



## **COMPUTER-BASED INTERVENTION FOR AUTISM SPECTRUM DISORDER CHILDREN AND THEIR SOCIAL SKILLS: A META-ANALYSIS**

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### **Abstract**

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Autism spectrum disorder(ASD) is a neurodevelopmental disorder that arises due to the abnormal development of the brain. ASD children mainly deficit in social and communication skills. Computer based intervention has been identified as one of the most prominent method to improve social skills of autism spectrum disorder children. Computer based intervention such as serious game, virtual reality, robotic, neurofeedback and multitouch interfaces have been developed to support children with ASD. This paper analyses and reflects all the previous researches carried out in computer based interventions for children of ASD to improve social skills since 2010. This literature review addresses two systematic research questions: How the computer based intervention is used or developed and the effectiveness of computer based intervention for autism spectrum disorder children in improvement of social skills. Therefore, the specific objectives of this paper are described as; to review the computer based interventions which were used to improve social skills of autism spectrum disorder children; and to analyse the findings of the previous work. The analysis of different studies revealed that computer based games are popularly used to improve the social skills of the ASD children and it is also observed that computer based interventions proved to be the useful interventions to improve the social skills of autism spectrum disorder children.

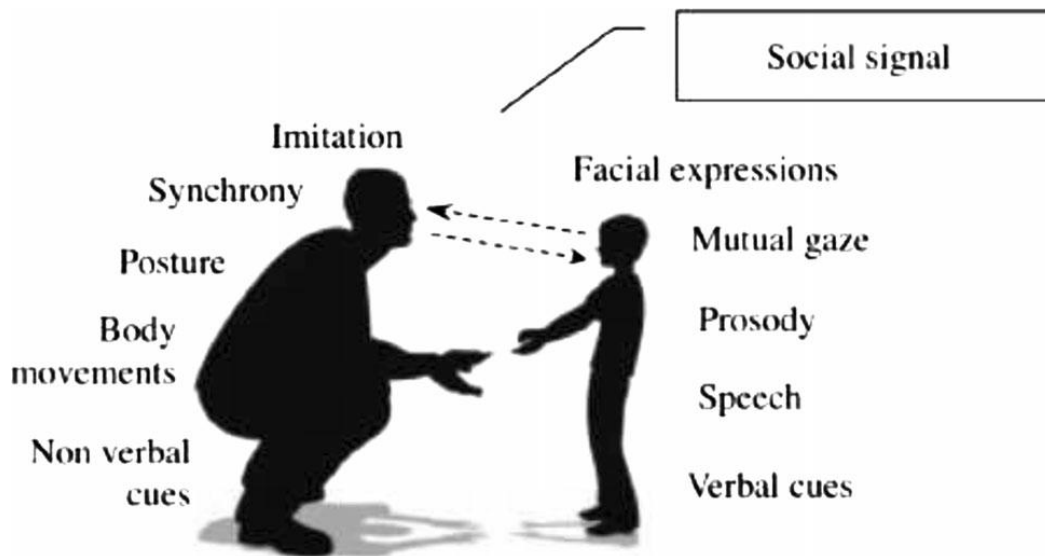
**Keywords:** Computer based intervention, Virtual Reality, Neurofeedback



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### **Introduction**

Society is a web of relationship which is highly complex, constantly undergoing the sudden change, unpredictable and dynamic. Rules governed by the society is too complex to be understood by autism spectrum disorder children. So, research in this field is very limited (Anderson et al., 2011). Typical developing children are able to interpret, identify and good in establish the positive relationship with other people (Fig No.1) but autism children failed in it. ASD is neurodevelopmental disorders with abnormalities or impaired development in mainly two areas: (1) persistent deficits in social communication and social interaction (2) repetitive behaviour.



