game offers a series of elements that are very interesting given the central characteristics of children with ADHD.

Some children diagnosed with ADHD present inattention symptoms that make it difficult for them to perform school tasks and daily activities, showing difficulty maintaining attention, following instructions, organizing, or paying attention for an extended time. Also, others children with ADHD have little motivation in tasks that do not positively and regularly reinforce their progress. It has been observed that the use of video games as a treatment for ADHD produces a series of consequences or positive repercussions on several of the symptoms mentioned above. For example, children with ADHD, when playing with SGs, since they are highly motivating and reinforcing tools (Krca, 2016), show greater sustained attention and adherence to the task (Green & Bavelier, 2012; O'Connell et al., 2006). The positive aspects they offer are the ability to immerse and the low resistance to using them, so this makes them an ideal tool for intervening on the cognitive processes underlying ADHD (Park et al., 2019; Wronska et al., 2015). Krca (2016) investigated the factors that reversed children's interest

with ADHD to undergo cognitive training and concluded that they respond better to SGs that present an environment that varies in content and images, that reward immediately, and contain familiar and easy exercises.

Klingberg et al. (2005) showed that children with ADHD between 7 and 12 could improve working memory and inhibitory control through intensive training of 25 to 40 minutes a day for 5 weeks. O'Connell et al. (2006) conducted a study in which training in sustained attention with the SART program was applied to 15 children diagnosed with ADHD, who had a significant short-term change in reducing errors due to commission. They concluded that sustained attention could be improved in children with ADHD from computer-based cognitive training. Shalev et al. (2007) evaluated an intervention program's efficacy to improve children's attention with ADHD from the progressive attentional training program (CPAT), a structured program with four games that worked on sustained, executive, and orientation attention. The children, ages 13-15, improved in reading comprehension, and parents reported a significant distraction reduction. Attentional games help formulate strategies, help improve solving techniques, and, underlyingly, work on controlling sustained attention directed to learning objectives (Van de Sande et al., 2015). Another factor that influences ADHD and which has been the study is working memory. Children with ADHD, after six weeks of working memory training, decreased their motor activity and improved their working memory (Klingberg et al., 2002). Cognitive training is a useful tool to improve working memory in ADHD (Cortese et al., 2015).

In the stimulation of working memory and visual memory, the following stand out: 'Treasure Hunt' and 'The Night' (Santo et al., 2013). The first game trained visual memory. A symbol was the computer screen for a few seconds, then the symbol was hidden, among others, and the child had to distinguish which one was shown first. The second game, 'The Night', stimulated short-term memory. A series of symbols were shown that the subject had to memorize to later reproduce in the same order. These games were made up of 10 levels in which the difficulty was increasing. The program was applied to both children with a diagnosis of ADHD and children without attention problems, but the results were not significant; in working memory, one of the programs developed for this is the Monkey Game (Van de

Weijer-Bergsma et al., 2015). The children had to remember a series of words that were exposed audibly, and later they had to select the mentioned words presented in images. The difficulty increased as the number of words to remember increased. The results obtained showed improvements in working memory.

In time management and planning, the 'Plan It Commander' program stands out. The program's purpose was to teach children between the ages of 8 and 12 to plan, manage time, and have prosocial behavior. The effects of play were examined in a clinical study with 170 children. The results suggest that the participants were satisfied with this game and improved their time management strategies, planning, organization, and improvement in prosocial skills (Bul et al., 2016). Researchers observed that children developed teamwork skills since they had to interact within a community where the subject saw and evaluated others' actions; thus, they had to help each other find solutions to the problems presented during the game (Bul et al., 2016). Frutos-Pascual et al. (2014) developed a program aimed at adolescents between 12 and 19 years old to teach how to manage and organize time. The study was carried out with a sample of 17 participants, and the program consisted of working on the skill in prioritizing tasks. The acceptance of the program among the adolescent population was positive. In contrast, it was found that the exercises were easy for the subjects who participated in the study, due to the broad age range in which the sample was composed (Frutos-Pascual et al., 2014).

