A Visualization Study of Emotional Expression for Children with Autism Spectrum Disorder

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Abstract. Autistic children have a lot of difficulty in interpreting emotional expressions as well as displaying emotions. Although highly structured interventions that are traditional may help enhance behaviors of the training environment, they are often characterized by the lack of contextualization, and being prone to immediate dependency. The paper uses literature review and case study to investigate the application of augmented reality (AR) as a tool of emotional learning support. Using the ability of AR, this paper suggest an AR emotional visualization design framework, which will be specific to children with ASD. It is a framework which translates emotional states into visual variables in the form of colour, shape and integrates them in ordinary environments. The strategy of adjustable intensity will minimize the threat of dependency. It suggests such main aspects as visual elements, intensity regulation, and moral frames that allow further developing the prototype with principles of design and theoretical underpinnings.

Keywords: Autism Spectrum Disorder (ASD); Augmented Reality (AR); Emotion Visualization; Cue Intensity Modulation.

1 Introduction

Autism Spectrum Disorder (ASD) is a diagnosis that implies children who tend to experience serious and constant communication challenges in a social context, the most evident one being a lack of ability to identify and communicate emotions. Studies also show that ASD children have difficulties in decoding emotional expressions of people through facial expressions, the intonation of voice, and body language during interpersonal contacts, as well as in relationships and communication building, which are essential in such activities [1]. These limitations in perception and expression of emotions also affect the socialization training of children: on the one hand, the emotional signals are not received in time, on the other hand, when the child is not able to express the emotions successfully, the social stress strengthens making the child be subjected to behavioral disorders and emotional outbursts. Thus, assisting ASD children in their emotional expression is a problematic concern in the modern rehabilitation and education domains. The emotional problems referred to in this document mainly mean the problems of

ICIAAI 2026, May 22-24, Singapore, Singapore

DOI 10.4108/eai.22-5-2026.2365233

functioning with regard to emotion recognition, expression, and regulation among autistic children and not the such diagnoses like depression and bipolar disorder.

Continued developments of therapeutic and intervention modalities of children with ASD have been made since the turn of the 21 st century. Although they have been shown to have certain effectiveness in particular settings, these adjunctive methods have general limitations. Considering the conventional well-organized behavioral intervention experiments (such as DTT), Xiao directly noted that these interventions have limitations such as inability to generalize learning results, unresponsiveness and inflexibility of children, and excessive use of prompts [2]. These limitations are common within similar approach structured training: ASD children involve in learning their emotional reactions under controlled conditions, which in turn cannot be reflected in real-life situations where these children cannot engage in the process of building the triangle of communication: expression-understanding-response. Therefore, although the application of traditional interventions can enhance behavioral performance in training contexts, such performance hardly extends to the real social contexts because of generalization challenges. This implies that there is still much to be desired in terms of contextualization of the available emotion intervention tools.

Augmented Reality (AR) is a new type of research that can be used to resolve the above challenges. AR is not a screen-based media, unlike the rest of the traditional media, so the abstract content with emotional undertones may be represented in the form of visual and spatial elements through the introduction of digital information on the real world. In the case of children with ASD, the outside expression of emotions explored by constant and unknown visual parameter, externalizes the inner feelings and emotions, thus making them shareable through communication terms. In the case of AR, the new technology offers innovative ways of viewing and perceiving the world, overlaid with computer-generated auxiliary information on the three-dimensional spaces or the physical world [3]. At the same time, the ability to read emotional conditions and combine them into reality dynamically by means of neural response systems and present them to other people means that this technique transforms the viewers, making them seem like tangible objects in the environment. Remembrance of spatial mapping helps these cues to dynamically interrelate with actual objects intensifying expression of emotion [4]. To conclude, AR as an emerging technology can potentially extrapolate the emotional signals of ASD children that can be difficult to capture in words and format them as hard-to-see visuals. This establishes a more natural communication channel between the expression of emotions and the process of social interaction.

