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Video games and Intellectual Disabilities: a literature review

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Abstract

Video games are ubiquitous in the society and this technology has transcended its initial playful side to become also an educational and cognitive training tool. In this sense, different studies have shown that expert game players gain advantages in various cognitive processes respect to non-players and that playing with video games can result in particular profits that in some cases could be generalized to other tasks. Accordingly, video games could be used as a training tool in order to improve cognitive abilities in atypical populations, such as relating to individuals with intellectual disabilities (ID). However, literature concerning video games in people with ID is sparse. In this paper we executed a narrative review of the studies about the use of video games in relation to people with ID.

Keywords: Video games; Intellectual Disability; Cognitive Improvement.

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1. Introduction

Video games are ubiquitous in society and, according to the latest surveys, they are one of the favorite leisure activities for children and young people (Etxeberría, 2011).

Video games can be classified into three macro categories: "Edugames", a type of video games that are designed to develop a skill or implemented as a learning exercise while one is actually playing the game itself. (Quiroga Herranz, Gómez-Abad, Kebir, Ruiz, & Colom, 2009). Among the examples of edugames could be the game Prime Climb, whose aim is to teach number factorization (Conati & Manske, 2009), or Magalú, a game in which players practice language and communication abilities and mathematical concepts (Rosas, Nussbaum, Cumsille, Marianov, Correa, Flores *et al*., 2003). In addition to educational video games there are COTS (Commercial Off The Shelf). These kinds of video games have been designed only for entertainment, but it has been discovered that they represent as well an intellectual challenge and for this reason they might be used to foster cognitive abilities (Charsky & Mims, 2008). The third category consists of "exergames", a type of video game in which physical exercise is accomplished actually while playing (for example the Nintendo's Wii Fit).

Several studies have shown positive effects of video games on a number of cognitive processes, such as perceptual skills, visual and spatial abilities, short term memory, attention and reaction time and some generalization effects to other tasks not specifically trained in children, young adults, and older adults (e.g. Green & Bavelier, 2003).

For this reason, several authors have conceived of video games as a good way to train cognitive skills in individuals with atypical development.

One category of atypical development that might benefit from cognitive training with video games is those individuals with intellectual disability. The use of video games with this group of individuals might be suitable for several reasons; for example, for their characteristic motivational power, for the wealth of stimulus they contain, because they can be easy to use and for the enjoyable repetition and gradual increase in level of challenge.

However, we should note that the choice of video games is important for several reasons. Firstly, we should find video games that are effective in improving a certain cognitive ability; secondly, the video games should be suitable for individuals with disability, so the video games must follow certain technical criteria such as to be simple to understand, to adopt easy to follow instructions to activate the programs, to require simple movements,

to incorporate large-size icons etc., because of the inherent deficits that are linked to intellectual disability.

Therefore, the main aim of this work is to create a theoretical review concerning the study of video games designed for people with intellectual disability. To this end, at first we will review some studies that have shown that video games work as tools for cognitive training in children, adults and older adults with typical development, and also in research concerning computerized cognitive training in clinical populations. Finally, we will discuss the few studies as yet dedicated to the study of video games in people with intellectual disability.

1.1. Video games in typical development and clinical populations

According to Boot, Kramer, Simons, Fabiani and Gratton (2008) the interest in video games as a tool to improve basic perceptual and cognitive skills goes back to the 80s when studies with video games like Pac Man or Donkey Kong in older adults showed improvements in the reaction time (Clark, Lanphear, & Riddick, 1987). Since then, several studies among adults have found that habitual players of video games, especially action game players, outperformed non-players in a number of measures of basic cognition. For example, Boot *et al.* (2008) carried out a cross-sectional study with 11 experienced action game players and compared them with 10 non-players. The results showed that expert players outperformed non-expert in several aspects: they were more accurate in short-term memory tests, they had a lower cost of task switching, and they were faster and more accurate when they had to express judgments regarding rotated objects. In the same way, Wilms, Petersen and Vangkilde (2013) conducted research on 42 male young adults. They divided them into three groups depending on the amount of time that they had previously dedicated to playing action video games and applied to this group several measures of governing visual attention and short-term memory. The results showed that playing an action video game seems to improve the processing speed of visual information in short-term memory tasks. According to the authors, playing with video games imposes high demands to the system of attention, and practice with video games helps a player to use the limited capacity of short-term memory more efficiently.