Another area in which SG has been applied is the development of social skills in children with ADHD. Ahmadi et al. (2015), created the TARLAN program, a game composed of 40 scenarios in the children's daily experience, in which social skills were worked. With a sample of 20 children between 8 and 12 years old, the results showed significant improvements in social skills. Platforms have also been developed that offer support to family members and teachers through pages where information, advice, and activities are given.

For what has been stated so far, SGs in the treatment of ADHD offer many application possibilities to stimulate attention and control impulsivity, treating working and visual memory, planning and time management, and social skills. It is certainly a developing area and requires more research.

In light of prior research, the aim of this study is to develop a treatment program in Serious Games format, carried out in two phases, to improve attention in children with Attention-deficit/Hyperactivity disorder (ADHD). Specifically, this project aimed to apply the treatment program to children with ADHD in a SG format and in a pencil and paper format comparing both groups in different components of attention such as selective and sustained attention, and its impact as a training program in reducing errors in execution.

## Method

### Design

A pretest-posttest design was used with a cohort of children between 8 and 10 years old diagnosed with ADHD. While a group performs attention training developed in SG format (experimental group), another group performs the same training with paper and pencil exercises (control group). The improvement in care assessed by the D2 and the CSAT was considered as a dependent or outcome variable.

### Participants

A total of 30 children diagnosed with ADHD were included in the study, with 20% girls ( $n = 6$ ) and 80% boys ( $n = 24$ ) with a mean age of 9.4 years ( $SD = 0.63$ ; range of 8 to 10 years). Four schools and a clinical center from Catalonia, Spain participated in the composition of the sample.

The inclusion criteria were (1) having a diagnosis of ADHD disorder at the time of the study having been diagnosed by a psychiatrist or specialist psychologist, (2) being between the ages of 8 and 10 and (3) having an intellectual quotient (IQ) equal to or greater than 85. The exclusion criteria included (1) being under pharmacological treatment, (2) presenting a behavioral disorder and (3) not accepting the parents/ legal guardians or the children participating in the study.

Participants were alternately assigned to experimental and control groups. The size of both groups was equal; half ( $n = 15$ ) followed the treatment program in Serious Games format, and the other half ( $n = 15$ ) followed the treatment program in pencil and paper format.



### Measurements

#### *Children Sustained Attention Task –CSAT- (Servera & Llabrés, 2004)*

The CSAT is one of the most widely used instruments to assess sustained attention (Losier et al., 1996; Rapport et al., 2000; Servera & Cardo, 2006). This test consists of randomly presenting numbers one by one and where the participant has to press the space bar on the keyboard each time a 3 appears after a 6. The different digits follow each other quickly, so the child must be attentive to respond successfully to this sequence. The CSAT is a version of the so-called “continuous execution tasks” applied individually and computerized to children between the ages of 6 and 11. The approximate duration to complete the test is 7 minutes. For this study, the following indicators have been used: the hits and omission errors (the total number of hits and the number of omissions), the reaction time of the hits (the average response latency of the subject in identifying the targets), errors of commission or false alarms (the total number of times the subject had identified a target when it was not), and reaction time to alarms (the average latency of the subject’s response to false alarms). CSAT has showed good psychometric indices and it is proposed to use in further applied or clinical studies. The test-retest reliability in a sample from 6 to 11 years of age ranged between .59 and .88. (Servera & Llabrés, 2004).

