A Review of Serious Games for Children with Autism Spectrum Disorders (ASD)

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Abstract. This paper reviews 40 serious games designed for children with autism spectrum disorders (ASD) and these games/studies are classified into four categories; technology platform, computer graphics, gaming aspect and user interaction. Moreover, the paper discusses serious games designed for the improvement of communication skills and social behavior, social conversation, imaginative skills, sensory integration and learning accounts in ASD children. The children usually interact with these games by ordinary IO (input/output) e.g. keyboard and mouse or touchscreen tools. Previous researches show the effectiveness of playing serious games on mobiles or tablet devices in helping ASD children to express their feelings and improve the level of engagement with others. However, there are limitations in designing games for helping autistic children with sensory processing disorder (SPD), improving imaginative play, and teaching first aid. Further, there is not much research that addresses repetitive behavior in ASD children.

Keywords: Serious games (SG), Autism Spectrum Disorder (ASD), Education and therapy, Interactive tools, Technologies platforms, Computer graphics.

1 Introduction

Autism Spectrum Disorder (ASD) is described as a serious neurodevelopmental disorder, which involves delay in the development of many basic skills including the ability to socialize and communicate [1], as well as the ability to speak [2]. Nowadays, (ASD) is considered as a "paediatric health issue" as it has been shown that 1 in 88 children in the USA [3], 1 in 100 children in the UK [4] and 1 in 625 children in Malaysia [5] have diagnosis with ASDs. Moreover, recent research suggests that the percentage of people who have autism has grown in recent decades [6]. Hence, it is important to identify effective ways to help them communicate and participate in their society more easily, with a view to improving their quality of life.

Autistic individuals have a limited range of interests, and struggle to bond emotionally with their parents and those around them, and also have repetitive behaviors and sensory processing disorders (SPDs), such as being sensitive to sound, sight, touch etc. Having said that there is also considerable heterogeneity within those diagnosed with ASD [6],[7]. Over the years, many researches have been conducted on how to improve the lives of individuals affected by ASDs. Different technologies

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have been developed to assist autistic children in developing social skills, communication skills, vocabulary building and vocalization; as well as classroom visual support systems [6]. Surprisingly, children with this disorder interact well with technology, however they find it hard to relate to their environment. This has led to a lot of research being conducted which focuses more on how to improve their communication and social interaction skills. Interrelating important areas associated with this disorder will not only open a door to a better future for children with this disorder, it will also increase their chances of becoming independent upon adulthood. Children's brains are still under development and the chances of improving their social and communication skills are greater compared to adults, because they are not fully exposed to the harshness of society [8].

Several articles have reviewed serious games for ASD; [9] have investigated the use of Virtual Reality (VR) studies from 1996 to 2010 and reviewed their examined studies (age, number of patients, and results). Moreover, [5] have reviewed articles focusing on serious games for ASD children between 2002 and 2011 in different aspects (technology classification and purpose of serious game). However, this paper provides a review of existing research studies in serious games for ASD from 2004 to early 2014. It is structured in four sections: technology platforms, computer graphics, gaming aspect, and user interaction used in serious games.

2 Sensory Processing Disorder

Kanner saw abnormal behaviors in response to sensory stimuli in many children with ASDs [10]. Additionally, recent studies have increasingly recognized sensory signs in children with ASDs, which means there may be links between ASDs and SPDs, such as vision, smell, auditory, etc. [11], [12]. Most children with ASDs have exhibited "hyper-and hypo-sensitivities in multiple domains" [13]. Yet, there are unclear reasons behind sensory processing disorders in ASD. [10], [11], [14] point out there may be correlations between sensory processing symptoms and ASD, such as repetitive behavior, anxiety, restrictiveness, self-injuring and inattentiveness. For example, anxiety symptoms are more correlated with sensory hypersensitivity, while attention difficulties are more likely to be related to sensory hyposensitivity [14].

We summarize the SPD symptoms based on Kranowitz [15] in Table1, which could indicate to parents the signs of sensory processing dysfunction as they appear in children. However, this SPD checklist may not show all the characteristics of sensory abnormality symptoms. Furthermore, these symptoms may appear stronger on some days compared to others. Also, these characteristics are not standard criteria; it is educating parents to observe these symptoms in their children [15].

There is only serious game that targets sensory disorder in ASD children and vision only [16]. Thus there is a need for deep understanding of sensory symptoms in children with ASDs to treat these symptoms [10], [17]. In addition, more research is required to determine the efficacy of serious games on ASD children with sensory dysfunction [14]. Hence we suggest that those who are interested in developing serious games for ASD people should take into account dysfunctional sensory processing. Our consideration is developing a serious game for ASD children who suffer from sensory disorders, in order to enhance effective games that can improve their communication skills and which can be related to their environments.

