A Play Therapy Based Full-Body Interaction Intervention Tool for Children with Autism

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Abstract. Autism Spectrum Disorders (ASD) are characterized by social and communication difficulties, which can result in challenges forming relationships with peers and taking part in imaginative play. Play Therapy creates recreational spaces where children can learn social skills in an exploratory and creative manner. As children with ASD have a unique affinity towards computer based systems, play therapy approaches using Information and Communication Technologies (ICT) have proved useful in maintaining player motivation and engagement. In this article we will present an intervention tool inspired by play therapy that we have designed using full-body interaction technology, which has been successful in fostering social behaviors in children with ASD.

Keywords: Autism · ASD · Play therapy · Full-body interaction

1 Introduction

As children, play provides a safe space for developing the imagination and exploring creative narratives. According to Wieder et al. [66], play is the most important part of childhood, where children can share and explore thoughts and feelings. It is a time when children can distance themselves from real life enough to think in abstract terms, assigning symbolic meanings to everyday items. In the case of children with developmental disorders like Autism Spectrum Disorders (ASD), the imaginative world can expand regardless of the boundaries placed on physical and sensory means. In fact, research has shown the potential of play-based therapies in the development of social and communication behaviors in children with ASD [18].

Play can be built within or around the boundaries of game rules, or objects, while retaining a certain degree of freedom for creative construction [17]. The degree of interpretation given to players is dictated by whether the play arrangement is open-ended or goal oriented. Open ended play refrains from strict structural elements, and allows children to create their own rules for play [10]. For example, when given a plastic ball, children will begin to propose and negotiate play dynamics, all the while exploring the properties of the play object. In this process, creativity is drawn from each player's subjective frame of reference, mixing them with the experience and suggestions of other players [51].

In an experiment by Dewey et al. [25], it was found that rule based games were considered the most fun, and yielded the most complex interactions. However, when

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children were given glowing play balls in an experiment by Bekker et al. [10], it was observed that children liked playing more in free-play sessions than in game sessions with pre-defined goals.

In order to create an enjoyable, and more importantly, engaging, play experience, certain factors must be taken into account. In the realm of computer game development, there must exist a balance between sense of control, the chance to create strategies, and the search for new information [53]. Maintaining player engagement means the game play must also uphold a certain degree of challenge. These challenges are supported by clear goals and attainable goals which the player must work towards during the course of play [52]. When the challenge of a game is met with feelings of enjoyment, the player enters the moment of “flow” [21], which is considered a highly concentrated and fulfilling state [33]. Moreover, players can maintain motivation through feedback such as positive reinforcements, which can be a valuable tool in the process of developing new skills for children with developmental disorders such as ASD [47].

1.1 Autism Spectrum Disorder

Autism Spectrum Disorders are a collection of neurodevelopmental conditions which impact an individual’s propensity for social communication and social interaction [6]. Although people with ASD show a wide range of intellectual and motor capabilities [63], there are a few characteristics which are particularly common among diagnosed individuals. These include inhibitions in social communication and restricted, repetitive behaviors.

1.2 Social Difficulties with ASD

The pervasive deficits in social abilities among individuals with ASD frequently result in challenges in developing, maintaining, and understanding relationships with others. Individuals with ASD may show difficulties in social-emotional reciprocity, taking part in imaginative play, or initiating social interactions. As a result, children with ASD typically engage in a higher frequency of solitary, nonsocial play [44] and may have a higher incidence of social fragmentation in friendship and classroom circles [3].

Along with conversation, individuals with ASD also have difficulties understanding non-verbal language, which can lead to misinterpretations of unspoken social norms and expectations [24] or failure to detect contextual meanings of words [35]. Individuals with ASD also find seeking involvement and acceptance difficult, resulting in problems carrying out collaborative tasks [65].

Research has shown that early intervention in children with high-functioning ASD leads to better progress reports [67], thus increasing the potential for an improved quality of life.

1.3 Play Therapy

Play therapy is a set of play-based interventions, where a therapist builds communication with patients through driving play activities towards patients’ interests. It is commonly used as an intervention for the development of social and communication skills. Research evidences the efficacy of play-based therapy [15] and its specific benefits for the acquisition of social and communication skills [18]. Thus, play has potential as intervention given its structured nature upon which participants can build new needs and interactions.

