

Review

Serious games to improve social and emotional intelligence in children with autism[☆]

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ABSTRACT

The use of serious games provides a new dimension for treating individuals with Autism spectrum disorder (ASD). Researchers have carried out a substantial amount of work in this domain with promising results in the past two decades. This study reviews the literature to design serious games to improve social behaviour in an individual with ASD. Forty serious games, developed between 2000 and 2019, were selected, and their design was evaluated based on the conceptual framework from the literature. The Connolly scale was used to evaluate the quality of the study. The analysis shows that significant work in this field has targeted children with high-functioning ASD or Asperger syndrome. Apart from general social behaviour, more focus is titled on emotion recognition/production. In the design prospect, serious games should have a rather larger sample size; it also requires clinical validation and regular follow-ups. We summarized the shortcomings in the existing serious games' design and suggested improvements that can increase serious games' effectiveness for people with ASD.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that begins early in life and affects individuals to various degrees [1]. The significant symptoms comprise a lack of social interaction and communication—individuals with ASD encounter repetitive or restricted behaviour which causes functional disability throughout the lifespan [2]. Individuals with ASD are at risk of poor social outcomes and thus experience high anxiety and depression rates [3,4]. All these terms are the subcategory of social skills. Social skills can be defined as performing those behaviours that enable a person to achieve social capability [5]. Due to limitations in understanding and intellectual functioning, the teaching methods for people with autism differ from the typically developing people. The main idea is to facilitate individuals with autism to indulge in daily routine activities like their typically developing peers. That can be done by designing personalized goals and following suitable teaching methods [6].

The introduction of serious games for learning behavioural intervention has been introduced in recent times, showing promising results [7]. Computer games designed for a specific learning purpose other than mere entertainment are serious games [8]. People with ASD interact

well with various technology available. However, there are a few difficulties in transforming the learnt material in their actions [9]. Much research has been carried out to shorten this gap between user learning and transforming the learned social behaviour in real life [9–12]. The present research focuses on reviewing the literature on serious games designed to improve individuals with ASD's social behaviour. Several literature reviews in the literature focus on serious games. Still, most of them focus on some specific aspects of the game (behavioural interventions, results, training methods). Still, none of these focuses on the game design and its usability to be applied in daily life. So, we have selected 40 serious games for autism using standard systematic literature review protocol and reviewed their design based on three scales. After analysis, we pointed out the shortcomings in most serious games and suggested improvements that can help achieve better results.

The rest of the paper is organized as follows: Section 2 presents the existing literature on serious games for autism. Section 3 explains our research methodology and data extraction method, along with the inclusion/exclusion criteria. Section 4 explains the obtained results. In Section 5, we discuss the findings. Section 6 suggests improvements in the serious games and finally, in Section 7 conclusion of this study is presented.

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2. Related work

This systematic review's main purpose is to study the research on Serious games for individuals with ASD. For this purpose, existing, research and literature reviews were studied, and serious games were analyzed and evaluated based on proposed design frameworks.

Connolly et al. presented a review to explain the impact of serious games on kids' social behaviour [13]. They categorized the games based on their genre, outcome, intention, platform, and purpose categorized the games based on their impact. They also provided five criteria that must be considered while developing a serious game. The review showed that understanding the game's content and acquiring knowledge about the context are the most important factors. Papoutsis et al. [14] presented a review of mobile technologies to improve emotional intelligence in children with ASD. The authors reviewed various mobile applications and suggested improvements. They also highlighted the importance of mobile applications for ASD as mobile phones are easy to transport and enhance usability.

Weiqin Chen reviewed the tabletop technologies for individuals with ASD [15]. Their study focused on the importance of the use of tabletop technology and explained available multi-touch tabletop hardware. Chen comprehensively stated certain serious game interfaces (with the targeted disorder), which used tabletop technology and explained the researchers' challenges and opportunities in using these technologies [16,17]. It also explains how this technology can be used effectively for children and adults with ASD [18].

Zakari et al. also carried out a detailed review of serious games and classified them into four categories based on the technology platform, computer graphics, gaming aspect, and user interaction. Their study explains the game's targeted social skill and classifies the serious games based on their learning outcome and the type of technology used [19]. The authors stated the importance of gaming aspects in serious games, which can help achieve better results. They also urge the need to develop new serious games for Sensory processing disorder (SPD), with the combination of vestibular, auditory, and vision which can be possible using digital scent technology and haptics [20,21]. Moreover, the authors suggested more control of the games for parents/therapists to control repetitive behaviour in the game.

Noor et al. also reviewed 13 serious games for ASD from 2007 to 2013 [22]. They classified the games based on the type of technology, interaction, and the targeted skill addressed. They divided the games into two major categories, namely Education and Therapy and then in sub-division, they classified the games based on their development purpose. They have concluded that serious games are effective if developed as an educational tool using theoretical concepts.

Bellani et al. reviewed the literature on virtual reality (V.R.) solutions for individuals with Autism [10]. Eight different V.R. environments were studied and analyzed. Based on this, patients' information was extracted; the testing process was mentioned in detail and concluded that V.R. environments help improve individuals with ASD's social interactions. They also suggest that further work should be done on transforming the acquired skills into real-world and more work should be done on the impact of V.R. on neural networks that can sustain social skills.

Elisabeth M et al. analyzed the designs of serious games and proposed core principles that should be considered while designing a serious game for individuals with ASD [23].

The study proposes certain elements that should be considered while designing serious games to improve motivation and generalized learning, which have long-term effects on people with ASD's social behaviour. They have also proposed serious games' core attributes and suggested that the theoretical objective should be carefully transformed into gaming concepts with a natural setting. They emphasize studies that can provide more evidence that learned social behaviour through computer-based training can be replicated in ever-changing real-life scenarios.

Gossard et al. presented a review to improve social interaction for individuals with ASD [24]. They selected 31 serious games and reviewed them based on design, clinical validation, and usability. Furthermore, the authors used different scales to measure serious games' effectiveness based on certain attributes and the type of study. The authors also recommended that future serious games should have proper clinical validation. They suggested that new general serious game design frameworks be developed to help the developers follow the guidelines.

Abirached et al. [25] conducted a study to understand users' needs in serious games with ASD. They conducted semi-structured interviews with parents, and different observations from users were used to understand the needs. The authors concluded that serious games should be more adaptive, interactive, and developed for multi-touch platforms. The game should also be customizable according to the user needs. Parents said they want to teach their children emotions and social interaction, but they lack proper means to do it.