**Fig. 1 Social signal (Chaby et al.,2012)**

There is wide range of intervention for ASD children but serious games are the amongst emerging approaches for their educational potential. Computers based interventions are the prominent tool for the teacher to give training to children with autism(Chen & Bernard,1993; Higgins& Boone,1996) to improve their social skills and quality of life as they move from childhood to adulthood (Gennaro Reed et al.,2011). Research shows that when 18 students exposed with the both interventions (computer and teaching activities) then only one student get the benefit for teaching activities (Bernard-Opitz, Ross, & Tuttas,1990) In this metaanalysis, focus mainly on serious gameswhich are prominent intervention in improving social skills of autism spectrum disorder. The majority of serious games focussed on the following domain (a)Language skills (b) Affective skills (c) Interaction skills(Bernardini et al.,2014). The specific objectives of the study are:

- (a) To review serious games for autism which improve the social skills
- (b) To review on serious games which used the virtual environment for improving social skills.
- (c) To meta-analysis the 23 studies which focus on the social skills of children with ASD.

This paper divided into four section: Section one deals with growth of serious games, Section two deals with Method, Section three deals with serious game for improving affective skills among autism spectrum disorder, Section four deals with serious game used for

improving language skills among autism spectrum disorder and Section five deals with result and discussion.

## Section-I

### Growth of serious games

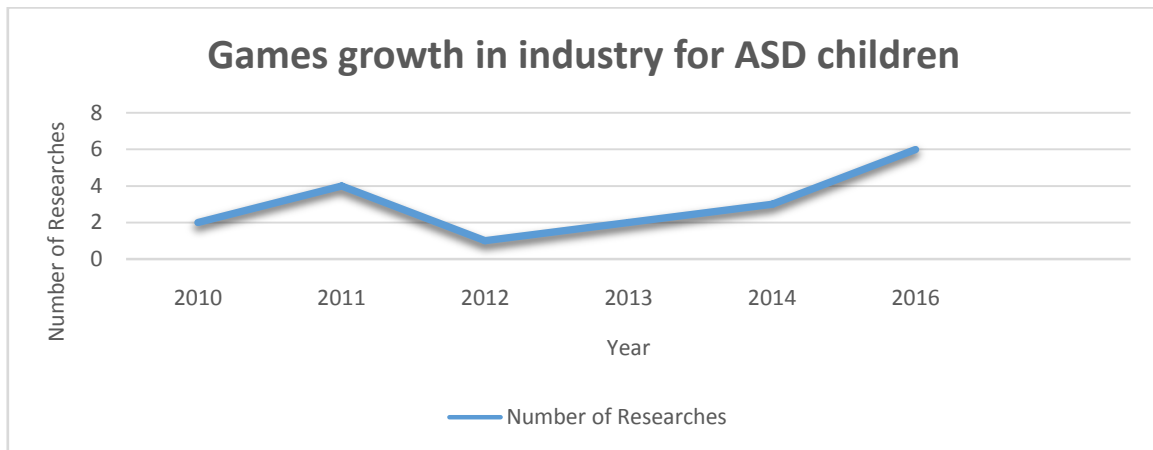


Fig.2Figure 2 shows that serious game has been growing rapidly over the last decade. In this review article, online archives are used for finding relevant article from 2010 to 2017.

## Section-II

### Method

To examine the available literature in serious games which specially meant for autism spectrum disorder, database (Scopus, DELNET) and Online e-journal publisher like science direct, JSTOR, Taylor and Francis and springer are used. To search the relevant article Keywords are used Serious game and autism, Virtual reality and autism, Social skills and autism. In order to extract the relevant paper from irrelevant article following selection criteria are used:

- 1.Those studies are not included which published before 2010.
- 2.The purpose of the study is to focus on those serious game which improve the social skills among autism spectrum disorder children.

By using this criterion, only 23 papers are relevant which focus on the improvement of social skills by using serious game.

### **Section-III**

#### **Serious game and Autism**

Serious games are those game which aims, coexistence of learning and fun. In these games primarily aim is learning and secondly,theaim is fun. There are several definitions of serious games;

“Serious games” is defined as digital games and equipment with an agenda of educational design and beyond entertainment (Sorensen, b.H.,2007)

From this definition, the serious game can be distinguished with the other video games by the design objectives. If you want to decide whether the game is serious game or not, one should need to evaluate the objective or intention of the game designer. Several studies show that autism spectrum disorder children show the positive attitude towards the computerized game(Putnam et al.,2008).

