

Games and ADHD-ADD: A Systematic Mapping Study

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ABSTRACT:

Attention Deficit Hyperactivity Disorder (ADHD) is a neuro-developmental disorder that starts in childhood and has a persistent pattern of behaviour involving lack of attention and/or hyperactivity-impulsiveness that interferes in social, academic or work processes, or reduces the quality of them. Through activities with games, children and adolescents improve memory, concentration, motor planning and time management skills. According to some studies these may present positive effects for the attention span, executive functions, working memory and other cognitive skills. However, there are few studies that explain their effects. This paper presents a systematic mapping study and underlines the direction taken by the empirical studies undertaken on the use of digital games in treating ADHD and ADD. A total of 12 articles, covering 2005 to 2015, were selected. The research questions behind the study were: RQ1 What particular characteristics have been investigated by researchers?; RQ2 What research methods have been used?; and RQ3 On which game has the study on ADD-ADHD been focused?. There are studies are focused on the risk of addiction, increased attention deficit or behaviour problems and studies evaluating the improvement in executive functions, reduction in hyperactivity and motivation. The research methods used were experimental and exploratory methods. Finally, the digital games are analyzed without distinguishing between the genres and theme of the game.

KEY WORDS:

adolescents, attention deficit disorder, attention deficit hyperactivity disorder, digital games, children, literature review, systematic mapping study.

Introduction

According to Salen and Zimmerman,¹ a game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome. Moreover “meaningful play occurs when the relationships between actions and outcomes in a game are both discernible and integrated into the larger context of the game”.² Through activities with games, players improve memory, concentration, motor planning and time management skills. Therapeutic sessions for children and adolescents with ADHD aim to help them improve executive functions and specific skills.³ Several scientists have proposed game-based cognitive-behavioural interventions, which seem to be highly promising.⁴ *Attention Deficit Hyperactivity Disorder* (ADHD) is a neuro-developmental disorder that starts in childhood and has a persistent pattern of behaviour involving lack of attention and/or hyperactivity-impulsiveness that interferes in social, academic or work processes, or reduces the quality of them. Currently it is one of the most prevalent neuro-developmental

1 SALEN, K., ZIMMERMAN, E.: *Rules of play*. Cambridge, MA : The MIT Press, 2004, p. 80.

2 Ibidem, p. 35.

3 RETALIS, S., KORPA, T., SKALOUMPAKAS, C., BOLOUDAKIS, M., KOURAKLI, M., IOANNIS, A., FOTEINI, S., PINELOPI, P., FENIA, L., PANAGIOTA, P.: Empowering children with ADHD Learning disabilities with the Kinems Kinect Learning Games. In BUSCH, C. (ed.): *Proceedings of the 8th European Conference on Games Based Learning*. Berlin : Academic Conferences and Publishing International Limited Reading, 2014, p. 470.

4 FRUTOS-PASCUAL, M., ZAPIRAIN, B. G., ZORRILLA, A. M.: Adaptive Tele-Therapies Based on Serious Games for Health for People with Time-Management and Organisational Problems: Preliminary Results. In *International Journal of Environmental Research and Public Health*, 2014, Vol. 11, No. 1, p. 750. [online]. [2019-11-03]. Available at: <<https://www.mdpi.com/1660-4601/11/1/749/htm>>.

disorders in child psychology and psychiatry, with around 5% of children and 2.5% of adults affected. According to DSM-5, ADHD is more frequent among males than females in the general population, with an approximate proportion of 2:1 in children and 1.6:1 in adults. Females tend to present rather features of lack of attention than males.⁵ ADHD has been identified as an upset in executive functions and emotional self-regulation. This means a difficulty in inhibiting replies, starting actions intentionally, a deficit in attention control, decision-making, objective planning and organization, mental flexibility as well as meta-cognition. ADHD is part of a wider alteration in executive functions.⁶

The results of studies in this field of psychology do not appear to be balanced. Investigation has shown both positive and negative effects (benefits and risk) in relation to digital games in terms of attention, executive functions, work memory and other cognitive skills. There are also few articles that carry out a review balancing the effects thereof during the child/juvenile period of boys and young people with ADHD. In terms of ADHD and digital games, authors such as Prot et al. present an overview of research findings on positive and negative effects of digital games, thus providing an empirical answer to the question, 'are digital games good or bad?' Several negative effects of digital games are reviewed including effects of violent games on aggression-related variables as well as effects on attention deficits, school performance and gaming addiction. In addition, related positive effects of digital games are described, including effects of action games on visual-spatial skills, and effects of educational digital games, exergames, and prosocial digital games.⁷ Furthermore, in various studies games have been defined in many ways, either in terms of the gaming experience, or as an interactive structure of endogenous meaning that requires players to struggle toward a goal.⁸

Method

The main goal of this paper is to summarize the main results obtained and outline future work. The research questions behind this study were the following: RQ1 *What particular characteristics have been investigated by researchers?*; RQ2 *What research methods have been used?*; RQ3 *On which game has the study on ADD-ADHD been focused?*

The study presented articles covering January 1, 2005 to December 30, 2015. Five major scientific databases were searched: ScienceDirect, SCOPUS, Pubmed, MEDLINE and Bio Med Central. After searching the databases with the keywords 'Attention Deficit Disorder', 'Attention Deficit Hyperactivity Disorder', 'Games' and 'Videogames' and removing the duplicates, the following search results were obtained: ScienceDirect (2),

5 *Manual diagnóstico y estadístico de los trastornos mentales*. Madrid : Panamericana, 2014, p. 500.

6 BARKLEY, R. A.: *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment*. New York : Guilford, 2006, p. 120.; NAVARRO, M. I., GARCÍA-VILLAMISAR, D. A.: Funcionamiento ejecutivo del trastorno de déficit de atención con Hiperactividad: Una perspectiva ecológica de los perfiles diferenciales entre los tipos combinado e inatento. In *Revista de Psicopatología y Psicología Clínica*, 2011, Vol. 16, No. 2, p. 1136. [online]. [2019-11-03]. Available at: <<http://revistas.uned.es/index.php/RPPC/article/view/10355/9893>>.

7 PROT, S., MCDONALD, K. A., ANDERSON, C. A., GENTILE, D. A.: Video Games: Good, Bad, or Other? In *Pediatric Clinics of North America*, 2012, Vol. 59, No. 3, p. 648. [online]. [2019-11-01]. Available at: <https://www.researchgate.net/publication/225072608_Video_Games_Good_Bad_or_Other>.

8 BARANAUSKAS, M., GOMES-NETO, N., BORGES, M.: Gaming at work: A learning environment for synchronized manufacturing. In *Computer Applications in Engineering Education*, 2000, Vol. 8, No. 3-4, p. 162. [online]. [2019-10-31]. Available at: <[https://doi.org/10.1002/1099-0542\(2000\)8:3/4<162::AID-CAE5>3.0.CO;2-K](https://doi.org/10.1002/1099-0542(2000)8:3/4<162::AID-CAE5>3.0.CO;2-K)>; COSTIKYAN, G.: I have no words & I must design: Toward a critical vocabulary for games. In *Computer Games and Digital Cultures Conference Proceedings*, 2002, Vol. 1, No. 1, p. 2343. [online]. [2019-11-02]. Available at: <<http://www.costik.com/nowords2002.pdf>>.

SCOPUS (5), Pubmed (4), MEDLINE (2) and BioMed Central (1). Based on abstracts we first filtered out all publications that are not related to games or ADD-ADHD, or are not published in peer-reviewed journals and magazines. This was followed by a second round of filtering in which based on the full text we removed the publications that are concerned with applying games to tasks which are not directly related to the field of Psychology and Psychiatry. We also removed early papers that only explain the concept of ADD-ADHD. The search was limited to publication dates within recent years (January 2005 to December 2015). A total of 12 articles were selected after three rounds of meetings between investigators. We used a systematic mapping design for the study. A systematic mapping study provides a categorical structure for classifying the published research reports. In addition, they are similar to systematic reviews, except because they employ broader inclusion criteria and are intended to map out topics rather than synthesize study results. Articles included in this review were required to meet all of the following selection criteria:

- a) They were published between January 1, 2005 and December 30, 2015.
- b) They were empirically based.
- c) They included participants between 6-18 years old.
- d) Sources were written in English, Spanish and French.