Another study, carried out by Khowaja et al., focuses on modalities in computer-based interventions to improve vocabulary and comprehension for people with ASD [26,27]. They concluded that very limited modalities are used in serious games and have recommended using serious games in conjunction with group activity can increase motivation. Pre-test and post-test results showed that the time required to use generalized training and maintenance interventions could vary. They also compared various experimental studies and recommended that combined use of serious games and therapists/teachers have better results.

Moon [28] evaluated Virtual reality (V.R.) based social training systems for individuals with ASD. Review shows that there is an importance of naturalistic design which includes simulations for body gestures, facial mimicry, and emotional designing non-playing character (NPC). The author suggested that a naturalistic social environment is important for effective V.R. based intervention for individuals with ASD.

3. Methods

3.1. Search procedure

Medline (PubMed version), Science Direct, and ACM Digital Library databases were used as search resources for this study which is among the most widely used research repositories of this field. We only considered the English articles and published in peer-reviewed journals between January 2000 to August 2019. The following string was used for searching the keywords: "Serious games for ASD" OR "Game-based learning" OR "Video games for ASD," OR "Virtual reality for ASD." The studies' reference lists and related articles that have cited those selected studies were also reviewed, and those that met the inclusion criteria were also included. We also used a tool called "Publish and Perish" by submitting keywords. After combining the results from all the sources, we applied our inclusion criteria.

3.2. Inclusion procedure

In the preliminary phase, the studies were selected by analyzing their titles and abstracts. We stored potential papers and discarded duplicates or irrelevant studies. Serious games focusing only on the social behaviour of individuals with autism are included. Games that were not described in the scientific literature and only mentioned in reviews or research papers were excluded.

3.3. Quality assessment

In the next stage, papers were filtered based on inclusion criteria. For each study, we have extracted the data on the skill and the population targeted. We also have checked whether the game is based on the specific model or some treatment framework. Similarly, based on different variables (population, sample size, design of the study, the time duration

of assessment), we assessed the game's clinical validation. The games that were only cited and were not present in the scientific literature were also excluded. We only included the games developed specifically for individuals with ASD and were specifically developed for social skills. Details can be found below in Table 1 and Fig. 1, respectively.

4. Results

In the first stage, 998 papers were found then in the preliminary phase, we filtered and collected 201 papers, and after applying our inclusion/exclusion criteria, the number of papers was 67. After discarding duplicate papers, we assessed the quality of the remaining papers, and finally, we found 40 Primary serious games, and these were included in our review. Few of the games were mentioned in more than one paper. The yearly paper publication is mentioned in Fig. 2 below. We extracted the targeted skills and design principles from each of the selected studies. While selecting a study, we ensured that either the game was developed for a specific treatment model or applicable and adaptable for other behavioural disorders [29] (CBT, DTT, VBA) and, most importantly, clinically tested. We considered sample size parameters, Training duration, and study type (open trial or controlled training [30]).

4.1. Data extraction

We selected a total of 40 serious games and rated these based on three different scales [13,30,31]. Connolly et al. [13] work was based on a criterion: the type of study, method and analysis, generalizability (size and representativeness of the sample), pertinence, and confidence in the results. Whereas Yusoff's [31] and Khowaja [30] et al. proposed frameworks to design serious games. Both frameworks have ample overlap, but the latter one is more comprehensive. The details of both frameworks can be found in Tables 2 and 3. We pooled all the serious games' data, and for the Connolly scale, we scored each study based on certain criteria if the criterion is fully present then it gets (High = 3, Medium = 2, Low = 1) rating based on it. To characterize the games better, we also summarized the attributes of serious games. Based on Yusoff's and Khowaja's work, we built a scale by rating each game based on the attributes present in it (2 = completely present, 1 = partially present, 0 = not present). We rated all the games by summing their attributes' scores (max = 24 for Yusoff's Scale and max = 40 for Khowaja's Scale). A higher score indicates that most attributes are present in the game, and authors have explained it explicitly in their work. Serious games were analyzed according to the details mentioned in their respective research papers and scores were given to the games, as mentioned in the selected scale. It is noteworthy to mention that the correlation between the three scales was weak, which indicates that all three scales measure different characteristics; details are mentioned in Table 2. The definitions of Yusoff's and Khowaja's work attributes are explained in Table 3 and Table 4, respectively, whereas details of all the selected 40 serious games are mentioned in Table 5.

Table 1
Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Studies from 2000 to 2019 Games Solutions	Older than 2000 Any other computer-intervention or educational software
Targeting social skills of ASD that includes design, development and evaluation process)	Studies that are only cited in reviews and not explained in the literature
Serious Games that were tested on enough samples and clinically validated and their in-game performance were validated.	Not enough sample size and not tested clinically.

5. Discussion

Our 40 serious games review shows that computer-based interventions are effective for individuals with intellectual disabilities and ASD. Literature research has shown that playing serious games can improve attention and visual perceptual skills [32]. Serious games will not be effective if they are not engaging for the user, which means we can develop a game with a good theoretical background, but it can fail due to poor implementation [33]. Usability is one of the most important factors in this regard. According to the international standard organization (ISO) usability is the extent to which the target users can use a product to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use [34]. This report presents a comprehensive review of the serious games for ASD in the past two decades. Fig. 2 shows the increase in publication every year. Most of the published work is focused on children (age < 10). In contrast, autistic adults also have serious social interaction and emotional recognition for their day to day activities.

It is noteworthy to mention that ASD has different categories: High Functioning (H.F.) (I.Q. > 80) or Asperger Syndrome, Low Functioning (L.F.) (I.Q. < 80), and Pervasive Developmental Disorder (PDD). We found out that a major portion of the serious games is intended for individuals with HF ASD or Asperger Syndrome. Very few interfaces focus on PDD and L.F. Few games required reading skills for training, making them difficult to access for a large portion. A major percentage of serious games are designed for facial emotion recognition or production. Facial emotions are important aspects and building blocks of non-verbal communication but apart from this other general social behaviour is also important. One more thing to consider is that the immediate effects of social training via serious games are significantly high. Still, these effects decline over the period, and only a few research papers mentioned follow-up studies [35,36]. Rest either have not conducted the follow-up or have not reported. However, this aspect should be worked on, and games should be developed with long-term goals so that effects are near to far transfer [15].