Children with ASD tend to show uncommon behaviors in imaginative and symbolic play when interacting with objects. Their approach to toys tends to be an exploration through taste and touch [60], becoming intimate and close to the objects. Nonetheless, playing is crucial in children with ASD as, although they might approach objects differently than neurotypically developing children, they can express themselves naturally through play. The Developmental, Individual-Difference, Relationship-Based (DIR) model, known as Floortime [66] is one form of child-led play therapy which consists of six milestones, including relationship building and complex communication. Bratton et al. found that humanistic non-directed play therapies produce significantly larger effects than non-humanistic directive therapies [15]. Non-directed interventions for children with ASD have been proven to be effective therapy [40]. The project we present in this article seeks for a humanistic non-directed intervention, as the system was designed to help children recognize their creativity and freedom by letting them play without enforcing any specific play style.

One of the most successful and known research projects on play-based therapy for children with ASD is by Legoff [42]. Legoff used LEGO brick sets as a tool for mediating communication between groups of children with high functioning ASD. During experimental sessions each child had a specific role in the building process, thus all children in each group were forced to cooperate and collaborate to achieve the final goal. The results showed an improvement in the acquisition of social abilities, specifically initialization of peer contact.

2 State of the Art

In an attempt to provide engaging and dynamic interventions, many research efforts have utilized Information and Communication Technologies (ICT) to create play and learning experiences for children with ASD [34]. Furthermore, it has been shown that children with ASD have a special interest in computerized learning [12], possibly due to the linear and systematic nature of most computer programs [16]. This clear structure can reduce anxiety for individuals with ASD, as they usually show increased responsiveness to stimuli when events are predictable [29]. Also, with ICT, change can be introduced and mediated in a discrete manner [2].

Various kinds of ICT have been shown to be effective for use in treatment and learning. Projects which use computer graphics displays have been recommended with ASD for the use of visually cued instructions. Examples include hand held devices for aiding communication [49], tangible user interfaces (TUI) for learning social communication skills [48], and multi-touch tabletops for teaching group collaboration [8]. Children with ASD have also shown positive responses to working with robots for practicing imitation and joint attention [28].

2.1 Virtual Reality Intervention for Autism

Virtual reality is a type of ICT which uses real time virtual displays which can represent real or imaginary events and environments [54]. These systems can provide a safe training environment to practice social behaviors, without the distraction of external stimuli [1]. VR approaches have proven beneficial for individuals with ASD in planning, problem solving, and management of behavior [64]. Examples of virtual reality interventions include head mounted displays for simulating real life situations [61], and virtual environments for social skills training [55].

2.2 For Socialization

Projects for children with ASD have successfully used a variety of virtual reality approaches to teach social skills. Social training can take place through simulation of everyday places, such as being in a restaurant [62], a birthday party [41], or a bus [55]. Virtual reality and multimedia approaches can also represent magical or imaginary situations to appeal to children's interests, such as a troll forest [68], an enchanted world [50], or an alien planet [32, 45]. Social skills training can also create a collaborative environment, where multiple users work together. Examples of collaborative ICT projects include solving a puzzle with a partner [8] and creating an apple orchard narrative [32]. The use of virtual agents as digital peers can be a valuable tool for teaching collaboration and to reduce avoidance mechanisms [2].

3 Full-Body Interaction

Full-body interactive technologies pose a unique stance to the interactive technologies paradigm, placing the body as the center of interaction [50]. These interactive technologies are operated by the natural gestures used in daily life for expression and communication, through the movements of the body and under-standing oneself as an active participant in relation to the surrounding physical and virtual space.

Virtual environments allow the user to have control over senses, movement, and communication in the virtual setting [20]. As individuals with ASD commonly have difficulties with motor skills [43], full-body virtual environments allow a freedom of movement beyond the traditional mouse and screen setup [19]. Full-body technologies in particular have been seen to assist in learning [5, 39]. Also, collocated full-body experiences allow for face-to-face collaboration withother users, which has been seen to foster social behavior [50]. This research shows that full-body interaction systems hold potential as intervention tools for individuals with social disabilities, such as autism.

The theoretical basis for full-body interaction may be understood as a dynamic relationship between cognitive processes and the subjective human experience that we construct by living and moving within the world. In fact, embodied cognition theories hold that cognition is mediated by the human body and its place within the surroundings [13]. It is this relation between body and space which defines our human condition [24], placing knowledge not as an abstract concept to be passed from one person to another, but rather a contextual construction which is influenced by our previously held perceptions and experiences. This perspective, known as situated learning, sets learning as a social activity between humans as constructors of knowledge [56]. Therefore, meaning is created as we collaboratively interact with others and the world around us [31].