#### **Serious games for improving affective skills among autism spectrum disorder children**

There has been ample of research work has been done for improving effective skills among children with autism spectrum disorder children. ASD children are mainly socially impaired as a consequence they are not able to understand the emotion of other persons and having difficulty in maintaining the eye-contact. Several studies confirmed that ASD student are the visual thinker and they learn better if some visual stimulate are used (Finkelstein et al., 2009).“**Let’s face it**” (Tanka et al.,2010) program consists of seven interactive computer games that included the recognition of changing emotion. The main finding of the study is that student performed well than the control group in face recognition task. The result of this study indicated that this intervention can be used as the treatment for improvement of face recognition skills of children with autism spectrum disorder. This programme has certain advantage of being free of cost, adaptable to the changing needs of students and can be used by parents and teachers efficiently.

Samanta et al., (2013) studied the impact of iPad version of serious game “**Life is Game**” aim is to improve the social and emotional skills of the children with ASD.Life is a game played by 11 children (9 males and 2 female) with ASD during a15-minute session. Each session recorded so that qualitative analysis can be done by therapist. Parents filled the questionnaire in which question based on technology usage of student and their emotional understanding. Life is game technology bring positive change in emotional understanding as

well as in quality of life. Life is game Ipad version includes five modes(a) Recon Mee-Free(Thought) (b) Reecon Mee Match (Players need to match characters of similar expression) (c)Sketch Mee(Watch the video of character changing emotion)(d) Memory Game(to match the pair of similar expression) (e) Build the face(Player draw facial expression according to the target given to the player).The memory game was long played by the ASD children and seven students voted that this game was their favorite game because of predictable, simple and repetitive characteristics. Only 3 students were able to play “Recon Mee” game because in this game children they have to understand the other person point of view in the given situation. During the “Build the face” session ten out of the eleven student able to efficiently copy the face of the character especially happy and sad emotion.

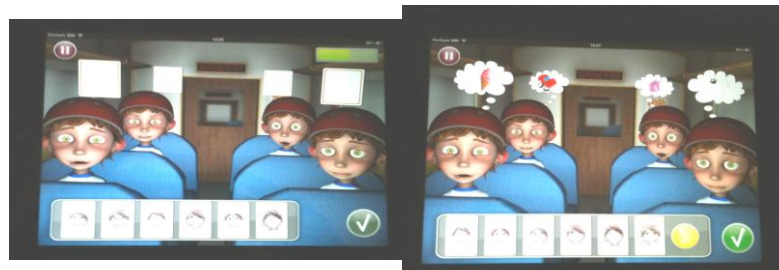


Figure 1. Game Mode “Recon Mee Match” Figure2. Game Mode “Recon Mee Mode

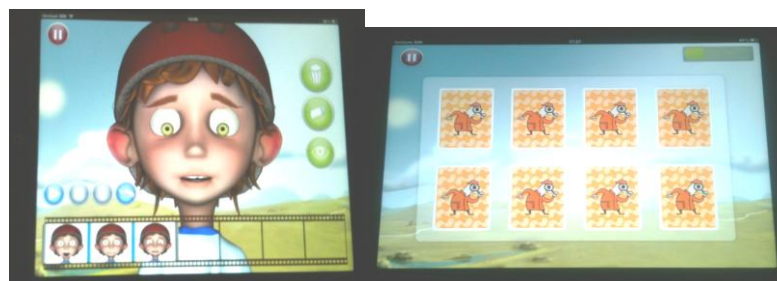


Figure 3. Game Mode “Sketch Mee” Figure 4. Game Mode “Memory Game”



Figure 5. Game Mode “Build the Face”

“**FaceSay**” is a computer-based intervention which used to improved social skills of children with ASD. The program consists of different computer games (Bandaid Clinic, Amazing Gazing, Follow the Face) to improve their social skills, emotion recognition, and facial recognition. The efficacy of the program is checked by several randomized controlled trial studies. These studies use different groups of participants which vary in age and the methods used to measure the results. This intervention can be used in school environment (Hopkins et al., 2011). **Game-Book** is another innovative approach in which autism children used to recognize and identify the emotion by increasing the attention span and giving motivation to the children. This study aims to integrate the interaction between the children/ story teller and his/her imagination. This game played on any mobile device like a tablet, laptop, iPad (Cuha et al., 2016).