Serious games for ASD itself is a multi-disciplinary (computer science and Psychology) field, and all the games should be developed by the fusion of knowledge of both the fields. All the games report ASD experts only except two studies [37,38], which makes the work questionable. A major portion of serious games lack clinical validation and thus fail to impact achieving goals greatly. A lot of serious games have a very small sample size with a short training period. We cannot generalize their work to all the ASD individuals as in ASD; every case varies from the other [39]. One important thing is that learning or mimicking emotion does not guarantee that these individuals will transfer this emotion in routine conversation in a real-life situation. So while designing the games, it should be kept in mind that its progress levels should closely resemble daily routine social interaction. Because this will help in transferring learned emotions to the daily routine. Therapists do agree that effective interventions can help improving social communication [40]. However, more research should be done to assess the connection between behavioural interventions and serious games and their effects on social interaction. Another portion of the games was without a control group (typically developing peers) [41]. The inclusion of a controlled group is mandatory because it helps us understand how typically developing peers will perform these serious games. Among the 40 reviewed serious games, 17.5% (N = 7) were not tested on individuals with ASD; hence there is not much we can comment on their effects. In other cases, we found 15% (N = 6) of the games that assess the games' usability and enjoyment separately. Both are interrelated, and both must be a part of serious games for ASD for better results [31]. For the last major group (N = 27), the effects of training during games on social improvements were reported, but these clinical studies' quality is not properly assessed [42].

Another limitation is the serious games' design as most games focus on the game's objective and not on the usability and enjoyment factor

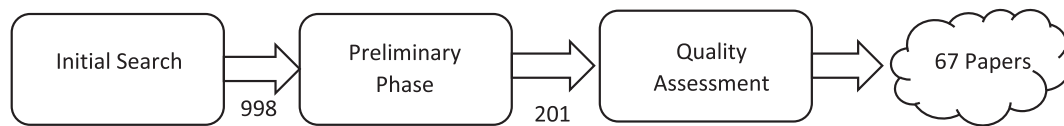


Fig. 1. Number of initial articles and final reviewed articles after applying inclusion criteria.

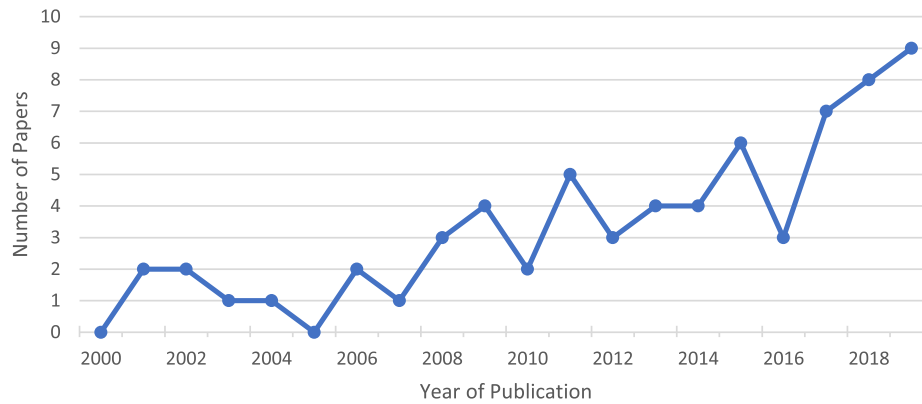


Fig. 2. The total number of papers that presented a serious game for ASD, intervention or assessment for autistic individuals in each year.

Table 2
Correlation among three scales.

	Khowaja	Yusoff	Connolly
Khowaja	1.000	0.317	0.268
Yusoff	0.317	1.000	0.331
Connolly	0.268	0.331	1.000

Table 3
Definitions of attributes used in yusoff's scale.

Attribute	Description
Incremental learning	The learning material is delivered in an incremental way
Linearity	Learning is arranged sequentially
Attention span	Duration for learning concentration
Scaffolding	Support and help during the learning
Transfer of learned skills	Applying skills to new learning based on previous learning
Interaction	Engagement in learning
Learner control	Self-learning and active learning based on learner pace
Practice and drill	Learning activities and exercises within the game
Intermittent feedback	Inform learner of his progress in learning
Reward	Incentives for the learner
Situated and authentic learning	Placing the learner in an authentic learning environment
Accommodating the learners' styles	Learning to suit learner preferences

associated with it. Instead, the games are designed, such as exercises for improving behavioural interventions. Which is a major obstacle in boosting the motivation for playing the game [43]. Fig. 3 shows the scores of Khowaja, Connolly, and Yusoff's scale. The researchers focused on validating the goals and not on the game's design, which is as important as social skills learning [44]. The search for these attributes enables the rater to judge the quality by describing how the authors designed a serious game in his work. Therefore, the raters' scores rely upon the game's portrayal in the paper and its general complexity (evident from the attribute found). This work can be a limitation, particularly because numerous authors concentrated on clinical examination strategies and testing instead of depicting the game activity. It shows a weak collaboration of this multi-disciplinary research area. The

Table 4
Definitions of attributes used in khowaja's scale.

Attribute	Description
Autism behaviors and Symptoms	Interventions of Behaviors
Instruction method	Effective intervention
Instructional Strategies	Motivation and focused learning
Modalities	Alternate ways of interaction with system Develop skills
Instructional Contents	Provide subject matter
Intended Learning outcomes	Define goals
Learning activities	Engaging activities
Game genre	Categorize activities
Game mechanics	Rules and regulations
Game dynamics	Emergent behavior
Game story	Develop story
Storytelling	Designers' & player's story
Narratives	Written or spoken words of designers' story
Non-Player Characters	Artificial intelligence-based non-playing characters
Game-based learning attributes	Validate learning as done in a classroom environment
Reflection	Improve thinking
User profile	User details
User achievements	User performance
Debriefing	Review of all the activities in which the user took part
Desirable Capabilities	Capabilities that players can develop by playing the game

developmental psychology and engineering field should understand each other's focus points before developing serious games [45]. That will automatically bring improvements in this collaboration.

For this reason, there are multiple frameworks available in the literature to develop and evaluate serious games [26,31,37,46]. However, as there is a lack of standard frameworks, this is responsible for serious games' heterogeneity. In this review, we have used Khowaja [30] and Yusoff's [31] framework to evaluate serious games based on design attributes. Khowaja's and Yusoff's work proposes certain attributes present in the serious games and rater's have judged the games based on these attributes' presence. As shown in Fig. 3, most of the game's score is low, and the reason is not using standard core elements of game-based learning. Some of the core design principles for developing serious games for ASD are mentioned below in Fig. 4. It is

Table 5
Summary of 40 serious games included in the study.