Table 1. Sensory Processing Disorders

<table>
<tr><th colspan="2">Poor functioning Tasks</th></tr>
<tr><td colspan="2">Auditory-Language Processing Dysfunction:
- Unable to locate the source of a sound
- Difficulty discriminating between sounds/words; i.e., "dare" and "dear"
- Difficulty reading, especially out loud (may also be dyslexic)
- Difficulty articulating and speaking clearly
- Difficulty putting ideas into words (written or verbal)
- Difficulty filtering out other sounds while trying to pay attention to one person talking
- Difficulty attending to, understanding, and remembering what is said or read
- Often ask for directions to be repeated and may only be able to understand or follow two sequential directions at a time
- Looks at others to/for reassurance before answering
- If not understood, have difficulty re-phrasing.</td></tr>
<tr><td>Poor Tactile Perception and Discrimination:
- Difficulty with fine motor tasks such as buttoning, zipping, and fastening clothes.
- Not be able to identify which part of their body was touched if they were not looking.
- Afraid of the dark.
- Be a messy dresser; looks disheveled, does not notice pants are twisted, shirt is half un tucked, shoes are untied, one pant leg is up and one is down, etc.
- Difficulty using scissors, crayons, or silverware-continues to mouth objects to explore them even after age two-has difficulty figuring out physical characteristics of objects; shape, size, texture, temperature, weight, etc.
- Not be able to identify objects by feel, uses vision to help; such as, reaching into backpack.</td><td>Poor Muscle Tone and Coordination:
- Have difficulty turning doorknobs, handles, opening and closing items
- Difficulty catching themself if falling
- Difficulty getting dressed and doing fasteners, zippers, and buttons.
- Have poor body awareness; bumps into things, knocks things over.
- Poor gross motor skills; jumping, catching a ball, jumping jacks, climbing a ladder etc.
- Poor fine motor skills; difficulty using tools (pencils, silverware, combs, scissors etc.)
- Difficulty licking an ice cream cone.
- Unsure about how to move body during movement, for example, stepping over something</td></tr>
</table>

Table 1. *(continued)*

Hyposensitivity (Under-responsively)	
Auditory: - Often does not respond to verbal cues or to name being called - Love excessively loud music or TV. - Seem to have difficulty understanding or remembering what was said. - -appear oblivious to certain sounds. - Appear confused about where a sound is coming from. - Talks self through a task, often out loud. - Needs directions repeated often, or will say, "What?" fre-	Tactile: - Needs to touch everything and everyone. - Not bothered by injuries, like cuts and bruises. - Crave vibrating or strong sensory input. - Frequently hurts other children or pets while playing. - Be self-abusive; pinching, biting, or banging his own head thoroughly enjoys and seeks out messy play.
Vestibular: - Over being tossed in the air. - Could spin for hours and never appear to be dizzy - Loves the fast, intense, and/or scary rides at amusement parks. - Always jumping on furniture, trampolines and spinning in a swivel chair. - Love to swing as high as possible and for long periods of time. - Always running, jumping, hopping etc. Instead of walking. - Rock body, shakes leg, or head while sitting - Like sudden or quick movements, such as, going over a big bump in the car or on a bike. - In constant motion, cannot seem to sit still.	Vision: - Difficulty telling the difference between similar printed letters or figures; i.e., p & q, b & d, + and x, or square and rectangle. - Difficulty locating items among other items; i.e., - Papers on a desk, clothes in a drawer. - Difficulty controlling eye movement to track and follow moving objects. - Difficulty telling the difference between different colors, shapes, and sizes - Difficulty finding differences in pictures, words, symbols, or objects - Difficulty with consistent spacing and size of letters during writing and/or lining up numbers in math problems - Have a hard time seeing the "big picture"; i.e., focuses on the details or patterns within the picture - Often loses place when copying from a book or the chalkboard. - Often loses their place while reading or doing math problems - Make reversals in words or letters when copying, or reads words backwards; i.e., "was" for "saw" and "no" for "on" after first grade - Complain about seeing double. - Tend to write at a slant on a page - Confuse left and right - Fatigue easily with schoolwork.
Oral Input: - Lick, taste, or chew on inedible objects. - Prefer foods with intense flavor; i.e., excessively spicy, sweet, sour, or salty. - Excessive drooling past the teething stage. - Frequently chews on hair, shirt, or fingers. - Act as if all foods taste the same. - Love vibrating toothbrushes and even trips to the dentist.	Olfactory: - Difficulty discriminating unpleasant odors. - Drink or eat things that are poisonous because they do not notice the noxious smell. - Do not notice odors that others usually complain about - Unable to notice or ignore unpleasant odors. - Make excessive use of smelling when introduced to objects, people, or places - Use smell to interact with objects.

