UNIVERSITY OF TWENTE.

The use of gamification and serious games within interventions for children with autism spectrum disorder

A systematic review

Anna M. Ern

January, 2014

Department of Positive Psychology and Technology

Supervisors:

1st Supervisor: Dr. Saskia Kelders

2de Supervisor: Dr. Roos van der Vaart

Abstract

Background: Autism is considered to be the most severe developmental brain disorder. Due to the numerous implications this disorder has on the affected person, such as immense communicational and attentional deficits, the consequences emerging from Autistic Developmental Disorders [ASD] are quite strong. Therefore, effective interventions are needed. These interventions are especially useful if they are aimed at children. A recently evolved field within such interventions focuses on the implementation of game-methods, such as gamification, serious games and off-the-shelf video games. This study wants to present the state of research of these methods within intervention for children with ASD. In doing so, this study focuses on characteristics, the targeted ability, the supporting material and the effectiveness of the already implemented game-methods.

Method: This was done by conducting a comprehensive literature search using 4 relevant databases. The search strategy led to the finding of 4,556 articles on October 1st, 2013. Several screening processes led to 14 relevant articles that were examined. The analysis of the found literature was done by applying categories that should extract the relevant data. Further, each game was described and scored by the application of the "10 Ingredients of Great Games" by Reeves and Read.

Results: Through this analysis, this study provides several important approaches that should be considered in further research. Most important findings: The target skills of the found interventions were limited and further research should focus on additional important abilities, such as perception. Further, only 6 interventions provided sufficient effectiveness measures, which limits the explanatory power of this elaboration. These 4 of these 6 interventions showed very positive measures and 2 were less effective.

Discussion: This review found that primarily serious games can be considered a feasible method within the treatment of children with ASD. The methods, mostly serious games, use components that are very useful for children with ASD, such as simple and explicit rules. These strategies may be useful in further game-methods as well. Further, they focus on important abilities in ASD like communicational skills. Research should aim these methods at other important skills within ASD, like sense perception, as well. Still, only 6 interventions within the 14 examined articles show sufficient effectiveness measures. These studies 4 of this 6 studies show very positive results. This emphasizes the strong need for further investigation of effectiveness within these methods.

Abstract

Inleiding: Autisme is een van de meest ernstige ontwikkelingsstoornissen in de hersenen. Deze stoornis heeft veelvoudige symptomen, zoals sterke communicatieve problemen en aandachtsstoornissen. Hierdoor zijn de gevolgen van Autistic Developemental Disorder [ASD] relatief ernstig. Het is daarom belangrijk om effectieve interventies te vinden en deze in te zetten bij kinderen. Een nieuwe veld binnen deze interventies voor kinderen met ASD is het gebruik van game-methoden, zoals gamification, serious games en off-the-shelf video games. Deze studie wil de stand van de actuele onderzoeken op dit gebied weergeven en de daaruit volgende implicaties voor volgende onderzoeken op een rij zetten. Daarbij word vooral gefocust op de karakteristieken van de game-methode, de vaardigheid waarop de interventie was gericht, op eventueel ondersteunend materiaal en op de effectiviteit van deze interventies.

Methode: Dit wordt bereikt door het doorvoeren van een literatuuronderzoek met vier verschillende databases. Deze zoek strategie leidde tot 4556 gevonden artikelen en werd uitgevoerd op 1 oktober 2013. Verschillende screening processen voerden tot 14 relevante artikelen. Deze artikelen werden geanalyseerd door het toepassen van categorieën. Hierdoor werd de belangrijke data uit de artikelen geëxtraheerd. Verder is elke game beschreven en gescoord op basis van de "10 Ingredients of Great Games" van Reeves and Read.

Resultaten: Door deze analyse kan deze studie belangrijke benaderingen en invalshoeken voor vervolgonderzoek bieden. De belangrijkste bevindingen: De methoden gebruiken verschillen in de uitvoer van de speel, maar hebben verschillende elementen gelijk. De doel-vaardigheden die de interventies wilden veranderen zijn relatief beperkt op communicatie vaardigheden. Verder laten er maar zes interventies metingen over effectiviteit zien. Van deze 6 interventies zijn 4 methoden effectief en twee minder effectief.

Discussie: Uit deze review is gebleken dat serious games een goede methode kan zijn in de behandeling van ASD bij kinderen. Het blijkt dat deze methoden, vooral serious games, strategieën gebruiken die heel nuttig zijn voor kinderen met ASD. Dit is bijvoorbeeld het gebruik van eenvoudige regels. Deze strategieën kunnen aanleiding geven voor verdere methoden om deze ook te gebruiken. Verder zal het voor vervolgend onderzoek nuttig zijn om deze methoden niet alleen maar op communicatieve vaardigheden, maar ook op andere belangrijke aspecten te richten, zoals waarneming. Ten nadele van dit onderzoek zijn er maar 6 interventies gevonden met een significant resultaat. Hierdoor wordt duidelijk dat er nog veel behoefte is aan toevoegende metingen over de effectiviteit van elk onderdeel van deze methoden.

Table of Contents

Introduction

Autism is considered to be the most severe developmental brain disorder (Baron-Cohen, 1995). Due to the range of symptoms associated with autism, it is often referred to as autism spectrum disorder [ASD] (Ramachandran & Oberman, 2006). Within ASD three subtypes are classified: autistic disorder, Asperger syndrome and pervasive developmental disorder-not otherwise specified (Ramachandran & Oberman, 2006). The definition of the DSM-V, one of the two leading diagnostic manuals for mental disorders, states that ASD is characterized by fundamental impairments in communication and social interaction, as well as by rare and stereotyped behavioral sequences and movements (American Psychiatric Association, 2013). These communicational and behavioral problems are assumed to be the result of disrupted perception: Individuals with ASD are not able to experience and understand their senses as others do (Hassan et. al, 2011). This contributes to the fact that individuals with ASD are generally experienced as living in their own world, as they sense the outer world in a different way.

The consequences of their disrupted conception are numerous: First, not only their verbal, but also their non-verbal communication is impaired. They may for example not respond properly with eye contact (Dautenhahn, Robins & Dickerson, 2012). This can also be linked to their tactile sensations: It is common within ASD to find touch experienced to extreme extents. Whereas some individuals with ASD are assumed to be hyposensitive, others appear to have no sense of pain at all (Dautenhahn et al, 2012). This may underline why for example something as common and polite as a handshake may be perceived differently by someone with ASD. Other possible behaviors emerging from ASD are: not responding to questions, false interpretation of voice intonation, misunderstanding of concepts, such as money, and numerous more (Hassan et al, 2011). Because of the range of behaviors that the impairments have impact on, autism can cause problems in various areas of life. Research shows that these influences are considerably distinct on the quality of life, independence and the constant need for help (de Urturi, Zorilla & Zapirain, 2011), which emphasizes the need for effective interventions.

Although ASD is not curable yet, it is possible to intervene early in the life of autistic children. ASD is mostly diagnosed at a very early age, between 2-6 years average (Jain et al, 2009).This is true due to the fact that ASD manifests itself in symptoms that can be observed objectively and distinctly (Jain, Tamersoy, Zhang, Aggarwal & Orvalho, 2009). These early

interventions may be preferable over interventions targeting older individuals: If interventions are implemented at an early stage of life, the impact of for example acquired skills and knowledge may have a stronger impact and the extent of ASD on the quality of life could be decreased (Corbett, 2003). The benefits of the establishing of intervening methods are the experience increased autonomy, a higher quality of life and an enhanced proper accommodation to society of people with ASD (de Urturi, Zorilla & Zapirain, 2011).

There are two fields of interventions for ASD: educational or behavioral interventions and medical care (Myers & Johnson, 2007). Medical care is generally not aiming at ASD directly, but at the comorbidities that are associated with ASD, such as depression or anxiety. These symptoms are normally treated with psychiatric medication. Jain et. al. (2009) state that unfortunately too little research has so far been conducted to draw conclusions about the effectiveness of medication in ASD. Furthermore, the implications of their side effects on health are rather strong (Jain et. al, 2009).