#### *Attention test -D2- (Brickenkamp, 2002)*

The D2 is a time-limited test that measures selective attention. It was selected because it is a widely used test in applied psychology (Brickenkamp, 2002). D2 can be applied individually and collectively, with an estimated time of between 8 and 10 minutes. On the front of the copy, there are 14 lines with 47 characters, a total of 658 elements. These stimuli contain the letters “p” and “d” that one or two lines may accompany; the subject will have to mark all the “d” with two stripes. The indicators obtained are: TR (total responses, number of items attempted in the 14 lines), TA (total hits, number of relevant items correct), OR (omissions, number of relevant items attempted but not marked), C (commissions, number of irrelevant items marked), TOT (total effectiveness in the test), CON (concentration index or TA-C), TR+ (line with the highest number of items attempted), TR- (line with the lowest number of attempted elements) and VAR (index of variation

or difference (TR+)-(TR-). This instrument was adapted by Seisdedo (2002) in the Spanish population. The scales for the Spanish population from 2 to 18 years in powerful percentiles and S ( $M=50$  and  $SD=20$ ).

Both tests were applied three times in the study: before treatment, during treatment (fifth session) and at the end of treatment (ninth session).

Two graphic designers, a programmer and a psychologist participated in the creation of the program. Two applications were used in the development of virtual environments: 3d Studio ® and Virtools 3 Dev ®.

### Treatment

The intervention consisted of a cognitive training based on a pencil and paper treatment program (control group) and on a Serious Games format (experimental group) in which attention, self-instruction and relaxation exercises were worked out.

#### *Control group*

The activities carried out in the control group for the improvement of attention were selected from five of the most used treatment programs for school-age children. The programs chosen were: *Memory enhancement and attention II* (García & González, 2005), *Cognitive intervention-behavioral therapy for children with attention deficit hyperactivity* (Orjales & Polaino, 2001), PIAAR (Level 1 and 2) *Educational intervention program to increase attention and reflexivity* (Gargallo, 2009), *Understanding verbal. initiation. Strengthening and development of skills basic mentals* (Yuste & Sánchez, 1999) and *Progesint 13. Attention-observation* (Yuste & Sánchez, 1992).

The selected exercises consisted of: (1) stimulus selection, (2) mark equal drawings, (3) eight differences, (4) hidden figures, (5) compare texts, (6) compare measures and shapes, (7) put model keys, (8) labyrinths and (9) memorization of drawings. In these exercises, sustained and selective attention, inhibition, planning, processing speed and working memory were trained (Guerrero, 2016). Two exercises were also selected about (10) written instructions and (11) comparing and matching to improve the capacity of organizing information and helping children to discriminate against the main information of, essential components to improve attention (Orjales, 1991). The activities gradually increased in difficulty at different levels. The self-instruction

program adapted by Orjales and Polaino (2010) inspired by the design of Meichenbaum and Goodman (1971) was used for training in self-instruction. Likewise, an adaptation of Jacobson's progressive relaxation (1929) for children by Orjales and Polaino (2010) was applied.

#### *Experimental group*

The activities carried out by the experimental group were the same as those of the control group but applied in a virtual environment in Serious Games format.

The first session began in the training area. The child had first exposure to handling the controls and operation of the game. The therapist instructed him how to move around the environment and the operation of the keyboard (see Figure 1). The child selected different objects that the therapist pointed out to him; he could manipulate, move, and move them. In this phase, an introduction to self-instructions was also carried out; the identification signs that would guide the child in their progress appeared on the screen. The therapist explained its functioning. Once the participant had become familiar with the environment, had learned to move in it, and had learned the self-instruction method, the activities were undertaken.

Figure 1

*Images of the instructions of the 'Serious Games' program*



The activities adapted to the SG format consisted of (1) stimulus selection, (2) mark equal drawings, (3) eight differences, (4) hidden figures, (5) compare texts, (6) compare measures and shapes, (7) put model keys, (8) labyrinths and (9) memorization of drawings. As an example:

Selection of stimuli: the exercise consisted of finding the bottles that were the same as the model (see Figure 2). The search would become more complex as the different levels followed one another. The objective of this activity was to practice discrimination of shapes, measurements, position and color, visual memory, and selective comparison.

