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RESEARCH PAPER

Design of a Virtual Assistant for Emotional Support of Children with Autism Spectrum Disorder

Adela Almazán, Sofia Gonzalez, Raymundo Cornejo, Karina Caro

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1. Abstract

Children with Autism Spectrum Disorder (ASD) face significant challenges in acquiring socio-emotional skills. This research focuses on exploring and understanding the characteristics of this topic to propose an application that includes a virtual assistant aimed at improving socio-emotional skills, centered explicitly on emotional recognition. This paper presents a thorough investigation to explore the use of innovative technologies on the subject and understand how to design the development of low-fidelity prototypes. This project aims to contribute to the emotional well-being of children with ASD through advanced technology.

2. Keywords:

Emotional Wellbeing Technology; Assistive Technology for Autism; Child Emotional Health; Digital Therapy Tools; Assistance Pet.

1 Introduction

According to the DSM-5 [1], autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by persistent deficits in communication and social interaction, along with restricted and repetitive patterns of behavior, interests, or activities. Individuals diagnosed with ASD face significant challenges in social communication and interaction with others. Each person with ASD exhibits different variations in characteristics, depending on the severity level within the spectrum.

ASD appears at an early age (around two years old) and is characterized by an intense focus on the person's inner world and poor contact with external reality. This condition has no prominent physical characteristics, which complicates the emotional recognition of others and does not allow individuals to recognize their own emotions, potentially leading to difficulties in reacting appropriately in stressful and emotionally charged situations [17].

According to the analysis of the 2023 Morbidity and Mortality Weekly Report (MMWR), published by the Centers for Disease Control and Prevention (CDC), it has been observed that 1 in every 36 8-year-old children has been diagnosed with ASD, representing 2.8% of the global population [3]. Furthermore, there is an upward tendency since this percentage has increased compared to the 2018 data, which recorded a 2.3% [3].

Among the strategies used to support individuals with ASD to develop socio-emotional skills, the use of assistance dogs is a strategy used by the families of individuals with ASD. These pre-trained pets help improve the quality of life for children with autism [6]. Assistance dogs acquired by these individuals have proven to be of great support, as they are trained before being handed over to families, enhancing the quality of life for children with autism [8].

The dog's training varies according to the type of support it will provide. An assistance dog that supports a user with ASD helps develop or improve social and emotional skills, increasing communication [9]. Burgoyne et al. [8] concluded that parents perceive the intervention of assistance dogs as valuable for children with ASD because these animals can provide emotional support, improve safety, and foster independence in children. However, despite their benefits, they also present some challenges. For example, having an assistance dog entails additional expenses and responsibilities [8].

Understanding ASD and its challenges motivates our objective to develop a technological solution to minimize the challenges of acquiring and training an assistance pet, as well as support emotion recognition in children with ASD. This research explores VR since it has proven to be a valuable tool in supporting the development of social and emotional communication skills, creating environments similar to the real world that facilitate more natural interaction [16].

2 Background

In this section, we present the emotional characteristics of children with ASD and how assistance pets have been present for almost three decades to support people with ASD.

2.1 Emotional traits within ASD and the emotional role of assistance dogs

The theory of mind (ToM), applied in 1999 to children with ASD by Simon Baron-Cohen, Alan M. Leslie, and Uta Frith, is relevant in psychosocial therapy. This theory explains why people with ASD have difficulties recognizing and understanding the emotions of others and may have problems with empathy, which significantly affects their social interaction and communication [12]. However, ToM also suggests people with ASD have strengths in systemizing and analysis.

Almazan A., Gonzalez S.., Cornejo R.
Universidad Autónoma de Chihuahua
Chihuahua, México.
Email: lopezadela606@gmail.com, a348451@uach.mx, rcornejo@uach.mx

Caro K.
Universidad Autónoma de Baja California
Ensenada, México.
Email: karina.caro.co@gmail.com

Since the 1990s, organizations like Assistance Dogs in the UK and 4 Paws for Ability in the US have developed specific programs to train assistance dogs for people with ASD. These dogs help children focus, calm down, take breaks, and improve their mood. Additionally, they expand children's emotional experiences by introducing them to the value of living beings and facilitating social interaction [19]. All of this requires leveraging the strengths in systemizing ASD.