Table 1. *(continued)*

Hypersensitivity (Over-responsively)	
Auditory - Distracted by sounds not normally noticed by others; i.e., humming of lights or refrigerators, fans, heaters, or clocks ticking. - Distracted by background environmental sounds; i.e., lawn mowing or outside construction. - Frequently asks people to be quiet. - Runs away, cries, and/or covers ears with loud or unexpected sounds. - Fearful of the sound of a flushing toilet (especially in public bathrooms), vacuum, hair-dryer, squeaky shoes, or a dog barking. - Refuse to go to movie theaters, parades, skating rinks, musical concerts etc. - Decide whether they like certain people by the sound of their voice.	Tactile: - refuse to walk barefoot on grass or sand - Avoid touching certain textures of material (blankets, rugs, stuffed animals) - Dislike messy play, i.e. sand, mud, water, glue, glitter, slime, shaving foam etc. - Complain about having hair brushed.
Vestibular: - Prefer sedentary tasks, moves slowly and cautiously, avoids taking risks. - Dislike elevators and escalators. - Dislike playground equipment; i.e., swings, ladders, slides, or merry-go-rounds. - Afraid of heights, even the height of a curb or step. - Afraid of being tipped upside down, sideways or backwards. - Fearful of feet leaving the ground. - Fearful of walking on uneven surfaces - Difficulty riding a bike, jumping, hopping, or balancing on one foot . - Loses balance easily and fearful of activities which require good balance - Avoids rapid or rotating movements.	Vision: - Enjoy playing in the dark. - Sensitive to bright lights; will squint, cover eyes, cry and/or get headaches from the light. - Difficulty keeping eyes focused on tasks/activities that require appropriate amount of time - Easily distracted by other visual stimuli in the room; i.e., movement, decorations, toys, windows, doorways etc. - Rub they eyes, have watery eyes or get headaches after reading or watching TV. - Avoid eye contact.
Oral Input - Lick, taste, or chew on inedible objects. - Picky eater, often with extreme food preferences; i.e., limited repertoire of foods, resistive to trying new foods or restaurants. - Dislike about toothpaste and mouthwash. - Difficulty with sucking, chewing, and swallowing. - refuse going to the dentist - Only eat hot or cold foods.	Olfactory: - Offended by bathroom odors or personal hygiene smells. - Bothered by smell of perfume or cologne. - Bothered by household or cooking smells. - Like someone or some place by the way it smells. - Tell other people (or talks about) how bad or funny they smell - Refuse to eat certain foods because of their smell.

3 Autism Games Reviewed

During recent decades, serious games development has utilized a range of technologies for ASD children with 2D and 3D graphics, including different platforms, learning objectives and modes of interaction (i.e. input/output devices). Table 1 presents 40 ASD games and case studies, which have been designed for various learning objectives targeting children with ASDs. For each game or case study, we list the platform that it runs on, computer graphics in terms of two-dimensional or three-dimensional representation, learning objectives, gaming aspects and interaction methods. Table 2 is also sorted by the purposes (learning objectives) of the games.

Table 2. Case studies in Serious Games for Children with ASD

Author	Year	Technology Platform	Computer Graphics	Purposes/ Objectives	Gaming Aspect	User Interaction
Lányi and Tilinger [18]	2004	Desktop/laptop	2D&3D	Education: Teach shopping & transportation	Yes	Ordinary IO
Pares et al. [19]	2005	Large screen	3D	Education: Interact with environment	No	Camera-based
Barakova et al. [20]	2007	Desktop/laptop	2D	Education: Social behavior	Yes	Ordinary IO
Finkelstein et al. [21]	2009	Desktop/laptop	2D&3D	Education: Teach Emotion Recognition	Yes	Ordinary IO
Battocchi et al. [22]	2009	Tabletop	2D	Therapy: collaboration & social interaction	Yes	Touch-screen
Arya et al. [23]	2009	Desktop/laptop	3D	Education: facial expression and emotion	Yes	Ordinary IO
De Leo et al. [24]	2010	Mobile	2D	Education: Improve communication skills	Yes	Touch-screen
Tsai et al. [25]	2011	Desktop/laptop	2D	Education: teaching facial emotion & communicate	Yes	Camera-based
Miranda et al. [26]	2011	Desktop/laptop	3D	Education: Teaching Facial Emotions	Yes	Ordinary IO
Artoni et al. [18]	2012	Desktop/laptop	2D	Therapy: eLearning environment	Yes	Ordinary IO
Abirached et al. [27]	2012	Desktop/laptop	2D	Education: Teaching emotion	No	Ordinary IO
Hourcade et al. [28]	2012	Tablet	2D	Education; Social skills	Yes	Touch-screen
Bereznak et al. [29]	2012	Mobile iPhone.	2D	Education: Teach Vocational & daily living skills	No	Touch-screen
Jain et al. [30]	2012	Desktop/laptop	3D	Therapy: Teaching facial expression	Yes	Ordinary IO and camera-based
Hulusica & Pistoljevic [31]	2012	Desktop/laptop	2D	Education: Teach basic skills	Yes	Ordinary IO
Hansen et al [32]	2013	Mobile	2D	Education: Learning facial expressions	Yes	Touch-screen
Piana et al. [33]	2013	Desktop/laptop	2D&3D	Education: Learning emotion expression	No	Ordinary IO and camera-based
Chukoskie et al. [34]	2013	Desktop/laptop	2D	Education: Natural social engagement.	Yes	Camera-based
Chen [35]	2013	Tablet	2D	Education: Develop social skills	Yes	Touch-screen
Bertacchini et al. [36]	2013	Tablet	3D	Education: Emotional learning environment	Yes	Touch-screen
Bartolome et al. [37]	2013	Desktop/laptop	2D	Therapy: interaction skills measurement	Yes	Camera-based