Bosavit et al., (2016) describes a Participatory Design approach for autism spectrum disorder children to learn geography concept via the Natural User Interfaces. The activities are based on which were guided by the interaction between the teachers and students. In this design, every stakeholder (teacher, programme developer and designer) take the role as a user, informant, tester, co-designer.

### **Virtual Environment used in Serious games for improving affective skills among Autism spectrum disorder**

Educational games which based on virtual reality are believed to maximize benefit for children with ASD because in virtual environment autism spectrum disorder children do not find social relationship stressful due to their predictable and stable nature, (Parsons, S. et al., 2011). Second, Virtual reality intervention provides the opportunity for repeated activities in dynamics social context. So, VR intervention facilitate to apply VR learning into day to day life activities (Parsons & Cobb, 2011, Herakleous & Poullis, 2015). Third, it provides the supportive environment to children with ASD to make errors without fear of rejection as not happen in face to face social interaction. Boucenna et al. showed that virtual environments are autistic friendly and promote social skills among autism children as compared to other intervention (Boucenna, S. et al., 2014). Moreover, autistic children prefer to interact with avatars and virtual environment specially if expressive avatars are used which improve the social skills (Hopkins, I. M. et al., 2011). Virtual reality environment triggers that real environment through the 3D models that evoke interaction, immersion and trigger the

imagination. Web-based 3D technologies with VR features helps in to improve constructivism approach to make learning more effective (Huang et al., 2016). It is not enough to use virtual reality environment but it is foremost important that virtual environment based on psychological theory (theory of mind, executive function, weak central coherence theory)(Rajendran,G.et al.,2012). Overall, virtual reality environment facilitates in the engaging, interactive and conductive environment to improve social skills of children with ASD.

Kandalaft et al., (2012) study investigated the effectivity of **Virtual Reality Social Cognition Training** intervention mainly focussing on social skills, social cognition, and social functioning. Eight participants completed successfully 10 sessions over the period of five weeks. There is a significant improvement in the theory of mind and emotional recognition as well as in real life activities. This result suggests that virtual reality environment is a promising tool in the improvement of the social skills. Seamless integration of a virtual reality with physiology based approach one of the most innovative intervention tool for autism spectrum disorder children to enhance their social skills(Lahri et.al., 2012). **ECHOES**, a serious game which improves the social skills of autism spectrum disorder. ECHOES game incorporate Interactive learning activities which take place in two-dimensional magical garden between the ECHOES agent(Andy) and Child which build on the SCERTS (social communication, emotion regulation, transactional support). The ECHOES learning activities focus on social communication especially on joint attention and symbol use. The Target population of the age five to seven was taken to study the impact of ECHOES learning activities on social skills of autistic children which were given for a 15 min for six weeks. ECHOES motivates the children to interact with the environment and to engage in the interactive activities. Virtual character named Andy positively build relation with autism children as compared to human practitioner(Bernardini et al., 2014).

Sylvie Serret et al., (2014) study design **JeStiMule** for high functioning and low functioning autism spectrum disorder children. JeStiMule aim to improve emotion recognition among children. For this purpose, nine expressions were presented in the game (six basic expressions, one complex expression and two neutral expressions). These emotions are executed by the animated avatars. JeStiMule computer game exposed to 33 participants for one hour per week over four weeks. JeStiMule comprised of three phases(a) JeStiMule

calibration phase (b) JeStiMule learning phase (c) JeStiMule training phase. The result shows that 73% participant completed allmodule and after training participant are more efficient in recognizing the emotion of the avatars. This result suggests that avatars meditations used to improve the social skills of autism spectrum disorder.