Project Name	Sample Size (Individual with ASD)	Targeted Skill	Support	Clinical Study	Comments	Average Percentage Score on three Scale
Just in time Situ [72]	15 participants (HF)	Emotion Recognition/ Production	Participants have to mimic those expressions and the game records their expressions and then they have to identify which emotion is this. They get automated response for each answer and can score points to make progress in the game	20 min a day (3 times a week) for 6 weeks	Pre-defined emotion set up training is important but producing emotions in Realtime scenario is a challenge as in social interaction each emotion reciprocated differently	49.7
Invasion of the wrong planet [73]	–	Collaborative Skills	Players have to defend the planet from aliens using virtual support. The game can be played in groups where players can collaboratively defend their planet	–	It was not implemented on ASD affected people and there was no mention of clinical validation or any ASD expert in designing the game and no evaluation done.	55.6
Proyet@Emoticons [74]	9 Children participants (HF and LF)	Emotion Recognition	A scenario is given to two participants and they select the best possible emotion for that scenario on correct answer player is rewarded	30 min a day (2 times a week) for 8 weeks	This game was language specific (in portugese). But showed good results in terms of learning	74.4
Life is Game [75]	9 Participants (HF and LF)	Emotion Recognition	Memory game with matching emotions	–	Participants enjoyed the game and were interested in playing the game. But there was no evaluation done about the learning outcomes of the game	47.8
Capture my Emotion [76]	12 Participants (HF and LF)	Emotion Recognition/ Production	Captures physiological data and recognize emotions using sensors	–	The specialized control environment is needed, and the accuracy of the results vary based on the outside environment	54.2
Can you copy me [38]	7 Participants (HF)	Emotion Recognition/ Production	Participant mimics emotions shown on screen	–	Mimicking an emotion alone is not enough to ensure the use of the same emotion in the real world. Scenario-based randomized controlled training is mandatory to achieve better results	30.0
Autisay [77]	–	Non-verbal communication	Participants express his/her emotions to a certain scenario by selecting emoji on the screen	–	Only applicable for children and with certain changes can be used by Adults. More social routine scenarios can be added plus more customization (addition of scenarios by parents/ therapists) power should be given to the user.	64.4
Zirkus Empathico [35]	11 participants (Typically developed) and 4 with ASD (HF)	Emotion Recognition/ Production	The game has different modules first participants learn their own emotions in different scenarios and then later identify the emotions of others in different scenarios	Participants were trained for 6 weeks (100 min per week)	It is more effective for children with HF ASD Plus, the progress of the participant should be measured by maintaining profile, adaptability should be introduced and can look forward to a multi-player scenario	66.4
Game Book [78]	–	Emotion Recognition/ Interaction	A storyline is narrated, and then multiple scenarios are shown to the participant and he/she must choose the correct emotional response to that scenario	–	First, this game should be evaluated, and results can be discussed, secondly first there should be modules where participants should learn about emotions as without the understanding of emotions, they cannot directly answer in the given scenarios	48.3
My Drama [79]	2 participants (male and female) the female participant had Attention Deficit	Emotion Recognition/ Production/ communication	Based on a storyline the player collects different emotions and then must place correct emotion for	Male participant finished the game in 25 min whereas female participant took 45 min	The evaluation was done by just one time finishing the game and no information is provided for the long-term effects of the study as there	68.9

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Table 5 (continued)

Project Name	Sample Size (Individual with ASD)	Targeted Skill	Support	Clinical Study	Comments	Average Percentage Score on three Scale
	Hyperactivity Disorder (ADHD) (LF)		every scenario (the emotion that fits that scenario)		was no follow-up study conducted. There was no adaptability in the game as for one participant it reached ceiling point very soon and for others it took time. And no information about clinical validation was mentioned either	
I know [80]	1 Participant and Therapist/Parent	Social Communication	Customize quizzes were created by Therapist/Parent from daily routine activities	16 min/week for 5 weeks	The sample size was very small and no information on clinical validation is provided also no follow-up studies were conducted	35.8
I can tell [80]	1 Participant and Therapist/Parent	Social Communication and Vocabulary	Participants can build stories from pictures taken in daily routine and then they must explain what they wanted to convey	9 min/week for 6 weeks	Sample size and training time was very small and no information on clinical validation is provided also no follow-up studies were conducted	41.9
ECHOES [41]	19 Participants (LF and HF)	Virtual Reality based game to improve social communication	Interaction with the virtual agent in 12 different activities. Participants must respond to the virtual character and assistance is provided with visuals and audios	15 min training 2 times a week for 6 weeks	This game addressed many important issues and evaluations showed positive results. More work can be done to generalize this work for a larger group of affected individuals	79.2
Drawing [81]	26 Participants (HF) and 40 typically developing	Social Communication/ coordination	Allows children to draw on tablets using a stylus and those who have communication problems can express their feeling via drawing (can be played in groups)	–	Only drawing cannot simply express the story (considering participants have ASD), participants can be demotivated soon and thus won't play the game for a longer period. This game is more effective if played in groups only	41.9
Music Authoring [81]	26 Participants (HF) and 15 typically developing	Motor skills/ collaboration	The screen works like a music device and can play music on it. It was used in groups, so participants collectively created a new music	13 session (2 h each)	Details of evaluation are not provided in the research. Work can be done in this game by adding mandatory scenarios for collaborating with other players. The storyline should be added to increase the motivation of participants	38.6
No Problem [82]	9 Participants (HF)	Social Interaction	A moderator presents different social tasks and participants proposes solutions by collaboration and conversation	6 sessions (45 min each)	In the current game, more control was with the moderator, in future more control can be given to participants and there should be cues to help giving better solutions	65.3
Face 3D [83]	3 Participants (HF)	Emotion recognition/ Production	A facilitator can add/remove facial expressions using virtual reality and can model real faces in the game and the participants must identify those emotional expressions on the faces	–	Learning emotions from customized faces is a good approach but it doesn't guarantee that participants will be able to reproduce those learned emotions in real life as no evaluation information provided. And modeling faces using 3D technology is tricky so a simple and easy interface can be handy in future improvements	49.4
Join In suite [17]	8 participants (HF)	Collaboration and Social competence	A group of two participants and a facilitator shares a screen and in multiple scenarios proposes the correct emotion for the situation	–	This is a good concept for the use of tabletop technology in serious games, but the patterns used are limited and more patterns can be added with time	44.2
SIDES [84]	4 Participants (Asperger Syndrome)	Collaboration and Social Skills	A board game in which by moving multiple objects the	6 rounds (30 min each)	Cooperative games are very helpful for individuals with	43.3