Table 2. *(continued)*

Schuller et al. [38]	2014	Desktop/laptop	2D	Education: facial expiration and emotion	No	Ordinary IO & camera-based
Yan [39]	2011	Tablet	2D	Therapy: consideration the emotional and social skills	Yes	Touch-screen
Davis et al. [40]	2007	Desktop/laptop	2D	Education: Narrative	Yes	Ordinary IO
Hoque et al. [41]	2009	Desktop/laptop	2D	Therapy: Learning speech	Yes	Ordinary IO
Sharmin et al. [42]	2011	Desktop/laptop	2D	Therapy: Increase intelligibility in speech	No	Ordinary IO
Frutos et al. [2]	2011	Desktop/laptop	2D	Education: learning speech	Yes	Ordinary IO
Rahman et al. [43]	2011	Desktop/laptop	2D	Therapy: Speech development	Yes	Ordinary IO
Anwar et al. [44]	2011	Desktop/laptop	2D	Education: Increasing fluency in the speech	Yes	Ordinary IO
Hailpern et al.[45]	2012	Desktop/laptop	2D	Therapy: Speech Delays	Yes	Ordinary IO
Al-Khafaji et al. [46]	2013	Mobile	2D	Education: Learning words	Yes	Touch-screen
Zancanaro et al. [47]	2014	Desktop/laptop	2D	Therapy: Teach social conversation skills	No	Ordinary IO
Choi & Lim. [16]	2010	Desktop/laptop	2D&3D	Therapy: Visual motor coordination, social skills, sensory Integration	Yes	Camera-based and a tangible device
Hassan et al. [48]	2011	Desktop/laptop	2D	Education: Learning money concept	Yes	Ordinary IO
Jercic et al. [49]	2012	Desktop/laptop	2D	Education: Emotion training in the context of financial decision-making	Yes	EEG-based
Wang et al. [50]	2010	Desktop/laptop	2D&3D	Therapy: Electroencephalogram (EEG) game	Yes	EEG-based
Bartoli et al. [51]	2013	Console, Xbox 360	3D	Therapy: Understanding motion-based touchless	No	Camera-based
Bai [52]	2013	Desktop/laptop	3D	Education: Imaginative play	Yes	Camera-based
Pomsta et al. [53]	2013	Desktop/laptop	3D	Education: Imaginative skills	Yes	Touch-screen
Ulturi et al [45]	2011	Mobile	2D	Education: Teach first aid	Yes	Touch-screen

3.1 Technology Platforms

Various ASD serious games have been utilized in different technologies, including desktops, laptops, smartphones, large screens and console games. As shown in Fig. 1, about 70% of serious games for autistic children were designed for PCs and laptop platforms.

Playing games on smartphones, pads, and tablets for educational purposes is becoming popular these days for children suffering from ASDs [46], because the small screen size of the device helps with ASD children's attention [39] and the touch screen interface provides a more intuitive interaction.

ASD games played on either smartphones or tablet devices have the next highest percentage at 22%. For example, PixTalki is a smartphone application, in which children can download photos from websites into their smartphones in order to use the photos to express their emotions and desires [24]. Lastly, large screens [19], tabletop [22] and game console [51] have the lowest share (2-3%) of technology platforms for ASD games.

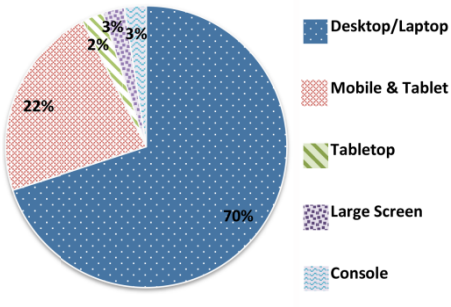

Fig. 1. Technology platforms of ASD games

3.2 Purposes

The general design of video games for ASD tends to achieve two main purposes: education and therapies. Fig. 2 depicts the purpose of serious games for ASD children, showing that there is more attention on developing communication and social skills than other goals. 54% of research focusing on serious games for ASD accounts for studies conducted in the improvement of communication and social skills. The study shows that children can select their favorite characters at the beginning of the game from some faces that have been drawn as cartoon characters: boy, girl and alien. The study shows that ASD players tend to play as a game character which is consistent to his/her real-life identity in terms of gender, i.e. males joining the game chose to play with a boy avatar, while girls preferred to play with a girl avatar. The game also presents a score panel of difficulty levels, so that it is easy for teachers and parents to recognize the children's achievement. However, there are repetitive behaviors in many ASD children; for instance, some selected wrong answers on purpose because they enjoyed the feedback sound. Thus, the study recommends having customization tools so that parents and teachers can control auditory feedback, to avoid such negative behavior.