Based on this, the purpose of this paper is to build a model of visualization of emotional expression with the help of AR technology. It reviews and synthesises the premises of design to make a proposal on a research direction of visualising AR emotional expression specific to children with ASD: the emotions of children are expressed visually as through colour, shape and animation and integrated into various interaction scenarios, such as home and classroom environments. This helps in promoting more explicit emotional externalization and communication to children with ASD which provides a new approach to their emotional expression.

2 Literature review

Chen et al. [5] suggested an ARs based self-facial modeling system (ARSFM), due to the lack of recognition and response to the proper facial emotional expression by teenagers with ASD when interacting with others under the circumstances. Specifically, confusion between fear and disgust was extremely evident especially in the baseline stage [5]. This study shows that patients with ASD have dissimilarities in perceiving and decoding facial expressions. They usually have difficulty with accurately reading and responding to the facial expression of other people and also express their own feelings accurately with the facial expression. This disables the effectiveness of conversations and formation of social relations. Other literature also reports that such deficiency as social skills, as well as the recognition of emotions, causes problems with social activities in daily situations. The mismatch of the expression of the facial emotions directly leads to misunderstanding during the interaction, which affects the development of social relationships [6]. At the same time, in many cases, the training exercises that are used to train emotions are highly structured, and thus they lose their connection with real-life situations, that is, recognition and corresponding skills in recognizing emotions are not applicable to the real life social activities of ASD individuals. Thus, as a balance to the method of traditional fixed labeling or highly designed training, Chen et al. [5] proposed the AR as the means to deliver emotion expression training, trying to teach ASD adolescents to engage emotions in real life when interacting with certain situations.

2.1 Research content and technical approach

In this research, the AR technology is used to superimpose facial expression related adequate cues on the face of the trainee [5]. This allows the trainees to have the opportunity of practicing in real-life scenarios by being subjected to the process of seeing, comparing, and adjusting in the real interactions. The research team initially took pictures of each participant in a frontal and lateral position in order to come up with 3D controls of the head that corresponded to his or her facial characteristics. There were 6 basic emotions of happiness, sadness, fear, disgust, surprise, and anger, whose 3D expression animation was built based on FACS. The models and animations were then coded into Unity and feature tracking had been coded in through Vuforia or QCAR to ensure the stability of the overlaying of virtual historical data on the photos of the actual world. Concerning AR design strategies, this paper clarifies the medium advantage of AR, as opposed to localizing emotion training to only 1 screen, AR utilizes the effect of overlay to incorporate the combination of enhancement and feedback with real world interactive experiences and ultimately develops visual aids. The methodology solves the insufficient contextualization issue and the generalization issues since it will teach the users to associate emotional tendencies with limited situations which includes where the event takes place, who one interacts with, what occurs, and who users get feedback. This allows learning to be more like the real-life perception and response, thus the motivational training is more likely to be generalized. Emotive expression, which can be represented as abstract ideas or word expressions, in the form of an experience gets turned into a specific experience by the implementation of this technology. It offers a direct empirical channel to answer the question whether the AR technology can be employed as the medium of expression of emotions between individuals with ASD. Moreover, it provides the practical assistance to the later design options which involve aspects like emotive cue overlaid procedures, feedback schemes, learning contexts and capability transference.

2.2 Design insights and risk boundaries

The substantial finding of Chen et al. [5] is to convert the intricate phenomenon of the emotional expression into something external, perceivable, and practiceable to visual interactive object. In theory, the research is not simply a presentation of predetermined facial expressions of other people. Rather, it allows users to get the visual feedback about their own wordings with the usage of AR technology, which decreases the self-monitoring pressure of the people with ASD when communicating nonverbally. In children with ASD, the emotional expression pressure does not entirely involve a failure to understand what is to be expressed, and it also does not involve the failure to express what they have to express with adequate precision; rather, the pressure lies in the social expectations of the emotional expression and social communication abilities. Therefore, decoding words and facial expressions into visual cues may indirectly solve the gap between personal expression of emotions and the perception of the others. But more than this, although the study by Chen et al. [5] indicates the ability of AR to depict emotion-related information, it does also point out the possible dangers associated with it: too strong AR feedback can cause users to become addicted to AR-related emotional support that it will turn their expression into the act of following prompts and disregard spontaneous emotional expression. The latter may eventually result in the drawbacks mentioned by Xiao [2] in DTT experiments when considering a heavily structured intervention.