This emphasizes the need for additional treatment possibilities. Behavioral and educational interventions on the other hand show improvement in several skills that are of striking relevance for autistic children. These skills are various and include motor skills, attentional abilities and social behavior (Baranek, 2002). Numerous methods are used to achieve such improvements, such as speech and language therapy, structured teaching and sensory integration therapy (Myers & Johnson, 2007). One of the most common methods is applied behavior analysis (ABA). Within this method, a highly individualized and intensive form of therapy is indicated. A therapist works with a child suffering from ASD for 20- 40 hours on several skills that this child needs to adjust. This is done step-by-step, which accounts for the large amount of time spent. Generally, even though these methods show improvements in the behavior of children with ASD, many of them seem quite time consuming (Myers & Johnson, 2007). Moreover, these behavioral interventions are not always effective (Jain et al, 2009). This is also the case due to the incurability of ASD in general. Therefore, there is a strong interest for new interventions in the treatment of ASD.

As already mentioned, it seems highly reasonable to aim interventions for ASD at children suffering from it. Within the treatment of ASD, a new field of technological interventions has emerged in recent years. The use of gamification, serious games and off-the-shelf video games in ASD interventions is an especially fast rising issue during the last decade (Deterding, Dixon, Kahled & Lennart, 2011). They are generally seen as effective new methods in the treatment of ASD, especially for children ((Frutos, Bustos, Zaiprain &

Zorrilla, 2011). These methods all make use of video game elements to achieve improvements in a non- gaming context. The application of gamification and serious games is as already mentioned a rather new approach which explains why there is still confusion about applying the terms and definitions of "gamification", "serious games", and so on. Therefore, the definitions used within this paper shall be discussed in the following section. Below, each method will be introduced and their implications for children with ASD discussed.

Gamification

Deterding et. al. (2011) elaborated a definition of gamification to distinguish its term from other concepts. According to them gamification can be defined as "the use of game design elements in non-game contexts" (Deterding et. al, 2011). It is essential to differentiate the term "game" from the concept of "play". While playing is characterized by a free, open-minded form of interpreting and reacting to different meanings and behaviors, gaming should be understood as a path towards a goal, guided by rules and competitive elements. This indicates that gamification may be a favorable method used within health intervention: A goal could be to improve any health-related issue and the rules needed to achieve the health goal could be implemented in the gamified context. It is additionally important to explore what is considered to be "game design elements". It is hard to include or exclude certain elements in this category, but Reeves and Read (2009) developed a list of "Ten Ingredients in Great Games" that could be helpful. Their work included for example narrative context, competition under rules that are explicit and enforced and three-dimensional environments (Reeves & Read, 2009). Each of these components, and others even more, may not be seen as game-like elements when taken out of the game context. Still, game design elements are part of various games, have a fundamental role in the game and are highly associated with it (Deterding et. al., 2011).

Serious games & off-the-shelf games

Serious games not only use game elements for a non-game context, but also implement whole games which were only designed for the purpose of a non-game context (Deterding et. al, 2011). To be more precise, serious games use the game shaped experience to achieve a non-game goal. According to the general opinion of research on serious games, the main result is enhancing the user's motivation to pursue the goal in real life through the gaming experience (Mader, Natkin & Levieux, 2012). Other effects that are aimed to be achieved are changes in

the knowledge, attitudes, cognitive skills, physical ability, health or mental wellbeing of the user (McCallum, 2012). This emphasizes the difference between an off-the-shelf video game and a serious game: A serious game is not aiming to have the user's entertainment as the main goal, but uses it to achieve other purposes, such as those named above.

Still, commercially available video games which were not especially designed for the health care sector can also be used for intervention. This was already done regarding several issues, for example the Wii Fit bowling game for stroke rehabilitation. These game-methods are frequently considered alternative methods with high potential (Saposnik et. al, 2010). Especially for children, research that examines the effects of methods such as exergames like the Wii Fit show promising results regarding cognitive, physical and social skills (Staiano & Calvert, 2011).

Implications for ASD

Returning to the issue of treatment for autistic children, the implementation of these game-methods seems highly feasible. To begin with, serious games and gamification function as powerful tools for the development of social, cognitive and psychological abilities (Frutos, Bustos, Zaiprain & Zorrilla, 2011). These abilities are all targets in ASD interventions, because the behavioral problems resulting from ASD have implications on all of these skills. Furthermore, the strengths of autistic children lie in visual perception. It is more than reasonable to apply video games as intervention methods, as they rely on visual cues. The literature considers picture-based systems, such as video games, to be successful in the treatment of children with ASD (Lancions & O'Reilly, 2001). In addition, it is possible to find even more characteristics associated with ASD that suit the application of video games. Corbett (2003) states that even behavior that is rated as unfortunate as repetitive behavior or selective attention can be beneficial when using video gaming as treatment method. Another aspect which accounts for the use of game-methods within ASD treatment is that these methods show strongly increased motivation within children with ASD (Murray, 1997).

Since the use of gamification and serious games within interventions for children with ASD is such a new researched subject, several studies have designed interventions using these methods (de Urturi, Zorilla & Zapirain, 2011). Still, no general overview could be found in the literature, which accounts for several problems. First, it is of great interest how the game-methods are realized within interventions. Through an investigation of these methods it would become clear what for opportunities the implementation of game-methods offers and how

future research could realize such methods. Second, it would be interesting to know when they are implemented and which circumstances are indicated during the implementation. Here one could obtain relevant information about the usefulness of different circumstances in this method. Last, maybe it is already possible to investigate the effectiveness of these methods and therefore draw conclusion over the usability of them. Even though the implementation of game-methods like gamification or serious games could be a beneficial method within the treatment of ASD in children, a state of research has to be established. Due to the fact that there are already existing interventions implementing these game-methods, a general review of the existing work would provide additional value. Future research would profit from general findings that could be contributed in such a review.

Therefore, the aim of this study is to give a review of interventions for autistic children using gamification, serious and off-the-shelf video games. To do so, several research sub-questions were formulated:

1. *What kinds of game methods are used to achieve improvement in the behavior of children with ASD?*
    i. *What are the methods characteristics and settings?*
    ii. *What other methods are used supporting the game methods?*
2. *What skills and behaviors of ASD are the interventions aiming to alter with game methods?*
3. *What is known about the effectiveness of gamification, serious games and off-the-shelf video games in ASD interventions for children?*

To answer these questions this study executed a comprehensive literature search of the relevant work that focuses on interventions using game-methods within the treatment of children with ASD. Through this, this paper will discuss the possible implications for the future emerging from the analysis of the found literature.

Method

Data sources & search strategy

To find suitable articles, a literature search using online databases was performed. Doing so, four online databases were selected to search for relevant material: PsychInfo, SciVerse Scopus, ScienceDirect and Web of Knowledge. This thesis is part of a bigger research conducted by two researchers. Due to that fact, the search aimed at a more general issue as that represented in this paper and was later reduced to articles relevant for the topic of this paper. This lead to the following search strategy (see fig. 1): The first four steps shown in fig.1 were aiming to find articles relevant to the use of games and gamification in health care in general. For the last three steps, the researchers applied criteria relevant to the purposes of their own studies. These steps will be further illustrated in the section "Inclusion & exclusion criteria in the screening process".