In the field of Human-Computer Interaction, embodied interaction takes the human as an active participant in the particular setting [27]. This concept of embodied interaction aims for direct manipulation of the virtual environment, also by collaborative user groups [4, 26]. In addition, as emotion is seen to be connected to cognition and understanding of information [36], full body interactive environments based in embodied interaction and user states can be advantageous for learning of concepts [58]. This was shown in an experiment by Benson and Uzgaris, where babies who were allowed to crawl through an environment found hidden objects easier than babies who had been carried through [11]. This shows how first person exploration of an environment leads to mental model construction [7]. Also, the framework of Embodied Facilitation describes how the layout of material objects and space relates to group behavior [38]. This theme is important when designing play experiences, as providing feedback to physical activity can be implemented in group settings to stimulate physical play [9].

4 Lands of Fog

In this section we will describe Lands of Fog, a full-body interactive play environment for children with ASD. The system allows children with ASD to play collaboratively with a neurotypical partner to learn and practice social behaviors, offering strategies to help children engage in the flow of the experience while reinforcing positive social behaviors.

The system Lands of Fog was formed as part of the IN-AUTIS-TIC project, funded by the Recercaixa 2013 grant. The project was based upon the project Lightpools, an interactive art installation with the goal of fostering socialization among users [37]. In an informal setting, the Lightpools system was tested with children with ASD and found to spark social initiation behaviors. Lightpools' interactive design was adapted to form the basis of Lands of Fog, which was created as a full-body interactive environment to foster socialization and collaboration in children with ASD. As in Lightpools, Lands of Fog utilized a 6 m in diameter, circular floor projected setting, which was considered large enoughto give each child their personal space for exploration but also small enough to encourage serendipitous encounters and meetings. The circular format was created to prevent potential isolation of children in corners and also naturally guide participants back to the middle of the physical and virtual environment.

For the design of the Lands of Fog, we conducted 5 participatory design sessions with children with ASD. Children directly defined the design of the game by contributing ideas for content and interactions. This practice falls in line with participatory design research which shows that when designing systems for individuals with special needs, is important to include their unique perspectives [30].

4.1 Design

In the gaming system, the virtual world is covered by a dense layer of virtual fog, which the users can partially open to reveal part of the world which lies below as they wander through the virtual scenario. The fog motivated users to adopt an active attitude towards the game by limiting viewpoints. This is referred to as a "peephole", a design strategy which Dalsgaard and Dindler suggested to promote exploration [22]. Moreover, limiting the viewing content was meant to help users focus on relevant information while exploring, as only one part of the virtual environment could be seen at a time.

Users carry a glowing butterfly net as a handheld device which works a cognitive offloader to channel the users attention into the play setting. Swarms of fireflies wander around the virtual environment, which can be caught with the butterfly net. Once caught, fireflies change their color to match their captor's net. Users understand easily the extent of their control in the system by moving around the butterfly net, and can create strategies for hunting insects, which helps children to get into the flow of the experience.

After users hunt a certain amount of fireflies, these insects will transform into a magical creature which follows the user (see Fig. 1). Each creature was designed by children with ASD in the aforementioned participatory design sessions. These creatures open a new level of interaction richness with the experience. This progression, from hunting fireflies to controlling a creature, was designed to offer the children an initial simple-to-grasp mechanic (i.e. hunting fireflies) that would foster their engagement while getting acquainted with the system. Davis et al. suggested that it was a good practice to first design features which would be easily understood by children with ASD, while novel and richer elements can be gradually introduced later on [23].

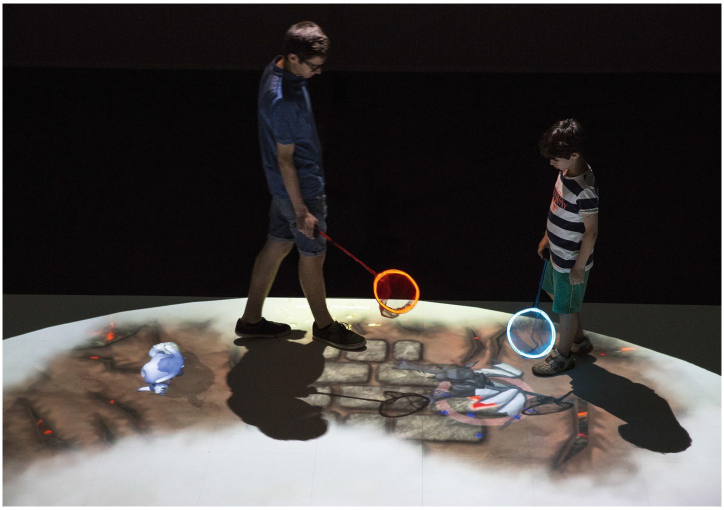

Fig. 1. Two players exploring the virtual environment in Lands of Fog.