For the purpose of reviewing the use of games in ADD-ADHD we use the term ‘game’ suggested by Salen and Zimmerman,⁹ that includes keywords as Videogames, Digital Games, Internet Games, Computer Games, Serious Games and Simulation Games. Table 1 below presents particular characteristics that have been investigated by researchers. For each result, corresponding references are presented. Table 1 below presents for each point, corresponding references. In total, 12 studies were included.

Table 1: Particular characteristics that have been investigated by researchers

Particular characteristics	Study
To examine training working memory in children with ADHD.	Klingberg et al. (2005)
To examine the inhibitory abilities of children with ADHD when playing computer games.	Shaw, Grayson, & Lewis (2005)
To analyze digital games and attention deficit hyperactivity disorder symptoms in adolescents.	Chan & Rabinowitz (2006)
To describe and compare the behaviour of hyperactive and control children playing digital games. Examine Child Behavior Checklist and PVP scale.	Bioulac, Arfi & Bouvard (2008)
Examine the deteriorative effects of computer game playing for people with ADHD.	Tahiroglu et al. (2010)
Exploratory study in ADHD children about of the use of the PVP scale.	Bioulac, Arfi, Michel & Bouvard (2010)
To examine whether game elements (Working Memory) would enhance motivation and training performance (and its efficiency) of children with ADHD.	Prins, Dovis, Ponsoien, Ten Brink & Van der Oord (2011)
Examine inattentive and hyperactive-impulsive symptoms on ADHD and Testing a brain computer interface-based attention training game.	Lim et al. (2012)
To examine digital game use in boys with autism spectrum disorder compared with those with ADHD or typical development and to examine features relating to problematic digital game use across groups.	Mazurek & Engelhardt (2013)

9 SALEN, K., ZIMMERMAN, E.: *Rules of play*. Cambridge, MA : The MIT Press, 2004, p. 80.

Tested the short and long-term efficacy of and executive functioning remediation training with game elements for children with ADHD.	Van der Oord, Ponsioen, Geurts, Ten Brink & Prins (2014)
To describe and compare the behaviour of hyperactive and control children playing digital games.	Bioulac et al. (2014)
To investigate the relationship between ADHD and internet addiction.	Weinstein, Yaacov, Manning, Danon & Weizman (2015)

Source: own processing

Results

In this section we present the answers to each of the formulated research questions. For RQ1 *What particular characteristics have been investigated by researchers?*, the aims of the investigation carried out are diverse and display an interest in the risks and benefits of digital games in children and teenagers with ADHD. We could divide the studies into two large groups. Studies on the negative consequences that digital games might entail, where we can find:

1. Potential risks of digital games on attention span.¹⁰
2. Risk of addiction and problematic use of digital games.¹¹
3. Evaluating behavioural problems associated with digital games with ADHD.¹²

To summarize, these studies have focused on the risk of addiction or problematic use of digital games, as well as in the increase in attention deficit due to this practice, and on behavioural problems. The second group corresponds to studies on the benefits of digital games:

1. Evaluation of response inhibition, reasoning and lack of attention.¹³

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- 10 CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 5. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>; TAHIROGLU, A. Y., CELIK, G. G., AVCI, A., SEYDAOGLU, G., UZEL, M., ALTUNBAS, H.: Short-term effects of playing computer games on attention. In *Journal of Attention Disorders*, 2010, Vol. 13, No. 6, p. 669. [online]. [2019-11-03]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.908.9776&rep=rep1&type=pdf>>.
 - 11 BIOULAC, S., ARFI, L., BOUVARD, M. P.: Attention deficit/hyperactivity disorder and video games: A comparative study of hyperactive and control children. In *European Psychiatry*, 2008, Vol. 23, No. 2, p. 134. [online]. [2019-10-31]. Available at: <<https://doi.org/10.1016/j.eurpsy.2007.11.002>>; BIOULAC, S., LALLEMAND, S., FABRIGOULE, C., THOUMY, A., PHILIP, P., BOUVARD, M. P.: Video game performances are preserved in ADHD children compared with controls. In *Journal of Attention Disorders*, 2014, Vol. 18, No. 6, p. 542. [online]. [2019-11-01]. Available at: <<https://www.ncbi.nlm.nih.gov/pubmed/22628143>>; MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 262. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>; WEINSTEIN, A., YAACOV, Y., MANNING, M., DANON, P., WEIZMAN, A.: Internet addiction and attention deficit hyperactivity disorder among schoolchildren. In *Israel Medical Association Journal*, 2015, Vol. 17, No. 1, p. 731. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/60db/5196467f70d985a18a70126cc6f34d58c895.pdf>>.
 - 12 BIOULAC, S., ARFI, L., MICHEL, G., BOUVARD, M. P.: Interest of the use of the Problem Videogame Playing (PVP) questionnaire from Tejeiro: Exploratory study in ADHD children. In *Annales Medico-Psychologiques*, 2010, Vol. 16, No. 8, p. 632. [online]. [2019-10-31]. Available at: <<https://www.em-consulte.com/en/module/displayarticle/article/266955/impression/vue6>>; SHAW, R., GRAYSON, A., LEWIS, V.: Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. In *Journal of Attention Disorders*, 2005, Vol. 8, No. 4, p. 166. [online]. [2019-11-02]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.817.3220&rep=rep1&type=pdf>>.
 - 13 KLINGBERG, T., FERNELLE, E., OLESEN, P. J., JOHNSON, M., GUSTAFSSON, P., DAHLSTRÖM, K., GILLBERG, Ch. G., FORSSBERG, H., WESTERBERG, H.: Computerized training of working memory in children with ADHD-A randomized controlled trial. In *Journal of the American Academy of Child & Adolescent Psychiatry*, 2005, Vol. 44, No. 1, p. 119. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/9172/65b9bbb2203528f57abfd31f4f97e7b238d0.pdf>>.

2. Evaluation of reducing symptoms of inattention, hyperactivity and impulsiveness.¹⁴
3. Evaluation of improvements in motivation and performance.¹⁵

To summarize, these studies have focused on evaluating executive functions via use of digital games, in particular the reduction in hyperactivity, impulsiveness and lack of attention, as well as examining their effect on motivation and performance. Table 2 presents the main characteristics and results of every paper.

Table 2: Results from RQ1

Characteristics		Results
	Intervention/Treatment	
Klingberg et al. (2005)	To investigate the effect of improving WM (working memory) by computerized, systematic practice of WM tasks.	Working memory can be improved by training in children with ADHD.
Prins, Dovis, Ponsioen, Ten Brink & Van der Oord (2011)	Examined the benefits of adding game elements to standard computerized working memory (WM) training to understand the motivation and training performance of children with ADHD and the effectiveness of training.	WM training with game elements significantly improves the motivation, training performance, and working memory of children with ADHD.
Lim et al. (2012)	This study evaluated the new version of the BCI-based attention training program in the treatment of combined and inattentive subtypes of ADHD.	Game represents a treatment modality for ADHD which not only has the potential for being used in combination with treatment.
Van der Oord, Ponsioen, Geurts, Ten Brink & Prins (2014)	Examined Efficacy of a Computerized Executive Functioning Remediation Training with Game Elements for Children with ADHD in an Outpatient Setting.	Positive evidence for the efficacy of Executive Functioning training with game elements.
Evaluation / Diagnosis		
Shaw, Grayson, & Lewis (2005)	To examine inattention and impulse response.	Parental reports suggest that when playing computer games, the inhibitory abilities of children with ADHD are unimpaired.
Chan & Rabinowitz (2006)	Investigate the relationship between time spent playing games for more than one hour a day and "Inattention" and "ADHD".	Playing games for more than one hour a day has negative social and academic effects.