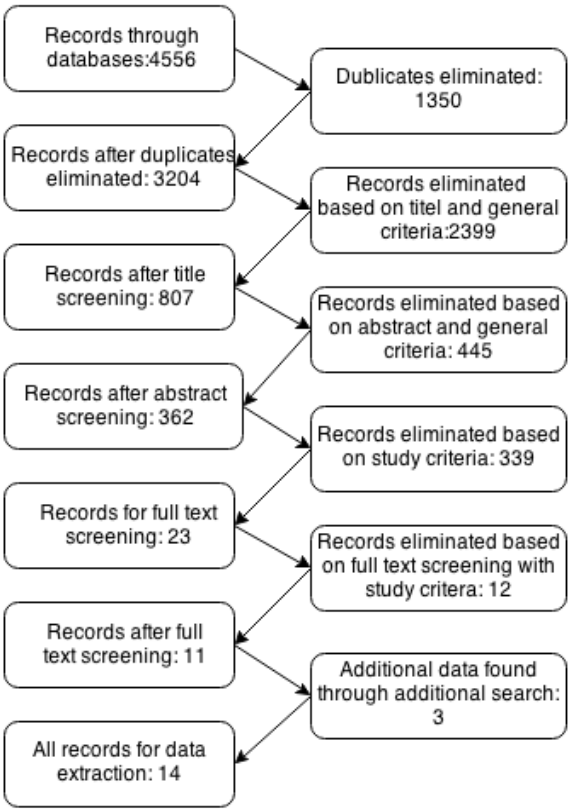

Figure 1. *Diagram of the literature search.*

For the search, distinction between four different constructs was made and used. The constructs were based on a search aiming to find articles relevant for the issue of the use of games and gamification in health care: the medium construct, the game construct, the health construct and the procedure construct (see fig. 2). The medium construct applies for everything that is related to the multimedia world and may relate to gamification or serious games. The game construct should ensure that only interventions using at least parts of games are found within the search. Further, the health construct was determined to account that the game method is not used within another sector than health care. Last, the procedure construct should guarantee that only interventions intended for patients would be found. The related keywords to each construct are shown in figure 2. This search strategy led to 4556 articles found on October 1st, 2013.

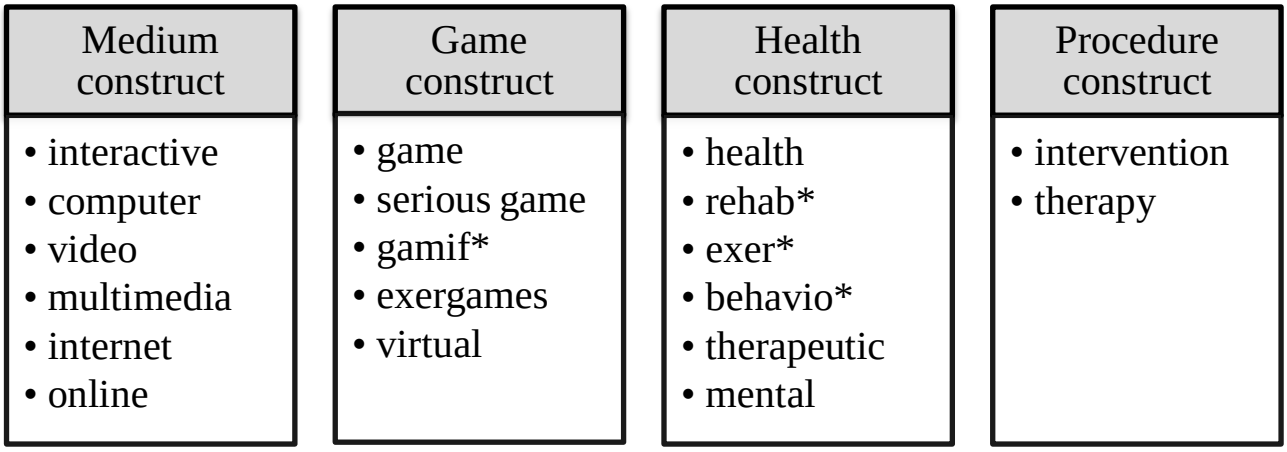

Figure 2. *Constructs & keywords used in the literature search.*

Inclusion & exclusion criteria in the screening process

The aim of the literature search was to find interventions using gamification, serious games and video games in the sector of health care. To ensure that only the articles matching this aim are present at the end of the search, three waves of screening were performed on the found 4556 articles.

For the screening process, inclusion and exclusion criteria were determined. The following inclusion criteria were determined: (1) The study is about an intervention, (2) the intervention is aimed at patients or people with health problems, (3) the intervention intended to promote health, (4) it contained at least game elements, (5) the study is retrievable online

and (6) the study is available in either English, Dutch or German. Further, exclusion criteria were established to eliminate a study from the search: (1) The study does not contain information on the game-elements and (2) the study is a review itself.

These criteria were applied during each wave of the screening process (see figure 1). The first wave contained screening the titles of the found articles and identifying their eligibility by two researchers. Then, the abstracts of the remaining articles were screened using again the inclusion and exclusion criteria to determine the eligibility of the studies. The last part of the screening process contained examining the remaining articles full-text for the criteria named above. Further, during this step the researchers only included articles relevant for their study purpose. To ensure that only suited articles remain, each researcher applied specific criteria for their own purpose. For this study, this meant to add one additional criterion to the screening process: (1) including only studies relevant in the treatment of children with ASD. At last, 3 additional studies were found through specific search caused by inducement of the already found articles. When the screening process was finished, 14 articles discussing 14 interventions had been included.

Data extraction

To fulfill the study's purpose and answer the examination question, all 14 studies had to be examined for relevant data. To do so, suitable categories were established in order to find the needed information in each study. These categories will be defined and illustrated in the following sections.

Method characteristics

It is of special interest how the game-methods are designed and what sort of properties are established. Various different conditions can be examined using this category during the analysis of the found literature. Aspects that are presented in this category can range from the structure of the game and the design to the content used. To give an impression of each game-method, this study will give a description of each method based on the information provided by the article in question.

Because of the variety within this category, it is useful to apply an additional instrument that can give a more structured overview than a summary. To do so, the "Ten ingredients of great games" by Reeves and Read (2009) were coded to score each game. Each

description of the game-methods within the found articles was read and then coded whether an ingredient was present or not. To review the code for each ingredient, see table 2 below.

Table 1. *Code scheme for "Ten ingredients of great games".*

Code	Ingredient of great games
1	Self representation with Avatars
2	Three-Dimensional Environments
3	Narrative Context
4	Feedback
5	Reputations, Ranks and Levels
6	Marketplace and Economies
7	Competition under Rules that are Explicit and Enforced
8	Teams
9	Parallel Communication systems that can be easily
10	Time Pressure

Intervention/ game name

To ensure a holistic overview, the intervention or the game name will be stated. If no name has been established till now, the name of the medium used, e.g. Xbox Kinect, will be given.

Used technology

Used technology should be understood as either the off-the-shelf video game, the game method or the used game characteristics implemented. Further, the medium on which the chosen game-method is operating will be given here (e.g. PC, Xbox 360,etc.).

Intended setting

This category was established to investigate under which circumstances the intervention should take place. Relevant aspects are the period of time, the place and whether the child is able to undertake the game alone or needs additional help. Additionally, it is important which device is needed to carry out the game. For some interventions, only within an experimental method the setting was described, e.g. when the study executed a pilot study. If this is the case, the data provide will relate to the setting used in the experiment.

Supporting material

In interventions, it is common to use not only one, but multiple methods or materials to achieve the chosen goal. It is crucial to identify those other factors that may contribute to the

effectiveness of the implemented method. Due to the fact, the additional material implemented in the intervention, except for the game-method, will be referred to in this category.

Targeted behavior/ ability

Each intervention is aiming to change health related behavior. In this category, it is important which ASD related behavior the intervention is aiming to reduce or enhance.

Target group

Some studies may be concerned with different forms within the spectrum of autism and direct their intervention at a specific group as Asperger syndrome and their characteristics, whereas other aim at the whole spectrum of the autism disorder.

Effectiveness

Even though this study is dealing with a highly recent issue, there are already measures to investigate the effectiveness of the used game-method. These measures are based on experimental designs using statistical methods. For those who established these methods, the effectiveness of each study will be determined by a method implemented by Morrison (2012). The intervention will be coded "either more effective"," less effective" or "ineffective", applying the criteria of Morrison (2012), as shown in table 1. If no investigation of effectiveness was conducted in the study, the intervention will be coded with "no measures available".

Still, not every intervention examined in this review is ready to provide these sorts of results. This may be the case because some of the found interventions only provide a pilot study due to the novelty of the examined issue. Even though these studies do not execute measures of effectiveness, most of them still provide additional investigation, as surveys, questionnaires etc. This data can possible be contributive for further investigations and will therefore be presented in the results as well under the subcategory "additional data".