In summary, the research question Can AR support emotional expression in people with ASD? can be analyzed by Chen et al. [5] as the clear pathway of evidence and the given key elements to ensure the construction of the design framework include how AR overlay mechanism externalizes emotional information, how feedback can be embedded within the scenarios, and how the intensity of the prompts can be controlled in order to avoid user dependency. Based on the theoretical premises of this research project, the focus of the training will not be limited to the individual expression analysis as per the present study, but rather on the variations in emotional classes and intensity, as well as the establishment of expressive tracks, through the visual means of color, form, and motion, to be carried out in the training in the second instance; Third, the transfer of the training will be to a high-frequency interaction situation. AR stimuli will prompt the user to say, and it forms a closed social interaction that facilitates communication. The prompt-intensity mechanism will also be implemented to mitigate the risk of dependency and counter the ethical issues associated with it. This paper as a result of this, is changing AR overlay feedback, which is only one-point training to an elaborate visual design framework in expressing emotion in everyday communication and giving it a structured basis on which prototype and its resultant evaluation can be done in the future.

3 Case analysis

Superpower Glass is a digital, wearable intervention created by a team at Stanford University [13] to offer children with ASD support, by providing perceptible low-interruption social-emotional cues, when interacting in a more natural setting. It is a system consisting of a camera in glasses to read the facial expression in the interactions, which offers social cue prompts in real-time in the field of view of the person wearing the glasses. This helps the children with ASD train on emotion recognition and social skills in the normal set-up. The essence of its functionality may be summarized into the following: it perceives emotions, processes them with the help of digital computation and AR device prompts, and eventually attains the objective of improving the perception ability of ASD children in terms of emotion processing. The summary of this process can be obtained as follows: The system reads facial emotion cues in a natural interaction process, it formats and classifies these cues through algorithms and algorithms and presents feedback in the form of prompts on the glasses. This practice leads to emotional perception, and social interaction in children with ASD through repetition.

3.1 Mechanism breakdown

In the emotion perception stage, the discrete category cues are mostly used in Superpower Glass [13]. It can recognize the facial expression of other people and give the wearer real-time information of the emotional condition through icons, text, or audio. The benefit of this design is that it produces low learning threshold which allows the training of ASD children to shift through the laboratory activities to the real world interactive experience. This offers a critical background and theoretical underpinning of the context embedding and training scenario generalization on the focus of the design framework that follows in this paper. In terms of calculation and encouragement, the system analyzes the received facial cues to effect an emotion recognition and classification that make complex intersocial scenarios simplified and visualized. Nevertheless, this method has a danger of making the users used to the answer-proving activities offered by the glasses, which may prevent children from seeing and rehearsing their emotions and others. This indicates that there is the danger of dependency that the future study and the paper should discuss. At the stage of developing ASD emotion perception, training goals are reached through the use of continuous feedback, and repetition to reinforce behaviors in the system. The project has adopted a glasseswork facility in which the phone is used as a control of management and coordination [13]. This will enable one to manage AR intervention, which guides wearers to emotional practice instead of depending on real-time emotional signals. This can be used to give an actionable reference to the future in-this-paper proposed design approach with adjustable intensity. Critiques of Superpower Glass also observe that not all research and product accounts are accurate on its effects and its capacity to manage multifaceted social settings needs to be considered seriously. In general, Superpower Glass places its use as a part of real-life situations of the daily lives of children as opposed to several instructional training methods of emotions made in a lab. The project raises more emotional prompts in natural environments, which increases its interventions closer to the real life and interaction patterns.