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Table 5 (continued)

Project Name	Sample Size (Individual with ASD)	Targeted Skill	Support	Clinical Study	Comments	Average Percentage Score on three Scale
Collaborative Puzzle game [85]	16 Participants	Improving collaboration	participants must pave the path for a frog to reach the final point A board game to move pieces of a puzzle on the tabletop screen to collectively solve the puzzle	–	ASD. SIDES was helpful in improving collaborative skills. In the future, more levels can be added for advance learning The research reports that the game was enjoyable but there is not much detail about the evaluation and results of the game. So, this can be used as a building block but introducing online gaming features in this concept can be useful	48.6
Autimo [86]	6 Participants (HF)	Emotion recognition/production	Identifying emotion and matching that with similar emotion and in second part picking the odd emotion out	–	No information provided about evaluation. The game was divided into multiple parts so it can be a bit confusing. No clinical validation was done	68.9
My memory App [87]	4 Participants (HF and Asperger Syndrome)	Emotion recognition/production	Taking own pictures and videos and then matching those with similar one it includes audio and written instructions for assistance	2 sessions/week (for 4 weeks)	The usability of the game is high because of its easy to use interface. More modules shall be added to make it more generalized for the different user as only memorizing emotions alone are not enough	75.0
Names to Faces [88]	6 Participants (HF)	Identity recognition	Take photos of your close friend/relatives and then name those faces by memorizing it	–	It targets one area of ASD for those who have memory issues and can't process different faces at once or are not able to memorize things for a long time. It targets a very small sample size and is a very initial step for social communication. Furthermore, complex modules regarding emotions shall be added with the existing customization feature in the game. Feedback should also be added for correct answers	46.9
Look at Me [89]	–	Eye contact and Facial expression	Different emotions on cards are displayed and the player must identify, label and describe emotions	3 sessions/week (4 weeks)	Feedback and interactive	53.9
Emotion Trainer [90]	11 Participants (HF and LF)	Emotion Recognition/Prediction	Identifying/predicting emotions of cartoon emojis and theory of mind	10 session in 3 weeks (30 min each)	It focuses on the theory of mind. It helps to understand own/others emotion	58.1
Emotoplay [91]	15 Participants (HF)	Facial Expression/gesture recognition	Multiple scenario-based tasks were given to the participants to identify 6 basic and 12 complex facial emotions and body gestures	120 min a week (8 weeks)	It helps to understand the cross-cultural comparisons of the children with ASD, but 2 different versions of the game were used in these countries and the time duration for training also varies in all three countries. So, it puts a question mark on the evaluated result, as we cannot compare it directly, as used parameters are not the same.	57.8
CMotion [43]		Emotion Recognition in context'	Virtual humans teach emotions to participants and using a drag-drop interface participant re-create the emotion	–	Culturally suitable design tools were created to identify and recreate the emotions, but the game has to be evaluated yet to study its impact	54.2
The Junior Detective [92]	26 participants (HF and Asperger Syndrome)	Emotion Recognition/Social Skills improvement	A special agent scenario is created where a detective (virtual character) identifies how suspects are feeling from	7 sessions (1 session/week)	Participants showed improvement in social skills and follow-up sessions were also conducted and results	72.8

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Table 5 (continued)

Project Name	Sample Size (Individual with ASD)	Targeted Skill	Support	Clinical Study	Comments	Average Percentage Score on three Scale
FaceSay2 [24]	49 Participants (24 with HF and 25 with LF)	Emotion Recognition/discrimination	their facial expressions and body gestures. When the detective correctly performs all levels then he is promoted	25 min a week (for 6 weeks)	showed good improvements for a longer period. There was a significant improvement in emotions but the results of all the tests for LF ASD were not mentioned	67.5
ChilDiBu [93]	–	Language Skills improvement	This is an application developed for children to learn and understand daily routine words using images by its context and graphical representation	–	It is only developed in the Bulgarian language, so it is a constraint. It targets a very small portion of ASD affected people as it doesn't have audio support and as no evaluation is carried out and no information is provided about the ASD expert during game development so the impact of this game cannot be calculated	41.7
Sindbad and the magic cure [94]	7 Participants with ASD (HF)	Auditory Hypersensitivity	Multiple virtual character were used who could identify and collect different objects by their sound and after collection they were rewarded to make progress in the game	20 min a day for one week	The results showed that at the end of the training participants were more accustomed to the sounds, but time duration for training is small and no follow-up done. Game should be more customizable so that players can have more control	51.7
The Transporters [95]	20 Participants (HF and LF)	Emotion Recognition/Emotional Vocabulary	A series of virtual reality games where cars were designed with 15 different emotions. In initial levels, participants have to identify the emotion and later they have to define the emotion according to the context	20 min a day, 7 times a week for four weeks	The result showed a very positive improvement in the emotional comprehension and even it can be generalized to other emotions there were not present in the training	75.8
Virtual Reality in second life [96]	8 Participants (HF and LF)	Emotional Recognition and conversational Skills	Use of virtual character to identify emotions with images and voices	10 sessions of 60 min each across 5 weeks	The study shows that participants had improvement in emotion recognition, but the game didn't help with conversational skills. Follow up study was also conducted, and it also showed that participants had long term improvements	65.0
MEDIUS [97]	10 Participants (HF)	Recognition of Daily life objects and learning the name of objects	The game consists of different microgames, identifying daily routine items, geometrical shapes, colors, recognizing and understanding different sounds and voices and face emotions detection when participants were playing the game	–	It is a multiplatform game. The first time a serious game integrates multiple games in one single game and it also supports non-verbal communication which is adaptable to every participant.	62.5
KidTalk [98]	4 Participants (HF and Asperger Syndrome)	Social Skills improvement	Multiple scenarios are presented to participants in the shape of context videos and images about daily routine emotions, and then they draw pictures to give answers to this. A therapist is a moderator as these tasks are performed in groups	–	It works on immediate feedback (automated and manual) to the participants. But there is no clinical validation or evaluation done at this stage so we cannot predict the outcome that how much it helped the participants	53.6
Raketeer [99]	14 Participants with (Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS))	Collaboration Skills	The game has 6 levels where participants must find different elements to construct a rocket to travel to space	20 min session/day (for 4 Weeks)	It used table-top technology as a support, but it is only helpful for collaborative skills. It is not adaptable and post-treatment results showed that only one participant showed improvement	72.8