Table 2. *Morrison effectiveness criteria.*

Intervention code	Criteria
More effective	• The intervention led to improvement on the majority of outcome measures • The intervention was at least as effective as comparison groups • The intervention was more effective than waiting list or no

	intervention control groups
Less effective	• The intervention led to improvement on a minority of outcome measures • The intervention was not necessarily as effective as comparison groups • The intervention was more effective than waiting list or no intervention control groups
Ineffective	• The intervention did not lead to improvement on any of the outcome measures • The intervention was no more effective than waiting list or no intervention control groups

Results

Before the found data will be represented, a code scheme for the interventions examined in these studies is shown. This scheme was elaborated to simplify the upcoming examination of the interventions. In the following, each intervention will be referred to by its code.

Not only does this scheme simplify the upcoming elaboration, but also provide additional information. Table 3 shows that all of the 14 articles were published between 2007 and 2013. This outlines the recentness of the examined issue. Even more, only three of the found interventions were published before 2010. This outlines the recentness of the examined issue.

Table 3. *Code scheme for the found literature.*

Code	Authors	Year	Title
I1	Bartoli, L., Corradi, C., Garzotto, F. & Valoriani, M.	2013	Exploring motion-based touchless games for autistic children's learning.
I2	Beaumont, R.& Sofronoff, K.	2008	A multi-component social skills intervention for children with Asperger syndrome: The Junior Detective Training Program.
I3	Ben-Sasson, A., Lamash, L. & Gale, E.	2012	To enforce or not to enforce? The use of collaborative interfaces to promote social skills in children with high functioning autism spectrum disorder.
I4	Cai, Y., Chia, N. K. H., Thalmann, D., Kee, N. K. N., Zheng, J. & Thalmann, N. M.	2013	Design and Development of a Virtual Dolphinarium for Children with Autism.
I5	De Silva, P. R. S., Higashi, M., Lambacher, S. G. & Osano, M.	2007	Monitoring of Emotion to Create Adaptive Game for Children with Mild Autistic.
I6	Guisti, L., Zancanaro, M., Gal, E. & Weiss, P. L.	2011	Dimensions of Collaboration on a Tabletop Interface for Children with Autism Spectrum Disorder
I7	Hiniker, A., Daniels, J. W. & Williamson, H.	2013	Go Go Games: Therapeutic Video Games for Children with Autism Spectrum Disorders
I8	Jain, S., Tamersoy, B., Zhang, Y., Aggarwal, J. K., & Orvalho, V.	2012	An interactive game for teaching facial expressions to children with autism spectrum disorders.
I9	Orvalho, V., Miranda, J. & Sousa, A. A.	2009	Facial Synthesis of 3D Avatars for Therapeutic Applications.

I10	Tanaka, J. W., Wolf, J. M., Klaiman, C., Koenig, K., Cockburn, J., Herlihy, L., Brown, C., Stahl, S., Kaiser, M. D. & Schultz, R. T.,	2010	Using computerized games to teach face recognition skills to children with autism spectrum disorder: the *Let's Face it!* Program.
I11	Yan, F.	2011	A SUNNY DAY: Ann and Ron's World an iPad Application for Children with Autism.
I12	Frutos, M., Bustos, I., Zapriain, B. G. & Zorrilla, A. M.	2011	Computer Game to learn and enhance speech problems for Children with Autism.
I13	Hassan, a. .Z., Zahed, B. T., Zohora, F. T., Moosa, J. M., Salam, T., Rahman, M., Ferdous, H. S. & Ahmed, S. I.	2011	Developing the Concept of Money by Interactive Computer Games for Autistic Children.
I14	De Urturi, Z. S., Zorilla, A. M. & Zapirain, B. G.	2011	Serious Game based on First Aid Education for individuals with Autism Spectrum Disorder using Android Mobile Devices.

Method characteristics

First the description of each intervention and their scores on the "Ten ingredients of great games" will be shown and examined. Table 4 outlines the main characteristics of each game-method used in the interventions by summarizing the descriptions given in the found literature. Within the description, each score of the "10 Ingredients of Great Games" chosen by the researcher will be provided. Additionally, the codes for each interventions are summarized in table 4.

As already said, the methods used within in the intervention are highly different. This is also the case for the descriptions done in table 4. Due to that fact, the codes for "10 Ingredients of Great Games" (see table 2) will be used in the following elaboration of table 4.

Table 4 outlines that every game-method was coded with ingredient 7, which means that every game-method applies explicit and distinct rules within the game. These rules should guide the user towards winning by making clear what needs to be done to achieve success within the game.

It is also remarkable that 11 interventions (I1, I2, I4, I6, I7, I8, I9, I10, I11, I12 and I13) use feedback within their chosen game-method. More than 2/3 of the interventions chose to give the user a response to their action within the game. Further, 9 interventions make use of reputations, levels or ranks to give additional feedback to the player. This is true for I2, I6, I7, I9, I10, I11, I12, I13 and I14. 6 of the chosen game-methods provide a narrative

background, namely I2, I4, I6, I7, I11 and I13. Additionally, 4 interventions chose to provide a self-presentation with an avatar, I1, I2, I11 and I13, and also 4 interventions added a 3-dimentional-enviroment to the game-method, I1, I4, I8 and I9. The factor of time pressure is present in 3 interventions elaborated (I1, I5 and I10). Last, 2 interventions chose to enable the user to work in teams, namely I3 and I6. Two of the "10 ingredients of great games" were not implemented in any of the found interventions: None of the interventions enabled the player to use a form additional communication, like chatting online while playing. Also, there were no forms of marketplaces or economies implemented in the game-methods.

Table 4. *Game description and score on "10 Ingredients of Great Games".*

Game-method	Main characteristics	Ingredient-code
I1	The intervention used 5 mini games out of 2 off-the-shelf video games(*Kinect Sports; Rabbids Alive & Kicking)* for Xbox 360 Kinect; the games used virtual 3-D environments, for example a bowling lane (*2,3,4*); the games corresponded to the motor and cognitive level of autistic children; the 5 games were all short and simple, using only one game rule und lasting only few minutes (*7*); still, diversity between games to avoid boredom was present; the games varied in terms of complexity, from easy to hard; differences within game in representation: avatar/ self(*1*), task type can be direct, which means one movement directly effects the virtual environment/ indirect & in time pressure/ multiple lives to restart a level (*10*)	1, 2, 4, 7, 10
I2	The game was 1 of 4 components within an intervention; Narrative context is present within the game(*3*): year 2030, the junior detective is specializing in the field of decoding the suspect's thoughts and feelings(*1*); levels arranged by complexity of the skills to be learned(*5*): Level 1- emotion recognition, Level 2- learning to deal with emotions, Level 3- applying the learned skills(*7*); every level works within the detective frame; During the game, the children can use a private agent journal to document the successful completed missions(*4*)	1, 3, 4, 5, 7
I3	The Collaborative Puzzle Game (CPG), played on tabletop device, is a multiplayer game (*8*), where the players work simultaneously; the task is to pick up, drag and release digital puzzles (*7*); 2 modes are present within the game: Free Play (FP), where each player can move the puzzles around independently and Enforced Collaboration (EC), where both player have to touch a puzzle simultaneously in order to move it	7, 8
I4	An 3-D Virtual Dolphinarium is designed, simulating a dolphin lagoon (*2,3*); The game is operating on a 320° 3-D screen and uses Microsoft Kinect devices for human gesture recognition; children act as dolphin trainers using the Kinect device for gesture-based controlling; Before playing the game, children are given a short introduction on how to interact through hand gestures with virtual dolphins when children use the right gesture, effects, e.g. water splashing, dolphin jumping, etc., are implemented; Children can use different	2, 3, 4, 7