- 14 LIM, C. G., LEE, T. S., GUAN, C., FUNG, D. S. S., ZHAO, Y., TENG, S. S. W., ZHANG, H., KRISHNAN, R.: A Brain-Computer Interface Based Attention Training Program for Treating Attention Deficit Hyperactivity Disorder. In *PLoS ONE*, 2012, Vol. 7, No. 10, p. 8. [online]. [2019-11-01]. Available at: <<https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0046692&type=printable>>. VAN DER OORD, S., PONSIOEN, A. J. G. B., GEURTS, H. M., TEN BRINK, E. L., PRINS, P. J. M.: A Pilot Study of the Efficacy of a Computerized Executive Functioning Remediation Training With Game Elements for Children With ADHD in an Outpatient Setting: Outcome on Parent- and Teacher-Rated Executive Functioning and ADHD Behavior. In *Journal of Attention Disorders*, 2014, Vol. 18, No. 8, p. 670. [online]. [2019-11-02]. Available at: <<https://pdfs.semanticscholar.org/b905/9fba8d4dc55b3e2fee8659f64255d1f24030.pdf>>.
- 15 PRINS, P. J. M., DOVIS, S., PONSIOEN, A., TEN BRINK, E., VAN DER OORD, S.: Does computerized working memory with game elements enhance motivation and training efficacy in children with ADHD? In *Cyberpsychology, Behavior, and Social Networking*, 2011, Vol. 14, No. 3, p. 117. [online]. [2019-11-01]. Available at: <https://pdfs.semanticscholar.org/bdee/e9a69d3192431d05cf6498fe8106a879ca9b.pdf?_ga=2.95729695.2012201865.1572700179-190068604.1572700179>.

Bioulac, Arfi & Bouvard (2008)	Describes and compares the behaviour of hyperactive and control children playing digital games.	ADHD children exhibited more problems associated with digital game playing and may be vulnerable to developing
Bioulac, Arfi, Michel & Bouvard (2010)	To evaluate the difficulties induced by an excessive "consumption" of digital games.	Hyperactive children present more problems associated with digital games.
Tahiroglu et al. (2010)	Time spent playing computer games can exert a short-term effect on attention span as measured by the Stroop test. Greater risks posed by computer game playing to people with ADHD-IT.	Time spent playing computer games can exert a short-term effect on attention in children with ADHD.
Mazurek & Engelhardt (2013)	To examine digital game use in boys with Autism Spectrum Disorder (ASD) compared with those with ADHD or typical development (TD).	Children with ADHD may be particularly at risk for problems related to game playing, including excessive game use.
Bioulac et al. (2014)	When playing digital games, inhibitory control is similar in the ADHD group and the control group.	Cognitive difficulties in ADHD depend on tasks.
Weinstein, Yaacov, Manning, Danon & Weizman (2015)	To investigate the relationship between ADHD and internet addiction.	Children with ADHD are more addicted to the Internet than those without ADHD.

Source: own processing

In terms of classification according to their characteristics, four studies deal with Intervention/Treatment, and eight of them with Evaluation/Diagnosis. In general, we have seen that the four studies classed as *Intervention/Treatment* had the aim of showing the improvement in ADHD via digital game training. These benefits of digital games in the short terms have focused on aspects of cognitive information processing, especially in executive functions,¹⁶ work memory¹⁷ and attention span.¹⁸ The study by Lim et al. also sought an improvement in the behavioural aspects of impulsiveness and hyperactivity.¹⁹ Whereas the eight studies classified as *Evaluation/Diagnosis* have looked to study the risk or negative consequences of intense use of digital games, by and large as descriptive, evaluative or diagnostic studies. They were carried out following

- 16 VAN DER OORD, S., PONSIOEN, A. J. G. B., GEURTS, H. M., TEN BRINK, E. L., PRINS, P. J. M.: A Pilot Study of the Efficacy of a Computerized Executive Functioning Remediation Training With Game Elements for Children With ADHD in an Outpatient Setting: Outcome on Parent- and Teacher-Rated Executive Functioning and ADHD Behavior. In *Journal of Attention Disorders*, 2014, Vol. 18, No. 8, p. 671. [online]. [2019-11-02]. Available at: <<https://pdfs.semanticscholar.org/b905/9fba8d4dc55b3e2fee8659f64255d1f24030.pdf>>.
- 17 PRINS, P. J. M., DOVIS, S., PONSIOEN, A., TEN BRINK, E., VAN DER OORD, S.: Does computerized working memory with game elements enhance motivation and training efficacy in children with ADHD? In *Cyberpsychology, Behavior, and Social Networking*, 2011, Vol. 14, No. 3, p. 117. [online]. [2019-11-01]. Available at: <https://pdfs.semanticscholar.org/bdee/e9a69d3192431d05cf6498fe8106a879ca9b.pdf?_ga=2.95729695.2012201865.1572700179-190068604.1572700179>; KLINGBERG, T., FERNELL, E., OLESEN, P. J., JOHNSON, M., GUSTAFSSON, P., DAHLSTRÖM, K., GILLBERG, Ch. G., FORSSBERG, H., WESTERBERG, H.: Computerized training of working memory in children with ADHD-A randomized controlled trial. In *Journal of the American Academy of Child & Adolescent Psychiatry*, 2005, Vol. 44, No. 1, p. 119. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/9172/65b9bbb2203528f57abfd31f4f97e7b238d0.pdf>>.
- 18 LIM, C. G., LEE, T. S., GUAN, C., FUNG, D. S. S., ZHAO, Y., TENG, S. S. W., ZHANG, H., KRISHNAN, R.: A Brain-Computer Interface Based Attention Training Program for Treating Attention Deficit Hyperactivity Disorder. In *PLoS ONE*, 2012, Vol. 7, No. 10, p. 9. [online]. [2019-11-01]. Available at: <<https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0046692&type=printable>>.
- 19 Ibidem, p. 9.

specific variables, such as the hours spent on digital games.²⁰ These studies underline an important point of vulnerability with ADHD subjects yet to develop: a dependence on digital games,²¹ a greater lack of attention.²² While the study by Shaw et al. also studies the effect on impulsive behaviour.²³

We could divide the results obtained into two large groups:

1. *Training, Improving ADHD symptoms.* Within this group we can find six articles focused on training-working, memory motivation, inhibitory abilities, executive functioning-inattention (Chart 1). Specifically, an article that deals with Efficacy Improvement and Executive Functioning.²⁴ Two articles focus on Inhibitory Abilities²⁵ and one on Working Memory, Motivation and Training Efficacy.²⁶ Another one speaks exclusively about Working Memory²⁷ and finally one more on improving attention.²⁸