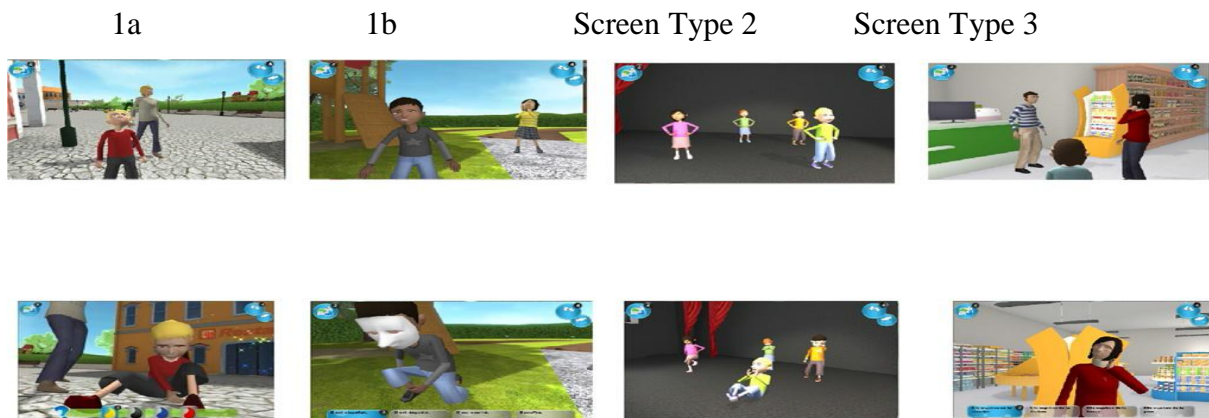


Figure 3. Example of scenes used in JeStiMule.

Hoarace et al., (2016) present a six unique virtual reality training environment to 100 school aged students with IQ greater than 70 in 28 sessions. The finding of the study suggests that there is an improvement in emotion recognition, affective expression, and social reciprocity. Nyaz et al., (2016) studied 30 participants of autism spectrum disorder (26 males and 4 females) in the age from 7 to 16 years exposed to 10 **virtual reality social cognitive training** sessions, two per week for one hour. In pre-test NEPSY-II AR (Korkman, Kirk, & Kemp, 2007) for emotion recognition, social attribution task (Abell, Happe & Frith, 2000) measured social understanding of the person, development neuropsychological assessment for measuring attention and executive function, are used. Virtual reality social cognition training emphasizes on social learning by giving varieties of contexts such as consoling friends when he/she lost their book, celebrating birthday party, meeting new people etc. After the intervention ASD students show improvement in the emotion recognition, social attribution and executive function. These findings suggest that Virtual reality social cognition training is an effective treatment for the improving social skills of autism spectrum disorder children.





Figure (a). VR screen shot of Session 4 “Sad Puppy.”  
Session 2 “Getting

Figure (b). VR screen shot of

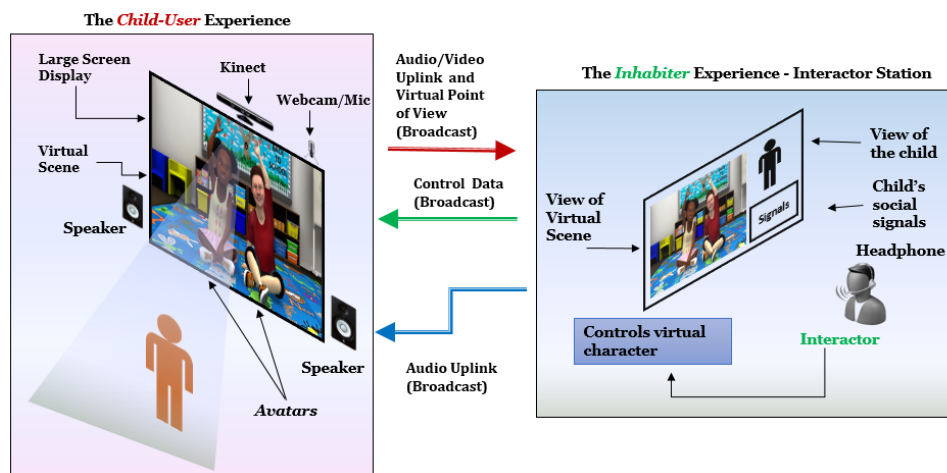


Figure(c). VR screen shot of Session 10 Recognize peers with few common interests to initiate activity in the lunch room.