	single- and two-hand gestures to try out dolphin reaction (*4,7*)	
I5	Emotion-based interactive game played on PC, which is played by 2 children, controlling the same game from different computers; One child suffers from mild autism, the other one is without any disabilities; each child can draw a line within the game square with the goal to get the longest line and to block the other player's line (*7*); therefore the speed of the line is important (*10*); while playing, the child's facial expressions are tracked by a specific system which then determines the speed of line according to the child's emotions	7, 10
I6	3 serious story games operating on multiuser devices, such as tabletop, focusing on joint engagement of the children are used; 3 games using three different socially problematic stories using avatars (*3*): 1. Apple Orchard game- joint performance, 2. Bridge Story- sharing, 3. Save the Alien- Mutual planning; Within each game, the children experience three different steps (*5*): a. *Explore the story* with problem cards and pictures giving verbal explanation of each part of the problem, b. Teacher and children *Choosing together* the matching card (*4*), c. Listen and Discuss about provided audio clips discussing alternative solutions to the problem (*5*); key characteristic is the simultaneous operation of the users; Each game has a further joint performance that needs to be done parallel by two users (*8*)	3, 4, 5, 7, 8
I7	Three video games available on App store for iPad aiming to teach autistic children better multiple cue responding through task requiring them to discriminate between several stimuli; Example situation within the three games: in the "Build-a-Train"-game the child has to select features to locomotive in the same way as another train shown on another track above (*3,7*); If task is done right, auditory and visual feedback is provide (*4*), if task is done wrong, minimal feedback is given; game difficulty rises with level number (*5*)	3, 4, 5, 7
I8	Based on the use of a webcam the game provides a second feedback loop in which visual input of the player enables a better human-computer-interaction and therefore more effective games (*4*); uses 3-D environments (*2*); 4 mini games: 1. recognize expression- match face and expression, 2. become your avatar: game requires the child to mimic an expression, mimic and impression of the player is recognized by the computer, 3. follow the change of expression- child has to imitate the expressions shown on the screen, 4. live a story- perform appropriate expressions to a story given on the screen (*7*)	2, 4, 7
I9	Game system operates on Pc and Xbox 360; user's interface : 3D avatar (*2*) on which the child himself can modify an expression, the score and the level of complexity (*4,5*); the child needs to create the expression on an avatar; Different tasks: Match the whole expression, match the upper facial part or match the lower part of the presented face (*7*)	2, 4, 5, 7
I10	*Let's face it*- skill battery beholds 7 computer games which are aiming at the face processing skills of autistic children; in every game, the player can chose among different modes and levels (*8*); high scores and other tables are presented (*5*); two examples: a. *Splash* game: faces appear randomly on the screen and child needs to find the matching face, b. *ZapIt* game: the child has to connect three matching faces; test of face processing skills within the game is given (*4,7*); time pressure is present within the games (*10*)	4, 5, 7, 10

I11	iPad Application, that should simplify the life of children with ASD and their social network supporting them, as family and friends; Start screen, where child can choose between 2 characters, Ron and Ann (*1*), which will then be assisting during play through verbal feedback (*4*); 7 mini games, 5 games related to everyday activities: getting up, teeth brushing, eating, bathing & going to sleep; All these games are related to different times of the day: day time, school time & night time (*3*); 2 additional games in the school time mode (*5*), which are aiming at the perception, concentration and other relevant skills; Example of one game: Food finding game- child has to pick the right food for an animal and is provided with animated sticker when succeeding (*7*)	1, 3, 4, 5, 7
I12	Verbal communication skills are learned via a computer app; 2 modes: 1. Basic mode- Child clicks on a display on the interface, has to pronounce it correctly, the app can determine right pronunciation (*4,7*); 2. Advanced mode- child has to name only the uncolored parts of an object, if pronounced correctly, the whole object will be colored in the end; Second app for parents to monitor the results of their child(*5*)	4, 5, 7
I13	A game running on every windows platform with different levels and objectives dealing with the concept of money; represented with avatar in the game (*1*); tutorial for money identification by first choosing the right amount of money and second find the matching note; 4 levels for learning money exchange (*5*): 1. buying a single item with a single note, 2. buying a single item with different notes, 3. buying multiple items with different notes, 4. choose the desired price from various notes (*3,4,7*)	1, 3, 4, 5, 7
I14	First aid app with 3 mini serious games that can be used by people with ASD on a system operating with android; All games are related to first aid; Description of the 3 mini games: 1. different parts of a first aid, e.g. handling of a burn accident, task are randomly ordered and have to be put in the right order, 2. associate medical specialties with the according picture, 3.helpful behavior in a hospital (*7*); Additional website linked to the game for the supporting network to review the performance of the individual (*5*)	5, 7

Second, the data derived from the analysis of the studies using the determined categories is listed in table 5. It shows the data that is relevant to the categories, which were implemented and will be further explained in the following section.

Table 5. *Data derived from categorical analysis.*

Article/ Data extraction	Intervention/ game name	Used technology	Intended Setting	Supporting Material	Targeted behavior/ ability	Target group	Effectiveness
I1	Kinect Sports & Rabbids Alive and Kicking	Two off-the-shelf games xBox360	FEL***:Therapeutic center, 5 "gaming meetings" á 45 minutes on weekly basis, therapist present, video taped	Video tapes, therapist notes & interview parents	Attentional skills, emotional &behavioral sphere	Autism	More effective
I2	Junior Detective Program	Serious game for Computer	FEL***, 7 sessions, parent and therapist assisted	group session (videotaped ,rated), teacher handouts, home missions	Emotional under-standing & social skills	Asperger Syndrome	More effective
I3	Collaborative Puzzle Game (CPG)	Multiple player serious game on tabletop interface	FEL***:Quite room in school, 2 sessions with 2 modes 1 month apart, adult present, experimental phase	-	Social behavior	High Functioning ASD	More effective
I4	Virtual Dolphinarium Interaction	3-D serious game in 320° immersive room, Microsoft Kinect	FEL: ***Immersive Room in Therapy Center, 20 minutes game playing video guided warm up, experimental phase	-	Non- verbal communication	ASD	Less effective
I5	Emotion-based interactive game	gamification with PC game	FEL, 20 times of game playing, NSCN*	-	Social interaction & communicational skills	Mild ASD	More effective
I6	Apple orchard, Save the alien& bridge game	Serious game for multi-user tabletop device	FEL***, In therapy, play completely, 2 players (child or therapists)	Video taping	Joint performance, Sharing & Mutual planning	ASD	No measures available
I7	Go go games	Serious game for IOS	SDL**, independent use on touchscreen IOS device	-	Multiple cues responding	ASD	No measures available

Note : *NSCN= No special circumstances needed; **SDL= Self determined location; ***FEL= Fixed external location.

Table 5. *continued.*

Article/ Data extraction	Intervention/ game name	Used technology	Intended Setting	Supporting Material	Targeted behavior/ ability	Target group	Effectiveness
I8	"Recognize the expression"- game	Serious game for PC/ Xbox 360	FEL***, play completely, NSCN*	-	Recognition of facial expressions	ASD	no measures available
I9	"Facial Player"	gamified video game for PC/ Xbox 360	SDL**, Child playing independent, NSCN*	-	Recognition of facial expressions	ASD	no measures available
I10	Let's face it!	Comprehensive computer- based skills battery	FEL***, average 20 hours over 19 weeks, therapist present	Plastic token reinforcers, money, high score website	Facial abilities	ASD	Less effective
I11	A sunny day	Serious game as iPad Application	SDL**, independent playing, NSCN*	-	Multiple skills	Autistic Children	no measures available
I12	Management application & learning application	Serious game on PC	SDL**, parent monitors child's playing, NSCN*	Management app for supporting network	Verbal communication skills	Autistic children	no measures available
I13	Interactive computer game to understand the concept of money	Serious game on Windows platform	SDL**, independent playing, NSCN*	-	Understanding the concept of money and the use of money	Autistic children	no measures available
I14	First aid serious game	Serious mini games on android operating systems	SDL**, Independent playing, help may be provided if needed	Website with reports for supporting network	Autonomy & first aid education	ASD or family members	no measures available

Note : *NSCN= No special circumstances needed; **SDL= Self determined location; ***FEL= Fixed external location.

Used technology

Almost all game-methods within the found interventions can be noted as serious games.(I2, I3, I4, I5, I6, I7, I8, I10, I11, I12, I13 & I14). Only two exceptions were made: First, I1 because it uses 2 off-the-shelf video games and second I9. I9 is in between being a gamification and being a serious game and is therefore not considered to be only a serious game.