If users adopt a passive attitude while playing, their creatures will try to call for their attention using positive feedback such as waving to their owner. All creature behaviors were implemented to engage users. Another example is when users are passive for a long time the creatures will try to get closer to the other user's creature. This mechanic was devised for sparking socialization behaviors between users during play.

When creatures come close, they perform a greeting action towards the other creature. We designed this so creatures would be models of social behaviors for the players. If the two users get even closer, the creatures will merge and create new creatures, which take the place of the old ones. Thus, children find that they have to collaborate if they want to discover all the creatures. If users just keep hunting fireflies, their creature will change its external appearance up to four times. The discovery of new creatures was designed as a positive reinforcement for collaboration to engage users and keep their motivation.

Apart from the creatures, the world scenario in which the users play is also populated by virtual elements which the users can interact with. As the creatures, all the virtual elements were designed during participatory design sessions. These virtual objects spark the interest of users, who share their discoveries with their partner and proceed to explore the world together. If a user approaches the virtual elements, their creature will point towards the element and make an exclamatory remark. This way the creature tries to communicate to the child that the element might be a point of interest. Again, these behaviors were devised to encourage the user to explore, and also to promote an inquisitive attitude that would foster socialization between users.

The virtual elements can only be activated when both users bring their creatures close to the element at the same time. If both creatures are close to an object, they will interact with it. The object will respond with an animation, as a positive reinforcement to collaboration, and then will disappear. Meanwhile the creatures will celebrate their discovery. Only through collaboration, children can discover all the virtual objects form the virtual world.

4.2 Experimental Evaluation

A series of experimental trials were carried out in Barcelona during the summer of 2015 and in London during fall of 2015. The sample included children between 10 to 15 years old with an ASD diagnosis by ADOS Model 3 diagnostic tool, designed for young people with verbal fluency. These selection criteria were chosen to include youth with autism who possessed adequate capabilities to explore the game's features, including moving freely within the scenario and conversing verbally with a partner.

We conducted two studies to evaluate the system. The first study, based on a repeated measures design with randomized couples, was in a controlled laboratory setting in Barcelona, where during the course of one month each child participated in 3 playing sessions of 15 min. The goal of this study was to evaluate the efficacy of the system in fostering user engagement, socialization and collaboration within the context of the virtual environment. In the second study, the Lands of Fog system was transported to London in November 2015, where it was installed in an integrated elementary school with a Special Educational Needs program. Over the course of one week, 20 children with ASD played in the system. An experimental protocol was defined by the researchers along with psychologists and school personnel, and it was decided that each child would play for 15 min with a typically developed classmate.

For evaluating the system we had three different data gathering methods. In Barcelona, questionnaires were administered to parents before and after each session to evaluate children's response to the experience. In London, after each session, children were interviewed, with a different questionnaires, about their experience and how they perceived their partner. The goal of these trials was to evaluate the efficacy of the system in an integrated school setting. The second method was based on video recording the sessions and subsequent coding of these with a video coding scheme designed alongside the psychologist. The last data gathering method was the activity logs generated by the system to record movement and playing data.

4.3 Experimental Results

The system was evaluated based upon its ability to motivate children with ASD to engage in playful social and collaborative behaviors with their partner. In the laboratory setting, we saw that the number of seconds remaining still decreased significantly from the first to the second session ($Z = -2.191$, $p = .029$) and from the first to the third session ($Z = -2.293$, $p = .022$). The number of collaborative interactions such as manipulating virtual elements increased significantly through the sessions (ANOVA: $F(2, 9) = 22.9$, $p < .05$) (Table 1). In Barcelona experimental setting, post-session questionnaires revealed that the activity level of the children was rated significantly higher by parents through the sessions (ANOVA: $F(2, 9) = 9.559$, $p < .05$) (Table 2). This marked increase in activity supports that the virtual environment motivated children to explore and play. Barcelona post-session questionnaires also revealed an increase in flexibility in the children with ASD through the playful experience with a significantly increase from the first to the second session ($Z = -2{,}414$, $p = .016$) and from the first to the third session ($Z = -2{,}060$, $p = .039$). As individuals with ASD have a tendency to adopt repetitive patterns of behavior, this change in flexibility demonstrates that the game fostered a willingness to embrace the playful acts of exploring, sharing and adopting collaborative behaviors. Multimodal data analysis revealed that in London experiments a 95% of children with ASD felt more comfortable interacting with their partner in the game setting than in physical education, and a 65% of typically developing children reported an increased willingness to get to know better their ASD playing partners.