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- 20 CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 5. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>; TAHIROGLU, A. Y., CELIK, G. G., AVCI, A., SEYDAOGLU, G., UZEL, M., ALTUNBAS, H.: Short-term effects of playing computer games on attention. In *Journal of Attention Disorders*, 2010, Vol. 13, No. 6, p. 669. [online]. [2019-11-03]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.908.9776&rep=rep1&type=pdf>>.
 - 21 BIOULAC, S., ARFI, L., BOUVARD, M. P.: Attention deficit/hyperactivity disorder and video games: A comparative study of hyperactive and control children. In *European Psychiatry*, 2008, Vol. 23, No. 2, p. 134. [online]. [2019-10-31]. Available at: <<https://doi.org/10.1016/j.eurpsy.2007.11.002>>; WEINSTEIN, A., YAACOV, Y., MANNING, M., DANON, P., WEIZMAN, A.: Internet addiction and attention deficit hyperactivity disorder among schoolchildren. In *Israel Medical Association Journal*, 2015, Vol. 17, No. 1, p. 732. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/60db/5196467f70d985a18a70126cc6f34d58c895.pdf>>.
 - 22 CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 8. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>; MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 261. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>; SHAW, R., GRAYSON, A., LEWIS, V.: Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. In *Journal of Attention Disorders*, 2005, Vol. 8, No. 4, p. 166. [online]. [2019-11-02]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.817.3220&rep=rep1&type=pdf>>; TAHIROGLU, A. Y., CELIK, G. G., AVCI, A., SEYDAOGLU, G., UZEL, M., ALTUNBAS, H.: Short-term effects of playing computer games on attention. In *Journal of Attention Disorders*, 2010, Vol. 13, No. 6, p. 670. [online]. [2019-11-03]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.908.9776&rep=rep1&type=pdf>>.
 - 23 SHAW, R., GRAYSON, A., LEWIS, V.: Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. In *Journal of Attention Disorders*, 2005, Vol. 8, No. 4, p. 669. [online]. [2019-11-02]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.817.3220&rep=rep1&type=pdf>>.
 - 24 VAN DER OORD, S., PONSIOEN, A. J. G. B., GEURTS, H. M., TEN BRINK, E. L., PRINS, P. J. M.: A Pilot Study of the Efficacy of a Computerized Executive Functioning Remediation Training With Game Elements for Children With ADHD in an Outpatient Setting: Outcome on Parent- and Teacher-Rated Executive Functioning and ADHD Behavior. In *Journal of Attention Disorders*, 2014, Vol. 18, No. 8, p. 670. [online]. [2019-11-02]. Available at: <<https://pdfs.semanticscholar.org/b905/9fba8d4dc55b3e2fee8659f64255d1f24030.pdf>>.
 - 25 BIOULAC, S., LALLEMAND, S., FABRIGOLE, C., THOUMY, A., PHILIP, P., BOUVARD, M. P.: Video game performances are preserved in ADHD children compared with controls. In *Journal of Attention Disorders*, 2014, Vol. 18, No. 6, p. 542. [online]. [2019-11-01]. Available at: <<https://www.ncbi.nlm.nih.gov/pubmed/22628143>>; SHAW, R., GRAYSON, A., LEWIS, V.: Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. In *Journal of Attention Disorders*, 2005, Vol. 8, No. 4, p. 166. [online]. [2019-11-02]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.817.3220&rep=rep1&type=pdf>>.
 - 26 PRINS, P. J. M., DOVIS, S., PONSIOEN, A., TEN BRINK, E., VAN DER OORD, S.: Does computerized working memory with game elements enhance motivation and training efficacy in children with ADHD? In *Cyberpsychology, Behavior, and Social Networking*, 2011, Vol. 14, No. 3, p. 117. [online]. [2019-11-01]. Available at: <https://pdfs.semanticscholar.org/bdee/e9a69d3192431d05cf6498fe8106a879ca9b.pdf?_ga=2.95729695.2012201865.1572700179-190068604.1572700179>.
 - 27 KLINGBERG, T., FERNELL, E., OLESEN, P. J., JOHNSON, M., GUSTAFSSON, P., DAHLSTRÖM, K., GILLBERG, Ch. G., FORSSBERG, H., WESTERBERG, H.: Computerized training of working memory in children with ADHD-A randomized controlled trial. In *Journal of the American Academy of Child & Adolescent Psychiatry*, 2005, Vol. 44, No. 1, p. 119. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/9172/65b9bbb2203528f57abfd31f4f97e7b238d0.pdf>>.
 - 28 LIM, C. G., LEE, T. S., GUAN, C., FUNG, D. S. S., ZHAO, Y., TENG, S. S. W., ZHANG, H., KRISHNAN, R.:



Chart 1: Results. Training, Improving ADHD symptoms

Source: own processing

2. *Risk*. In this group we can find six articles focused on Risk – Increase in Inattentive Behaviour – Dependence – Problematic use (Chart 2). Three articles state the risk of developing dependence or problematic digital game use.²⁹ Two more articles focus on an increase in inattentive behaviour.³⁰ Finally, only one article touches on behaviour disorders.³¹

A Brain-Computer Interface Based Attention Training Program for Treating Attention Deficit Hyperactivity Disorder. In *PLoS ONE*, 2012, Vol. 7, No. 10, p. 9. [online]. [2019-11-01]. Available at: <<https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0046692&type=printable>>.

29 BIOULAC, S., ARFI, L., BOUVARD, M. P.: Attention deficit/hyperactivity disorder and video games: A comparative study of hyperactive and control children. In *European Psychiatry*, 2008, Vol. 23, No. 2, p. 140. [online]. [2019-10-31]. Available at: <<https://doi.org/10.1016/j.eurpsy.2007.11.002>>; MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 140. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>; WEINSTEIN, A., YAACOV, Y., MANNING, M., DANON, P., WEIZMAN, A.: Internet addiction and attention deficit hyperactivity disorder among schoolchildren. In *Israel Medical Association Journal*, 2015, Vol. 17, No. 1, p. 733. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/60db/5196467f70d985a18a70126cc6f34d58c895.pdf>>.

30 CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 9. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>; TAHIROGLU, A. Y., CELIK, G. G., AVCI, A., SEYDAOGLU, G., UZEL, M., ALTUNBAS, H.: Short-term effects of playing computer games on attention. In *Journal of Attention Disorders*, 2010, Vol. 13, No. 6, p. 670. [online]. [2019-11-03]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.908.9776&rep=rep1&type=pdf>>.

31 BIOULAC, S., ARFI, L., MICHEL, G., BOUVARD, M. P.: Interest of the use of the Problem Videogame Playing (PVP) questionnaire from Tejeiro: Exploratory study in ADHD children. In *Annales Medico-Psychologiques*, 2010, Vol. 16, No. 8, p. 633. [online]. [2019-10-31]. Available at: <<https://www.em-consulte.com/en/module/displayarticle/article/266955/impression/vue6>>.

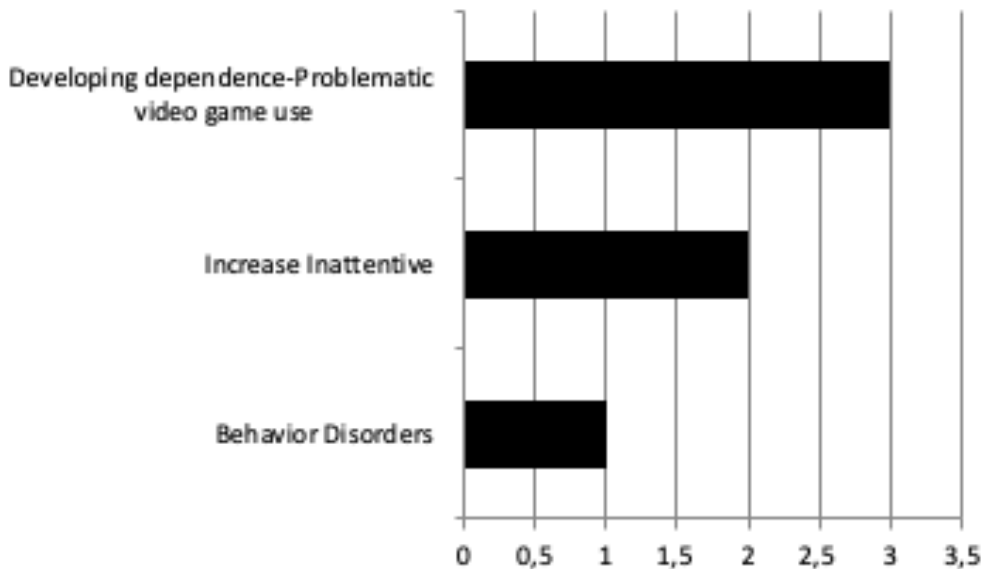


Chart 2: Results. Risk
Source: own processing

For RQ2 *What research methods have been used?*, a summary of the results of the research questions from RQ2 is presented in Table 3.