However, these studies failed in their aim of establishing causality. As Green and Bavelier (2003) have noted, these differences could have preexisted between those who play with video games, because – for example

– they are good at them, and those who do not play with video games. For this reason, these authors conducted an experiment to explore the effects of training with action video games on non-habitually young adults players that showed, after 10 hours of training (1 h per day for 10 consecutive days), an improvement in performance in several measures of visual attention. No improvements in these tasks were obtained using another kind of video games, such as Tetris.

Nevertheless, other studies did not find improvements in video game-based training. For example, Boot *et al.* (2008) carried out a longitudinal study with 82 non-gamer young adults, and divided them into four groups: one group played Medal of Honor, a first person shooter, the second group played Rise of Nation, a strategy game, the third group played Tetris, a puzzle game and the fourth was a control group. They applied to them an extensive cognitive battery that included visual and attentional tasks, spatial processing, spatial memory, executive control and reasoning. Their results showed that, with the exception of Tetris that produced an improvement in mental rotation, 21 hours of practice with action or strategy video games did not result in an improvement in any of the transfer tasks. According to the authors, perhaps 21 hours of practice is not enough to produce enhancements in such task.

Moreover, studies with older adults have found that in some cases video games can be a good option to stimulate cognitive functions that suffer from age-related cognitive decline. In fact, some studies in older adults have found an improvement in executive functions (Basak, Boot, Voss, & Kramer, 2008), cognitive control (Anguera, Boccanfuso, Rintoul, Al-Hashimi, Faraji, Janowich, & Gazzaley, 2013), executive control (Maillot, Perrot, & Hartley, 2012; Stern, Blumen, Rich, Richards, Herzberg, & Gopher, 2011) and processing speed (Maillot *et al.*, 2012), using a custom-designed video games (Anguera *et al.*, 2013), a commercially available strategy video game (Basak *et al.*, 2008), exergames (Maillot *et al.*, 2012) and a complex action game (Stern *et al*., 2011). However, not all the studies have found improvements in old people. For example, Boot, Champion, Blakely, Wright, Souders and Charness (2013) conducted a research with 62 participants with a mean age of 74 years, who were allocated to one of three groups: one of them playing with an action video game (Mario Kart), another group playing with a brain fitness game (Brain Age 2) and a no-contact control group. A number of cognitive abilities, namely processing speed, some aspects of memory, attention and executive control and reasoning ability, was assessed before and after training. The results did not

show improvements in the analyzed tasks in both intervention conditions compared to the no-contact control group. The authors explain their results in terms of low compliance and negative attitudes toward Mario Kart as expressed by the participants. Furthermore, the action game used for this research was different from the action games usually used in research which found effects of action video game-based training, that is regarding first person shooters. Moreover, the participants were allowed to choose the level of difficulty, so it was not possible to determine the improvement in the video game performance.

Regarding the effects of video game-based training in children, in an interesting work in which a combination of commercially available computerized and non-computerized games were utilized, Mackey, Hill, Stone, and Bunge (2011) conducted an intervention in 7-9 years old children who were economically disadvantaged. They divided them into two groups: one was trained in fluid reasoning and the other one was trained in processing speed. The children played Nintendo based games together with computerized and non-computerized games individually and in groups. The non computerized and computer and Nintendo based games in the group of fluid reasoning were games that involved the ability to solve problems in several steps and with several rules considered together, and the games in the group of processing speed were games that require rapid visual processing and rapid motor responses. Both groups showed improvements in the target skills. Moreover, Rosas *et al.* (2003) conducted a research with 1274 economically disadvantaged students in Chile and found that an educational video game that was designed for the study and consisted of games that include all the content of the school curriculum of math and reading in second grade, was effective in promoting learning and motivation. In this sense, it seems that some video games' features are positive for learning which require clear goals or immediate feedback.

