Highlights in the Literature Available in Serious Games for Intellectual Disabilities

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Abstract. This review examines the literature on Serious Games used as learning tools for people with intellectual disabilities. Although intellectual disabilities are a very broad field where each individual has very specific characteristics, it would be beneficial to have general evidence-based recommendations about how to design videogames adapted to their cognitive requirements. Thus, the purpose of this paper is to identify and review the available literature on Serious Games for intellectual disabilities classifying them according to the learning outcomes associated. Search terms identified 43 papers covering this topic and this review presents the initial results. The final goal is to identify what is working in this kind of games and how this can be generalized into a methodology to simplify the creation of more effective games for people with intellectual disabilities.

Keywords: Serious Games · Intellectual disabilities · Cognitive disabilities · Educational games · Autism spectrum disorder · Down syndrome

1 Introduction

The use of educational or therapeutic videogames (aka Serious Games) in scientific investigations has grown over the past years but their use for people with intellectual disabilities is still a relatively unexplored field. Even though intellectual disabilities are a very broad and diverse field where each individual has very specific characteristics, it would be beneficial to have general recommendations about how to design videogames adapted to their cognitive features. To pursue this goal, the purpose of this paper is to identify and review the available literature on Serious Games for intellectual disabilities and classify the research found according to the learning outcomes associated to them.

Early research on Serious Games for intellectual disabled people is mostly focused on adapting the interface of existing videogames [1, 2] but we consider that the real challenge is to design learning-games identifying the specific needs of intellectual disabilities users to ensure an effective learning outcome.

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2 Serious Games for Intellectual Disabilities

The AAIDD (American Association on Intellectual and Developmental Disabilities) describes 'Intellectual Disability' as a disability characterized by significant limitations both intellectual functioning (reasoning, learning or problem solving) and in adaptive behavior, which covers a range of everyday social and practical skills [3]. An individual is considered to have an intellectual disability based on the following three criteria: (a) intellectual level (IQ) is below 70–75, (b) significant limitations exist in two or more adaptive skills areas (like communication, self-care, social skills, home living, leisure, self-direction) and (c) the condition is presented from childhood [4].

Attending to this definition there is a wide range of mental conditions that can be considered intellectual disabilities, depending on its causes, signs and symptoms. Even though the different intellectual disabilities have similarities, it is not possible to standardize the learning mechanisms of all impairments and reflect them in the design of a videogame's mechanics. The result is that not all Serious Games are suitable as learning tools for all disabled game players [5, 6].

Although the search terms used in this review covers most of the intellectual disabilities in general to ensure that the results are representative enough, we are interested in identifying those articles referred to two concrete disabilities: ASD (Autistic Spectrum Disorder) and DS (Down Syndrome) for three reasons:

1. Down Syndrome is the most common genetic disorder found in newborns and the most common intellectual disability associated with mental impairment. The prevalence of Down syndrome has been reported to occur in about 1 out of every 600 live births [7].
2. ASD comprises a group of conditions within the category of developmental disorders. Due to its heterogeneity of symptoms, ASD is the disorder with the largest number of scientific investigations among the intellectual disabilities [8].
3. There are a large number of associations in Spain and US dedicated to ASD and DS (separately) that can provide us advice about the characteristics, skills, attitudes and behavior of each group and provide users for the actual game testing.

3 Method

We applied the same method used by Connolly et al. [9] to examine the available literature in Serious Games.

3.1 Databases Consulted

The databases consulted are relevant in three different fields according to the topic of this article: Computer Science, Psychology, Medicine and Science in general. All of them were accessed in their electronic format and are listed below: **ASSIA**, **BioMed Central**, **EBSCO** (consisting of Psychology and Behavioural Science, PsycINFO, PubMed, SocINDEX, Library, Information Science and Technology Abstracts, CINAHL, ERIC,

IEEE, Medline and Academic Search Premier), **IngentaConnect**, **Science Direct** and **Web of Science**.