Table 3: Evaluation tools used

Evaluation aim	Tool	Study
1. Attention problems	Conners Continuous Performance Test II (CPT II) Conners Parent Rating Scale (CPRS)	Shaw, Grayson, & Lewis (2005); Bioulac et al. (2014) Chan & Rabinowitz (2006); Bioulac, Arfi, Michel & Bouvard (2010)
2. Problem behaviour	Child Behaviour Checklist (CBCL)	Bioulac, Arfi & Bouvard (2008); Bioulac, Arfi, Michel & Bouvard (2010)
3. Working Memory	Working Memory Task	Klingberg et al. (2005); Prins, Dovis, Ponsoen, Ten Brink & Van der Oord (2011)
4. Internet Addiction and Problem Gamer Playing	Young's Internet Addiction Scale (YIAS) Problem Videogame Playing Scale (PVPS) Internet Addiction Test (IAT) Modified Problem Video Game Playing Test (PVGTT)	Chan & Rabinowitz (2006) Bioulac, Arfi & Bouvard (2008); Bioulac, Arfi, Michel & Bouvard (2010) Weinstein, Yaacov, Manning, Danon & Weizman (2015) Mazurek & Engelhardt (2013)
5. Stroop Effect Semantic interference in reaction time	The Stroop TBAG test	Tahiroglu et al. (2010)
6. Hyperactive-impulsive	ADHD Rating Scale	Lim et al. (2012)

7. Digital game use, Genre categories digital game, Problematic digital game use, Inattention, hyperactivity and impulsivity symptoms Social Communication	Questionnaire designed for the study Entertainment Software Rating Board website Modified version of the problem Video Game Playing Test (PVGTV) Vanderbilt Attention Deficit/Hyperactivity Disorder Parent Rating Scale (VADPRS) Social Communication Questionnaire-Current (SCQ)	Mazurek & Engelhardt (2013)
8. Executive Functions and Disruptive Behaviour Disorder	Behaviour Rating Inventory of Executive Functioning (BRIEF) Disruptive Behavior Disorder Rating Scale (DBDRS)	Van der Oord, Ponsoen, Geurts, Ten Brink & Prins (2014)

Source: own processing

The twelve investigations are experimental and exploratory; out of them all, nine use control groups. Mazurek et al. undertake a comparative investigation between Autism Spectrum Disorder (56), Attention Deficit Hyperactivity Disorder (44) and Typical Development (41);³² for their part, Klingberg et al. repeat the experiment on the same group three months later.³³ Chan and Rabinowicz focus on the parents of children with disorders³⁴ and Lim et al. study the same group over 2 months.³⁵ Of the articles revised, only one keeps this proportion in the sample,³⁶ with 64 boys and 37 girls. On the other hand, we must note that of the twelve investigations, in three of them the parents are involved, specifically in Chan and Rabinowitz, Lim et al. and Mazurek et al.³⁷ In the Chan and Rabinowitz study with 31 fathers and 41 mothers, we can see that more mothers participate than fathers.³⁸ In other investigations the number of parents taking part is not specified.

- 32 MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 263. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>.
- 33 KLINGBERG, T., FERNELL, E., OLESEN, P. J., JOHNSON, M., GUSTAFSSON, P., DAHLSTRÖM, K., GILLBERG, CH. G., FORSSBERG, H., WESTERBERG, H.: Computerized training of working memory in children with ADHD-A randomized controlled trial. In *Journal of the American Academy of Child & Adolescent Psychiatry*, 2005, Vol. 44, No. 1, p. 2005. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/9172/65b9bbb2203528f57abfd31f4f97e7b238d0.pdf>>.
- 34 CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 8. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>.
- 35 LIM, C. G., LEE, T. S., GUAN, C., FUNG, D. S. S., ZHAO, Y., TENG, S. S. W., ZHANG, H., KRISHNAN, R.: A Brain-Computer Interface Based Attention Training Program for Treating Attention Deficit Hyperactivity Disorder. In *PLoS ONE*, 2012, Vol. 7, No. 10, p. 9. [online]. [2019-11-01]. Available at: <<https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0046692&type=printable>>.
- 36 TAHIROGLU, A. Y., CELIK, G. G., AVCI, A., SEYDAOGLU, G., UZEL, M., ALTUNBAS, H.: Short-term effects of playing computer games on attention. In *Journal of Attention Disorders*, 2010, Vol. 13, No. 6, p. 669. [online]. [2019-11-03]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.908.9776&rep=rep1&type=pdf>>.
- 37 CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 9. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>; LIM, C. G., LEE, T. S., GUAN, C., FUNG, D. S. S., ZHAO, Y., TENG, S. S. W., ZHANG, H., KRISHNAN, R.: A Brain-Computer Interface Based Attention Training Program for Treating Attention Deficit Hyperactivity Disorder. In *PLoS ONE*, 2012, Vol. 7, No. 10, p. 10. [online]. [2019-11-01]. Available at: <<https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0046692&type=printable>>; MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 262. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>.
- 38 CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 8. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>.

The most commonly used tools in the studies analyzed are the Conners Scale and the Child Behaviour Checklist. There is no uniformity of tools with which to study Internet addiction of problematic use of digital games, perhaps due to there being no recognition of this disorder by the APA (American Psychiatric Association). In the last edition of the DSM-5 from 2014 (Diagnostic and Statistical Manual of Mental Disorders) the possibility of including the term 'Internet Gaming Disorder' has been left open, with the aim of carrying out a more in-depth study and to be able consider it as a disorder. In terms of analyzing executive functions overall, we draw attention to the Behaviour Rating Inventory of Executive Functioning (BRIEF), mentioned in Van der Oord et al.³⁹ For a partial study of executive functions, we can find adaptations thereof for the Work Memory study (WMTA) and the ADHD Rating Scale for Impulsiveness. For example, Klingberg et al. uses an adaptation to study WMTA.⁴⁰ In this same sense, the Stroop effect tool, mentioned in the study by Tahiroglu et al., can be used to evaluate the capacity of inhibiting the response.⁴¹

For RQ3 On which *Game has the study on ADD-ADHD been focused?*, gaming aspects of included studies are summarized in Table 4. These descriptions are derived to the best of our ability from the limited information describing each study.

Table 4: Results from RQ3. Specific gaming elements of each study

Game	Conclusion	Platform	Genre	Study
Robomemo Commercial game	Working memory can be improved by training in children with ADHD.	Computer game	Educational	Klingberg et al. (2005)
Frogger 2: Swampy's Revenge Crash Bandicoot II: Cortex Strikes Back Commercial games	Parental reports suggest that when playing computer games, the inhibitory abilities of children with ADHD are unimpaired.	Computer game Console game	Action/adventure Platforms	Shaw, Grayson, & Lewis (2005)
Games in general	Playing games for more than one hour a day has negative social and academic effects.	Console game Online game	Not specified	Chan & Rabinowitz (2006)

39 VAN DER OORD, S., PONSIOEN, A. J. G. B., GEURTS, H. M., TEN BRINK, E. L., PRINS, P. J. M.: A Pilot Study of the Efficacy of a Computerized Executive Functioning Remediation Training With Game Elements for Children With ADHD in an Outpatient Setting: Outcome on Parent- and Teacher-Rated Executive Functioning and ADHD Behavior. In *Journal of Attention Disorders*, 2014, Vol. 18, No. 8, p. 670. [online]. [2019-11-02]. Available at: <<https://pdfs.semanticscholar.org/b905/9fba8d4dc55b3e2fee8659f64255d1f24030.pdf>>.

40 KLINGBERG, T., FERNELL, E., OLESEN, P. J., JOHNSON, M., GUSTAFSSON, P., DAHLSTRÖM, K., GILLBERG, Ch. G., FORSSBERG, H., WESTERBERG, H.: Computerized training of working memory in children with ADHD-A randomized controlled trial. In *Journal of the American Academy of Child & Adolescent Psychiatry*, 2005, Vol. 44, No. 1, p. 119. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/9172/65b9bbb2203528f57abfd31f4f97e7b238d0.pdf>>.

