Computer Fraud and Security
ISSN (online): 1873-7056

Emotiplayground Design of Interactive Assistive Toys for Emotional Communication Disorders in Autistic Children

Zhenmeng Zou

Shenzhen ZouDesign Industrial Design Co., Ltd., simon@id-zoudesign.com

ABSTRACT

This research is about the development of EmotiPlayground, an interactive toy that is designed to help children with autism spectrum disorder (ASD) develop emotional and social skills. An increasing number of autism cases globally makes it necessary to have effective interventions. Principles of emotional interaction design and Internet of Things (IoT) technology are used in EmotiPlayground to develop a customized experience to deal with the specific difficulties of children with ASD. As the toy is designed with a friendly bear design and color-coded emotion cards, it is the toy that allows children to explore and express their feelings. By using a user-based design (survey and interview with parents and educators), the toy is assured to conquer the specific user needs. The research shows how assistive technology could help promote emotional growth and family relationships to make Autism a more inclusive experience for children.

Keywords: Autism Spectrum Disorder, emotional communication, interactive toys, Internet of Things, assistive technology, user-centered design, emotional interaction design.

INTRODUCTION

Autism Spectrum Disorder, or Autism, is a neurodevelopment condition that involves having three areas of concern: social interaction, communication, and behavior. The number of autistic children has been increasing immensely all across the world. In the United States, we currently have an incidence of approximately 1 in 44 children with Autism, a number also being reported in China [1]. There are no specific autism medications, which is why traditional treatment methods usually consist of some form of educational intervention. For a child with Autism to develop socially and be integrated into society, the emotional and developmental needs of this child must be addressed in the early years.

Children with Autism often find it hard to know and express their emotions, and that makes it difficult for them to form relationships and participate in social play. Many autistic children have problems reading social cues and, therefore, often misread and feel isolated as research has shown [1]. The emotional disconnect is such that they cannot interact meaningfully in social interactions, and consequently, the quality of their life is lowered. Therefore, the need arises to develop innovative solutions that would support emotional communication in children with Autism.

Advancements in technology, especially in assistive technology (AT), have enabled a more excellent way of supporting children with ASD. The high interest in smart toys and APPs seeped with Internet of Things (IoT) technology has demonstrated potential in facilitating emotional interaction and serving as a means for rehabilitation for children with autism [1]. These innovative toys can offer tailored experiences that lead to cognitive and emotional development and are, therefore, relevant resources, especially for such children with ASD.

Assistive technologies for children with Autism need to understand the concept of emotional interaction design. Emotional design is creating products that trigger positive emotional responses to the user, be it through the product's sensory experience. Typically, the toys used with children with ASD are functional and engaging, yet such is not enough; toys must also be supportive of their emotional needs as well. Interactive design has been proven to enable productive interactions between children and toys, improving their play and emotional self [2].

Despite many potential benefits of assistive technology (AT), a vast gap persists in meeting the different product needs of children with ASD. This review of the current assistive technology shows that many products

are not suited for the particular needs of Autism. Psychology and education are areas that receive most of the studies, whereas few others focus on engineering and design [2]. It emphasizes the necessity to adopt an interdisciplinary approach, frantically combining ideas derived from different fields to bring in a new solution.

This research responds to these challenges by presenting an interactive toy ("EmotiPlayground") that can help children with Autism to increase their emotional communication skills. The friendly bear design on a yellow, blue, and red scale of three colors demonstrates three distinct emotions—happiness, sadness, and anger—emotes the play and the feeling of children about the emotions. Based on emotional interaction design principles, the design of this toy is informed by the emotional characteristics that children will relate to.

A user-centered design process is followed to develop the methodology of EmotiPlayground. The research aims to locate the particular emotional communication difficulties posed by children with Autism based on surveys and interviews with parents, educators, and therapists. This will generate insights that will help in the design of EmotiPlayground so that it fills in the gaps that are in need of attention, particularly by the users.

Finally, the integration of IoT technology into smart toys like EmotiPlayground can hopefully deepen emotional interaction and help in the developmental support of children with Autism to a greater extent [3]. With a focus on emotional design principles and an emphasis on the specific needs of children with ASD, this research intends to develop a product that would be both entertaining and lead to learning and emotional growth.