3.2 Contextual implementation

In application environment their main advantage is that Superpower Glass [13] can facilitate emotion learning not only as a part of clinical work but it can also be used in the context of the real life of the wearer: The glasses have the external camera which scans the faces of other people in the environment where they are in use and the interpretations which are made are displayed in the form of prompts depending on the context of the immediate social situation within the focus of the worn glasses. This facilitates training to be done in the flow of normal conversations. The project applies semi-structured and structured approaches, which are blended to make it viable in the home settings. As an example, using the free play, the wearers need to maintain the contact bearing the device on themselves, being constantly informed of their emotions. Training should take a form of an activity that can be incorporated in the family time and gamified parent-children activities such as the activity of guessing my emotional state would be perfectly fitting [13].

3.3 Ethical and governance risks

On the ethical front, the case study demonstrated the weaknesses in the current boundaries of ethics where AR technology is used in emotional exercises. The cameras used by the system to record the facial expression and behavioral data such as facial expressions and eye contacts, raise questions against the privacy of third parties, their informed consent, and data insecurity as these actions depend on cameras [13]. Hence, it is essential to modify the ethical breaches of privacy in new AR technologies and balance privacy protection and technology. Therefore, future designs in this paper will bear in mind the principles of data minimization, storage and access permissions by developing clear protocols. Also, limits to consent and disclosure that are appropriate in normal public context will be made to reduce the risks that may occur due to technology intervention.

4 Application

4.1 Core proposition

In the paper, a theoretical framework of the visual cue mechanisms of recognizing the emotions of others is going to be developed upon the basis of the framework mentioned above. It suggests AR overlay prompts as the major resourceful tool of supporting emotional learning, and goes further to suggest a design framework of visualizing emotional expression. In particular, this paper suggests a medium of emotional communication, namely, augmented reality overlay cues. Such a strategy will be associated with converting abstract emotional stimuli into concrete visual impressions, which will facilitate the training of emotional awareness in the ASD children and externalization of emotional expression in the actual social context interactions. AR is technologically an operating method as it recognizes facial features on real-time video stream and superimposes interactive prompts on top of the real world scene; It works in various milliseconds and this way, users can see constantly, the real world scene with new prompts attached to it; This leads to the creation of immersive recognition support that does not disrupt their activity significantly [7]. At the same time, the application of AR interventions has been reported in various areas such as social interaction and emotion recognition of children with ASD with significant positivity in improving social skills. It is also worth stating that every child with ASD is different, and the effectiveness of the standardized technology may be different among various individuals [8]. In overcoming the challenge previously determined as the structured training source of the generalization difficulties and cue dependency, the AR-overlaid cues have no value in offering definite social responses, but rather in the process of laying cues into real-time interactions. This helps children with ASD to develop organized expressional emotional and reviewing potentials between social interactions. The cues change into transferable emotional training materials through intensity-modulated design and are no longer meant to be immediate assistance systems. As such, this paper identifies AR-overlaid prompts as the fundamental openness of the next scheme. The method provides an active, practical, and, at the same time, in real time, interaction channel as well as a research base with potential of application to the emotional recognition and support of social interaction in children with ASD.

4.2 Theoretical basis

Recent emotional interventions targeting children with ASD are not aimed at teaching them a specific answer, but rather supporting them to acquire slowly autonomous capacity to recognize, regulate and express emotions. Thus, the prospects can be seen in the externalization of emotional cues into visual ones and its implementation in practical situations of interaction with the real world, conducted with the help of AR within the framework of rehabilitation training of children with ASD. On the one hand, the last ten years of studies on social-emotional competencies among children with ASD have been devoted to the principles, methods, goals, and practical principles related to the intervention, which have essential impact on their appearance and evolution in this field [9]. In contrast, neurofeedback relies on the EEG measures to offer visual or auditory feedback about the condition of an individual to help him or her deal with self-regulation. This practice has proved effective in the intervention of emotion perception and personal control, which promote positive changes [10]. These include expression externalization, which is an extension offered in the paper in accordance with the current evidence. In a nutshell, when the pathway of the social-emotional intervention is combined with the element of the neurofeedback technical support through the visualization of the emotional clues in various everyday situations, ASD children can develop the inherent mechanisms of practice and adaptation. This will help them to transfer emotional expression out of the training settings to real life and thus develop their social competencies. Taken together, the existing emotionally intervention instruments and neurofeedback studies are the combined theoretical basis of this paper, giving methodological and research rationality to the suggested design model of emotional expression visualization framework.