41 TAHIROGLU, A. Y., CELIK, G. G., AVCI, A., SEYDAOGLU, G., UZEL, M., ALTUNBAS, H.: Short-term effects of playing computer games on attention. In *Journal of Attention Disorders*, 2010, Vol. 13, No. 6, p. 669. [online]. [2019-11-03]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.908.9776&rep=rep1&type=pdf>>.

Games in general	ADHD children exhibited more problems associated with digital game playing and may be vulnerable to developing.	Computer game Console game Online game	Not specified	Bioulac, Arfi & Bouvard (2008).
Colin McRae Rally 3 Commercial game	Time spent playing computer games can exert a short-term effect on attention in children with ADHD.	Computer game	Racing	Tahiroglu et al. (2010)
Games in general	Hyperactive children present more problems associated with digital games.	Computer game Console game	Not specified	Bioulac, Arfi, Michel & Bouvard (2010)
Robomemo Commercial game	WM training with game elements significantly improves the motivation, training performance, and working memory of children with ADHD.	Computer game	Educational	Prins, Dovis, Ponsioen, Ten Brink & Van der Oord (2011)
CogoLand Non-commercial game	Game represents a treatment modality for ADHD, which not only has the potential for being used in combination with treatment.	Computer game	Simulation	Lim et al. (2012)
Games in general	Children with ADHD may be particularly at risk for problems related to game playing, including excessive game use.	Computer game Console game Online game	Gamespot, Action/adventure, Role-playing, Strategy, Puzzle game, Educational, Fighting, First-person shooter, Music, Platforms, Racing, Simulation, Sports and fitness.	Mazurek & Engelhardt (2013)
Braingame Brian Commercial game	Positive evidence for the efficacy of Executive Functioning training with game elements.	Computer game	Simulation	Van der Oord, Ponsioen, Geurts, Ten Brink & Prins (2014)
Secret Agent Bubble Hit Kung Fu Panda 2 Commercial games	Cognitive difficulties in ADHD depend on tasks.	Console game	Platforms Puzzle game Action-adventure	Bioulac et al. (2014)
Games in general	Children with ADHD are more addicted to the Internet than those without ADHD.	Computer game Online game	Not specified	Weinstein, Yaacov, Manning, Danon & Weizman (2015)

Source: own processing

In none of the papers where a specific game is mentioned is the genre, content or narrative structure of the game gone into in any detail. In five papers the concept 'games' or 'digital games' are mentioned generally without specifying if they are commercial games or not. In the other studies, the specific names of the thirteen games analyzed are mentioned. In these papers, authors did not also specify the game genre, and they only specify the game platform.⁴² The mechanics, dynamics or narrative structure of the game are not specified, neither is the use of an avatar in the case of RPGs, mentioned by Mazurek et al.⁴³ The majority of the games (11) are computer games, 4 are console games and 4 online games. Only 6 of these games are commercial games, but it could be concluded that digital games used by Bioulac et al. (2008, 2010), Chan and Rabinowitz, and Mazurek et al., are commercial games too from their description as console games.⁴⁴ Genre categories included: Gamespot, action/adventure (3), role-playing (1), strategy (1), puzzle game (2), educational (3) fighting (1), first-person shooter (1), music (1), platforms (3), racing (2), simulation (3), sports and fitness (1), and GameSpot (1). *Robomemo*⁴⁵ is a commercial game and has been used in two interventions,⁴⁶ delivered via a PC computer. This game was used to investigate the effect of improving working memory via a computerized, systematic practice of working memory tasks, although with the information available it was difficult to determine the rules, goals and objectives of the game. In two cases,

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- 42 BIOULAC, S., ARFI, L., MICHEL, G., BOUVARD, M. P.: Interest of the use of the Problem Videogame Playing (PVP) questionnaire from Tejero: Exploratory study in ADHD children. In *Annales Medico-Psychologiques*, 2010, Vol. 16, No. 8, p. 633. [online]. [2019-10-31]. Available at: <<https://www.em-consulte.com/en/module/displayarticle/article/266955/impression/vue6>>; BIOULAC, S., ARFI, L., BOUVARD, M. P.: Attention deficit/hyperactivity disorder and video games: A comparative study of hyperactive and control children. In *European Psychiatry*, 2008, Vol. 23, No. 2, p. 140. [online]. [2019-10-31]. Available at: <<https://doi.org/10.1016/j.eurpsy.2007.11.002>>; CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 140. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>; MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 262. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>; WEINSTEIN, A., YAACOV, Y., MANNING, M., DANON, P., WEIZMAN, A.: Internet addiction and attention deficit hyperactivity disorder among schoolchildren. In *Israel Medical Association Journal*, 2015, Vol. 17, No. 1, p. 734. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/60db/5196467f70d985a18a70126cc6f34d58c895.pdf>>.
- 43 MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 263. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>.
- 44 BIOULAC, S., ARFI, L., BOUVARD, M. P.: Attention deficit/hyperactivity disorder and video games: A comparative study of hyperactive and control children. In *European Psychiatry*, 2008, Vol. 23, No. 2, p. 135. [online]. [2019-10-31]. Available at: <<https://doi.org/10.1016/j.eurpsy.2007.11.002>>; BIOULAC, S., ARFI, L., MICHEL, G., BOUVARD, M. P.: Interest of the use of the Problem Videogame Playing (PVP) questionnaire from Tejero: Exploratory study in ADHD children. In *Annales Medico-Psychologiques*, 2010, Vol. 16, No. 8, p. 632. [online]. [2019-10-31]. Available at: <<https://www.em-consulte.com/en/module/displayarticle/article/266955/impression/vue6>>; CHAN, P. A., RABINOWITZ, T.: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. In *Annals of General Psychiatry*, 2006, Vol. 5, No. 16, p. 9. [online]. [2019-11-02]. Available at: <<https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/1744-859X-5-16>>; MAZUREK, M. O., ENGELHARDT, CH. R.: Video Game Use in Boys with Autism Spectrum Disorder, ADHD, or Typical Development. In *Pediatrics*, 2013, Vol. 132, No. 2, p. 262. [online]. [2019-11-01]. Available at: <<https://pediatrics.aappublications.org/content/pediatrics/132/2/260.full.pdf>>.
- 45 COSMED: *Robomemo*. [digital game]. Stockholm : Cogmed, 2004.
- 46 KLINGBERG, T., FERNELL, E., OLESEN, P. J., JOHNSON, M., GUSTAFSSON, P., DAHLSTRÖM, K., GILLBERG, Ch. G., FORSSBERG, H., WESTERBERG, H.: Computerized training of working memory in children with ADHD-A randomized controlled trial. In *Journal of the American Academy of Child & Adolescent Psychiatry*, 2005, Vol. 44, No. 1, p. 120. [online]. [2019-11-03]. Available at: <<https://pdfs.semanticscholar.org/9172/65b9bbb2203528f57abfd31f4f97e7b238d0.pdf>>; PRINS, P. J. M., DOVIS, S., PONSIOEN, A., TEN BRINK, E., VAN DER OORD, S.: Does computerized working memory with game elements enhance motivation and training efficacy in children with ADHD? In *Cyberpsychology, Behavior, and Social Networking*, 2011, Vol. 14, No. 3, p. 117. [online]. [2019-11-01]. Available at: <https://pdfs.semanticscholar.org/bdee/e9a69d3192431d05cf6498fe8106a879ca9b.pdf?_ga=2.95729695.2012201865.1572700179-190068604.1572700179>.