Fig 4. Virtual reality social cognition training game screen shot

Herakleous&Poullis, (2015)facilitate the design and **apply immersive virtual reality environment** to improve the emotional skills of the children with autism spectrum disorder. This design serves the purpose of school students of age between 7 to 12. This design shows a significant improvement in the children emotional competences.Recently,Nojavanasghari,B.et al., (2017) use **Avatar-mediated and virtual environments**are used for promoting social skills in children with autism. This paper focuses on the design of theinteractive system that uses avatars for promoting human to human interaction to imbibe social skills among autistic children.The system consists of two stations (a)Child’s station (b) Interactor station. In Child station, child interacts with avatars. The postures and the facial expressionof children are monitored through software’s. In

Interactor station, avatars are controlled by interactor through giving a warning if child experiencing a negative state such as anxiety and anger. This system aims to offer: (1) avatars are controllable and, interaction between the avatars and autism child was dynamic which based on the child's affective states. (2) provides visual support for children to teach them different social skills because visual supports such as venn diagram, drawing are effective in teaching as compared to verbal instruction (Rao et al.,2006) (4) reduces the cognitive load of the instructor by providing feedback about a child's affective states.



**Figure 5:** Overview of system. The system has two main stations (1) child station where the child will interact with the system (2) Interactor station where the interactor will control the avatars and talk to the child (Nojavanasghari,B.et al.,2017).



Figure6. Examples of the visual support that children receive in the interaction

## Section-IV

### Serious game for improving language skills among autism spectrum disorder

Autism student finds difficulties in communication, many studies focus on the improvement of the communication skills through the training on language related skills. Some studies tackle this problem through by providing speech training (Hoque, et al.,2009; Rahman, et al.,2011). However, research in this field pick the pace for last five years.Arshia et al., (2011) study revealed that **personalized game based** on digital story-telling concept that helps the children to understand the concept of money. It also trains the autistic children how to behave while shopping. The game is developed on BYOB (Build Your Own Block). Extending this work,Hetzroni and Tannous (2015) developed an **interactive software program (I Can Word It Too)** which contain three elements of language (form, use, and content)which based on daily life activities (play, food and hygiene). This programme was administered on five children with autism between the ages of 7 and 12.In this study Multiple base design was used to examine the effects of softwareamong autism spectrum disorder. The authors found that by using this program all participant showed positive response in improving the communication skills as well as generalized learning in natural setting of classroom.

Aziz, et.al.(2014) studied that educational app for children with autism spectrum disorder help in promoting the communication skills.This app helps parents to know what their ASD children want to say. In this app there are two option in main menu, one for parent and one for children. PARENTS button will open another interface for add activities for their children. On the sharp contrast, the child button is used by the children so that they start their own activities. By using this app child listen audio of associated object and parents can easily understand the needs of their children because it helps the ASD children to communicate effectively.

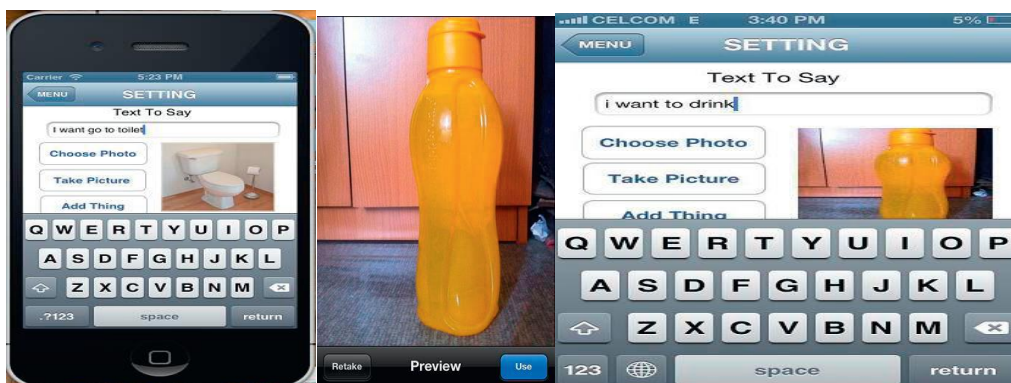


Figure7.shows how the children with ASDs can use this application to express what they are trying to speakout based on pictures. For example, the pictures illustrate toilet which relates to text “I want to go to toilet” that produce sounds “I want to go to toilet”. Therefore, it will help the children to express their needs or what they are trying to do at that given situation (Aziz; et al.,2014).