Figure 2

*Stimulus selection exercise*



Mark the same pictures: different pictures were displayed in two rooms of the house; the child had to go from one room to another and mark the same pictures (see Figure 3). At higher levels, the differences were less evident. The objective of this activity was the discrimination of shapes, position, color, visual memory, and selective comparison.

Figure 3

*Mark the same pictures exercise*



### *Procedure*

Once the contact with the educational centers was established and the request to apply the study was accepted, the responsible of the center selected the students who met the inclusion criteria. The place, the day and the hours in which the treatment would be carried out were established.

#### *Experimental Group (Serious Games)*

Distribution of the sessions in the experimental group: Serious Games. Nine sessions were held, structured in the same order, twice a week, lasting between 30 and 45 minutes. They were structured following three levels of difficulty:

**Level I.** The therapist acted as a model, guiding the child to become familiar with the self-instructions and the game's functioning. The self-instructions appeared after the statement of each activity so that when reading the statement, the participant began the analysis of the exercise. The participant read the instructions aloud as he/she answered, and the therapist helped the child to solve the questions or to rephrase the questions.

Session 1. The tests (CSAT and D2) were applied, the program was started in the training area, the functioning of the self-instructions was explained, and the exercises were performed.

Session 2. The labyrinth exercises were carried out, the different drawings were compared according to their shape, and the exercises of selection of stimuli, hidden figures, and selection of identical drawings were carried out.

Session 3. Activities of selecting identical drawings, written instructions, selection of stimuli, reading, and Jacobson's guided relaxation were carried out.

**Level II.** At this level, only the self-instructions appeared at the beginning of the program as a reminder. The child verbalized the same and answered them without the therapist's help, unless there were difficulties.

Session 4. The search for differences, labyrinths, comparison, and relation of objects exercises were carried out.

Session 5. The tests (CSAT and D2) were applied, and the exercises of selection of stimuli, hidden figures, selection of identical drawings, and written instructions were carried out.

Session 6. The exercises for comparing objects based on Jacobson's form, reading, and relaxation were carried out.

**Level III.** At this level, it was expected to achieve the internalization of the self-instructions, which the child verbalized with an internal voice and solved the exercises.

Session 7. The search for differences, labyrinths, comparison, and relation of objects exercises followed one another.

Session 8. The exercises of selection of stimuli, hidden figures, selection of identical drawings, and written instructions were carried out.

Session 9. The exercises for comparing objects based on Jacobson's form, reading, and relaxation were carried out. The tests (CSAT and D2) were applied.

#### *Control Group*

Nine sessions were also performed with the control group, twice a week with duration of between 30 and 45 minutes each. The activities carried out in the control group were the same as those carried out in the experimental group. They were distributed in the same way and the use of the self-instructions was carried out in the same order, but in this case they were shown in a cardboard. Jacobson's relaxation was performed using an audio file equal to that used in the experimental group. In the first, fifth and ninth sessions, the CSAT and D2 tests were applied.

Throughout the process, both groups were evaluated before, during and at the end of the treatment. Once the treatment was finished, the results obtained by each participant were presented through interviews with the parents and the educational team.

#### *Ethical aspects*

This project was not evaluated by an ethics committee; however the corresponding authorizations were requested from the authorities of the four educational centers in Catalonia with which we work. Similarly, the parents of the children were informed of the details of the study and subsequently signed the written consent. During the intervention, all ethical principles (Singapore agreement) were respected so that the children could participate comfortably and safely. The degree and time of exposure to monitors were protected, thus avoiding any visual or perceptual discomfort. After this, the data analysis process adhered to strict confidentiality and protection.



### *Statistical analysis*

In order to evaluate the effectiveness of the Serious Games program and compare it with the conventional pencil and paper program, the results obtained in the different tests applied (CSAT and D2) were analyzed by a two-factor ANOVA with repeated measures in one factor. The factor between subjects is determined by the type of treatment applied to each group (SG vs. pencil and paper). The intragroup factor has three levels, which correspond to the measures of the dependent variables in three moments: before treatment, during treatment (fifth session) and at the end of treatment (ninth session). For the application of ANOVA, the assumption of normality was tested through the Shapiro-Wilk test ( $p > .05$ ).