2.2 Technology for supporting Emotional Support in the Autism Spectrum

Technology has emerged as an innovative tool to support people with ASD in managing and understanding their emotions [12]. In 2008, Eric Lewin Altschuler [14] proposed a method in which children adopt and care for virtual pets, improving the functioning of mirror neurons, which are essential for imitation and understanding emotions [14].

In 2016, Cheng, Luo, and Lin developed the 3CFER system, which uses a mobile learning environment with 3D humanoid characters to improve the understanding of complex emotions in children with ASD [11]. The results indicated significant improvements in emotion comprehension and social interaction.

Virtual reality (VR) has proven to be a promising tool, based on a 2018 study that revealed VR can enhance emotional and social skills in children with ASD, offering several benefits. It provides a safe and controlled environment where children can practice social interactions without fear of negative consequences. Additionally, a significant improvement in children's social interaction was observed after VR training [18].

In 2022, Garcia-Garcia et al. Developed the EmoTEA application, designed as a serious game to teach children with ASD to identify and express emotions [13]. Preliminary evaluation showed positive results, highlighting the application's acceptance and effectiveness.

It has been proven that technology can be a valuable tool for improving emotional understanding and social skills in children with ASD. However, it is necessary to delve deeper into the research on the specific characteristics this technology requires and adapt it to the users' needs. Furthermore, it is essential to explore how users can enhance these skills through technology, combining its use with conventional therapeutic activities.

3 Methods

This exploratory research focuses on understanding emotional recognition by following a user-centered design (UCD) methodology [10]. The goal was to identify patterns and generate ideas for developing a prototype that could complement emotional therapies for children with ASD. An analysis was conducted based on previous research and information from therapists and caregivers. The low-fidelity prototype was created following user-centered design principles [15]. Collaborations were established with two associations in northern Mexico that provide specialized care to children, adolescents, and adults with ASD to enhance their quality of life. These associations provided relevant and necessary information to develop the technology's functionalities and features.

3.1 Participants

We recruited twelve therapists (eleven women and one man) specializing in psychomotricity, contemporary dance, language development, physical development, child psychology, speech and hearing disorders, and human communication. Seven had completed at least one course or training in ASD. On average, they had three years of experience in behavioral and emotional therapy.

In addition, we recruited five tutors (all female) with at least one child with ASD. On average, tutors' children had attended one year in either of these two associations. Children across all levels of the autism spectrum were included, both verbal and non-verbal, as well as those exhibiting hypersensitivity or hyposensitivity.

All participants signed consent forms to participate in the study. Furthermore, all tutors signed consent forms for their children to be observed during therapy and to continue collaborating during subsequent stages of the research.

3.2 Data collection

We have conducted nine interviews with therapists, three with psychologists, and five with tutors. The interview protocols varied so that therapists/psychologists and tutors could understand each participant's perspectives towards ASD and emotions. The topics addressed by therapists and psychologists were behaviors in the emotional area, development of emotional recognition skills, evaluation of emotional recognition, technology, and assistance pets.

The interviews with tutors included questions about the child's personality, diagnostic information and time in treatment, deficiencies in emotional recognition and regulation, techniques used at home to improve this aspect, and technology usage. Their opinions on technological functions that could enhance results were also explored. Two authors transcribed audio recordings of all the interviews.

The interviews, which had an average duration of 20 minutes (with parents and therapists), increased our understanding of the perceptions of both groups (therapists and tutors) and possible ways to implement psychological strategies as functionalities of the application. Finally, feedback was requested on integrating technology as therapeutic support and ideas for its implementation.

3.3 Data analysis

We analyzed the transcripts using Constructivist Grounded Theory techniques [2]. Using this approach allows the development of ideas from the collected data and prior theory. Coding was carried out, in which the transcripts were divided into relevant categories, allowing for the identification of similarities and differences between the interviews. During the content analysis, recurring trends were found in both the interviews with the therapists and those with the guardians. These trends were represented in a diagram, grouping the most relevant themes. This approach allowed us to highlight the topics that could provide valuable information for the development of the application. Finally, conclusions were drawn on each topic addressed in the interviews.

3.4 Low-Fidelity Prototype Design

In this phase, the main design objective was precisely defined, considering the information obtained from the data analysis. The themes that emerged from the data analysis influenced the development of the design. These themes help identify users' primary needs and preferences, which shape the overall design approach.

To materialize these design ideas, storyboard scenarios were employed to design low-fidelity prototypes. They were used to illustrate how users might interact with the system in different contexts, highlighting key features and user paths.