METHODOLOGY

This research aimed to explore the effectiveness of interactive toys for children with Autism, focusing on enhancing emotional communication and social skills. A mixed-methods approach was employed, combining qualitative and quantitative research methods to provide a comprehensive understanding of the impact of these toys. Additionally, secondary data sources were utilized to enrich the findings.

Data Collection Methods

Qualitative Data Collection:

- ✓ **Interviews**: Semi-structured interviews were conducted with parents, educators, and therapists who have experience in dealing with children with Autism. These interviews served the purpose of finding insights into their ideas of interactive toys as well as any changes in children's behavior and emotional expression.
- ✓ **Focus Groups:** Held in group conversations and facilitated stakeholder discussion to exchange their stories and thoughts. The objective of this research was to identify the benefits of such toys and focus on some of the challenges we faced when using them.

Quantitative Data Collection:

- ✓ **Controlled Trials:** Specific interactive toys were the focus of a series of controlled trials to determine how effective they were for progressively strengthening the child's visual tracking and hand-and-eye coordination. The toys were divided into interactive and traditional play, and the children with Autism were divided into two groups: one group played with the interactive toys, and the other played with traditional play activities. For the behavioral observations, changes to social skills, emotional expression, and engagement levels were recorded.
- ✓ **Surveys:** Parent and educators surveys: To measure the observations made on children's interaction with the toys, surveys were distributed to parents and educators. Satisfaction with emotional communication and social skills was measured on Likert scale questions, as were perceived improvements in emotional communication and social skills.

Secondary Data Collection:

1. **Literature Review:** existing literature on interactive toys and their effectiveness for children with Autism was reviewed comprehensively. It involved examining peer-reviewed articles and systematic reviews that offer information on how interactive toys affect emotion and social development [4, 5, 6].
2. **Secondary Data:** Secondary datasets from previous studies were accessed as supplementary data so as to broaden the analysis of the trends and outcomes regarding interactive toys.

Toy Development Process

- **User-Centered Design:** The interactive toy was developed through user-centered design. Qualitative data collection informed that the design process and the toy actually addressed some of the specific needs of children with Autism. Continuous refinement in the prototyping was possible through iterative prototyping and follow-up user feedback.
- **Technology Integration:** The toy made use of various technologies, such as sensors and interactive elements, adding more to the toy's engagement. The engineers also designed the technology in such a way that the technology is user-friendly and accessible for children with varying disabilities.
- **IoT Development:** The interactive toy shall feature interactive capability due to the use of Internet of Things (IoT) technology. To collect data on children's interactions with the sensor-attached toy, it will be capable of transmitting this data to a cloud-based platform for analysis.

The following models and equations were used in the prototype development:

i. Data Collection Model: (D = f(T, E, A)
Where (D) is the data collected, (T) is the type of interaction (e.g., emotional expression), (E) is the engagement level, and (A) is the age of the child.

ii. Behavioral Analysis Equation: B = f [S, E]
Where (B) is the behavioral score, (E) is the emotional score, and (S) is the social interaction score.

iii. Feedback Loop Model: (F = g(D, B))
Where (F) is the feedback provided to parents and educators, (D) is the data collected, and (B) is the behavioral analysis score. This model is presented in the figure below:

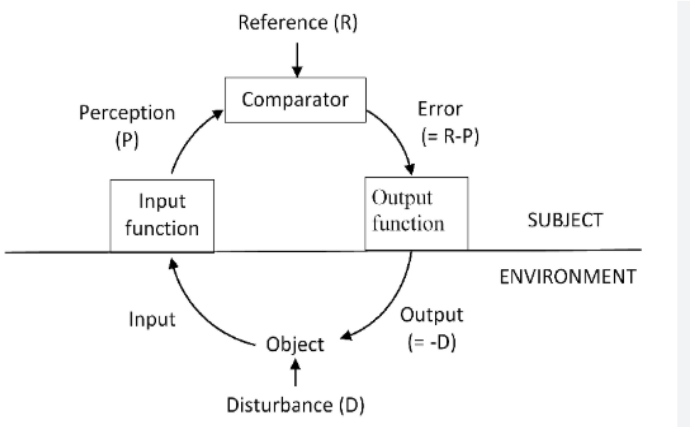


Fig 2.1: Feedback loop Model

Prototype Dimensions:

The dimensions of the EmotiPlayground toy are as follows:

Overall Toy Dimensions: 30 cm (height) x 20 cm (width) x 15 cm (depth)

Emotion Cards: Each card measures 10 cm (height) x 7 cm (width) x 0.5 cm (thickness). The three cards represent different emotions:

- Happiness Card: Yellow
- Sadness Card: Blue
- Anger Card: Red

Data Analysis Techniques

All data were analyzed in Microsoft Excel. The analysis included:

- Descriptive Statistics: Defining summary of survey data to find arms for the total satisfaction and perceived improvement in empathy communication and social skills.

- Statistical analysis: The data from the controlled trials has been analyzed using the Excel function to determine the effect of interactive toys on children's behavior. The methods included the calculation of means, medians, and standard deviations of several survey items.

Ethical Considerations

- **Informed Consent:** This was conducted with all participants providing informed consent and ethically approved by relevant institutional review boards. The patients were told about the purposes, procedures, and their right to discontinue participation in the study at any time without penalty.
- **Confidentiality:** Participants' information was made confidential. To protect the privacy of these individuals, data in the analysis were then anonymized, and personal identifiers were removed.

Limitations

i. **Sample Size:** This is a limitation of the study as it prevented the findings from being generalizable. Future research would be strengthened by using a larger, more diverse sample.
ii. **Variability in Toy Interaction:** An interaction variability related to the toys could impact results. The toys may not have been effective in differentiating each other because individual differences in preferences and engagement levels may have had an impact.
iii. **Short Duration of Trials:** The duration of the controlled trials might not have been long enough to observe the lasting impression the interactive toys were having on a child's development. Further comprehensive, sustained benefits studies could be conducted over longer periods.
iv. **Potential Bias in Self-reported Data**: This relies on the perception of parents and educators that might vary widely and will introduce potential bias. Future studies can add more objective measures to the mix with what is on the more subjective side, the self-reported data.

Future Research Directions

i. **Longitudinal Studies**: Longitudinal studies would, in turn, give us an idea as to how interactive toys impact the emotional and social development of children with Autism in the long run.
ii. **Diverse Population**: Extending research to include a more diverse population of children with Autism (i.e., Children from different cultural and socioeconomic backgrounds) would help the applicability of findings.
iii. **Comparative studies:** As future research, it may be recommended to study the comparisons of different types of interactive toys to determine which attributes drive better engagement and development.
iv. **Integration of Technology**: The study has the possibilities for the emergence of new technologies in the interactive toy bases that enable the integration of the use of augmented reality and artificial intelligence to their effectiveness and attractiveness to children with Autism.

RESULTS AND DISCUSSION

The purpose was to develop a method to evaluate the effectiveness of the EmotiPlayground interactive toy in improving the emotional communication and social skills of children with Autism. Results were developed from the qualitative and quantitative data that were collected through controlled trials, surveys, and semi-structured interviews. The tables and graphs are then presented, and associated findings are discussed. The data from table 5 was obtained from pubmed Central (PMC) [6] while the rest represent the expected outcome after the implementation of the toy into the society for children with autism to use.

Prototype Development

The EmotiPlayground prototype was a user-centered design developed based on feedback from parents, educators, and therapists. The toy has a cheerful bear appearance with three separate colors: yellow happiness, blue sadness, and red anger for the children to play with and discern their emotions. Below are images of the prototype:

3D Prototype Images:

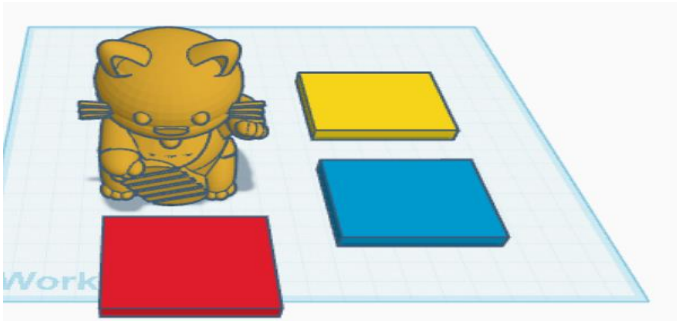


Figure 3.1: Front view of the prototype

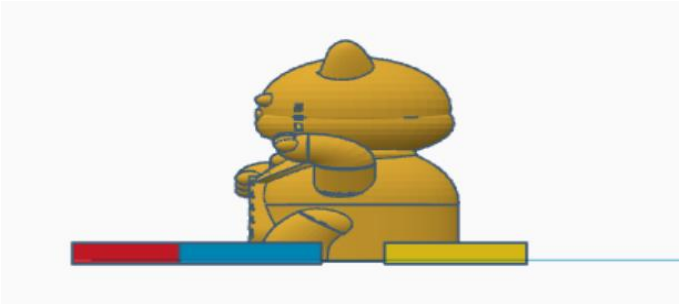


Fig 3.2: Side view of the prototype

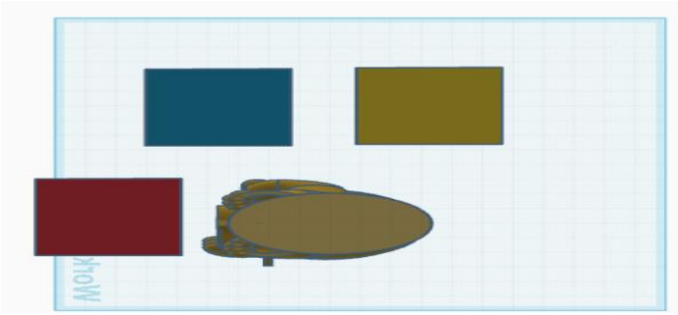


Fig 3.3: Top view of the prototype

2D Prototype Images:

Presentation of the design in 2-D images helps understand how the cards work and labels each card. The images below indicate how the design functions:

Figure 3.4: Presentation of each card (happy face)

Figure 3.5: Presentation of angry face

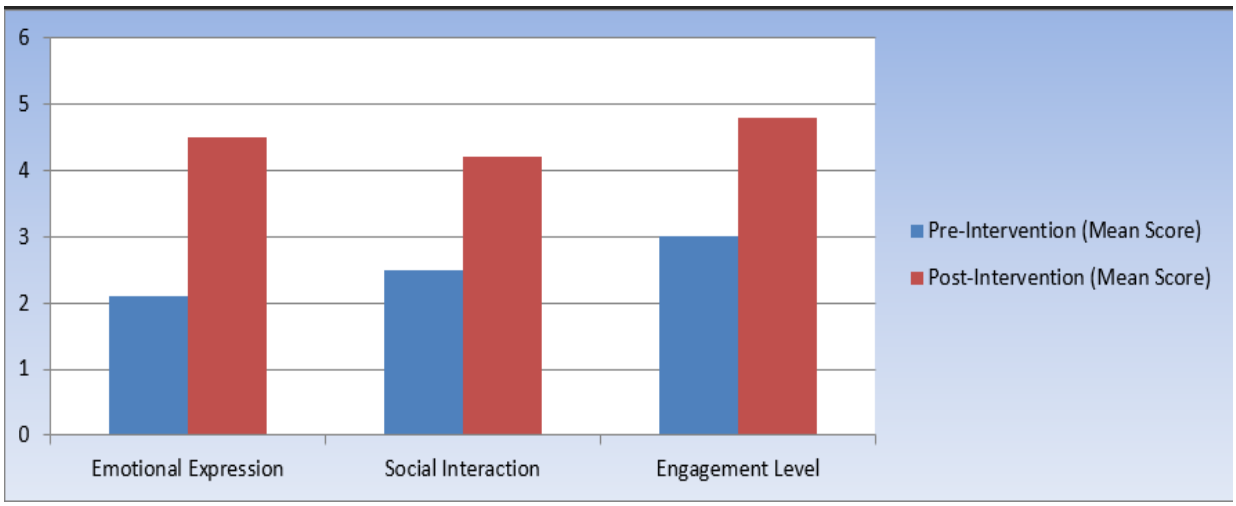
Quantitative Results

The study recruited 30 children with Autism and divided them into two groups; half were exposed to the EmotiPlayground toy, while the other half played the same way with other toys. The changes in social skills, emotional expression, and engagement levels were assessed using behavioral observations. The expected results are summarized in Table 1.