Table 1. Virtual elements manipulated

Source	N	M	SD
Session 1	10	4.5	4.2
Session 2	10	16.1	9.2
Session 3	10	23.5	6.6

Table 2. Activity level

Source	N	M	SD
Session 1	10	4.1	3.14
Session 2	10	5.1	3.48
Session 3	10	4.8	3.59

We observed significant increases in social initiations and responses from the first to the third session in Barcelona experiments ($Z = -2{,}807$, $p = .005$) and from the second to the third session ($Z = -2{,}040$, $p = .041$). This means that, in the context of the playful experience, children with ASD were successful in engaging in social communication with their partner. In addition, 95% of children with ASD reported that they preferred playing with their partner in the game than in physical education class.

5 Discussion

By using child-led play as a model for gameplay, our aim was not to lead the children through a set of pre-defined objectives, but rather to bring out their own creative and exploratory nature as they work together with a partner to build their own understanding of the environment. Through this experience, we aimed for a non-directed spontaneous form of interaction, the same as might be found while playing on the playground or other peer-to-peer play settings. Results show that Lands of Fog was successful on motivating users to engage in collaborative play within the system, while also fostering social behaviors between players. Moreover, parent, professional and user feedback through questionnaires shows that the game was well received.

Basing the design of our intervention tool on play therapy allowed us the develop a system which could be effectively used to help children with ASD to learn and practice social and collaborative behaviors. The strategies designed for the game successfully helped children with ASD to get acquainted with the system and the control. The initial mechanics helped children to get into the flow of the experience and quickly adopt social behaviors in order to collaborate and discover the different positive rewards.

It is important to note that, although children showed increases in positive social behaviors and collaboration during the course of playing the game, these results have not been tested for generalization into other areas of their daily life.

As the longest duration of testing was over three sessions, we cannot expect that the sessions had a large impact on the neurodevelopmental condition and habits that have been formed over the course of their lives. In observing that the children were motivated to engage in the collaborative play activity, we are encouraged to see that playing with a partner can be a positive experience for these children to foster socialization. Further research must include multi-modal data collection which can help determine to what extent the children are comfortable in the collaborative play setting when interacting with their partner, and how these experiences can be built to accommodate the special tendencies that individuals with autism have regarding social interaction.

In the design of interfaces for children with special needs, several patterns have emerged as indicators of successful design. For example, including children has been held as an important aspect of the design process, as their interests, abilities and values differ greatly from adults [57]. This inclusion of children's voices can be done through participatory design studies [46]. Also, using common, recognizable objects (in our case, butterfly nets) is a way to create intuitive interaction [51].

For children with ASD, activity based learning with peers is preferred by children rather than direct instruction [14]. Constraints and structure in the system work to the benefit of children with ASD [32], along with task consistency and gradual introduction of new elements [23]. Finally, sensory reinforcers have been shown to motivate learning in young children with ASD [59].

Finally, future work should focus on assessing the system in more longitudinal studies where the system is integrated into a classroom or intervention program, so the system could be evaluated as an intervention tool for children with ASD.

6 Conclusions

This article presents a novel potential digital intervention tool for motivating social initiation and collaborative behaviors in children with ASD, which was inspired by humanistic non-directed play therapy and its design was informed by objective population through a series of participatory design sessions. Results of the two experimental studies we have done show that the full-body interaction system is successful in promoting social behaviors and collaboration during game play between users.

We believe that Lands of Fog demonstrates the potential of full-body interaction technology to design playful intervention systems for social communication therapy. This kind of systems could be deployed in special education centers and inclusive schools as intervention tools, but also as aids for social inclusion for children with ASD in playful settings with peers, as results show the system was successful on changing positively how peers perceived each other after playing with the system.