4 Results

Relevant information was obtained to determine which features should be implemented in the application and to identify the needs the application should focus on. Therefore, this section presents the interviewees' perspectives and the common themes in making design proposals.

4.1 Expert Insights: Common Themes Identified in Interviews with Therapists, Psychologists, and Tutors

The analysis of interviews conducted with psychologists, therapists, and family members of children with ASD has identified essential characteristics for the development of interactive technologies that support these children's socio-emotional development. Our study organized the research findings according to the occurrences found in the transcripts.

Customization According to the Child's Needs

Technology must be adaptable to the specific needs and reactions of each child with ASD. Given the variability in sensitivities and interests, it must allow adjustments in the intensity of sensory stimuli such as sound, light, and movement. This will ensure a comfortable and safe interaction in the virtual environment [20]. The interviewees emphasized the importance of personalizing therapeutic activities to suit each child's individual needs.

Visual and Auditory Techniques for Emotional Recognition

Children with ASD often find it challenging to recognize and express emotions. Incorporating modules with pictograms, educational videos, and stories can facilitate emotional learning, as children with ASD learn better through visual means [21]. Therefore, it is essential to design attractive visual interfaces without overwhelming sensory stimuli, particularly in the auditory aspect, as a relevant characteristic in people with ASD, especially children, is their low tolerance to sounds.

Emotional Regulation Activities

Including relaxation techniques and guided breathing within the VR environment is fundamental to helping children manage frustration [22]. These exercises offer practical tools for emotional self-regulation based on commonly used therapeutic techniques. These tools will be visible when the child opts to "withdraw" or "ask for help," and they are presented as reminders.

Integration of Sensory Diet

Integrating activities with different textures and movements within the VR can address the specific sensory needs of children with ASD [23]. As the therapists and parents interviewed suggested, simulated therapeutic experiences can be very beneficial for the children's sensory regulation.

Controlled Use of Technology

Limiting and controlling the use of VR to avoid sensory overload. Scheduling sessions with a maximum duration of 30 minutes and frequency adapted according to the technology use permitted by the parents to ensure beneficial and safe exposure, as recommended by the parents interviewed.

Feedback and Communication

Since many children with ASD have verbal communication difficulties [24], VR should provide communication and feedback during the activity process, mainly through appealing images. This includes leaving activities at any time to express frustration or discomfort.

Anticipation and Structured Routines

Creating alerts and explaining activities within the VR in advance can reduce anxiety and frustration, improving the adaptability of the children. This feature is based on therapeutic strategies that prepare children for future situations.

Evaluation and Progress Tracking

It is essential to assess the impact of interventions and adjust activities based on observed progress. Positive feedback and visualizing achievements can motivate children to improve their skills and progress in the application.

Use of Virtual Pets as Assistants

Integrating virtual pets as assistants within VR can impact the socio-emotional development of children with ASD. These pets can interact, guide, and offer constant and friendly support. Therefore, it is essential to consider alternative avatar designs that are non-animal, as some children do not tolerate the texture of animal fur and do not have positive interactions with pets, as mentioned in some interview cases.

4.2 Design proposals

We developed several alternatives based on the previously obtained requirements and information gathered. The resulting designs are presented below, highlighting the creation of scenes with the support of a virtual assistant, considering that the user's preferred assistant can be used.

4.2.1 Narration of a Social Story

This design utilizes a social story narrated by a virtual assistant, who guides the user throughout the process. Figure 1 shows how the assistant offers practical advice on various situations and addresses emotional topics, describing the feelings and sensations the user might experience in real-life scenarios. Additionally, it illustrates how the assistant provides guidance on how to effectively face and manage these emotions. This application addresses situations based on everyday activities, focusing on the emotions in these contexts. By normalizing these common emotions, the application helps prevent potential future frustrations, promoting healthy emotional management.