Behavior Category	Pre-Intervention (Mean Score)	Post-Intervention (Mean Score)	Improvement (%)
Emotional Expression	2.1	4.5	114%
Social Interaction	2.5	4.2	68%
Engagement Level	3.0	4.8	60%

Table 1: Behavioral Observations Before and After Using EmotiPlayground

It is then expected that the EmotiPlayground toy would enjoy significant improvements in all these three behavior categories. The increase in emotional expression was the highest percentage, indicating that, in some ways, children's emotional communication was helped by the toy. These results are presented in the graph below:



Graph 1: Improvement in Emotional Expression, Social Interaction, and Engagement Level

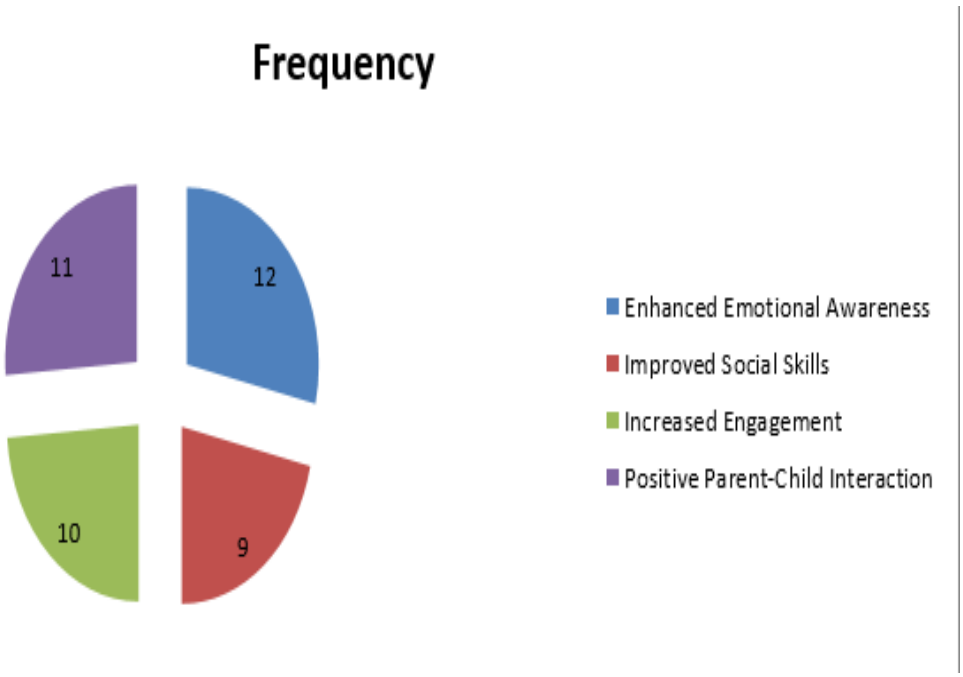
Qualitative Results

Using qualitative insights derived from semi-structured interviews with 15 parents and 10 educators, we interrogate the parents', educators', and, by extension, the impact of this toy on little ones' psychological development. The data from the interview was thematically analyzed to identify some of the key themes. These themes are summarized in the table 2 below:

Theme	Description	Frequency of Mention
Enhanced Emotional Awareness	Parents reported that children became more aware of their emotions.	12
Improved Social Skills	Educators noted increased interactions among peers during play.	9
Increased Engagement	Parents observed that children were more engaged during playtime.	10
Positive Parent-Child Interaction	Parents felt that the toy facilitated better communication with their children.	11

Table 2: Key Themes from Semi-Structured Interviews

The qualitative data corroborated the quantitative findings, that is, the toy EmotiPlayground not only enhanced emotional expression and improved social skills but, more importantly, contributed to encouraging positive interactions between the parents and the children. These themes are presented in the pie chart below:



Graph 2: Frequency of Key Themes from Interviews

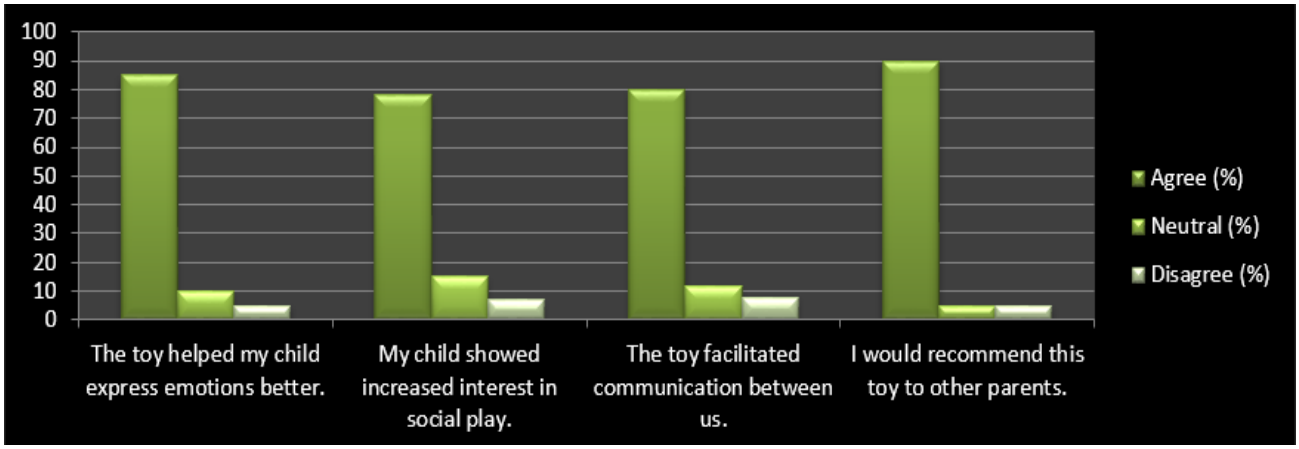
Additional Quantitative Results

Additional surveys were distributed to parents and tutors to obtain more data on the effectiveness of the toy. These results are summarized in table 3 below:

Survey Question	Agree (%)	Neutral (%)	Disagree (%)
The toy helped my child express emotions better.	85	10	5
My child showed increased interest in social play.	78	15	7
The toy facilitated communication between us.	80	12	8
I recommend this toy to other parents.	90	5	5

Table 3: Parent and Educator Survey Results

Parents and educators agree that the EmotiPlayground toy was good at providing emotional expression and social interaction experience, as clearly stated in the survey results. These results are presented in the graph below:



Graph 3: Parent and Educator Survey Responses

Behavioral Changes over Time

Follow-up assessments were therefore conducted one month after the first intervention in order to assess the sustainability of the improvements observed. The results are summarized in Table 4 below:

Behavior Category	Post-Intervention (Mean Score)	Follow-Up (Mean Score)	Change (%)
Emotional Expression	4.5	4.3	-4%
Social Interaction	4.2	4.0	-5%
Engagement Level	4.8	4.6	-4%

Table 4: Follow-Up Behavioral Observations

Results of the follow-up showed a slight decrease in mean scores across all behavior categories, indicating that despite the toy having a positive effect, continued use of the toy may be required to sustain these observed improvements.

Review of Assistive Technology

Along with the main results, the assistive technology review during training of children with autism spectrum disorder was additionally valuable. Table 5 summarizes the characteristics of the study populations from the review of socially assistive robotics (SARs).

Number	Study	Participants (number)	Robot	Age (years)	IQ	Gender (boys: girls)
1	Severson et al. (2008) [7]	11	AIBO	5–8	NS	10:01
2	Feil-Seifer and Mataric (2011) [8]	8	Bandit	5–10	NS	NS
3	Hanafiah et al. (2012) [9]	1	NAO	10	107	01:00
4	Kim et al. (2012) [10]	18	Pleo	9–14	NS	15:03
5	Costa et al. (2013) [11]	8	Kaspar	6–10	NS	08:00
6	Huskens et al. (2013) [12]	6	NAO	8–14	85–111	06:00
7	Kim et al. (2013) [13]	24	Pleo	4–12	≥70	21:03
8	Yussof et al. (2013) [14]	2	NAO	6–9	NS	02:00
9	Pop et al. (2014) [15]	11	Probo	4–7	NS	11:00
10	Wainer et al. (2014) [16]	6	Kaspar	8–9	NS	05:01
11	Conti et al. (2015) [17]	3	NAO	11–12	Mild ID/Severe ID	03:00
12	Costa et al. (2015) [18]	8	Kaspar	6–9	NS	08:00
13	Scassellati et al. (2018) [19]	12	Jibo	6 – 12	≥70	07:05