Within the category of used technology, also the systems on which the game-methods are operating were extracted from the articles. The devices, systems or mediums that were used were the computer (I2, I5, I7, I8, I9, I10, I12 & I13), the Xbox (I1, I4, I8 & I9) and tabletop devices, such as the iPad (I3, I6, I11 & I14). Last, I4 is a specialty, which operates with Microsoft Kinect.

Intended setting

This category can be subcategorized in: (1) the intended location, (2) intended time investment, (3) involved persons and (4) additional aspects.

The interventions vary distinctively in the used location (1). A difference can be made between interventions with a fixed, extern location, as for example a therapeutic center, or interventions, who allow the child to use the game-method in a self-determined location. A fixed location is present in the interventions I1, I3, I4, I5, I6, I8 and I10. I2, I7, I9, I11, I12, I13 and I14 permit a free choice of location.

Within the second category (2), there is an extraordinary amount of variation present. Further, some articles do not indicate a fixed amount time. Due to that fact, it is not possible to cluster the data found in the interventions here. To review the amount of time, see table 5.

The third category, involved persons (3), can be further divided in subcategories: Child only, therapist/adult present and other person involved in the game-method. Intervention I5, I7, I8, I9, I11 and I13 are implying that the child uses the game-method independent. In intervention I1, I3, I4, I10 and I14 it is suggested that another person, like a parent or therapist, is present, for different reasons. In I2, I6 and I12 the involvement of a third person is even higher: He or she participates in the chosen game-method.

The last category (4) indicates further aspects, which were found in the literature and have further indications on the setting. This is the case for interventions I3 and I4: Both interventions imply a warm-up or experimental phase before playing the game.

Supporting material

As already said, some of the found interventions use additional material to the chosen game-method. 3 interventions made videotapes of the experience with the game-method for further investigation, namely I1, I2 and I6. These 3 interventions used the videos for different purposes: I1 used it to determine the effectiveness of the game-method, I2 implemented the game-method within group session and I6 added the game-method to an existing therapy. Within I2, there were additional materials as teacher handouts and home missions dealing with the content and the problematic approached in the game-method.

I10 used further material as well: the children got monetary compensation for the gameplay and all families received plastic token reinforcers in order to enhance the motivation of the player and to improve the impact of the game-method. Further, a website with the high scores of all players was established. At last, I12 created an additional app for parents, therapists or other members of the supporting network of an autistic child, in order to manage the game-method for the child.

Targeted behavior/ ability

Based on the data found, 4 subcategories of behavior or/abilities, that were aimed to be changed by the intervention, can be established. The subcategories are: Behavior/abilities related to attention (I1 & I7), behavior/ abilities related to social interaction and communication (I2, I3, I4, I5, I6 & I12), facial behavior/ abilities (I8, I9 & I10) & behavior/abilities for every-day use (I11, I13 and I14).In all categories, other distinction between the target skills can be made: Where as some interventions focus on quite broad defined abilities, others focus on specified sub-skills. An example to illustrate this is given here: I5 focuses on broad skills as social interaction and communication skills. A skill which could be referred to as inferior to this category is the target skill of intervention I4, non-verbal communication.

Target group

Most of the interventions examined are focusing on children suffering from "ASD", including I4 I6, I7, I8, I9, I10 and I14. I14 is additionally aiming to involve family members and other social contacts within the game. Due to the different disorders united under the term ASD, there were also different target groups found in the interventions. The second highest group named as target in the interventions are "autistic children" (I1, I11, I12 and I13). Additionally, some of the interventions are aiming at specialties within the sector of ASD: I2 is concerned

with children suffering from Asperger Syndrome, I3 addresses children with high functioning autism and I5 gives attention to mild autistic children.

Effectiveness

While analyzing the found data for effectiveness measures, it was found that 6 interventions provide this sort of investigation. All interventions were coded based on the scheme by Morrison (2012): I1, I2, I3 and I5 could be coded with "more effective", I4 and I10 with less effective and I6, I7, I8, I9, I11, I12, I13 and I14 with "no measures available". This outlines that all of methods that were tested with an experimental design showed positive results.

Additional data

As already mentioned, not all of the chosen game methods were tested within an experimental design, but still provided further relevant additional data. I7, I8, I11 and I14 investigated additional feedback through interviews (I9 &I 14) or other, not further explained methods (I8 &I11). This additional information is presented in table 6 below. The most important findings provided by this additional feedback were that visual stimuli should be preferred over other those using other sense modalities (I11).

Discussion

This review used a comprehensive literature search in order to describe the state of research of the use of game-related methods in the treatment of children with ASD. Important aspects of this topic emerged during the analysis of 14 relevant interventions. First, it was found that the game- methods were realized in different ways, but still share several characteristics. This is also true for the setting and the supporting material of the game-methods. Second, this study shows that a considerably high number of the found material focus on the same skills, namely enhancing the communication abilities of children with ASD. Third, although the found material provides only limited information regarding the effectiveness, it can still be stated that these are quite positive. Further some limitations regarding this study were found. This review will end with a suggestion for further research based on the findings of this paper.

Game-method

When talking about the game-method, the most striking result is that nearly all of the 14 analyzed interventions chose to implement a serious game. Only two interventions were not a serious game: Bartolli, Corradi, Garzotto and Valoriani (2013) used 2 off-the-shelf games and Orvalho, Miranda & Sousa (2009) used very few game ingredients and therefore their method was not considered as serious game, but has still too much to be referred to as a gamification. This is highly interesting because the found literature considers gamification as an exceedingly promising new method in the health care sector (Deterding et. al, 2011). This view cannot be supported by the results of this review, at least when one is referring to gamification in the treatment of ASD. This may be due to the fact, that regarding this specific issue, serious games are a very valuable method and therefore most of the interventions focus on applying this method. They are such a well chosen method because they enhance the user's motivation through the game-context which then accounts for changes in a non-game context (Mader, Natkin & Levieux, 2012).

Returning to the game-method, this study chose to analyze all 14 methods by applying a code scheme of the '10 Ingredients of Great Games". Here, the most important finding is that all of the game-methods applied distinct rules which enable the player to understand and to win the game. This is so important because it creates the basis for the experiencing of fun whilst playing (Deterding et. al, 2011). Through rules, the player can win and relate this win to his own competence. Therefore, skills acquired whilst playing may have a greater impact. Also when relating this ingredient to the concept of ASD, it is highly useful to indicate rules

that are explicit and easy to understand. Further, most of the interventions note that they try to only use one game rule at a time. All this eliminates additional distraction and thus simplifies the use of the game-method for autistic children. Moreover, it is highly reasonable to use 3-D context within game-methods for autistic children due to the fact that these children tend to react positively to visual input and can elaborate stimuli communicated through this manner in a better way than through other senses (Bartolli et al., 2013). Still, only 4 interventions chose to make use of 3-D environments within their interventions. This may be due to the fact that not all interventions run on devices that support 3-D environments. Further, the additional feedback provided by Yan (2011) states that the serious game should focus more on visual than on auditive stimuli. For the future, it is definitely useful to put even more emphasis on the visual design. Still, one has to take in consideration that children with ASD can easily be overwhelmed: In the work of Cai et. al (2013), where a 320° immersive room with 3-D environment on it was used, various children were overwhelmed by the 3-D experience and the use of the 3-D glasses. Therefore, additional research should be considered to which extent visual stimuli should be present in the treatment of children with ASD.

This study did not only provide an analysis of the "10 Ingredients of Great Games", but also outlined other important characteristics of the game-methods. It is very interesting how the advantages and disadvantages of the location within the game-setting may have influence on the experience with the game-method. If a fixed, external location is chosen, the game-method can function in a controlled setting. Here, disrupted stimuli can be controlled and suppressed. Furthermore, the surroundings, for example the room, can remain in the same way to reduce anxiety within the patients, which is very common in ASD. This is not the case for self-determined location. Still, here the user will properly choose a location where he does not feel anxiety either. In the fixed location, it is also easier to provide help for the children if required. However, a fixed, external location also has disadvantages: Autistic children tend to drive off into their inner world. If that is the case during their stay in the external location, it will be extremely challenging to get them to focus on the game-method. The results found in this study show no clear choice between those two possibilities: 7 interventions chose for a fixed, external location and also 7 interventions implemented a self-determined location. Therefore, further research may focus on which location may be suitable for which kind of ASD. For example, is it better for children with ASD with extremely low attentional skills to imply a self-determined location or is a fixed, external location with possible assistance the better choice? Due to the lack of sufficient measures of effectiveness, the explanatory power

of this study to answer this question is quite limited. Moreover, 6 interventions using a fixed, external location report effective measures. Even more, 4 of them reported more effective measures. This suggests that further research may also find that fixed, external locations are a good choice for implementing. Still, this has to be stated with caution because no assertions can be made about the effectiveness of the interventions using self-determined locations. None of the intervention using this reported effectiveness measures.