4.3 Design framework

In the above examination of the drawbacks in organized training cases, such as inadequate contextualization, issues in generalization, and prompt dependence, and utilizes case findings and risk-taking taken into account in AR self-facial modelling and prompts, the paper suggests an AR emotion visualization design architecture of emotional training in ASD children.

Information representation. The essence of the framework consists in converting the emotional states into a visual language that is stable and can be learnt with multidimensional encoding and the three key variables (color, shape and animation). Color is an intuitive mapping tool using which the emotional valence is quickly given to differentiate moods. Differences in saturation and brightness are another means to convey the intensity of emotions, which makes preliminary comprehension between the parties involved in communication possible with minimum language load. Shape is used to provide more contextually specific differences, including the building of relations between emotions and other elements that may cause them, including current situation events like task pressure, external environmental stimulations and even individuals reactions to others, to avoid simple or one-dimensional interpretations of emotions. This helps the user to elaborate on the reasons as to why they feel the way they do in addition to their mood. Animation illustrates the dynamic changes in the emotional states, the intensity trends and duration is reflected through the rhythm, frequency, and amplitude of the changes. This renders emotional experiences, which are easy to describe at times, visible, and relatable. The design rules at such level include recognizability and memorability: the amount of variables is to be limited to a range that children can study, where early guidance by the doctor or guardian is owed to help reduce the level of understanding. The emotional can be the result of self-selection of the children, annotation by the guardians/physicians/teachers or an outcome of recognition based on facial emotion results.

Generalization strategies and interaction processes. Overcoming the latter challenge of generalization, the framework integrates training in high-frequency and sustainable everyday environment such as home and classroom. Low-pressure, high repetition practice opportunities are formed in the home scenarios, incorporating the emotional training into the daily communication. Complex testing environments of task pressure, peer interaction, and restrained rules are provided in classroom environments, making them more realistic to test emotional training. The framework focuses on progressive principle: users initially learn and understand visual coded methods of communication in the relatively monitored interactions at home. They subsequently apply this mode of communication progressively to more complicated real life situations such as in the classroom and in everyday social life. The step-processed emotional expression increases the training performance replicability in practice in the social context.

The system also incorporates emotional indicators in the form of AR overlays through which interactions are based to make sure that there is visualization as opposed to display only. The users do very little-effort confirmation acts that are a mere response to visual stimuli, and at the same time obtain self-awareness. They then externalize expressions with the help of prompts in form of verbal phrases or gestures. Partners of interaction subsequently tailor their response style and pacing to the communication relationship and create a chain of communication as users use a prompt to say something and partners comprehend the emotion and give reliable advice. This process is fundamentally based on the transformation of training goals towards the conceptual emotional recognition into the actual emotional communication. This is achieved repeatedly through the activation of expressive skills when interacting thus attaining the desired outcome as an emotional training to children with ASD.

Intensity regulation and ethical governance. In order to decrease the risks of dependency related to AR visualization, the intensity regulation as well as gradual fade-out is required as a mandatory constraint mechanisms in the framework. AR emotional visualization can also utilize more geometric cues (such as more visible indications) or additional auditory signals, which gradually decrease in force, presentation time and frequency as the user becomes more proficient with it. Gradual fading requires the system to facilitate the instilling of the abilities of users to express emotions through labels decreased progressively. To allow controlled intervention, the framework suggests the introduction of a management portal to control the intensity and fade-out parameters, making AR less an answer that is constantly present and more of a metrically manageable supplementary phenomenon.