(continued on next page)

Table 5 (continued)

Project Name	Sample Size (Individual with ASD)	Targeted Skill	Support	Clinical Study	Comments	Average Percentage Score on three Scale
GOLIAH [100]	10 Participants (HF)	Imitation and collaboration	A multiplayer game (therapist and participant). Total 11 different games based of emotional intelligence and social collaboration	Open trial for 3 months 6 sessions/week	The number of sessions for each game were different participation of all the participants was around 80%, game showed improvement in parent/therapist and participant relationship	65.6
JEMimE [101]	-	Facial Expression	The game had two phases, training phase, and playing phase, in first phase participants had to learn expressions and in the later phase, they have to produce same facial expression and then these expressions via their virtual avatar and these were recorded and tested for credibility and if correctly produced the player gets points	-	No evaluation is done and no information provided on clinical validation	65.3
Virtual Café [102]	7 participants	Social Understanding	Videos are shown to the participants at the start, middle and at the end of the game session of the real café environment and then they are placed in a virtual café and they have to perform the different level of interaction based on their training from the videos already shown to them	3 weeks (120 min a week)	Participants show high-interest rate and showed improvement in social behavior. Adding a few initial modules of learning basic emotions can be handy for a better understanding of social life and context.	69.2
Story Table [23]	14 Participants (HF who can read and write)	Collaboration Skills	This game can be played in a group where participants manipulate multiple objects and characters based on their group partner's virtual character movement. Each participant have different characters and they can also change their character	11 sessions over a period of 3 weeks	Post-test of the game showed improvements in participants in terms of their negotiations, comfort to look and to play game collaboratively	60.0

Khowaja (max = 40), Connolly Scale (max = 15) and Yusoff (max = 24) shows score of 40 serious games on the basis of training social and emotional training for individual with ASD

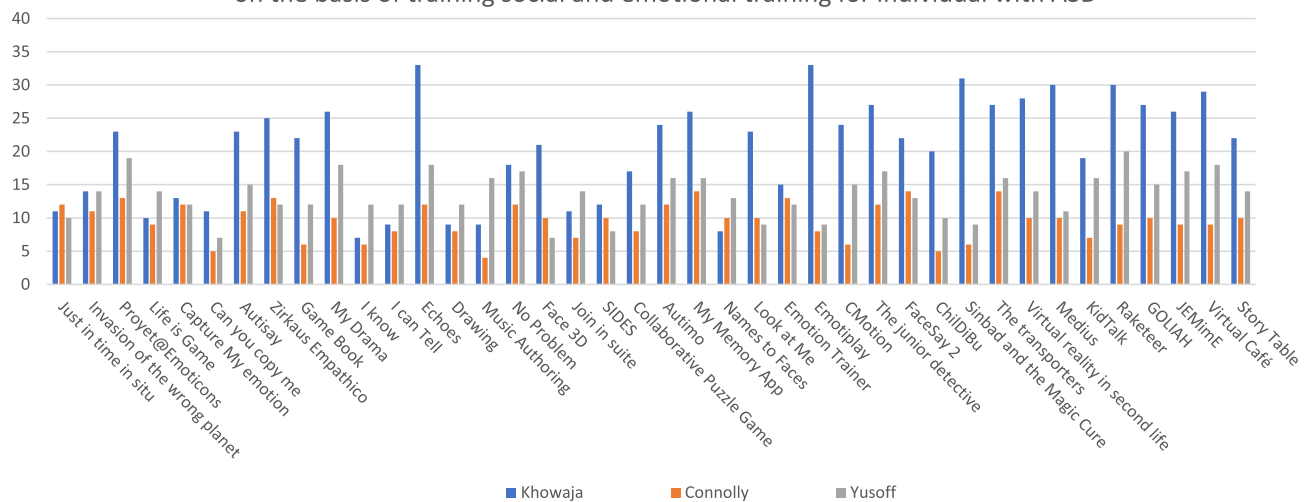


Fig. 3. Khowaja, connolly and yusoff scale score.



Fig. 4. Design principles of serious games for individual ASD.

pertinent to mention here that serious games and general video games have many similar features. The difference is in the intended purpose of those gaming features [47]. One important aspect is that serious games are tailored to a specific user with specific learning outcomes. In contrast, video games use the same entertainment features only and target a more general audience. Literature shows that the different features mentioned in this review are mandatory for successful serious games, whereas all the features can/cannot be used in general games.

6. How we can improve the design of serious games

Many serious games report learning of social skills but the majority

report near-transfer skills. Very few studies focus on the follow-up and have reported the long term learned skills. Kirst and Fridenson et al. [35,36] showed that learning outcomes immediately after training were high. Still, after some time, a follow-up study showed a decline in expressing the already learned emotions. Details can be found below in Figs. 5 and 6, respectively.

The major reason for this decline in follow up study is the lack of motivation to play such games over a long period [48]. Lack of motivation is because of the lesser game elements present in the game [49]. Thus, the individual playing the game gets bored and does not prefer to play the game for a longer period. There are a few basic points to increase motivation and achieving long-term goals that should be a part of every serious game: (1) Use of storyline and reward system (2) Adaptability (3) User Profile (4) Customization (5) Multiplayer. Details of these above-mentioned attributes are explained below.

6.1. Use of storyline and reward system

Most of the serious games in the literature show a lack of storyline and reward system. Studies have shown that serious games with storyline and reward systems increase motivation and produce better results in achieving the required goals [50–53]. This lack of engagement in serious games is a potential limitation in learning (near-transfer). With a strong storyline, the in-game characters’ reaction and understanding that answering correctly can help us gain rewards and link with the actionable emotional expression to achieve the said goal. Because this can make players curious about what will happen next, which will lead to motivation to play the game [54] further. It is further dependent on some more components to facilitate the learning activities are described below.

6.1.1. Game genre

The set of challenges in gameplay defines the game genre. It is a term used to classify the games based on their interaction with the player. It can range from action-adventure, board simulations, sports, and strategy, among others.