In the same way, homogeneity of variances and sphericity were checked. In none of the analyses, the nullity hypothesis regarding differences in variances could be rejected, applying the Levene test. However, the sphericity hypothesis was rejected in some comparisons. In those cases where the assumption of sphericity could not be assumed according to Mauchly's W statistic, the degrees of freedom were corrected by adjusting Greenhouse-Geisser. The general significance adopted was  $p < .05$ . To make multiple comparisons, post-hoc contrasts were used. To control the probability of committing type I errors, the Bonferroni correction was applied.

## **Results**

### *Sustained Attention Across Tasks*

The results of the ANOVA showed an interaction effect (group x moment),  $F(1.28)11,826, p = .002, \eta^2 = 0.297$ , which indicates that both groups presented a different evolution of the sensitivity index of the CSAT throughout of treatment. In the SG group the improvement was progressive, while in the pencil and paper group the improvement was quadratic, that is, it occurred between the pre-treatment and the fifth session, not between the fifth and ninth sessions.

Global comparisons between groups did not indicate statistically significant differences. Intragroup comparisons at the three moments of the evaluation showed the existence of statistically significant differences ( $F(1.28)27,304, p < .001, \eta^2 = 0.494$ ), so there was an improvement in the attentional capacity after treatment in both groups. Multiple

comparisons a posteriori revealed the existence of significant differences between the pre-treatment and the fifth session ( $-18,333, p < .001$ ), between the fifth session and the post-treatment ( $-6,300, p = .042$ ) and between the pre and post treatment ( $-25,133, p < .001$ ).

### *Total Correct Answers in The Task*

The ANOVA results indicated that there was no interaction (group x moment). Global comparisons between groups did not indicate statistically significant differences. Intragroup comparisons at the three moments of the evaluation showed the existence of statistically significant differences ( $F(1.28)8.825, p = .006, \eta^2 = 0.240$ ), that is, there was an improvement in the total number of successes after the treatment in both groups. Multiple a posteriori comparison revealed the existence of significant differences between pretreatment and posttreatment (differences between means =  $-17.233, p = .018$ ).

### *Commission Error Rate During Task*

The results of the ANOVA indicated that there were no intragroup differences ( $F(1.28)1.046, p = .347$ ), nor between groups ( $F(1.28)0.967, p = .339$ ), but there was an effect interaction (group x moment),  $F(1.28)8.004, p = .011, \eta^2 = 0.308$ . This indicates that initially in the pre-treatment measure both groups did not differ in the rate of commission errors of the CSAT, but subsequently the SG group decreased linearly, from an average of 35 errors per commission in the first test (before treatment) to one of 8.5 in the last. Both groups differed statistically significantly after the first test (34.5 vs. 13.9,  $t = 2,496, p = .02$  and 30.5 vs. 8.5,  $t = 2,550, p = .01$ ).

### *Total Score in Selective Attention to the Task*

The results of the analysis of variance of repeated measures and the multiple a posteriori comparisons in the total score in D2 showed the absence of statistically significant interaction (group x moment), indicating that there was no different evolution of this measure in the two groups throughout the treatment. Nor were significant differences found in comparisons between groups, but intragroup. Comparisons at the three moments of the evaluation showed the existence of statistically significant differences ( $F(1.28)63.485, p < .001, \eta^2 = 0.694$ ), that is, there was an improvement in the total D2 score after the

treatment in both groups. Multiple a posteriori comparison revealed the existence of significant differences between pretreatment and fifth session ( $-27.867, p < .001$ ), between the fifth session and post treatment ( $-8.933, p = .001$ ) and between pre and post treatment ( $36.800, p < .001$ ).