Since AR emotion prompting functions frequently utilize data related to cameras and behavior, the training might not only be conducted with the use of personal data of children but also third-party data (teachers and other family members). As such, some ethical boundaries need to be set as design requirements. The framework upholds the principle of data minimization: rests on default to local processing and aims to ensure that images are not stored such that they hold identifiable information on other people. In case user scenarios need to be reviewed or evaluated, explicit access control and deletion procedures ought to be put in place with emphasis being placed on summarized material as opposed to unprocessed video data. In semi-public places such as classrooms, explicit notification and consent procedures should be put in place with the right of third parties to deny recording and system deactivation procedures. The framework further suggests that the user should wear the identifiers, which are of relevance in ensuring that the right of the other person to know is not compromised in semi-public and public places. This diminishes the social pressure related to the unknowing capturing or recording of such thus holding up the legitimate and sustainable use of the technology in actual situations.

4.4 Significance

The visualization of emotions that is offered by AR technology puts the contrasting relationship of individuals with ASD at a lesser threshold of receiving and expressing nonverbal emotions, which in turn improves the quality of social interactions in the community activity. To begin with, the AR self-facial modeling system directly makes use of 3D facial expression animation of six simple emotions superimposed on the faces of the participants. This offers visual self-feedback of participants in training process and is an emotion practice mechanism [11]. This process is important since it is changing the interpretation of facial expression, which historically depended on other people, into a visible, practicable external thing, hence minimizing ambiguity when it comes to expression. Second, the AR technology shows positive and promising outcomes in helping ASD people with emotion recognition [12], which gives theoretical justification to the viability of AR as an emotion learning support medium. Application of such arguments to the current work, the most important thing about visual visualization is not to inform ASD children about the emotional answers, but to convert the not only verbalized feelings and abstract ideas, but also to visualize and embed them in the interactive situations in an increase of learning. In a nutshell, Chen gives first design proofs of 3D animations superimposed on the faces to facilitate practice [11]; Poglitsch proves effectiveness of AR in emotion learning at systemic evidence level generally [12]. They all speak in favor of the fact that AR is not only visually representable but also a methodologically important concept, which in this paper is backing the introduction of AR emotion visualization framework as a process-oriented approach to emotional expression and communication (as opposed to the study being focused on recognizing activities).

5 Conclusion

The current paper is devoted to the difficulties encountered by children with the ASD in the area of recognizing and expressing their emotions and the issues with the traditional structured training. It suggests an AR-overlaid cue prompt visualization design method of expressing emotions. According to the literature and case studies, this paper suggests the AR emotion visualization design model to be used in training the emotional state of ASD children: At the information representation level, the emotional state is converted into shareable visual cues and visualized through the combination of elements such as color, shape and animation to reduce the barrier burden of nonverbal emotional expression. At the interaction and contextual level, the framework focuses on integrating training into high frequency daily situations. It uses a gradual approach in the development and teaching of skills and overcomes generalization factor of emotional training that is the problem with base of skills training. More importantly, the system does not give definite social answers. Rather, it provides flexible emotional cues like intensities of emotions during realistic provides to ASD children so as to motivate them through expression or communication skills. To avoid cue dependency, cues are slowly faded away to hand the control over. The design approach that includes the flow of interaction with this pathway, real life context, and cue intensity and dependency risk boundaries wish to offer a systematic base on which the next prototyping efforts will be based in terms of codification potential, scenario integration, control of intensity and ethical constraints. This model provides ASD children with an externalization point in emotions where the child attempts to develop an expression-understanding-response communicative cycle in everyday social life and improve the quality of communication overall. The next steps must promote the implementation of the prototypes and pilots testing, which will be the comprehensive procedure of performing the work with a professional growth and evaluating possibility. At the same time, develop parallel ethical frames, such as data minimization, semi-public processes, introducing opt-in/opt-out, etc. to develop sustainable and ethics-compliant practices.

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