References

1. Rizzo, A.S., Kim, G.J.: A SWOT analysis of the field of virtual reality rehabilitation and therapy. Presence **14**, 119–146 (2006)
2. Alcorn, A., et al.: Social communication between virtual characters and children with autism. In: Biswas, G., Bull, S., Kay, J., Mitrovic, A. (eds.) AIED 2011. LNCS (LNAI), vol. 6738, pp. 7–14. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-21869-9_4
3. Anderson, A., Locke, J., Kretzmann, M., Kasari, C., AIR-B Network: Social network analysis of children with autism spectrum disorder: predictors of fragmentation and connectivity in elementary school classrooms. Autism **20**, 700–709 (2015)
4. Antle, A.N.: Research opportunities: embodied child computer interaction. Int. J. Child-Computer Interact. **1**(1), 30–36 (2013)
5. Antle, A.N., Corness, G., Droumeva, M.: What the body knows: exploring the benefits of embodied metaphors in hybrid physical digital environments. Interact. Comput. **21**(1–2), 66–75 (2009)
6. American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders, 5th edn. Washington, DC (2013)
7. Bartoli, L., Corradi, C., Garzotto, F., Valoriani, M.: Exploring motion-based touchless games for autistic children's learning. In: Proceedings of the 12th International Conference on Interaction Design and Children, IDC 2013, New York, pp. 102–111. ACM Press, June 2013
8. Battocchi, A., Pianesi, F., Tomasini, D., Zancanaro, M., Esposito, G., Venuti, P., Ben Sasson, A., Gal, E., Weiss, P.L.: Collaborative puzzle game. In: Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces, ITS 2009, New York, p. 197. ACM Press, November 2009
9. Bekker, T., Sturm, J.: Stimulating physical and social activity through open-ended play. In: Proceedings of the 8th International Conference on Interaction Design and Children, IDC 2009, New York, p. 309. ACM Press, June 2009

10. Bekker, T., Sturm, J., Wesselink, R., Groenendaal, B., Eggen, B.: Interactive play objects and the effects of open-ended play on social interaction and fun. In: Proceedings of Advances in Computer Entertainment Technology, pp. 389–392 (2008)
11. Benson, J.B., Užgiris, I.Č.: Effect of self-initiated locomotion on infant search activity. Dev. Psychol. **21**(6), 923–931 (1985)
12. Bernard-Opitz, V., Sriram, N., Nakhoda-Sapuan, S.: Enhancing social problem solving in children with autism and normal children through computer-assisted instruction. J. Autism Dev. Disord. **31**(4), 377–384 (2001)
13. Borghi, A.M., Cimatti, F.: Embodied cognition and beyond: acting and sensing the body. Neuropsychologia **48**(3), 763–773 (2010)
14. Bottema-Beutel, K., Mullins, T.S., Harvey, M.N., Gustafson, J.R., Carter, E.W.: Avoiding the "brick wall of awkward": perspectives of youth with autism spectrum disorder on social-focused intervention practices. Autism Int. J. Res. Pract. (2015). https://doi.org/10.1177/1362361315574888
15. Bratton, S.C., Ray, D., Rhine, T., Jones, L.: The efficacy of play therapy with children: a meta-analytic review of treatment outcomes. Prof. Psychol. Res. Pract. **36**(4), 376–390 (2005)
16. Brown, J., Murray, D.: Strategies for enhancing play skills for children with autism spectrum disorder. Educ. Train. Ment. Retard. Dev. Disabil. **36**(3), 312–317 (2001)
17. Caillois, R., Barash, M.: Man, Play, and Games. University of Illinois Press, Champaign (1961)
18. Casenhiser, D.M., Shanker, S.G., Stieben, J.: Learning through interaction in children with autism: preliminary data from asocial-communication-based intervention. Autism Int. J. Res. Pract. **17**(2), 220–241 (2013)
19. Chen, W.: Multitouch tabletop technology for people with autism spectrum disorder: a review of the literature. Procedia Comput. Sci. **14**, 198–207 (2012)
20. Cobb, S., Parsons, S., Millen, L., Eastgate, R., Glover, T.: Design and development of collaborative technology for children with autism: COSPATIAL, March 2010
21. Csikszentmihalyi, M.: Creativity: Flow and the Psychology of Discovery and Invention. Harper Collins Publishers, New York (1996)
22. Dalsgaard, P., Dindler, C.: Between theory and practice. In: Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems, CHI 2014, New York, pp. 1635–1644. ACM Press, April 2014
23. Davis, M., Dautenhahn, K., Powell, S.D., Nehaniv, C.L.: Guidelines for researchers and practitioners designing software and software trials for children with autism. J. Assist. Technol. **4**(1), 38–48 (2010)
24. De Jaegher, H.: Embodiment and sense-making in autism. Front. Integr. Neurosci. **7**, 15 (2013)
25. Dewey, D., Lord, C., Magill, J.: Qualitative assessment of the effect of play materials in dyadic peer interactions of children with autism. Can. J. Psychol. **42**(2), 242–260 (1988)
26. Dillenbourg, P., Evans, M.: Interactive tabletops in education. Int. J. Comput. Support. Collab. Learn. **6**(4), 491–514 (2011)
27. Dourish, P.: Where the Action Is: The Foundations of Embodied Interaction. MIT Press, Cambridge (2001)
28. Duquette, A., Michaud, F., Mercier, H.: Exploring the use of a mobile robot as an imitation agent with children with low-functioning autism. Auton. Robots **24**(2), 147–157 (2007)
29. Ferrara, C., Hill, S.D.: The responsiveness of autistic children to the predictability of social and nonsocial toys. J. Autism Dev. Disord. **10**(1), 51–57 (1980)