#### *Concentration Score Throughout the Task*

The ANOVA results indicated that there was no statistically significant interaction effect (group x moment); both groups behaved similarly in the evolution of this measure throughout the treatment. Nor were significant differences found in comparisons between groups. Intragroup comparisons at the three moments of the evaluation showed the existence of statistically significant differences ( $F(1.28) 27, p < .001, \eta^2 = 0.496$ ), that is, there was an improvement in the concentration score of the D2 after treatment in both groups. Multiple comparisons a posteriori revealed the existence of significant differences between the pre-treatment measure and the fifth session ( $-23.800, p < .001$ ), between the fifth session and the post-treatment ( $-8.933, p = .001$ ) and between the pre and post-treatment ( $36.800, p < .001$ ).

## **Discussion**

Previous studies have shown that, programs specifically designed for the training of the care of children with ADHD have shown significant improvements in selective attention (Carpio, 2020; Tamm et al., 2010), as well as in the decrease in impulsivity (Valls-Llagostera et al., 2015). In the same way it has been shown that the application of Serious Games in the training through cognitive-behavioral techniques has an impact on improving the attention and impulsivity of children with ADHD (Avila et al., 2018; Lim et al., 2010), increasing, in turn, motivation and adherence to treatment (Dovis et al., 2012).

The purpose of the present investigation has been to develop a treatment program in Serious Games format to improve the care of children with ADHD and to evaluate its effectiveness by comparing the results obtained after its administration with those of an attention training program in the format of pencil and paper. The prediction was made that the SG-format program would be more effective than the pencil-and-paper program in relation to (1) the

improvement in selective attention assessed by the D2 test, (2) the improvement in the level of concentration in the test D2, (3) the improvement in the index of sensitivity or attentional capacity (attention sustained) in the CSAT test, (4) the total correct answers in the CSAT test, and (5) the decrease in commission errors evaluated by the CSAT test.

After the intervention, both with the program in SG format and the program in pencil and paper format, changes in attention and decreased commission errors were observed. This improvement was more pronounced in the SG group since in commission errors, participants in the experimental group achieved better performance at the end of treatment than those in the control group. The results obtained were consistent with the literature, in which there is evidence that cognitive-behavioral treatments are effective for ADHD, improving attention and reducing impulsivity (Cortese & Rosello-Miranda, 2017; Valls-Llagostera et al., 2015). Likewise, the results obtained specifically with the SG program are consistent with those obtained in large part of previous studies (Fernández-Jaen et al., 2017; Thompson, 2017; Wrońska et al., 2015).

Specifically, concerning the improvement of selective attention, evaluated by D2, both groups improved their results significantly in the post-treatment period. Our results did not show significant differences in the SG format program's favor. The results of this study thus showed that, regardless of the format of the program with which the training is carried out (SG or pencil and paper), it is effective in improving selective attention. These results are consistent with most of the studies that have been carried out to date and indicate an improvement in selective attention in people who are trained, either through exercises based on pencil and paper or through programs similar to SG like video games. For example, Green and Bavelier (2007) describe improvements in selective attention among regular video game players. These players could detect and ignore inputs more quickly; they presented a higher resolution in visual attention and selective attention in space. Likewise, Feng et al. (2007) point out that women with greater use of video games improved in attention and spatial abilities. Programs specifically designed for attention training in children with ADHD have also shown significant improvements in selective attention (Kerns et al., 1999; Samson et al., 2021; Tamm et al., 2010).

Regarding sustained attention, the total number of correct answers on the CSAT test was similar in both groups, but between the first and fifth sessions, the control group (pencil and paper) showed a more significant increase in sustained attention than the experimental group (Serious Games). However, at the end of the treatment, both groups showed similar levels of improvement. In our study, the control group improved more rapidly initially in sustained attention, and the experimental group's progression was slightly slower but reached similar levels at the end of treatment. Research on these different rates of improvement related to the methods used for training may open new lines of work in the future.