The next highest percentage (26%) of ASD games relates to social conversation [44], [47], learning words [46] and speech therapy purposes [38], [43], [47]. Games aiming for therapeutic intervention for sensory processing disorders [16], learning first aid [54] and improving imaginative play [53] have the lowest percentage in ASD games. There is a need for more consideration to provide serious games for ASD children with sensory processing disorders, since they are a ubiquitous feature of ASDs and have been important biomarkers for diagnosis and monitoring of therapeutic interventions for the conditions.

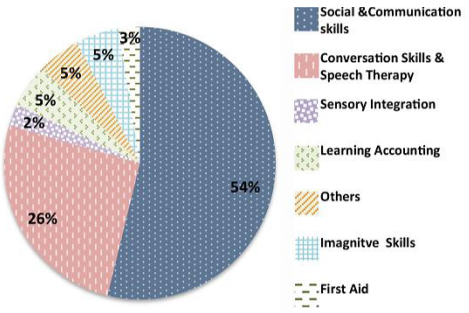

Fig. 2. Purposes

3.3 User Interaction

Figure 3 presents the modes of interaction which have been used serious games for ASDs. The most common interaction in these games is keyboard and a mouse. These ordinary Input/output (IO) devices are used in 45% of games, while the touchscreen is the second highest interactive tool used in serious games. It has been reported that dealing with touchscreen devices is more effective than interacting with a computer using a mouse [39]. Previous literature suggests interfaces like touch devices have the least amount of learning curve due to the implicit direct manipulation in the interaction. Touchscreen devices are more commonly used and favored [35], and this creates greater impact on social interaction and how it reflects positively on autistic life. Camera-based interface is used in 13% of studies, while 10% of studies utilize more than one mode of interaction in their games [46], [39]. An example of a game requiring the use of two interaction modes is the "Interactive therapy system" designed for ASD children [16], which uses a digital camera to capture body movement, and also a tangible device like a 30cm wand for children to break animated balloons. It is worth to mention that a small percent of studies (2%) use electroencephalography (EEG) based brain computer interface in their games [49], [50].

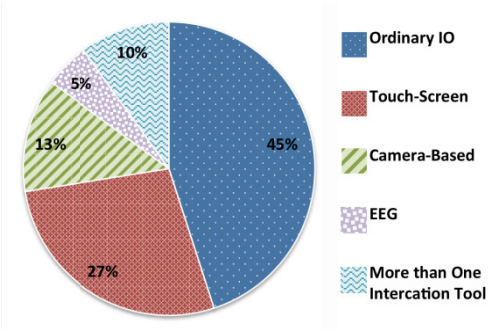

Fig. 3. User Interaction

3.4 Gaming Aspect

According to studies from 2004 to early 2014, video games for ASD children have been developed, examined or analyzed, showing that 80% of studies designed games for playing or assisting applications. Developing a game has three activities in order to improve different skills in children with ASDs, while an e-learning application is just a game which helps autistics to learn words through photos, videos and sounds. The other studies (19%) have only tested or analyzed existing games to understand the autistic needs in serious games, whether for educational or therapeutic purposes, testing several Kinect games to identify the way in which children experience movement-based games with full body interaction.

According to the previous studies there are various gaming aspects in serious games for ASD children; matching or filling (shapes) [51], [31], game level up [34], [16], multiplayer [35], [36] collecting or beating objects [18], 39], constructed shapes [20], [25], 39] and puzzle pictures [22], [26]. Having gaming elements in autism applications is more beneficial to ASD children [22], [35], [53], because collaborative play will enhance social communication and improve level of interaction with others

There are some application games for smartphone in App Store and Google Play that may be used for ASD children with sensory dysfunction. For example, Figure 7 (Blanc ball) is a game requires the player to place the balls in their small colored holes by tilting the device, in order to achieve this the player should avoid obstacles (big holes). The game would be improved the balance in ASD children with vestibular dysfunction, whereas playing the game rely on accurate physical engine. Moreover, Sky Burger game requires the player to catch the right ingredients the full form sky, which may improve level of attention in ASD children.

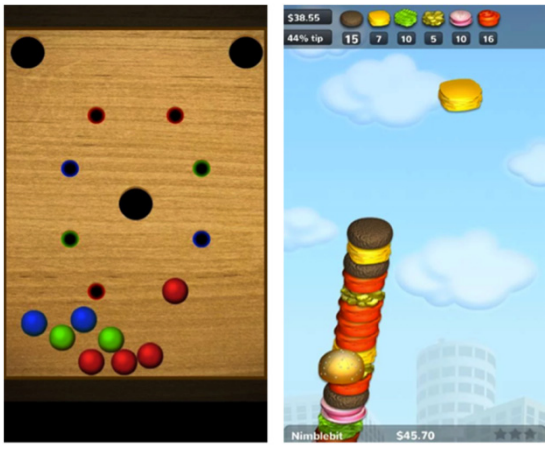

Fig. 4. App Games (Balance Ball [55] and Sky Burger [56])

4 Conclusion and Future Work

This paper has reviewed previous studies (2004-2014) of serious games designed for children with ASDs. As shown by earlier studies, there is only one game for sensory processing disorders; and it focuses on vision only [16]. Due to the nature of multi-sensory stimuli and multimodality of digital technologies, it is possible to combine vision, auditory, and vestibular in serious games for SPDs. There are limitations for simulating other sensory stimuli such as tactile, olfactory and oral input. However, recent advances in computer technology have started exploring the possibility to integrate tactile and olfactory senses using haptics [57] and digital scent technology [58].