3.2 Search Terms

We identified three groups of search terms which combination helps us to perform an accurate search in databases referred to the technology, the subject and our particular interest in game design and development methodologies. The final query used in the databases remains as follows:

("videogame" OR "game") AND ("intellectual" OR "cognitive" OR "disability" OR "behavior" OR "down syndrome" OR "autism") AND ("design" OR "methodology" OR "survey")[1]

3.3 Selection of Papers for Inclusion in the Review

We applied the following selection criteria to the 498 studies found in the databases searched in order to choose which articles include in our review:

1. The purpose of the study is to test the acquisition of knowledge through videogames designed or adapted considering specific needs of a particular intellectual disability or a common feature in people with intellectual disabilities in general.
2. The purpose of the study is to identify patterns and behaviors in the use of videogames in people with intellectual disabilities.
3. The purpose of the study is to apply a methodology in the design or development of videogames for a particular intellectual disability or intellectual disabilities in general.

In addition, we discarded the studies that do not appear in scientific publications and those published before 2005. Those papers that do not report an empirical evidence of the results has been included only when the results show relevant behaviors of the users or when best practices are identified.

Once the inclusion criterion is applied, 43 studies have been included in our review.

The classification of the Serious Games is a controversial issue since there is not a single taxonomy widely accepted by the scientific community [10, 11, 12, 13, 14]. We chose the taxonomy proposed by Wouters et al. [15] who described a classification consisting of four categories of learning outcomes in Serious Games: cognitive, motor skills, affective and communicative. The studies included in our review are classified as follows: First, we determined the purpose of the investigation in accordance to one of our three inclusion criteria. Second, we applied the taxonomy described by Wouters to those studies which purpose is to learn a skill.

[1] Note that each database has its own nomenclature. We adapted the query to each database's search requirements without removing any search term.

4 Studies and Results Classified by Purpose of the Investigation and Learning Outcomes

See Tables 1, 2, 3, 4 and 5.

Table 1. Acquisition of knowledge through the design or adaptation of videogames. Cognitive skills

Author/s	Domain	Control group	Effect	Summary/Results
Brown et al. (2011)	Intellectual disabilities	Young	+	Positive and effective results in planning, rehearsing and travelling routes independently
Chang et al. (2014)	Intellectual disabilities	Adults	+	The participants improved their success rates and maintained their acquired skills after the three phases of the study, suggesting the effectiveness of the developed video game for learning long, complex and difficult recycling tasks
Curatelli et al. (2014)	Intellectual disabilities	Children	+/−	Positive results in manipulating abstract elements in people with mild intellectual disabilities. Medium to severe intellectual disabilities had troubles in the management of memory, recall past events and actions, fix in memory new facts and in the management of attention and concentration
Delavarian et al. (2014)	Mild intellectual disabilities	Young	+	Improvements in visual-spatial, auditory and speaking skills
Gonzalez et al. (2009)	Intellectual disabilities	Children	+/−	Practical example of designing a personalized SG centered in four cognitive processes: motivation, attention, concentration and emotion. Not tested with users yet
Grynszpan et al. (2007)	Autism spectrum disorders (ASD)	Children	+/−	Protocol that studies the influence of the specific constraints of the learning areas (spatial planning versus dialogue understanding) as well as Human Computer Interface modalities for children with Autism

(*Continued*)

Table 1. (*Continued*)

Author/s	Domain	Control group	Effect	Summary/Results
Hussaan et al. (2011)	Intellectual disabilities	General	+/−	System that generates learning scenarios depending on the cognitive abilities and the domain competences of the user. Not tested yet
Jimenez (2008)	Learning disabilities	Children	+	Users showed an improvement in phonological awareness and word recognition during the playing sessions
Lee et al. (2012)	Intellectual disabilities	Old	+	Evolution in game scores during sessions suggest that users improved in performing basic daily activities such as setting the table, peeling a fruit and using the elevator
Ripamonti and Maggiorini (2011)	Down syndrome	Children	+	All participants achieved the purpose of the Learning Game (reading the time) after sessions playing with a custom-developed SG
Sajjad et al. (2014)	Other	Young	+	The game has remained effective in helping psychotherapy by reducing symptoms like depression, anxiety, anger and disruptive behaviour