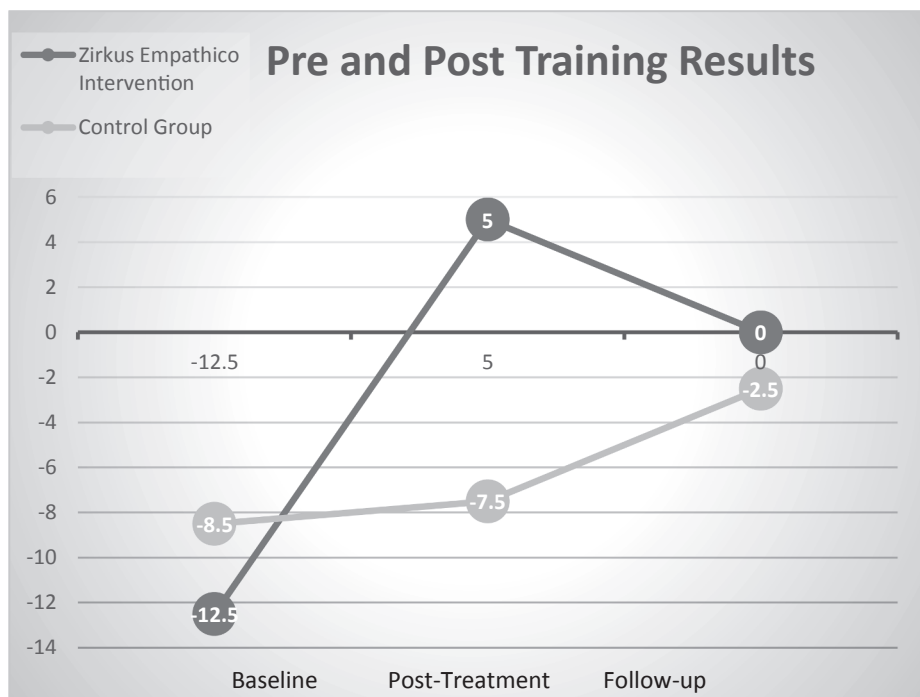


Fig. 5. Pre and post training results of zirkus empathico.

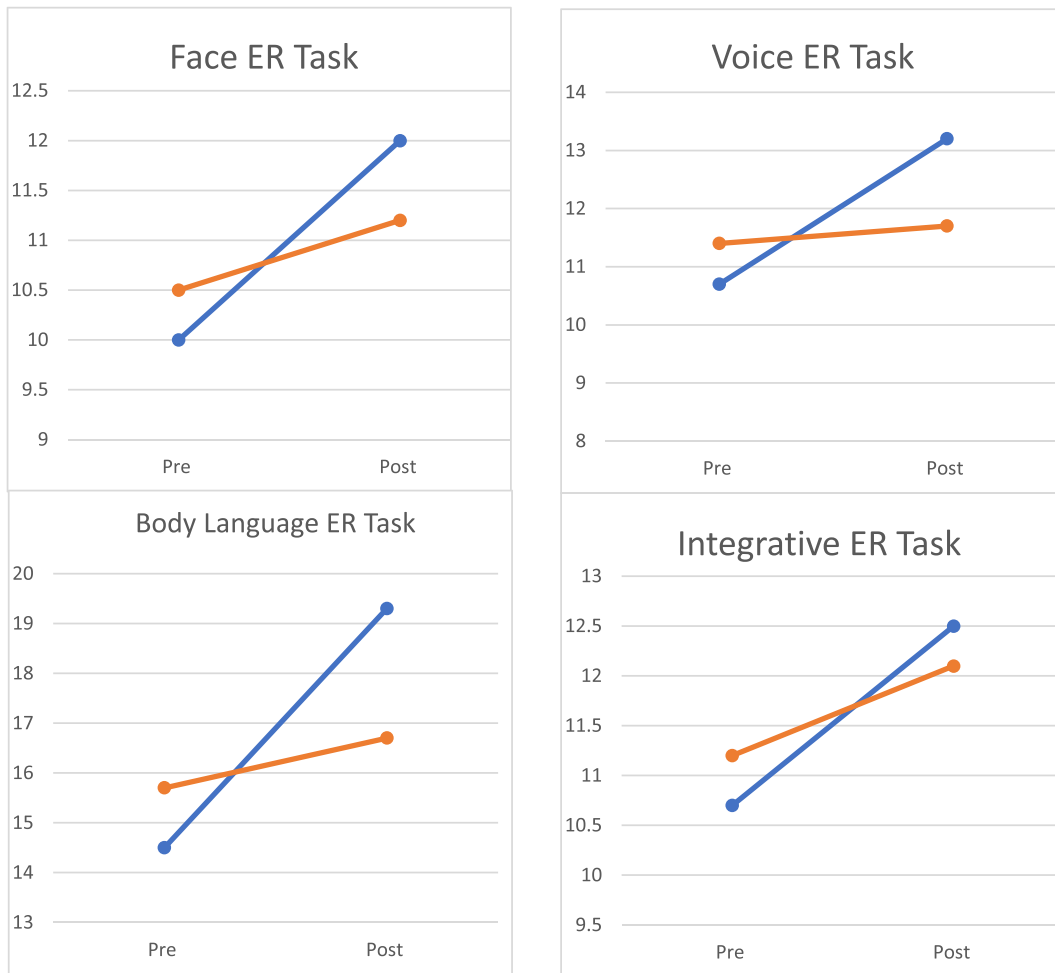


Fig. 6. Pre and post training results for a cross cultural implementation of serious game face 3D.

6.1.2. Narrative

Narrative means the story that is presented to the user during the gameplay [54]. The narrative is for setting up the game environment. So that the user can interact with that. Nevertheless, quite often, it is not the main focus of the game. It is used to keep players motivated in the gameplay. The game's narrative consists of certain goals and is unfolded step by step with the game's progress. In terms of serious games for ASD, choosing the appropriate narrative is very important, which should be light enough not to target or trigger any specific emotion [55].

6.1.3. Game dynamics

It refers to the changes that occur within the game. These are very important in serious games for ASD because the same autistic kids could have completely different understanding levels. There is a possibility that one kid can easily adapt to the changes in-game while the other is not up for it. So, this should be controlled with adaptability and A.I. The dynamics should be subject to the performance of the player.