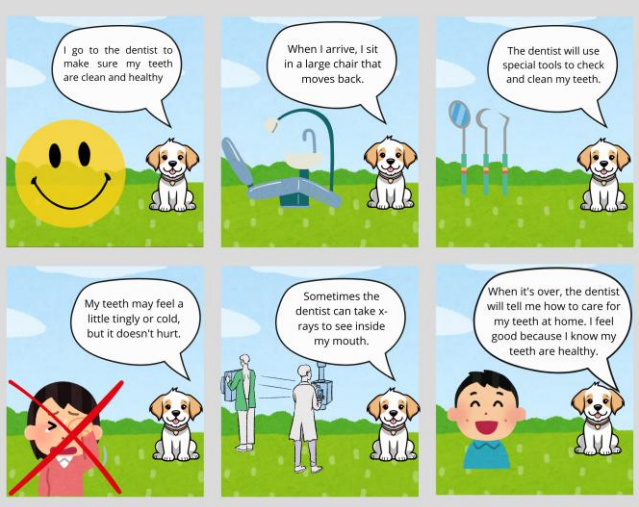

Figure 1. A social story about visiting the dentist and its implications.

4.2.2 Interactive Multiple-Choice Game Based on Stories

This proposal suggests creating various everyday situations guided by a virtual assistant that will narrate the presented scenes. Figure 2 shows how the assistant will provide clear instructions to facilitate the user's interaction with the application. Among the features, there will be multiple options for the user to choose from, and based on the selected option, advice on the next steps will be offered. The user will have the freedom to exit the activity at any time if they feel uncomfortable or do not wish to continue.

Figure 3 illustrates how the emotions experienced during the simulated situations are reflected, allowing the user to associate these experiences with real-life scenarios. This approach aims to improve the understanding of emotions and appropriate responses to various conditions, offering an interactive and adaptable tool that facilitates learning and practice in a safe environment.

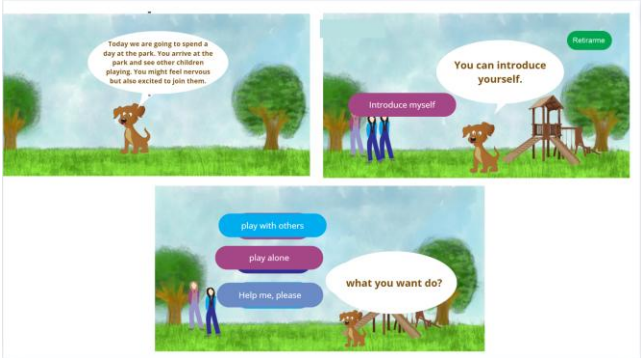

Figure 2. Designing Interactive Multiple-Choice Game Based on Stories (1).

Figure 3. Designing Interactive Multiple-Choice Game Based on Stories (2).

5 Discussion

In recent years, there has been an increase in the development of applications designed to support individuals with special needs, including those with ASD [10]. Virtual reality (VR) offers immersive experiences that can enhance both learning and entertainment. However, the growing use of this technology raises concerns about user safety, such as the risk of virtual dizziness or a potential increase in social isolation [5].

Currently, there is limited evidence on the effects of brief exposure to virtual reality in children under the age of 14, even when conducted under supervision. Although virtual reality can provide a controlled environment that facilitates social learning for children with ASD, there is a risk that excessive use may replace real-world interactions and thereby intensify isolation [4]. Nevertheless, our preliminary findings suggest VR may be an alternative solution to support ToM and support emotional integration in children with ASD.

It is crucial to find a balance in integrating VR into children's lives, ensuring that this technology serves as a complement rather than a replacement for opportunities for genuine social interaction.

6 Conclusion

Research has shown the potential use of assistive technologies, such as virtual assistants and virtual reality, to improve emotional recognition and management of specific situations. The prototypes designed focus on narrating social situations and interactive games based on everyday scenarios, which is promising for facilitating the user's understanding and emotional regulation.

Interviews conducted with the support of associations and families were fundamental in obtaining crucial information and requirements for developing each of the designs presented. Through a user-centered approach, relevant features that must be incorporated into the application have been identified, such as the preference for visual assistants without stressful sounds and the need for different types of assistants to adapt to the various preferences and sensitivities of children with ASD.

7 Future work

In future work, we will continue interviewing tutors to obtain a balanced perspective on each topic. We also plan to evaluate the proposed designs with experts and parents to select the design that best suits specific needs and make necessary adjustments based on the feedback received. Design evaluation involves presenting low-fidelity designs to the specialists involved, the children in the research, and their families.

In this way, it is possible to determine which options best suit the user's needs and comfort and evaluate potential improvements to incorporate into the prototype. This phase can be repeated several times to refine the final design if necessary. Subsequently, a high-fidelity prototype will be created, followed by the corresponding evaluation to visualize the technology's results and effectiveness.

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