An additional research question emerging from this considers another part of the interventions setting: There were differences found in the persons involved within the intervention. One factor leading to this difference is definitely the targeted skills. Some interventions chose to aim at skills that should improve collaborative functioning, such as Ben-Sasson, Lamash and Gal (2012) and Guisti, Zancanaro, Gal and Weiss (2011). Here the additional persons are obligatory. Still, in other interventions, such as de Urturi, Zorilla and Zapirain (2011), help may be provided if the user is in need. It would be interesting to see if there are differences concerning the effectiveness of the whole intervention due to the presence of an additional person. Does it enhance the effectiveness of the chosen method or does the help cause drawbacks in the autonomy of the player? Again, this study can only provide limited suggestions what future research might find out due to the limited effectiveness measures. Still, 5 out of 6 interventions providing effective measures include the presence of an additional person, such as a parent or therapist. Additionally, the fact that 8 out of 14 interventions intended an additional person to be involved in the intervention may account for future research finding that this may enhance the effectiveness of the game-methods.

Supporting material

This review provided a section with the additional material used in the intervention. The point of doing so was to investigate whether these methods contribute to the effectiveness of the used game-method. Unfortunately this study could not provide additional information if this was the case or not because the relevant studies did not provide those measures. Further research should therefore also consider investigating whether the supporting material has additional impact or not. Although no measures were done, it still seems reasonable to provide websites with high scores or at least some form of additional data that makes it possible for the parent, therapists or other involved persons to review the child's outcomes. No negative consequences should emerge from this additional information. Rather, the

involved persons will get a better picture of the needs of the child and therefore can make decisions concerning the child's future treatment on a better elaborated basis.

Targeted skills/ group

To start, it is important to outline the skills the interventions were aiming at: The category that was most focused on is behavior and abilities related to social interaction and communication. However, other categories, like the improvement of facial recognition skills, would most likely also lead to an improvement in social interaction and communication. It seems reasonable that the majority of the interventions want to improve the communication skills of autistic children, since this issue is, as already mentioned, one of the key symptoms of ASD (Hassan et. al, 2011). When returning to the introduction, other problems related to ASD can be recalled, as sense perception and repetitive, rare behavior (American Psychiatric Association, 2013) could not be found in the interventions analyzed. Only 2 interventions focused on abilities that are broader defined and therefore have impact on several sub-skills, such as attention. However, other studies that make use of different methods, such as ABA, than those examined in this study are working with sense perception and other broader defined abilities as well (Baranek, 2002). Therefore, it may be a consequences emerging from this study to also aim at these skills in upcoming interventions using game-methods. Matson et. al (2012) state that interventions using other methods also aim at the comorbidities associated with ASD, such as anxiety disorders or depression. This implies that future interventions should also use game-methods to find out whether those methods could achieve improvements in the comorbidities as well. Still, it is reasonable that also further interventions should focus on communication skills, since this a major issue within ASD.

This problem should also be related to the chosen target groups: Most of the interventions defined their target group as "children with ASD". As said in the beginning, the range within autistic disorders is extraordinarily wide (Bartolli et. al, 2013). Therefore, not all children with ASD show the same symptomatic. Even though, the interventions try to implement a method useable for all children with ASD, it seems reasonable to divide the target group further if it is possible. A reason for doing so was found within this elaboration. Beaumont and Sofronoff (2008) who focused only on children with Asperger Syndrome and Ben-Sasson, Lamash and Gal (2012) are aiming at children with high functioning autism. These studies show remarkable results regarding their effectiveness. The literature that reviews other interventions, such as Applied Behavior Analysis, used in ASD in children also

suggests that further research should focus on specifying the target groups (Peters-Scheffer, Didden, Korzilius & Sturmey, 2011). Peters-Scheffer et. al (2011) state that further distinction between groups beyond age and IQ differences, may account for better outcomes regarding the effectiveness. This could also be true for interventions using game-methods. Still, some interventions are definitely useful for all children with ASD, such as the interventions related to every-day use.

Effectiveness

A considerable problem found within the 14 articles is the reliability in general. Only 6 interventions provide measures of effectiveness that were considered reliable enough to be referred to in this study. This is unfortunate, since the studies which do execute those experimental methods used to determine the effectiveness, show remarkable results. None of those interventions were rated as not effective and only 2 out of 6 as less effective. This provides reason to state that serious games in ASD could be considered an effective method in interventions. The examined literature supports this view (de Urturi, Zorilla & Zapirain, 2011). Since using game-methods within the treatment of ASD is such a recent topic, it seems logical that many studies cannot already provide those measures. Still, it is very important to implement those in the future. This review reveals results that may lead to the conclusion that following measures of effectiveness may also lead to positive results.

Limitations

Although this review provided several implications for future research, it also contains some limitations. Within this review, an analysis of each game was done by applying the "10 Ingredients of Great Games" by Reeves and Read (2009). Although this analysis showed several important results, these ingredients were based on off-the-shelf video games. Serious games may be video games for non-game related content, but they still differ from normal video games. This may contribute to the fact that the "10 Ingredients of Great Games" may not be the best possible choice for analyzing serious games. Also, the ingredients were based on video games that were not limited to children with severe developmental disorders. Therefore, the categories within the "10 Ingredients of Great Games" may be too limited to normal off-the-shelf video games. The differences between the focus of those to game-methods may account for that: Whereas normal off-the-shelf games focus on the enjoyment of the user, serious games only use the enjoyment to pursue other goals. Therefore, other

ingredients may be relevant. Future work should concentrate on either another method or an adaption of the work of Reeves and Read. In this adaption, some of the ingredients could be altered. For example, the two missing ingredients, Parallel Communication systems that can be easily implemented and marketplaces and economies, should be revised. Due to the fact that they were found in no interventions it may be reasonable to erase them for further investigation. Further, during this adaption, it may be useful to focus on the differences between children and other age groups. It may be useful for serious games for other adults to implement even more ingredients within the game, but not for children and especially not for children with ASD.

Further, the study analyzed 14 articles which were all concerned as interventions. Even so, several articles were just at the end of the design process and did not provide enough information about future method in the upcoming intervention. They still indicated that the described game-method will be used within an intervention and there they were included within the literature search. The analyzed articles had an additional throwback: Most of the intervention did not provide reliable results or statistical analysis of the demonstrated material. This contributes to the fact that this review cannot provide enough results concerning effectiveness measures. Other aspects of this study suffer from this throwback because they have low explanatory power. If there were more measures concerning the effectiveness, this study could provide more implications for further research. Even though this is not a limitation caused by this study, it still affects its explanatory power.

Implications for further research

Still, this review shows remarkable results of game-methods in the treatment of children with ASD and contains important objectives for future research. First, although it is important to focus on communication skills within intervention for ASD, further research has to occupy with additional skills. This is especially important for attentional abilities, as well as for perception skills due to their implications on other abilities.

Second, this study illustrates the usability of explicit rules and 3-D scenarios within the design of these methods. Still, this has to be stated with caution, due to the missing effectiveness reports. General additional ingredients of games may also provide an enhancement through the chosen method, such as the narrative context. Feedback by parents showed that especially this subitem is considered as useful. Therefore, further research also has to focus on the usefulness of the “10 Ingredients for Great Games” and how these

ingredients should and can be modified. Maybe it is even reasonable to provide a separate list with the most important ingredients in game-methods for children with ASD.