Regarding the errors by commission, the children that received the training in SG format reached a better performance at the end than those of the control group. The errors per commission score reflect a control problem motor or inhibition-impulsivity. Although a study by [Steiner et al. \(2011\)](#) found a different result than that of the present investigation, the trend of results of the previous investigation endorses what we have reported. Other authors, such as [Sholberg and Mateer \(1989\)](#), also developed sustained attention training programs and observed improvements after treatment. Kerns et al. (1999), with the Play Attention program, also observed improvements in sustained attention in children diagnosed with ADHD, as did authors such as [Dye et al. \(2009\)](#), [O'Connell et al. \(2006\)](#) and [Sújar et al. \(2022\)](#). Various aspects already mentioned, such as the greater attractiveness of the stimuli or the greater motivation of the task in this modality, could influence a better performance in children with ADHD of some cognitive processes, such as sustained attention or working memory, executive function, which make it possible to have fewer commission errors.

Taking these results into account, it can be stated that both the SG format program and the pencil and paper format program were effective, with the former showing superiority over the latter in some outcome measures.

Research on these different rates of improvement related to the methods used for training may open new lines of work in the future. At the same time, these results are an incentive for psychologists to consider using new technologies, such as SGs, to treat and diagnose mental conditions that involve cognitive deficits, such as ADHD ([Doulou et al., 2022](#)), and general mental health ([Dewhirst et al., 2022](#)).

All this gives professional practice greater tools to face challenges such as better performance when studying and higher levels of concentration when doing schoolwork and in the classroom. This type of treatment is not intended to replace other treatments but to be part of multidisciplinary programs or treatments that complement each other. What should be clear is that in these times, video games or digital technologies are increasingly part of people's minds, and considering them for specific treatments is therefore reasonable, and by the way, even more so if research progressively gives us promising data ([Sújar et al., 2022](#)).

#### *Limitations and Future Studies*

First, the sample sizes were reduced, which affected the power of the analysis and the generalizability of the results. Second, explicit measures only included the assessment of attention deficit, limiting the conclusions that can be drawn in other areas such as motivation, hyperactivity, anxiety, or depression. Third, the fact that explicit measures were collected through questionnaires applied to the participants themselves makes them susceptible to certain types of bias. Fourth, children who were under pharmacological treatment were excluded, so we do not know the effects of the program in patients with medication, and the possible combined effect. Fifth, the maintenance of the changes has not been evaluated, so the improvements of long-term interventions are unknown.

Finally, future research may focus on measuring the level of motivation and adherence to the treatment of interventions with programs in the Serious Games format. However, when faced with this type of game, certain precautions must be taken since excessive use of the Internet, offline games, and addiction are serious concerns for young people with ADHD. Children with ADHD can be vulnerable as these games operate in short segments that require no attention. Also, they offer immediate rewards with a strong incentive to increase the reward when attempting the next level. Time spent playing these games can also exacerbate ADHD symptoms, if not directly, through the loss of time spent on more challenging tasks ([Schmidek et al., 2018](#)).

As has already been revealed, another critical aspect related to future studies' design is the longitudinal perspective that allows assessing the stability of the improvements over different follow-up periods. Finally, with the results obtained in the current study that show a significant improvement in

commission errors, it would be relevant to assess Serious Games programs' effectiveness in improving impulsivity in children with ADHD.

### Conclusions

To summarize, this study showed evidence that both the program in Serious Games format and the program in pencil and paper format were effective, observing a similar improvement in both groups in sustained and selective attention throughout the treatment. The SG group obtained a more progressive improvement throughout the treatment in the average commission errors than the pencil and paper group. Treatments such as the one developed here, brief and in group format, can be applicable in the educational system, and / or in the public and / or private health system, with lower cost than an individual therapy and allowing to offer treatment to a greater number of patients.

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