Beyond the studies in children, adults and older adults with typical development, video games also have been used with good results in clinical populations. In this way, Fernández-Calvo, Rodríguez-Pérez, Contador, Rubio-Santorum and Ramos (2011) conducted research with 45 patients with Alzheimer's disease. They divided them into three groups: the experimental group played with a video game of brain fitness (Big Brain Academy) for 1 hour per day, 3 days per week for 12 weeks, another group received the same hours of treatment with a traditional stimulation program with paper and pencil activities and the other group was a control group. The results showed that the group that played with the video game exhibited less

cognitive impairment and fewer depressive symptoms than the other two groups. In the same way, Ilg, Schatton, Schicks, Giese, Schöls and Synofzik (2012) carried out a research project with 10 children with degenerative ataxia. The children played with three video games with the Kinect, a motion sensor of the game console Xbox, during 8 weeks. The results showed that symptoms of ataxia were reduced and balance capacities were improved. In another work, Deutsch, Borbely, Filler, Hunh and Guarrera-Bowlby (2008) used the Wii Nintendo Sports game to test the feasibility of this system to improve the rehabilitation in an adolescent with cerebral palsy and they concluded that the system is feasible. In fact, visual perception processing, postural control and functional mobility were improved after intervention. In another study, Caglio and colleagues (Caglio, Latini-Corazzini, D'Agata, Cauda, Sacco, Monteverdi, *et al.*, 2012) used a commercially available driving simulator video game with a patient with traumatic brain injury. The intervention consisted of 15 sessions of 90 minutes each one, three times a week. The patient was evaluated with neuropsychological measures of spatial and verbal memory, attention and executive functions, and with functional magnetic resonance. The results showed an improvement in spatial memory which was maintained in the follow up 1 year later. In another work, Franceschini, Gori, Ruffino, Viola, Molteni and Facoetti (2013), conducted a research in 20 children with dyslexia. They were assigned to one of two groups: one group played with an action video game and the other with a non-action video game (the video game was the same for the two groups, but single activities were selected to create an action and a non-action condition). The training consisted of nine sessions of 80 minutes. The results showed that the group that played with the action video game improved in attentional abilities and in reading speed.

Taken together the results on the use of video games as a training tool are still not clear. Probably this is partially due to the fact that the studies are very heterogeneous and the video games used are very different. In this sense, there are various genres of video games and each type of video game involve (and train) different skills (Spence & Feng, 2010). According to that the choice of video game is very important in relation to what ability we want to improve.

Putting aside the cognitive effects of video games, other positive effects have been noted. For example, sense of mastering or non-hierarchical interaction (Gómez del Castillo, 2007). However, video games also have negatives outcomes like actions of violence or addiction. Precisely stated, action video games like Medal of Honor or Halo, which have been used in

video game-based training with young adults, can be categorized as violent video games. At present, there is a debate about the influence of violent digital games in real-life aggression, without any conclusion (Elson & Ferguson, 2014). However, studies such as this of Greitemeyer (2014), who find that violent video games produced a change in the perception of what is aggressive, advise us about the use of this kind of video game and how cognitive training, especially in a vulnerable population context. Regarding the aspect of addiction, it seems that pathological gamers have greater impulsivity when they have to make a decision (Irvine, Worbe, Bolton, Harrison, Bullmore, & Voon, 2013), but it would depend on the genre of video game. For example, Bailey, West and Kuffel (2013) found that playing with a first person shooter correlated positively with greater impulsivity but playing with strategy games did not, and even correlated negatively with impulsivity. Anyway, perhaps the hours that a person spends playing with video games in a cognitive training session is not enough to produce addiction, since pathological gamers spent a lot of hours per week playing with video games.

In summary, it seems that in some cases video games may serve as a tool to train several cognitive functions in people with typical development and in clinical populations. Moreover, video games have the advantage that they are intrinsically motivating. However, video games might also have negative outcomes like violence and addiction that have to be taken under control.