Table 2. Acquisition of knowledge through the design or adaptation of videogames. Motor skills and affective learning

Motor skills				
Author/s	Domain	Control	Effect	Summary/Results
Elaklouk et al. (2012)	Traumatic brain injury (TBI)	General	+/−	Collection of game design principles to develop therapeutical SGs. Not tested yet
Golomb et al. (2010)	Hemiplegic cerebral palsy	Young	+	Results showed improvement function of the plegic hand in all participants
Karal et al. (2010)	Mild intellectual disabilities	Children	+	Results showed a positive attitude and motivation of the users while playing a SG aimed to assist the psychomotor development

(*Continued*)

Table 2. (*Continued*)

Montani et al. (2014)	Traumatic brain injury (TBI)	Young	+	Results showed that the SG developed enhances mental flexibility, multitasking, attention skills and executive functions
Salem et al. (2012)	Developmental delay	Children	+	Results showed an improvement of the motor skills and motor performance of players using WiiFit
Schoene et al. (2013)	Elderly with cognitive and physical impairments	Old	+	Results showed an improvement of physical and cognitive parameters of fall risk
Affective learning				
Benveniste et al. (2012)	Alzheimer	Old	+	Usability study shows that patients are able to understand and use the interface using Wiimotes. Therapeutic impact is the next step of the investigation
Fernandes et al. (2012)	Autism spectrum disorders (ASD)	Children	+/−	Positive reaction to the game, but it is necessary a context to achieve the goals and the possibility of customization. More research is required
Fernandez-Aranda et al. (2012)	Intellectual disabilities	General	+	Patients started to show new coping styles with negative emotions in normal stress life situations, additional generalization patterns and more self-control strategies after using the SG described in the paper
Isleyen et al. (2014)	Schizophrenic	Adults	+	Use of HE (Heuristic Evaluation) and TA (Think-Aloud) together is useful to identify interface usability problems for patients with Schizophrenia and/or autism

(*Continued*)

Table 2. (*Continued*)

Kostoulas et al. (2012)	Intellectual disabilities	Adults	+	Description of a speech interface (speech recognition and emotion recognition component) implemented on a platform for the development of SGs. Results showed that patients applied the strategies of the game to reality

Table 3. Acquisition of knowledge through the design or adaptation of videogames. Communicative Learning

Communicative learning				
Author/s	Domain	Control	Effect	Summary/Results
Bernardini et al. (2014)	Autism spectrum disorders (ASD)	Children	+	Improvement in social interaction through the VG character in all players
Frutos et al. (2011)	Autism spectrum disorders (ASD)	Children	+	Positive qualitative results in users' pronunciation compared with the pre-established pattern recorded in the game
Gonzalez et al. (2007)	Autism spectrum disorders (ASD)	Children	+	Positive effect in concentration, motivation, attention and better assurance in the learning process.
Silva et al. (2014)	Autism Spectrum Disorders (ASD)	Children	+	Interaction on the multitouch interface and the collaboration patterns encourage the user to interact with other users performing tasks in the interface, guiding the partner, having physical contact, asking for help, answering, rectifying, complaining, smiling and thanking