Prins et al. and Shaw et al., and in the second part of their study, authors used a computerized version of a Pokemon task;⁴⁷ an isomorphic task that can add game elements to standard computerized training. However, as in the previous case, with the information available it was difficult to determine the game's goals and objectives. One intervention includes the game *Colin McRae Rally 3*⁴⁸. Authors said that this commercial computer game has an effect on cognitive function and a positive effect on attention over the short term, but it is not clear what this effect is. In summary, in view of the number of articles and their objectives, there is concern about the use of games in the studies but there is little clarity about which elements of a game can be beneficial or harmful. Both commercial and non-commercial games vary greatly, depending on their genre and themes. One can't compare an educational game with something from the fighting genre. None of the papers investigates the genre, content or narrative structure of the game or how this might create specific problems or benefits for ADHD.

Discussion

This paper provides one of the reviews of the relationship between digital games and ADHD. This systematic study has led us to conclude that the aims of the investigations were oriented towards evaluating the benefits and harmful effects of applying digital games to ADHD-affected children and young people. Especially so, towards evaluating executive functions, work memory, academic performance, level of attention, impulse regulation and the risk of dependence after sessions with games. In general, there are several studies (7) that seek to improve the symptoms of ADHD with digital games. The results of the investigations have shown irregular effects. There are both positive and negative effects as to the attention, memory and also on other cognitive abilities. As to the executive functions, the positive conclusions of some of these studies should be regarded with caution because they pose methodological problems. By way of an example, the study by Lim et al.⁴⁹ has important limitations as it is an uncontrolled open test. The evaluation and control measures are solely collected from the subjective evaluation of the mothers and fathers, and not from the adolescents or the healthcare professional. Therefore, we cannot conclude with empirical certainty that there is an improvement in the symptoms. This positive instability (controversial support) in the results, opposes recent systematic revision and meta-analysis studies in regard to general cognitive and certain cognitive domains in the clinical and non-clinical population (Stanmore et al. 2017), which has found significant effects in executive functions, attention and visual spatial abilities. To be more specific, digital games have proved to be useful in improving inhibitory control and

47 PRINS, P. J. M., DOVIS, S., PONSIOEN, A., TEN BRINK, E., VAN DER OORD, S.: Does computerized working memory with game elements enhance motivation and training efficacy in children with ADHD? In *Cyberpsychology, Behavior, and Social Networking*, 2011, Vol. 14, No. 3, p. 118. [online]. [2019-11-01]. Available at: <https://pdfs.semanticscholar.org/bdee/e9a69d3192431d05cf6498fe8106a879ca9b.pdf?_ga=2.95729695.2012201865.1572700179-190068604.1572700179>; SHAW, R., GRAYSON, A., LEWIS, V.: Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. In *Journal of Attention Disorders*, 2005, Vol. 8, No. 4, p. 167. [online]. [2019-11-02]. Available at: <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.817.3220&rep=rep1&type=pdf>>.

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49 LIM, C. G., LEE, T. S., GUAN, C., FUNG, D. S. S., ZHAO, Y., TENG, S. S. W., ZHANG, H., KRISHNAN, R.: A Brain-Computer Interface Based Attention Training Program for Treating Attention Deficit Hyperactivity Disorder. In *PLoS ONE*, 2012, Vol. 7, No. 10, p. 9. [online]. [2019-11-01]. Available at: <<https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0046692&type=printable>>.

cognitive flexibility. However, it is impossible to compare both articles because the characteristics of the samples studied, as well as the instruments of evaluation, are heterogeneous. The selections of studies of the clinical population they have used are also non-comparable. Alzheimer's disease, Parkinson's disease, schizophrenia, diabetes, etc. In any case, we think ADHD is a disorder with a neurobiological cause and is the result of a complex interaction of genetic and environmental factors. This complexity requires a profound and specific study of the application of digital games and ADHD.

Different investigations are confirming, with consistency, that digital game players, versus non players, perform better in spatial tasks but this advantage cannot be explained through faster attention or from more efficient responses from stimuli,⁵⁰ that is to say, we are not improving their attention processing. We are proposing that digital games could be psycho educationally beneficial in boys and girls with ADHD to improve their spatial relationships. The immediate reinforcement that a player obtains through digital games could influence achieving a positive adhesion to ADHD treatment. The definition of Salen and Zimmerman highlights four features as constituting a game: system, rules, artificial conflict, and quantifiable outcome.⁵¹ The latter term referring to a measurable goal state upon which the player and the system can evaluate progress. In a game, a combination of cognitive pace and effort is necessary. In this area, it could act positively on the work memory, seriously affected in children with ADHD.⁵² The overall improvement in executive function (work memory, behavioural inhibition and cognitive flexibility) is also proven in the study carried out by Van der Oord et al. in which using a computer game achieved a notable reduction in ADHD attributable to the impact of immediate reinforcement of task results in children with ADHD.⁵³ As such, adding external incentives to potentially unstimulating and boring tasks and including contingent reinforcement to the tasks is proven to improve interest and interest amongst these children when carrying out different kinds of tasks on computers.

The Neurofeedback performs thanks to the feedback from the reward system. Thereupon, the most promising therapies use neurofeedback digital games to train the self-regulation in the attention of children with ADHD.⁵⁴ Digital games can aid as a motivational tool to encourage children to overcome their attention problems. This is achieved by providing highly interactive experiences that intend to create an optimal adherence to the treatment. Furthermore, the physiological signs exhibited can be used to

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- 52 PRINS, P. J. M., DOVIS, S., PONSIOEN, A., TEN BRINK, E., VAN DER OORD, S.: Does computerized working memory with game elements enhance motivation and training efficacy in children with ADHD? In *Cyberpsychology, Behavior, and Social Networking*, 2011, Vol. 14, No. 3, p. 117. [online]. [2019-11-01]. Available at: <https://pdfs.semanticscholar.org/bdee/e9a69d3192431d05cf6498fe8106a879ca9b.pdf?_ga=2.95729695.2012201865.1572700179-190068604.1572700179>.
- 53 VAN DER OORD, S., PONSIOEN, A. J. G. B., GEURTS, H. M., TEN BRINK, E. L., PRINS, P. J. M.: A Pilot Study of the Efficacy of a Computerized Executive Functioning Remediation Training With Game Elements for Children With ADHD in an Outpatient Setting: Outcome on Parent- and Teacher-Rated Executive Functioning and ADHD Behavior. In *Journal of Attention Disorders*, 2014, Vol. 18, No. 8, p. 670. [online]. [2019-11-02]. Available at: <<https://pdfs.semanticscholar.org/b905/9fba8d4dc55b3e2fee8659f64255d1f24030.pdf>>.
- 54 TERUEL, M. A., NAVARRO, E., ROMERO, D., GARCÍA, M., FERNÁNDEZ-CABALLERO, A., GONZÁLEZ, P.: An innovative tool to create neurofeedback games for ADHD treatment. In VICENTE, J. et al.: *Natural Artificial Computation for Biomedicine and Neuroscience*. Madrid : Springer, 2017, p. 186.; RAJABI, S., PAKIZE, A., MORADI, N.: Effect of combined neurofeedback and game-based cognitive training on the treatment of ADHD: A randomized controlled study. In *Applied Neuropsychology: Child*, 2019, Vol. 1, No. 1, p. 2-10. [online]. [2019-11-03]. Available at: <https://www.researchgate.net/publication/330980059_Effect_of_combined_neurofeedback_and_game-based_cognitive_training_on_the_treatment_of_ADHD_A_randomized_controlled_study>.

generate medical information that is of great value to better understand the complexities of the phenomenon of ADHD.⁵⁵ When we associate ADHD and digital games, the alarm bells start to ring. Even though digital games are considered, for the most part, an activity capable of producing beneficial effects for its players. There is growing evidence that suggests that games are addictive and associated with health related and behavioural problems.⁵⁶ This is one of the major concerns of the articles that have been reviewed. ADHD is a risk factor that increases the addictive behaviour in the TIC and virtual activity. In the adolescent population with ADHD, a lack of attention provokes the use of digital games and addictions to the Internet, while hyperactivity/impulsivity provokes addiction to gambling. Additional risk factors are school-related problems, aggressions and family relationships that provoke addictions to the Internet or games.⁵⁷ Studies also indicate that girls with ADHD have more attention difficulty than boys, while boys have more behavioural problems. As they grow, girls with ADHD have a higher probability of developing depression, substance abuse and eating disorder problems as compared to girls who do not have ADHD.⁵⁸ Future investigations should further examine the differences in gender and the evolution of such problems.