Despite the studies about use of video games in people with typical development, research in the field of intellectual disabilities is still lacking.

The present paper is aimed at analyzing and synthesizing in the form of a narrative review, utilizing current evidence from literature about the effects of the use of video games in people with intellectual disability.

2. Methods

2.1. Information sources, search strategy, literature search

The search was conducted in April 2014 and electronic databases (PsycINFO, ScienceDirect, Scopus) were also searched. The following keywords were used: “video games” AND “intellectual disability OR mental retardation”, “computer games” AND “intellectual disability OR mental retardation”. In addition, the search terms “special needs” and “computerized cognitive training” were used in order to extend the search.

The literature was searched also by scanning reference lists. The search was restricted to papers in English and Spanish language.

2.2. Eligibility criteria

In the present paper we considered all studies focusing on children, adolescents, young and older adults. To be included a study had to consider participants with intellectual disability, to focus on the use of computer-game based training or video-game based training, to use a design that tested the effects of the use of video games/computer games training.

The search produced totally 80 references. On the basis of the papers availability and after applying the eligibility criteria only 11 of them were selected and were included in the narrative review.

3. Results

3.1. Video games and intellectual disabilities

People with intellectual disabilities have several difficulties in dealing with life's daily activities. These difficulties can have some consequences on the independence and inclusion in society and, finally, on the quality of life itself.

In recent years the evidence in favor of using computer-based activities with people with intellectual disability is growing (Standen, Camm, Battersby, Brown, & Harrison, 2011). The advantages of computer use by people with intellectual disability include: enhanced independence, increase in self-determination, greater self-esteem and increased opportunities for training (Davies, Stock, & Wehmeyer, 2004). Several authors have used specific computerized training programs with individuals with ID showing their utility in improving cognitive abilities, such as non-verbal reasoning (e.g. Söderqvist, Nutley, Ottersen, Grill, & Klingberg, 2012), working memory (e.g. Pulina, Carretti, Lanfranchi, & Mammarella, in press.; Van der Molen, Van Luit, Van der Molen, Klugkist, & Jongmans, 2010), visuospatial short-term memory (Benett, Holmes, & Buckley, 2013), metacognition (Moreno & Saldaña, 2005), in improving learning of basic mathematical concepts (Jansen, De Lange, & Van der Molen, 2013; Ortega-Tudela & Gómez-Ariza, 2006), science (Smith, Spooner, & Woods, 2013), basic computer skills (Davies *et al.*, 2004), words spelling (Purrazzella &

Mechling, 2013), emergency numbers (Ozkan, Oncul, & Kaya, 2013) and writing skills (Pennington, Ault, Schuster, & Sanders, 2011).

Just recently, on the basis of some encouraging results of studies on typical development, video games have been used with individuals with ID.

Regarding the use of video games by people with ID, Abells, Burdbidge, and Minnes (2008) carried out research in which they asked parents of children with ID about the leisure activities of 63 adolescents and, according to the parents, 8 played video games with peers or family members and 11 played alone. This is a smaller proportion respect to typically developing adolescents, at least in Spain where according to Pinto (2008) almost 80 percent of children and adolescents are habitual players of video games. It is possible that adolescents with ID do not play video games because of problems of accessibility and for other reasons; for instance, problems with fine motor skills, though they still feel attracted by video games.

However, the use of video games with individuals with ID might have several advantages. Firstly, video games represent a safe environment (Griffiths, 2002) where people with ID can prove different skills without any negative consequences. Moreover, some video games have the advantage that they can simulate real life situations. Other advantages of video games include introducing children to the computer, which can help to decrease the "digital gap" and the possibility of repeating the same action all the times that is necessary. Moreover, video games use several sensorial systems (Casey, 1992) and promote individualized learning (McClarty, Orr, Frey, Dolan, Vassileva, & McVay, 2012). Additionally, they provides immediate feedback (Sastre, 1998) and aid in the fact that the students can learn at their own pace. Another aspect is that video games favor the decision-making process because they strongly favor problem-solving methods (Rezaiyan, Mohammadi, & Fallah, 2007). As Brown (2011) noted, it is better using popular technologies rather than design expensive assistive technology creating false distinctions between people with typical development and those with ID. However, to date only very few studies have studied directly video games in people with ID.