30. Frauenberger, C., Good, J., Alcorn, A., Pain, H.: Supporting the design contributions of children with autism spectrum conditions. In: Proceedings of the 11th International Conference on Interaction Design and Children, pp. 134–143 (2012)
31. Fuchs, T., de Jaegher, H.: Enactive intersubjectivity: participatory sense-making and mutual incorporation. Phenomenol. Cogn. Sci. **8**, 465–486 (2009)
32. Giusti, L., Zancanaro, M., Gal, E., Weiss, P.L.T.: Dimensions of collaboration on a tabletop interface for children with autism spectrum disorder. In: Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems, CHI 2011, New York, p. 3295. ACM Press, May 2011
33. Goh, D.H., Ang, R.P., Tan, H.C.: Strategies for designing effective psychotherapeutic gaming interventions for children and adolescents. Comput. Hum. Behav. **24**(5), 2217–2235 (2008)
34. Goldsmith, T.R., LeBlanc, L.A.: Use of technology in interventions for children with autism
35. Grynszpan, O., Martin, J.C., Nadel, J.: Multimedia interfaces for users with high functioning autism: an empirical investigation. Int. J. Hum. Comput. Stud. **66**(8), 628–639 (2008)
36. Harrison, S., Tatar, D., Sengers, P.: The three paradigms of HCI. In: CHI, San Jose, USA, pp. 1–21 (2007)
37. Hoberman, P., Pares, N., Pares, R.: El ball del fanalet or lightpools. In: Proceedings of International Conference on Virtual Systems and Multimedia, January 1999
38. Hornecker, E., Buur, J.: Getting a grip on tangible interaction. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI 2006, New York, p. 437. ACM Press, April 2006
39. Howison, M., Trninic, D., Reinholz, D., Abrahamson, D.: The mathematical imagery trainer. In: Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems, CHI 2011, New York, p. 1989. ACM Press, May 2011
40. Josefi, O.: Non-directive play therapy for young children with autism: a case study. Clin. Child Psychol. Psychiatry **9**(4), 533–551 (2004)
41. Ke, F., Im, T.: Virtual-reality-based social interaction training for children with high-functioning autism. J. Educ. Res. **106**(6), 441–461 (2013)
42. LeGoff, D.B.: Use of LEGO as a therapeutic medium for improving social competence. J. Autism Dev. Disord. **34**(5), 557–571 (2004)
43. MacDonald, M., Lord, C., Ulrich, D.A.: Motor skills and calibrated autism severity in young children with autism spectrum disorder. Adap. Phys. Act. Quart. **31**(2), 95–105 (2014)
44. Macintosh, K., Dissanayake, C.: Social skills and problem behaviours in school aged children with high-functioning autism and asperger's disorder. J. Autism Dev. Disord. **36**(8), 1065–1076 (2006)
45. Malinverni, L., Mora-Guiard, J., Padillo, V., Mairena, M., Hervás, A., Pares, N.: Participatory design strategies to enhance the creative contribution of children with special needs. In: Proceedings of the 2014 Conference on Interaction Design and Children, IDC 2014, New York, pp. 85–94. ACM Press, June 2014
46. Malinverni, L., Mora-Guiard, J., Pares, N.: Towards methods for evaluating and communicating participatory design: a multimodal approach. Int. J. Hum. Comput. Stud. **94**, 53–63 (2016)
47. Malone, T.W.: Heuristics for designing enjoyable user interfaces. In: Proceedings of the 1982 Conference on Human Factors in Computing Systems, CHI 1982, New York, pp. 63–68. ACM Press, March 1982
48. Marwecki, S., Rädle, R., Reiterer, H.: Encouraging collaboration in hybrid therapy games for autistic children. In: CHI 2013 Extended Abstracts on Human Factors in Computing Systems on CHI EA 2013, New York, p. 469. ACM Press, April 2013