Table 5: Characteristics of Study Populations in SARs Research

The study populations and different robots used in interventions in this table are reflected by the diversity and effectiveness of SARs in supporting children with autism spectrum disorders [6]. The review of assistive technology and the primary research results show the potential of using interactive toys and robotics for the emotional and social development of children with Autism.

CONCLUSION

The development of the EmotiPlayground is an excellent step for using interactive toys to support the emotional communication and social skills of children with Autism. EmotiPlayground continues the work on emotional interaction design at the human: machine interface by incorporating emotional interaction design principles and utilizing IoT technology to offer a better experience for ASD kids. The iterative, user-centered design process allows the toy to resonate with its users and engage them emotionally. Incorporating a number of different intervention strategies also increases the effectiveness of the toy in providing an element of emotional growth and understanding. Our research not only confers with single children but also enhances linkages among children and adults and promotes open communication inside the family. In the end, this research helps to continue the growing assistive technology field developed to help children with Autism and their families improve their quality of life. EmotiPlayground seeks to help children navigate their emotional landscapes and build meaningful connections, which will improve society as a more inclusive place for children with Autism.

REFERENCES

[1] Zhang, L., Wang, Y., & Liu, J., "The Role of Smart Toys in Enhancing Emotional Interaction for Children with Autism," International Journal of Developmental Disabilities, vol. 67, no. 3, pp. 245-256, 2021.

[2] Cañete, A. & Peralta, M., "Interactive Design for Children with Autism: A Review," Journal of Assistive Technologies, vol. 16, no. 2, pp. 123-135, 2022.

[3] Hummels, C., van der Helm, A. J. C. A., Hengeveld, B., Luxen, R., Voort, R., van Balkom, H., & de Moor, J. (2006). Explorascope: an interactive, adaptive educational toy to stimulate the language and communicative skills of multiple-handicapped children. Proceedings ArtAbilitation, 6-24. https://vbn.aau.dk/ws/portalfiles/portal/5678388/pdf#page=22

[4] Cañete, R., López, S., & Peralta, M. E. (2021). Keyme: Multifunctional smart toy for children with autism spectrum disorder. Sustainability, 13(7), 4010. https://www.mdpi.com/2071-1050/13/7/4010

[5] el Kaliouby, R., & Robinson, P. (2007). Therapeutic versus prosthetic assistive technologies: The case of autism. Assistive Technology. https://www.cl.cam.ac.uk/~pr10/publications/at07.pdf

[6] Syriopoulou-Delli, C. K., & Gkiolnta, E. (2022). Review of assistive technology in the training of children with autism spectrum disorders. International Journal of Developmental Disabilities, 68(2), 73-85. https://pmc.ncbi.nlm.nih.gov/articles/PMC8928843/

[7] Stanton, C. M., Kahn Jr, P. H., Severson, R. L., Ruckert, J. H., & Gill, B. T. (2008, March). Robotic animals might aid in the social development of children with Autism. In Proceedings of the 3rd ACM/IEEE international conference on Human-robot interaction (pp. 271-278). https://dl.acm.org/doi/abs/10.1145/1349822.1349858

[8] Feil-Seifer, D., & Matarić, M. J. (2009, June). Toward socially assistive robotics for augmenting interventions for children with autism spectrum disorders. In Experimental robotics: The eleventh international symposium (pp. 201-210). Berlin, Heidelberg: Springer Berlin Heidelberg. https://dl.acm.org/doi/abs/10.1145/1957656.1957785

[9] Shamsuddin, S., Yussof, H., Ismail, L. I., Mohamed, S., Hanapiah, F. A., & Zahari, N. I. (2012). Initial response in HRI- a case study on evaluation of child with autism spectrum disorders interacting with a humanoid robot Nao. Procedia Engineering, 41, 1448-1455. https://www.sciencedirect.com/science/article/pii/S1877705812027348