Through a work project, Rezaiyan *et al.* (2007) conducted research with 60 children with mild ID (IQ range between 50 and 70) with the aim to improve attention through computer games. These individuals were randomly allocated to one of two groups: the experimental group played with a path-finding game (in which you have to find the shorter path) and the control group, which did not receive treatment. The measure used was the Tolouse-Pieron Scale, a test for assessing sustained attention that

consists of a standard cancellation test, where the subject had to cross out the target stimuli. The training consisted of 35 sessions; each session lasted approximately 20-30 minutes. The results showed an improvement in attention in the experimental group but not in the control group. However, not statistically significant differences were found in the follow-up 5 weeks later, so the gain was not stable. The authors attributed this low consistency to characteristics of people with ID as rapid forgetting. Standen, Karsandas, Anderton, Battersby and Brown (2009) carried out research whose aim was to improve the choice reaction time in people with severe ID through a computer game. The game had been designed specifically for people with severe to profound intellectual disability, in fact, it appeared very simple for its perceptive features and for its required objective. In particular, the game involved a man jogging across the screen and encountering several obstacles. The aim was to avoid obstacles until the finish line, making the man jump by a single press of a "jelly bean" microswitch, in the appropriate time in order to allow the man to clear the obstacle (Standen *et al*., 2009). Sixteen participants took part in the study (8 in the experimental group and 8 in the control group; participants in the control group played a game without a time-limited response). The results showed that the mean choice reaction time decreased in the experimental group but did not in the control group, and the number of correct switches increased in the experimental group. Additionally, participants in the experimental group needed less help from the tutor. In the same way, Standen, Rees and Brown (2009) conducted a research on 12 adults with intellectual disability. Participants were divided into two groups, matched on age and ability as resulted by the British Picture Vocabulary Test (Dunn, Dunn, Whetton, & Burley, 1997). The experimental group played Cheese Factory, a game similar to Tetris, specifically designed for people with severe intellectual disabilities. Cheese factory involves sections of various sizes of cheese falling from the top of the screen. Participants have to decide in which direction to move the cheese so the section falls in the correct space to form the whole piece of cheese. In this way, this game involved visual spatial abilities and reaction time. The control group played Running Man (see previous research; Standen, Karsandas, *et al*., 2009), another game also designed for people with intellectual disabilities that only involves simple reaction time. The results showed that the experimental group improved in the scores of the game and they needed progressively less research assistance to play the game. Moreover, they showed a significant improvement in the two tests that measured decision-making. Agarwal and Singh (2012) conducted a case

study with two children with mild intellectual disability aimed at studying the effects of computer games on attention and memory. Both children played with "Virtua Cop 2", an action game, for 1 hour daily for one month. Their results showed that the two children improved in the amount of time that they were able to pay attention and in the number of words that they recall. In another study, Singh and Agarwal (2013) used computer games to teach mathematics to children with intellectual disability, between 6 and 16 years of age. The games concerning mathematics concepts, like numbers, time or money, which were found on internet. They compared the performance of two groups: the first group (control group) was taught by a traditional method to teach mathematics to children with intellectual disability and another group (the experimental group) was taught by computer games. Their results showed that teaching by computer games was more effective than traditional methods in improving the mathematical conceptual capacity in the children with ID.