In term of designing serious games for ASD children, it is necessary to provide a customization mechanism in these games to allow parents and teachers to discourage certain player behaviors, such as repetitive behaviors. Moreover, ASD children's games could provide a data analysis or visualization tools which presents the progress and development of the child's skills. For future research, our plan is to design and develop a serious game for ASD children with sensory processing difficulties, and to implement it for Android-based touchscreen smartphones, tablets and touchpads, which is the most popular operating system for mobile platforms at present.

References

1. Cross, M.: Children with Emotional and Behavioral Difficulties and Communication Problem. Jessica Kingsley Publishers, London (2004)
2. Frutos, M., Bustos, I., Zapirain, B., Zorrilla, A.: Computer Game to Learn and Enhance Speech Problems for Children with Autism. In: 16th International Conference on Computer Games, pp. 209–216. IEEE, Louisville (2011)
3. Centers For Disease Control And Disorder (2011), http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6103a1.htm?s_cid=ss6103a1_w
4. NHS, http://www.nhs.uk/conditions/autistic-spectrum-disorder/Pages/Introduction.aspx
5. Noor, H., Shahbodin, F., Pee, N.C.: Serious Game for Autism Children: Review of Literature. World Academy of Science, Engineering and Technology 64, 648–652 (2012)
6. Abirached, B., Zhang, Y., Park, J.: Understanding User Needs for Serious Games for Teaching Children with Autism Spectrum Disorders Emotions. In: World Conference on Educational Multimedia, Hypermedia and Telecommunications. AACE, Denver (2012)
7. AHRQ, Effective Health Care Program (2011), http://effectivehealthcare.ahrq.gov/ehc/products/106/709/aut_fin_to_post.pdf
8. Centers For Disease Control And Disorder, New Data on Autism Spectrum Disorders (2014), http://www.cdc.gov/features/countingautism/
9. Bellani, M., Fornasari, L., Chittaro, L., Brambilla, P.: Virtual reality in autism: state of the art. Epidemiology and Psychiatric Sciences 20, 235–238 (2011)
10. Rogers, S.J., Ozonoff, S.: Annotation: What do we know about sensory dysfunction in autism? A critical review of the empirical evidence. Journal of Child Psychology and Psychiatry 46, 1255–1268 (2005)
11. Case-Smith, J., Weaver, L., Fristad, M.: A systematic review of sensory processing interventions for children with autism spectrum disorders. Autism 18, 1–6 (2014)

12. Tomchek, S., Dunn, W.: Sensory Processing in Children With and Without Autism: A Comparative Study Using the Short Sensory Profile. American Journal of Occupational Therapy 61, 190–200 (2007)
13. Marco, E., Hinkley, L., Hill, S., Nagarajan, S.: Sensory Processing in Autism: A Review of Neurophysiologic Findings: Neuropsychiatric Disorders and Pediatric Psychiatry. Pediatric Research 69, 48–54 (2011)
14. Hazen, E., Stornelli, J., O'Rourke, J., Koesterer, K., McDougle, C.: Sensory symptoms in autism spectrum disorders. Harvard Review of Psychiatry 22, 112–124 (2014)
15. Kranowitz, C.: The Out of Sync Child. The Berkley Publication Group, New York (1998)
16. Choi, M., Lim, C.: Interactive Therapy System Design for Children with Autistic Spectrum Disorders. In: International Conference on Kansei Engineering and Emotion Research, KEER, France (2010)
17. Dowson, G., Watling, R.: Interventions to Facilitate Auditory, Visual, and Motor Integration in Autism: A Review of the Evidence 30, 415–421 (2000)
18. Lányi, C.S., Tilinger, Á.: Multimedia and Virtual Reality in the Rehabilitation of Autistic Children. In: Miesenberger, K., Klaus, J., Zagler, W.L., Burger, D. (eds.) ICCHP 2004. LNCS, vol. 3118, pp. 22–28. Springer, Heidelberg (2004)
19. Pares, N., Carreras, A., Durany, J., Ferrer, J., Freixa, P., Gomez, D., Kruglanski, O., Pares, R., Ribas, J., Soler, M., Sanjurjo, A.: Promotion of Creative Activity in Children with Severe Autism Through Visuals in an Interactive Multisensory Environment. In: Conference IDC 2005 Interaction Design and Children. ACM, New York (2005)
20. Barakova, E., Wanrooij, G., Limpt, R., Menting, M.: Using an emergent system concept in designing interactive games for autistic children. In: 6th International Conference on Interaction Design and Children. ACM, Aalborg (2007)
21. Finkelstein, S., Nickel, A., Harrison, L., Suma, E., Barnes, T.: cMotion: A New Game Design to Teach Emotion Recognition and Programming Logic to Children using Virtual Humans. In: IEEE Virtual Reality Conference, pp. 249–250. IEEE, Lafayette (2009)
22. Battocchi, A., Pianesi, F., Venuti, P., Ben-Sasson, A., Gal, E.: Collaborative puzzle game: Fostering Collaboration in Children with Autistic Spectrum Disorder (ASD) and with Typical Development. In: The International Conference on Interactive Tabletops and Surfaces, pp. 197–204. ACM, New York (2009)
23. Arya, A., Dipaola, S., Parush, A.: Perceptually Valid Facial Expressions for Character-Based Applications. International Journal of Computer Games Technology, 13 (2009)
24. De Leo, G., Gonzales, C., Battagiri, P., Leroy, G.: A smart-Phone Application and a Companion Website for the Improvement of the Communication Skills of Children with Autism: Clinical Rationale, Technical Development and Preliminary Results. Journal of Medical Systems 35(4), 703–711 (2011)
25. Tsai, T.-W., Lin, M.-Y.: An Application of Interactive Game for Facial Expression of the Autisms. In: Chang, M., Hwang, W.-Y., Chen, M.-P., Müller, W. (eds.) Edutainment 2011. LNCS, vol. 6872, pp. 204–211. Springer, Heidelberg (2011)
26. Miranda, J., Fernandes, T., Augusto Sousa, A., Orvalho, V.: Interactive Technology: Teaching People with Autism to Recognize Facial Emotions, pp. 299–312. InTech (2011)
27. Artoni, S., Buzzi, M.C., Buzzi, M., Ceccarelli, F., Fenili, C., Rapisarda, B., Tesconi, M.: Designing ABA-Based Software for Low-Functioning Autistic Children. In: Cipolla-Ficarra, F., Veltman, K., Verber, D., Cipolla-Ficarra, M., Kammüller, F. (eds.) ADNTIIC 2011. LNCS, vol. 7547, pp. 230–242. Springer, Heidelberg (2012)
28. Hourcade, J., Bullock-Rest, N., Hansen, T.: Multitouch Tablet Applications and Activities to Enhance the Social Skills of Children with Autism Spectrum Disorders. Personal and Ubiquitous Computing 16(2), 157–168 (2012)