We should pay special attention to preventing inappropriate use of Internet and digital games, especially so with children and young people with ADHD given their potential for addiction. The length of play (high frequency) and the characteristics and type of digital game will have to be taken into consideration. MMORPG (Massive Multiplayer Online Role-Playing Games) are more addictive than other Internet applications or other kinds of digital games.⁵⁹ In addition, we have to consider that this play activity takes place in a technological context in which the internet amplified the addictive potential of these games due to easy access, speed of connection, immediate reinforcement and anonymity. If what we are seeking to do is to modify hyperactivity disorder (certain executive functions) via certain digital games, we think that intervention/treatment studies must have a deeper knowledge of the components and skills of executive intelligence, as well as being able to evaluate the empirical efficacy of the aforementioned treatment according to the methodological requirements to these ends. Otherwise, the positive results may be attributed to the initial motivation and not so much to the characteristics of the digital game themselves. It may be interesting, then, to empirically evaluate the efficacy of

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- 56 GOMEZ, R., STAVROPOULOS, V., BEARD, C., PONTES, H. M.: Item response theory analysis of the recoded internet gaming disorder scale-short-form (IGDS9-SF). In *International journal of mental health and addiction*, 2018, Vol. 17, No. 1, p. 870. [online]. [2019-11-03]. Available at: <<https://link.springer.com/content/pdf/10.1007%2Fs11469-018-9890-z.pdf>>; PONTES, H., VASILEIOS, S., GRIFFITHS, M.: Measurement invariance of the internet gaming disorder scale-short-form (IGDS9-SF) between the United States of America, India and the United Kingdom. In *Psychiatry Research*, 2017, Vol. 257, No. 4, p. 477. [online]. [2019-11-03]. Available at: <<https://link.springer.com/article/10.1007/s11469-018-9925-5>>.
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- 58 NADEAU, K. G., ELLEN, B., LITTMAN, E. B., QUINN, P. O.: *Understanding Girls with ADHD*. Altamonte Springs: Advantage Books, 1999, p. 341.
- 59 KUSS, D. J., LOUWS, J., WIERS, R. W.: Online gaming addiction? Motives predict addictive play behavior in massively multiplayer online role-playing games. In *Cyberpsychology, Behavior and Social Networking*, 2012, Vol. 15, No. 1, p. 482. [online]. [2019-11-03]. Available at: <https://www.researchgate.net/publication/230847772_Online_Gaming_Addiction_Motives_Predict_Addictive_Play_Behavior_in_Massively_Multiplayer_Online_Role-Playing_Games/link/0046351a9dd710f8b200000/download>.

a certain type of digital game to a therapeutic or psycho-pedagogical end, and even to regulate behavior within ADHD. On the other hand, we detected that the use of boys is greater than girls. The evidence suggests that the prevalence of ADHD is higher among males than females.⁶⁰ A possible explanation for the differences in the presence of ADHD among both sexes is the under-diagnoses of girls with ADHD. The probability is that boys are three times more likely to be diagnosed with ADHD than girls and also tend to be diagnosed younger than girls.⁶¹ Girls may have a higher probability than boys of suffering from an unaware type of ADHD and could experience more internalised symptoms in contrast to the hyperactivity and aggression exhibited by boys. Studies of women with ADHD are growing but still very limited.

In terms of RQ1 *What particular characteristics have been investigated by researchers?*, the studies can be divided into studies that have focused on studying the risk of addiction or problematic use of digital games as well as on the increased attention deficit due to this practice, as well as behaviour problems. The second group has focused on evaluating the improvement in executive functions via digital gaming, the reduction in hyperactivity, impulsiveness and inattention, as well as examining its effect on motivation and performance. In terms of RQ2 *What research methods have been used?*, the twelve investigations analysed showed experimental and exploratory methods; nine of them used control groups, another carried out a comparative investigation and one repeats the experiment on the same group, but three months later, focusing on the parents of teenagers with disorders. Finally, the last study focused on a single group over 2 months. Only in one study was there a proportion of the sample using boys and girls similar to the prevalence of ADHD between the sexes. On the other hand, we should note that of the twelve investigations, only three of them did any work with the parents. The instruments most used were the Conners scale, which has the widest acceptance in evaluating attention problems, and the Child Behaviours Checklist to evaluate behavioural problems. There is no uniformity in the instruments chosen to study Internet addiction and problematic use of digital games, given that there is no recognition of this disorder by the APA (DSM-5), and at any rate its consideration as a disorder is under study. In terms of analyzing executive functions, for the overall study we note the Behaviour Rating Inventory of Executive Functioning, and for the partial study of executive functions we found adaptations for studying Work Memory and to evaluate Impulsiveness, ADHD Rating Scale and the Stroop Test effect. In terms of RQ3 *What Game has the study on ADD-ADHD been focused on?*, the elements that make up a game can be both beneficial or harmful are not made clear. The digital games are analyzed without distinguishing between the genres and theme of the game. None of the articles go into depth in the content or narrative structure of the game and how this could cause specific problems or benefits for ADHD.

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Conclusion

The studies can be divided into studies that have focused on studying the risk of addiction or problematic use of digital games and a second group evaluating the improvement in executive functions via digital gaming, the reduction in hyperactivity, impulsiveness and inattention, as well as examining its effect on motivation and performance. Authors used experimental and exploratory methods. The instruments most used were the Conners scale, which has the widest acceptance in evaluating attention problems, and the Child Behaviours Checklist to evaluate behavioural problems but there is no uniformity in the instruments chosen to study Internet addiction and problematic use of digital games. In terms of analyzing executive functions, for the overall study we note the Behaviour Rating Inventory of Executive Functioning, and for the partial study of executive functions we found adaptations for studying Work Memory and to evaluate Impulsiveness, ADHD Rating Scale and the Stroop Test effect. Finally, the digital games are analyzed without distinguishing between the genres and theme of the game. None of the articles go into depth in the content or narrative structure of the game and how this could cause specific problems or benefits for ADHD. As a result of the data obtained, as well as the evidence and the controversial debate described, these are the conclusions and proposals:

- Digital games could help in the treatment of ADHD as well as in the cognitive deficiencies of the clinical population.
- More empirical studies on psychotherapeutic and psych educational interventions are necessary to confirm the effectiveness of digital games in the improvement of executive functions with children and adolescents affected by ADHD. These investigations should take into account the age, gender and type of ADHD as well as the genre, content or narrative structure of the game.
- Digital games for ADHD must be designed with the objective of improving the executive function that can have direct implications in the attention and behaviour present in the real world (a general learning process).
- In future studies, the 'FITT' components of digital games should be registered (frequency, intensity, time and type). Using these indicators in the design of the game and the information gathered from the testing of the digital game will help to collect optimal information on the variable that affects the results.
- The genres of each digital game could influence the improvement of cognitive and attention abilities (monitoring many objects, problem solving, strategy in real time). The mechanics of each one of them, could lead to concrete advantages and disadvantages.
- Regarding the actions performed in the digital games, we believe that the designers need to further delve into the conscious actions of the process. Instead of focusing on a specific result or a specific achievement, the designers need to pay closer attention to the actions that will produce improvements in the meta cognitive with the objective of 'learning to learn'. This will allow the broadening of learning into other scenarios.
- Take into account that ADHD is a risk factor to behavioural addictions.

As for future work, it would be interesting to revise and select new articles that talk about the measures evaluated by means of digital games, specifically 'Executive Functions, Spatial Planning Problem Solving, Sustained Visual Attention, Concentration, Impulsivity'.

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