Other applications of video games have involved people with autism. In a work project, Anderson-Hanley, Tureck and Schneiderman (2011) made use of exergames to decrease repetitive behaviors and improve executive function in children with autism spectrum disorders. They conducted two pilot studies. In the first study, the participants played with Dance Dance Revolution (an exergame that consists of imitating the dance steps of a dancer that is displayed on the screen) during one session of twenty minutes and after that, measures of executive function and repetitive behavior were administered. In the second study, another exergame that consist of a cyberbicycle (a stationary bicycle connected with a video game) was used. The repetitive behaviors were videotaped while the participants played with Lego or Play-Doh and coded in accordance with the GARS-2 (repetitive behavior scale). Regarding executive functions, the measures consisted of Backward Digit Span, Color Trail Test and the Stroop Task. The results showed that compared with a control condition, in which the participants viewed a video, the repetitive behaviors decreased and participants improved in the test Backward Digit Span after they played with the video games. In a interesting study, Blum-Dimaya, Reeve, Reeve and Hoch (2010) showed four children with autism aged between 9 and 12 years how to play independently the commercially available video game Guitar Hero II as a leisure activity. To this end, they used a photographic activity schedule, video modeling that was part of the game and taught them several songs to generalize the skills. The controller consists of a device with the shape of a guitar with five buttons of different colors (although the participants played

in practice mode with only three buttons) and the game consists of a board that is displayed on the screen. The task consists in matching the notes (shown in the screen like colored circles) by pressing the correct button in the controller corresponding to the color of the notes. The results showed that the children were able to learn how to play and generalize the skill to other songs and other settings.

Other applications are Virtual Reality (VR) with virtual environments that are similar to a game. For example, Yalon-Chamovitz and Weiss (2008) carried out research with 33 participants with moderate intellectual disability and cerebral palsy. The experimental group (n = 17) played several games through a GestureTek's Gesture Xtreme video capture VR system, a device that allows participants to view themselves on a screen and react to the movements of the subjects in real time. The participants reported that the activity was enjoyable and they learned how to play without difficulty. Additionally, they showed preference for some games instead of others. However, in this particular study, the VR was adapted for use like a leisure activity. However, VR also has been used to enhance cognitive skills, to improve social skills and to increase skills to support independent living (e.g. Standen & Brown, 2005).

4. Discussion

Studies about the benefits of the use of video games in education, learning and cognition have been increasing in recent years.

Regarding the use of video game based training in individuals with ID, literature is sparse. The few studies encountered have shown that video games could be a useful tool to improve skills like the choice reaction time, attention or decision making skills. However, the samples used are few, and other positive effects of video games have not been explored. Moreover, it is important to note that due to deficits that are linked to intellectual disability, probably not all the video games are adequate for people with ID so it is very important to establish which video games are suitable and effective for these people. Furthermore, the games used in some cases are very simple and designed for people with ID but different from video games used in the training in people with typical development, so it is very difficult to expand the results found in the studies with typical development people to also include people with ID. The genre of video games is another issue of interest since greater improvements have been found with action games. However,

with the exception of the study of Agarwal and Singh (2012), the studies have not used action games.

Another point of interest is the maintenance of the advantages gained once the training is finished. Only the study of Rezaiyan *et al.* (2007) considers a follow-up in their research. In our opinion, it is very important to explore the maintenance of the training effects through time and further research should consider this issue between their other objectives.

Also the possibility of negative outcomes of video games on people with ID should be studied. Perhaps, people with ID are more sensitive to negative features of video games like violence or addiction and additionally, maybe, they play in more solitude and more often than people with typical development.

Another aspect that we consider relevant for further research is the study of immediate and future effects of video games on cognitive abilities. In this sense, it seems that the training procedures involved in some video games produce a gain in the abilities specifically trained, but this is not so clear in the case of those skills not trained specifically. Further research should determine immediate and future effects of video games on cognitive and everyday life abilities.

To conclude, it seems that video games have been used successfully in people with ID to improve several cognitive abilities. It appears also that people with ID can learn how to play video games with adequate support. However, the number of samples used in these studies was small. Despite the results of video game-based training in typical development people and the results of computer based training in people with ID, the potential of video games for cognitive training in people with ID has been little explored. Therefore, more research is needed to determine the advantages and disadvantages of video game-based training on this particular group, as well as to determine the characteristics that a video game needs to have in order to be useful for individuals with ID, and the maintenance through time of achieved gains.

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