29. Bereznak, S., Ayres, K., Mechling, L., Alexander, J.: Video Self-Prompting and Mobile Technology to Increase Daily Living and Vocational Independence for Students with Autism Spectrum Disorders. Journal of Developmental and Physical Disabilities 24, 269–285 (2012)
30. Jain, S., Tamersoy, B., Zhang, Y., Aggarwal, J.: An Interactive Game For Teaching Facial Expressions To Children With Autism Spectrum Disorders. In: The 5th International Symposium on Communications, Control and Signal Processing, ISCCSP, Rome (2014)
31. Hulusica, V., Pistoljevic, N.: LeFCA: Learning Framework for Children with Aut-ism. Procedia Computer Science 15, 4–16 (2012)
32. Hansen, O.B., Abdurihim, A., McCallum, S.: Emotion recognition for mobile devices with a potential use in serious games for autism spectrum disorder. In: Ma, M., Oliveira, M.F., Petersen, S., Hauge, J.B. (eds.) SGDA 2013. LNCS, vol. 8101, pp. 1–14. Springer, Heidelberg (2013)
33. Piana, S., Stagliano, A., Camurri, A., Odone, F.: A set of Full-Body Movement Features for Emotion Recognition to Help Children affected by Autism Spectrum Condition. In: IDGEI International Workshop (2013)
34. Chukoskie, L., Soomro, A., Townsend, J., Westerfield, M.: Looking' Better: Designing an at-Home Gaze Training System for Children with ASD. In: 6th International IEEE Conference on Neural Engineering, pp. 1246–1249. IEEE, San Diego (2013)
35. Chen, C.: Developing a Tablet Computer Game with Visual-Spatial Concept Jigsaw Puzzles for Autistic Children (2013), http://design-cu.jp/iasdr2013/papers/2197-1b.pdf
36. Bertacchini, F., Bilotta, E., Gabriele, L., Vizueta, D., Pantano, P., Tavernise, A., Vena, S., Valenti, A.: An emotional learning environment for subjects with Autism Spectrum Disorder, pp. 653–659. IEEE, Kazan (2013)
37. Bartolome, N., Zorrilla, M., Zapirain, G.: Autism Spectrum Disorder Children Interaction Skills Measurement Using Computer Games. In: 18th IEEE International Conference on Computer Games: AI, Animation, Mobile, Interactive Multimedia, Educational & Serious Games, pp. 207–211. IEEE, Louisville (2013)
38. Schuller, B., Marchi, E., Cohen, S., O'reilly, H., Pigat, D., Robinson, P., Daves, I.: The State of Play of ASC-Inclusion: An Integrated Internet-Based Environment for Social Inclusion of Children with Autism Spectrum Conditions. In: CORR, 1403 p (2014)
39. Yan, F.: A SUNNY DAY: Ann and Ron's World an iPad Application for Children with Autism. In: Ma, M., Fradinho Oliveira, M., Madeiras Pereira, J. (eds.) SGDA 2011. LNCS, vol. 6944, pp. 129–138. Springer, Heidelberg (2011)
40. Davis, M., Otero, N., Dautenhahn, K., Nehaniv, C., Powell, S.: Creating a Software to Promote Understanding About Narrative in Children with Autism: Reflecting on the Design of Feedback and Opportunities to Reason. In: 6th International Conference on Development and Learning, pp. 64–69. IEEE, London (2007)
41. Hoque, M., Lane, J., Kaliouby, R., Goodwin, M., Picard, R.: Exploring speech therapy games with children on the autism spectrum. In: INTERSPEECH, pp. 1455–1458 (2009)
42. Sharmin, M., Rahman, A., Ahmed, M., Rahman, M., Ferdous, S.: Teaching Intelligible Speech to the Autistic Children by Interactive Computer Games. In: Symposium on Applied Computing. ACM, New York (2011)
43. Rahman, M., Ferdous, S., Ahmed, I.: Increasing Intelligibility in the Speech of the Autistic Children by an Interactive Computer Game. In: International Symposium on Multimedia, Taichung, pp. 383–387. IEEE, Taichung (2010)