6.2. Adaptability and AI

AI in terms of games can be defined as an unscripted response to the player during game activity. A.I. influences serious games on two fronts: (a) adjustment within the game. Through agents; and (b) adjustment of the game itself through adaptivity. A.I. in serious games means to adapt the game according to the user experience. This can be achieved with machine learning, which will also help achieve individualization. Non-Playing characters (NPC) feed on scripted details in different situations during gameplay. Here A.I. means gameplay adjustments

according to the user performance. The game should be challenging with achievable goals to increase the potential of learning. In an individual with ASD, every subject is different from others, and their level of understanding and response can vary significantly [56]. If serious games are too difficult, they frustrate and discourage the user, and if the difficulty level is too low, the user can reach the ceiling point too fast. Both these cases may lead to a lack of motivation [57]. Theory suggests that learning engagement is maximum when the perceived challenges match the individual's skills [58]. Therefore, there is a great need for individualization of the game. Serious games should be designed to adapt itself according to the user's playing condition. If the user is doing well with the game levels, then the game levels should get harder as the game progresses, and if the user is not performing better, then the game should adapt itself so that the levels should be easy for the individual. This will increase the engagement of the player and thus will help in boosting motivation [59].

6.2.1. Non-playing character (NPC)

There are different types of NPC in serious games. It can be used according to the game concept; it can be a mascot for guiding the player throughout the game; it can also be a playing character to pretend to customize. It can also be a supporting character to help the player during the game. Each NPC's role can vary they can be used effectively to provide supports to the children with ASD during the gameplay whenever they are stuck in the game or do not understand what to do. It can counter the problem of repetitive behaviour in ASD. These characters can also be a part of the game playing strategy or maybe use to interact with the player when needed. The usage of these players depends on

game type and goals. It is commonly used in serious games, and the majority of the NPC have scripted responses to a particular situation. With one of the proposed methodologies [60,61], we can also use dynamic machine learning to improve NPC handling. Which if achieved, could be more productive in serious games.

6.2.2. Scaffolding

Children with ASD have anxiety and repetitive behaviour issues from an early age. The effective use of scaffolding components in genuine games should challenge the kids when they are right, clarify their slips up when they are incorrect, and give prompts and useful data if kids experience issues following the task [62]. The scaffolding model must consider overcoming any barrier between the kid's underlying skill level and target skill level. More significantly in genuine games, educators should have the option to screen player students down advancement, making a move towards closing this gap student profiling is the starting stage for the scaffolding cycle which is significant as the student's underlying ability corresponding to the required ability is fundamental to the student's direction assurance. Gameplay and training give this direction.

6.3. Customization

Current literature suggests that providing the choice to customize the game is an important factor to increase the enjoyment and motivation in serious games [63,64]. In this way, the user feels more control over the game. This idea can be used as a secondary reward system (User can choose the game scenario, type of virtual character) There should be available choices in the game and let the user decide what he wants to do. A recent study shows that if the choices are designed to learn relevant educational content, it increases motivation [65].

6.4. User profile

There should be a user profile, where all the data and the earned rewards should be stored. By clicking on the profile, the user can assess its performance in the games' levels played previously and its result. This will help the therapist and parents easily see the patient's progress and the screen time spent using the game and compare this with the improvement throughout this time. Barry et al. [66] also mentioned the importance of user profile to increase serious games' usability for individuals with autism.

6.4.1. Debriefing

The review of all the game activities during the gameplay is called debriefing [67]. For each activity, there should be a response provided. It can also be done by guiding the player on possible options that can be adopted for the gameplay. This option is important for serious games so that the player should be aware of all his/her actions and explain the preferred choices. The focus should be to provide feedback to the user without overloading them to be more helpful in the learning process.

6.5. Multiplayer

Multi-player games have two or more persons playing together or against each other in a competition. Current research shows that multiplayer games are more effective in engaging players than individual games [68]. It helps in making social collaboration and interaction with the peer. It can also counter the argument that serious games can isolate individuals with ASD, and they will not feel comfortable interacting with their peers in daily routine life. These games can be offline and online too. In the case of a serious online game, the best part is that the individual will be playing the game from their home (their comfort zone) and at the same time learning the new social content. For the offline game, they will have the chance of real-time interaction with their peers, and they will understand how to work collaboratively. Most

of the serious games for ASD individuals are single-player except those that include virtual reality intervention. Studies show that it can positively affect playing serious games with their friends (with ASD or typically developing) as autistic kids showed positive friendship qualities [69,70]. So, this idea can be linked to serious games to get better outcomes.

7. Conclusion

The use of computer interventions shows promising results in treating individuals with autism in different ways, and it can also be used to improve a variety of skills. Serious games have proved very helpful in training an autistic individual to improve their social and emotional skills. We evaluated the 40 serious games' design for ASD individuals to improve social behaviour and found limitations in the study's design and quality. As already mentioned, it is multi-disciplinary research so that more work should be done to strengthen this collaboration and improve understanding among both the fields. Current studies Only 7 out of 40 games had better scores according to the currently available quality frameworks. That suggests that there should be more focused on developing new design frameworks that can improve serious games.

8. Limitation and future work

We cannot generalize all the serious games because there are many serious games for different people and different parameters. Secondly, this review only targets those serious games that are in the English language. Another limitation of this work is that the different serious games' scores depend on how the game is described in the paper. Many authors could have focused on the research methods instead of explaining it in the literature.

Future games should be developed using the tested design framework. Results demonstrate that the effects of training are not long-lasting, and the patient's motivation level decreases with the time, which is a major drawback. Interaction within the game should be increased with real-time response. The games' design feature should closely resemble reality so that learned emotions can later easily be used in daily routine scenarios. Larger sample size should test serious games, and follow-up studies should also be conducted to draw conclusive evidence on the results obtained. Apart from Asperger syndrome and high-functioning autistic individuals, there is a need for designing games for individuals with low functioning and sensory processing disorder (SPD). The average age of these games' user is significantly lower as major work is done for children with autism. So, there is a gap in designing games for autistic adults. Serious games should have these elements and shall focus on the quality of the games instead of quantity. It will also help in increasing the usability of the games. There is little evidence of using gamification elements; game elements should be strongly considered while designing such games to help engage users and show promising results [71].

The current state-of-art focus on one specific skill of emotion recognition/production; more work can be done to develop serious games for the improvements in other social skills. We foresee using advanced technologies such as Artificial intelligence, Augmented reality, and Virtual agents. The focus on context, content, and usability can be handy in promoting continuous learning and better user experience for individuals with ASD.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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