Table 4. Patterns and behaviors

Blum-Dimaya et al. (2010)	Autism spectrum disorders (ASD)	Children	+	General improvement in the activities proposed in the video game Guitar Hero II. The activities implied: the use of (a) an activity schedule to set up, turn on and turn off the game and system, (b) simultaneous video modeling embedded in the game to teach how to manipulate the game. controller and (c) the training of multiple exemplars of songs
Facoetti et al. (2014)	Learning disabilities	Children	+	Positive results in usability tests. Children have been successfully performed through touch screens connected to a PC and tablets without a previous training session
Foran and Cermak (2013)	Autism spectrum disorders (ASD)	Children	+/−	No differences reported between ASD and TD (Typical Development) children in the use of commercial videogames
Mazurek and Engelhardt (2013)	Autism spectrum disorders (ASD)	Children	+/−	Results showed that daily videogame use was positively correlated with age. Most preferred video game genre is Action, followed by Platform and Shooter. There is a positively correlation between daily hours of video game play, the type of video game preferred and PVGT (Problematic Video Game Playing Test)
Mazurek and Wenstrup (2013)	Autism spectrum disorders (ASD)	Children	+/−	Boys with ASD spend more time playing video games than TD boys. Inattentive symptoms were strongly associated with problematic video game use for ASD
Noor et al. (2012)	Autism spectrum disorders (ASD)	Children	+	Review of articles for Autism children with diverse positive outcomes in therapy and education
Whyte et al. (2014)	Autism spectrum disorders (ASD)	General	−	Limited evidence of generalization from tasks learned in the videogame to the real-world

Table 5. Methodology for game design or development

Author/s	Domain	Control	Effect	Summary/Results
Alaribe (2015)	Mild intellectual disabilities	Young	+/−	Summary of learning strategies and need analysis to create a SG to use public transportation. Game not developed yet
Archambault et al. (2008)	Other	General	+/−	State of the art of accessibility (physical and intellectual) in computer games
Cankaya and Kuzu (2010)	Autism spectrum disorders (ASD)	Children	+/−	Proposal of project for investigating how children with Autism interact with SGs. Presents application stages for the design and development Not tested yet
Elaklouk et al. (2013)	Traumatic brain injury (TBI)	General	+/−	Framework that provides a game tailoring environment customized to therapist and reduces the development cost of the games
Horne-Moyer et al. (2014)	Intellectual disabilities	General	+/−	Provides clinical recommendations to design SGs for cognitive therapeutic purposes based on several studies
Lanyi et al. (2012)	Learning disabilities	General	+/−	Collection of Design principles for SG oriented to cognitive disabilities in general. Not tested yet
Sauve et al. (2015)	Other	Old	+/−	List of recommendations for game design oriented to old people. Aspects like challenge, competition, learning content, feedback, readability and user-friendliness were positively valued by players in a survey
Tome et al. (2014)	Intellectual disabilities	General	+/−	List of design principles to implement in a SG divided by: interface, user control, identification with the game, feedback, transmission of concepts and accessibility.
Torrente et al. (2014)	Other	General	+/−	List of strategies for adapting SGs for players with disabilities classified by disability: blindness, low vision, motor disability, hearing disability and cognitive disability

(*Continued*)

Table 5. (*Continued*)

Author/s	Domain	Control	Effect	Summary/Results
Torrente et al. (2012)	Down syndrome	Young	+/−	General guidelines and lessons learnt for designing VG for people with cognitive disabilities

Note: + = A positive result is reported, − = A negative result is reported, +/− = Results are inconclusive

5 Conclusions and Future Work

We provide an outline of the research available on Serious Games for intellectual disabilities by reviewing and classifying 43 studies according to the purpose of the investigation and the learning outcomes associated to them. This is only a first step to obtain guidelines for creating games for users with intellectual disabilities. We have identified challenges and trends after reviewing the literature.

In general terms, most of the studies are designed for users with a certain disability because of the heterogeneity of the skills that this type of users have. Most of the studies describe methodologies and design guidelines that provide recommendations and best practices for a particular disability, but a large number of them have not tested their effectiveness in an actual development with a relevant cohort of users.

We also observed that the results of the studies seem to be positive. Apparently, disabled users acquire new skills through the use of Serious Games but not many investigations provide qualitative results that prove the efficiency of this type of games in a long-term learning process. The use of learning analytics can fill this gap collecting data about the gameplay and the progress of the user, tracking the selected skills to reinforce the learning process.

As a conclusion we believe that the number of the studies and the results obtained are not enough to ensure general recommendations but is a good start point to identify what is working in this type of games. It would be desirable to identify, compile, implement and test these best practices to systematize the creation of tailored serious games for people with intellectual disabilities into a general methodology to simplify the creation of more effective games.

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