44. Anwar, A., Rahman, M., Ferdous, S., Ahmed, S.: A Computer Game based Approach for Increasing Fluency in the Speech of the Autistic Children. In: 11th IEEE International Conference on Advanced Learning Technologies, pp. 17–18. IEEE, Athena (2011)
45. Hailpern, J., Harris, A., La, B.: Designing visualizations to facilitate multisyllabic speech with children with autism and speech delays. In: Designing Interactive Systems Conference, pp. 126–135. ACM, New York (2012)
46. Al-Khafaji, N., Al-Shaher, M., Al-Khafaji, M.: M-Learning Application for Autistic Children using Android Platform. In: Future Trends in Computing and Communication (2013)
47. Zancanaro, M., Giusti, L., Zviely, N., Eden, S., Gal, E., Weiss, P.: NoProblem! A Collaborative Interface for Teaching Conversation Skills to Children with High Functioning Autism Spectrum Disorder. In: Interfaces that Invite Social and Physical Interaction, pp. 209–224 (2014)
48. Hassan, A., Zahed, B., Zohora, F., Moosa, J., Salam, T., Rahman, M., Ferdous, H., Ahmad, S.: Developing the Concept of Money by Interactive Computer Games for Autistic Children. In: IEEE International Symposium on Multimedia, Dana Point, pp. 559–564 (2011)
49. Jercic, P., Astor, P., Adam, M., Hilborn, O.: A Serious Game Using Physiological Interfaces For Emotion Regulation Training In the Context of Financial Decisionmaking. In: ECIS, 207 p. (2012)
50. Wang, Q., Sourina, O., Nguyen, M.: EEG-based "Serious" Games Design for Medical Applications. In: International Conference on Cyberworlds. IEEE, Singapore (2010)
51. Bartoli, L., Corradi, C., Garzotto, F., Valoriani, M.: Exploring Motion-Based Touchless Games for Autistic Children's Learning. In: 12th International Conference on Interaction Design and Children. ACM, New York (2013)
52. Bai, Z.: Augmenting Imagination for Children with Autism. In: 11th Interaction Design and Children, pp. 327–330. ACM, New York (2012)
53. Porayska-Pomsta, K., Anderson, K., Bernardini, S., Guldberg, K., Smith, T., Kossivaki, L., Hodgins, S., Lowe, I.: Building an Intelligent, Authorable Serious Game for Autistic Children and Their Carers. In: Reidsma, D., Katayose, H., Nijholt, A. (eds.) ACE 2013. LNCS, vol. 8253, pp. 456–475. Springer, Heidelberg (2013)
54. de Urturi, Z.S., Zorrilla, A.M., Zapirain, B.G.: A Serious Game for Android Devices to Help Educate Individuals with Autism on Basic First Aid. In: Omatu, S., Paz Santana, J.F., González, S.R., Molina, J.M., Bernardos, A.M., Rodríguez, J.M.C. (eds.) Distributed Computing and Artificial Intelligence. AISC, vol. 151, pp. 609–616. Springer, Heidelberg (2012)
55. Balance Ball, `https://play.google.com/store/apps/details?id=com.sumadagames.balanceBall`
56. Sky Burger, `https://itunes.apple.com/gb/app/sky-burger/id311972587?mt=8`
57. Changeon, G., Graeff, D., Anastassova, M., Lozada, J.: Tactile Emotions: A Vibrotactile Tactile Gamepad for Transmitting Emotional Messages to Children with Autism. In: Isokoski, P., Springare, J. (eds.) EuroHaptics 2012, Part I. LNCS, vol. 7282, pp. 79–90. Springer, Heidelberg (2012)
58. Tillotson, J.: Scentsory Design: Scent Whisper and Fashion Fluidics. In: Adams, R., Gibson, S., Müller Arisona, S. (eds.) DAW/IF 2006/2007. CCIS, vol. 7, pp. 403–417. Springer, Heidelberg (2008)