In conclusion, the following answers to the research question can be given. The game-methods used within the treatment of ASD are mostly serious games, which use concentrate on the use of ingredients suited for ASD, such as the implementation of only one game rule at a time and the focus on visual stimuli. They also focus on very important abilities in ASD, mostly communication skills. The most important finding is still that the effectiveness measures provide highly positive results, but that there are too few measures of effectiveness done by the studies to draw general conclusions. This study cannot generally conclude whether serious games are a better way of treatment for children with ASD then others. Therefore, this study outlines the importance for additional studies using game-methods with sufficient experimental design to enable better general conclusions of these feasible methods. Still, this study gave several reasons to expect further research to find especially serious games to be an effective method within the treatment of ASD for children.

Literature

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Baranek, G. T. (2002). Efficacy of Sensory and Motor Interventions for Children with Autism. *Journal of of Autism and Developmental Disorders, 32* (5), 397-422.

Baron-Chonen, S. (1997). *Mindblindness- Essay on Autism and the Theory of Mind. Cambridge:* MIT Press.

Bartoli, L., Corradi, C., Garzotto, F. & Valoriani, M. (2013). Exploring motion-based Touchless Games for Autistic Children's Learning. *Proceedings of Interaction Design and Children '13*, June 24-27 2013 New York City, New York, USA.

Beaumont, R., & Sofrononoff, K. (2008). A multi-component social skills intervention for children with Asperger syndrome: The junior detective training program. *The Journal of Child Psychology and Psychiatry, 49* (7), 743–753.

Ben-Sasson, A., Lamash, L. & Gale, E. (2012). To enforce or not to enforce? The use of collaborative interfaces to promote social skills in children with high functioning autism spectrum disorder. *Autism, 17*, 608-622.

Cai, Y., Chia, N. K. H., Thalmann, D., Kee, N. K. N., Zheng, J. & Thalmann, N. M. (2013). Design and Development of a Virtual Dolphinarium for Children with Autism. *IEEE transactions on neural systems and rehabilitation engineering:* a publication of the IEEE Engineering in Medicine and Biology Society 2013.

Corbett, B. A. (2003). Video Modeling: A window into the World of Autism. *The Behavior Analyst Today, 4(3*), 101-111.

Dautenhahn, K., Robins, B. & Dickerson, P. (2012). Embodiment and Cognitive Learning-Can a Humanoid Robot Help Children with Autism to learn about tactile Social Behaviour. In S. S. Ge, O. Khatib, J.-J. Cabibihan, R. Simmons & M.-A. Williams (Eds.), *Social Robotics* (pp. 66-75). Berlin, Germany: Springer.

De Silva, P. R. S., Higashi, M., Lambacher, S. G. & Osano, M. (2007). Monitoring of Emotion to Create Adaptive Game for Children with Mild Autistic. *Computer Analysis of Images and Patterns- Lecture Notes in computer Science, 4673*, 326-333.

Deterding, S., Dixon, D., Khaled, R. & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining "Gamification". *MindTreck, 11*, 9-15.

Frutos, M., Bustos, I., Zaiprain, G. & Zorrilla, A. M. (2011).Computer Game to learn and enhance speech problem for Children with Autism. In Q. Mehdi, A. Elmagharaby, R. Moreton, R. Yampolskiy & J. Chariker, *the 16th International Conference on Computer Games CGAMES 2011*. Symposium Conducted on the meeting of IEEE Society in Louisville, Kentucky, USA.

Guisti, L., Zancanaro, M., Gal, E. & Weiss, P. L. (2011). Dimensions of Collaboration on a Tabletop Interface for Children with Autism Spectrum Disorder. *Proceedings of the SIGCHI Conference on Human Factiors in Computing Systems,* 3295- 3304. doi: 10. 1145/1978942.1979431

Hassan, a. .Z., Zahed, B. T., Zohora, F. T., Moosa, J. M., Salam, T., Rahman, M., Ferdous, H. S. & Ahmed, S. I. (2011). Developing the Concept of Money by Interactive Computer Games for Autistic Children. In A. del Bimbo, K.-R. Park & P. C. Y. Sheu (general Co-Chairs), *International Symposium of Multimedia.* Symposium Conducted on the meeting of IEEE Society in Dana Point, California, USA.

Hiniker, A., Daniels, J. W. & Williamson, H. (2013). Go Go Games: Therapeutic Video Games for Children with Autism Spectrum Disorders. In N. Sawhney, E. Reardon, J. P. Hourcade (general Co-Chairs), *Interaction Design and Children.* Symposium Conducted on the meeting of ACM in New York City, NY, USA.

Jain, S., Tamersoy, B., Zhang, Y., Aggarwal, J. K., & Orvalho, V. (2012). An interactive game for teaching facial expressions to children with autism spectrum disorders. In S. K. Mitra, A. Neri & G. Vernazza (general Co-Chairs),*5th International Symposium on Communications Control and Signal Processing ISCCSP.* Symposium conducted on the meeting of IEEE Society in Rome, Italy.

Lancioni, G. E., & O'Reilly, M. F. (2001). Self-management of instruction cues for occupation: Review of studies with people with severe and profound developmental disabilities. *Research in Developmental Disabilities, 22,* 41–65. doi:10.1016/S0891-4222(00)00063-9.

Mader, S., Natkin, S., Levieux, G. (2012). How to analyse therapeutic games: The player/ game/ therapy model. In: Herrlich, M., Malaka, R., & Masuch, M. (2012). *Entertainment Computing- ICEC 2012* (p. 193-206). Berlin: Springer.

Matson, J. L., Turygin, N. C. , Beighley, J., Rieske, R., Tureck, K. & Matson, M. L. (2012). Applied behavior analysis in Autism Spectrum Disorders: Recent developments, strengths and pitfalls. *Research in Autism Spectrum Disorder, 6,* 144-150.

McCallum, S. (2012). Gamification and Serious Games for Personalized Health. *Studies in Health Technology and Informatics, 177,* 85-96.

Murray, D.K.C. (1997). Autism and information technology: Therapy with Computers. In S. Powell and R. Jordan (Eds.) *Autism and Learning: A Guide to Good Practice* (p.100-117). London, England: David Fulton Publishers.

Myers, S., M. & Johnson, C. P. (2007). Management of Children With Autism Spectrum Disorder. *American Academy of Pediatrics 120*(5), 1162-1182. doi:10.1542/peds.2007-2362.

Peters-Scheffer, M., Didden, R., Korzilius, H. & Sturmey, P. (2011). A meta-analytic study on the effectiveness of comprehensive ABA-based early intervention programs for children with Autism Spectrum Disorders. *Research in Autism Spectrum Disorders, 5,* 60-69.

Reeves, B. & Read, J.L. (2009). *Total Engagement: Using Games and Virtual Worlds to Change the Way People Work and Businesses Compete*. Boston: Harvard Business School Press.

Ramachandran, V.S. & Oberman, L. M. (2006). Broken mirrors: A theory of autism. *Scientific American, 295,* 62-69.

Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D., Thorpe.K. E., Cohen, L. G. & Bayley, M. (2010). Effectiveness of Virtual Reality Using Wii

Gaming Technology in Stroke Rehabilitation: A Pilot Randomized Clinical Trial and Proof of Principle. *Stroke, 41(7)*, 1477-1484.

Staiano, A. E. & Calvert, S. L. (2011). Exergames for Physical Education Courses: Physical, Social and Cognitive Benefits. *Child development Perspective, 5 (2)*, 93-98.

Tanaka, J. W., Wolf, J. M., Klaiman, C., Koenig, K., Cockburn, J., Herlihy, L., Brown, C., Stahl, S., Kaiser, M. D. & Schultz, R. T., (2010). Using computerized games to teach face recognition skills to children with autism spectrum disorder: the *Let's Face it!* Program. *Journal of Child Psychology and Psychiatry, 48*, 1122-1130.

Yan, F. (2011). A SUNNY DAY: Ann and Ron's World an iPad Application for Children with Autism. In M. Ma, M. F. Oliveira & J. W. Pereira (Eds.), *Serious Games Development and Applications- Lecture Notes on Computer Scienes 6944* (129-138). Berlin: Springer.