49. Mirenda, P.: Toward functional augmentative and alternative communication for students with autism. Lang. Speech Hear. Serv. Schools **34**(3), 203 (2003)
50. Mora-Guiard, J., Crowell, C., Pares, N., Heaton, P.: Lands of fog: helping children with autism in social interaction through a full-body interactive experience. In: ACM SIGCHI Interaction Design and Children 2016 (2016)
51. Morrison, A., Viller, S., Mitchell, P.: Open-ended art environments motivate participation. In: Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology, ACE 2011, pp. 1–8 (2011)
52. Myers, D.: A Q-study of game player aesthetics. Simul. Gaming **21**(4), 375–396 (1990)
53. Neal, L.: Implications of computer games for system design, pp. 93–99, August 1990
54. Parsons, S., Cobb, S.: State-of-the-art of virtual reality technologies for children on the autism spectrum. Eur. J. Spec. Needs Educ. **26**(3), 355–366 (2011)
55. Parsons, S., Leonard, A., Mitchell, P.: Virtual environments for social skills training: comments from two adolescents with autistic spectrum disorder. Comput. Educ. **47**, 186–206 (2006)
56. Rambusch, J., Ziemke, T.: The role of embodiment in situated learning. In: Proceedings of the 27th Annual Conference of the Cognitive Science Society, pp. 1803–1808. Lawrence Erlbaum, Mahwah (2005)
57. Read, J.C., MacFarlane, S.: Using the fun toolkit and other survey methods to gather opinions in child computer interaction. In: Proceeding of the 2006 Conference on Interaction Design and Children, IDC 2006, p. 81 (2006)
58. Revelle, G.: Applying developmental theory and research to the creation of educational games. New Dir. Child Adolesc. Dev. **2013**(139), 31–40 (2013)
59. Rincover, A.: Variables affecting stimulus fading and discriminative responding in psychotic children. J. Abnorm. Psychol. **87**(5), 541–553 (1978)
60. Rowland, C.M., Schweigert, P.D.: Object lessons: how children with autism spectrum disorders use objects to interact with the physical and social environments. Res. Autism Spectr. Disord. **3**(2), 517–527 (2009)
61. Strickland, D.: A virtual reality application with autistic children. Presence Teleoperators Virtual Environ. **5**(3), 319–329 (1996)
62. Strickland, D.C., McAllister, D., Coles, C.D., Osborne, S.: An evolution of virtual reality training designs for children with autism and fetal alcohol spectrum disorders. Topics Lang. Disord. **27**(3), 226–241 (2007)
63. Tager-Flusberg, H., Joseph, R.M.: Identifying neurocognitive phenotypes in autism. Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci. **358**(1430), 303–314 (2003)
64. Trepagnier, C.: Virtual environments for the investigation and rehabilitation of cognitive and perceptual impairments. Neurorehabilitation **12**(1), 63–72 (1999)
65. van Ommeren, T.B., Begeer, S., Scheeren, A.M., Koot, H.M.: Measuring reciprocity in high functioning children and adolescents with autism spectrum disorders. J. Autism Dev. Disord. **42**(6), 1001–1010 (2011)
66. Wieder, S., Greenspan, S.I.: Climbing the symbolic ladder in the DIR model through floor time/interactive play. Autism Int. J. Res. Pract. **7**(4), 425–435 (2003)
67. Zachor, D.A., Ben Itzchak, E.: Treatment approach, autism severity and intervention outcomes in young children. Res. Autism Spectr. Disord. **4**(3), 425–432 (2010)
68. Zarin, R.: Trollskogen: a multitouch table top framework for enhancing communication amongst cognitively disabled children. In: Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces, ITS 2009, p. 1. ACM Press, New York, November 2009