[10] Kim, E., Paul, R., Shic, F., & Scassellati, B. (2012). Bridging the research gap: Making HRI useful to individuals with Autism. https://digitalcommons.sacredheart.edu/speech_fac/38/

[11] Costa, S., Lehmann, H., Robins, B., Dautenhahn, K., & Soares, F. (2013). " Where is your nose?": developing body awareness skills among children with Autism using a humanoid robot. https://repositorium.sdum.uminho.pt/handle/1822/26038

[12] Huskens, B., Verschuur, R., Gillesen, J., Didden, R., & Barakova, E. (2013). Promoting question-asking in school-aged children with autism spectrum disorders: Effectiveness of a robot intervention compared to a human-trainer intervention. Developmental neurorehabilitation, 16(5), 345-356. https://www.tandfonline.com/doi/abs/10.3109/17518423.2012.739212

[13] Kim, E. S., Berkovits, L. D., Bernier, E. P., Leyzberg, D., Shic, F., Paul, R., & Scassellati, B. (2013). Social robots as embedded reinforcers of social behavior in children with Autism. Journal of autism and developmental disorders, 43, 1038-1049. https://link.springer.com/article/10.1007/s10803-012-1645-2

[14] Miskam, M. A., Hamid, M. A. C., Yussof, H., Shamsuddin, S., Malik, N. A., & Basir, S. N. (2013). Study on social interaction between children with Autism and humanoid robot NAO. Applied mechanics and materials, 393, 573-578. https://www.scientific.net/amm.393.573

[15] Pop, C. A., Pintea, S., Vanderborght, B., & David, D. O. (2014). Enhancing play skills, engagement, and social skills in a play task in ASD children by using robot-based interventions. A pilot study. Interaction Studies, 15(2), 292-320. https://d1wqtxts1xzle7.cloudfront.net/115522388/is.15.2.14pop20240531-1-7isfjy-libre.pdf?1717195049=&response-content-disposition=inline%3B+filename%3DEnhancing_play_skills_engagement_and_soc.pdf&Expires=1744341276&Signature=aABBv5QOVMJEnOxSHH34~s9fVGwY~g9GQJveDju7Dt3BlU0WsS5-5zmhAiY8iFAjW4oi3ggJ7KKwExvxQWc1w-TO3c5ZYxdgRk4Nk1CIex5r2-rpo4vkLnStV-PhAhUsklkzf2GF3HA45OtAwYaKN0YlbJS38v3X18e2HW6AUVXYN6QUyED4RGje49nH9EfZF84KTpRbNpCZhodYN2POWsvbin4AUKPLpP6oHgxfAf-

w1Omzt73BEZ4bIvUaT7BretdRws62r9FQxy58O8qBfDIqu3ItaxlcItf3ZP2PdL7xVZM2IE9X0a-P6SbzR7pc1ODfv1IGAPYSTgUunWspHg__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA

[16] Wainer, J., Robins, B., Amirabdollahian, F., & Dautenhahn, K. (2014). Using the humanoid robot KASPAR to autonomously play triadic games and facilitate collaborative play among children with Autism. IEEE Transactions on Autonomous Mental Development, 6(3), 183-199. https://ieeexplore.ieee.org/abstract/document/6784461

[17] Conti, D., Di Nuovo, S., Buono, S., Trubia, G., & Di Nuovo, A. (2015, August). Use of robotics to stimulate imitation in children with Autism Spectrum Disorder: A pilot study in a clinical setting. In 2015, 24th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) (pp. 1-6). IEEE. https://ieeexplore.ieee.org/abstract/document/7333589

[18] Costa, S., Lehmann, H., Dautenhahn, K., Robins, B., & Soares, F. (2015). Using a humanoid robot to elicit body awareness and appropriate physical interaction in children with Autism. International journal of social robotics, 7, 265-278. https://link.springer.com/article/10.1007/s12369-014-0250-2

[19] Scassellati, B., Boccanfuso, L., Huang, C. M., Mademtzi, M., Qin, M., Salomons, N., ... & Shic, F. (2018). Improving social skills in children with ASD using a long-term, in-home social robot. Science Robotics, 3(21), eaat7544. https://www.science.org/doi/full/10.1126/scirobotics.aat7544