iPrompts help ASD student to give visual support so that it enables the children to stay organized and understand the events which support the surroundings. Picaa is another software which includes four activities(a)Exploration (b)Association (c)puzzle (d) Sorting, which personalize by teachers at content and interface(Zamfir,B.et al., 2012).

### **Use of Virtual environment for improving language skills**

Virtual characters in game stimulate the social behaviour of the student as in the study of Peter Mitchell et al., (2010) used virtual environment for teaching social behaviour to autism spectrum disorder children based around a small café, and consisted of 4 levels, preceded by a training session. In training session children trained in how to click area, for example, liking on the chair to sit down. Level one to four designed in increasing order of complexity. In level 1 all the table in café was empty and in level 4 no empty table was there. Participant social understanding inferred from the description and explanation to their teacher to how they behave in scenes shown in a video. This virtual reality training programme administered to the 6 adolescents (three male and three female) of age 14-16-year-old. A Panel of 10 judges interpreted the choices of the participant made in five videos (two of café and three of buses) to know about the participant social reasoning. In this study two participant show no errors in any session but three students made a few error in the initial period and one student excluded from the study because of continuing inappropriate behaviour despite feedback from the programme. All the participant become proficient as they working through the levels, as reflected by all participant quickly complete session. This study not only providing same context(cafe) to the participant but it generalizes in another context (bus).

Omamiaet al., (2013) presentsa virtual real environment of a typical home to autism spectrum disorder children in the age ranging 5 to 16 years. In this environment children are able to move from one place to another place and engage in series of activities related to this room. After the activities, children have been presented with the game so that understanding and perception of the student can be checked. Using this software, autism

children gaining improvement in communication skills, vocab, daily habits. Communication of autism spectrum disorder children improved by providing virtual reality job interview training(VR-JIT)(Smith et al.,2014). **Collaborative Virtual environment and author able virtual peer(AVP)** technology shows improvement in communication skills of children with ASD (Huan, Z. et al.,2016; Tartaro,A. et al.,2014). Chan,S.et al., (2016) designed **virtual pink dolphins** game in which 12 participants act as dolphins trainer. The result of this study shows that the by using this game autism student shows drastic improvement in the social communication. These preliminary studies can be taken to further level in near future for improving social skills of children with ASD.

## Section-V

### Result and Discussion

Research in interventions for children with ASD are very limited. But in last half decades, field of serious game has been exponentially growing as discussed in the first section of this paper. In this paper, focus mainly on serious games used as intervention for improvement of the social skills by giving training in affective skills discussed in second section (face recognition task, emotion deduced task etc.) and language skills as discussed in third section. Review studies shows that serious game in last two to three years focus on virtual environment (ECHOES, I Can Word it Too, Virtual pink dolphins) in which ASD children shows positive attitude towards the game. On the other hand, these studies direct towards some critical factors which accelerate the growth of the serious game in future which are as follows:

- (a) serious game should be based on some psychological principle like executive function, theory of mind and coherence of mind(Rajendran ,2013).
- (b) Software should be designed according to the needs of the individual
- (c) Review shows that very few studies generalized their finding in real environment.
- (d) Sample size in these studies are very small

**Findings of the study:** The analysis of different studies revealed that computer based games are popularly used to improve the social skills of the ASD children and it is also observed that computer based interventions proved to be the useful interventions to improve the social skills of autism spectrum disorder children. Our findings supported by the Ramfoss,

D.,2012which revealed that computer based intervention is prominent in improvement of social skills of children with ASD.

Serious game can be a prominent intervention for ASD children if designer of the game should keep balance between the fun and educative learning. Serious game focus on the learning as well as fun part so that children engage in these activities. More research should be done to make serious game as an effective intervention for target population.

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