Augmented Reality Based Social Stories Training System for Promoting the Social Skills of Children with Autism

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Abstract Profound social reciprocity deficits are a core feature of the autism spectrum disorders. Children with autism often lack appropriate social skills when they need to interact with other people. A social stories training is one type of children-specific intervention for teaching social skills. It helps learn social skills through combination of visual and verbal cues. We use augmented reality (AR) technologies to visually conceptualize the social stories. Interactive social stories are played using several tangible markers and AR technologies that overlays the markers with corresponding virtual images. The new way to interpret social stories demonstrates an improvement of attraction and enhances effects of social skills training. Finally, We have a prototype for the social skill—"greeting" and an initial pilot study to support the therapy of high-functioning autism children.

Keywords High-functioning autism · Augmented reality · Social skill

1 Introduction

Autism is a spectrum neurodevelopmental disorder. The severity and range of disordered including intelligence, communication skills and behaviors vary within wide limits, ranging from very low to very high functioning. High-functioning autism children often have milder symptoms than those low-functioning ones and possess better potential and developmental possibility in comparison to adults with autism. Despite this, they still face the same problem in social interactions with properly.

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Profound social interactive deficits are a core feature of the autism spectrum disorders. Common deficits include initiating and terminating interactions, learning the interests of others, joining social groups, eyes contacting, turn taking, recognizing facial expressions and nonverbal social cues understanding [1]. Children with autism often lack appropriate social skills when they need to interact with other people, and then result in a frustrated and embarrassed situation.

A simple but important social skill is "greeting". Greeting to other people like parents or friends consists of many regular manners and needs autistic children to learn and practice. They have challenges saying "hi" to people who they loved and also struggled to interact appropriately with them. Owing to lake of social skills, children may act out aggressively during misunderstandings or stare at people not knowing what to do or say [2].

Interventions for individuals with autism usually begin early in life and are typically aimed at teaching social and interactive strategies. A social skills training (SST) is one type of child-specific intervention [3]. This intervention involves teaching specific skills (e.g., maintaining eye contact, initiating conversation) through behavioral and social learning techniques [4]. One of the common training methods is using visual supports such as images and drawings because of the reason that autistic people often have strengths in the visual spectrum; these individuals excel in response to visual interventions [5]. Visual supports have been applied in developing visual schedules and social stories to help deal with daily lives. Now, most of the available social skills training tools use visual supports as a main interventional method.

Social stories are one type of the social skills training therapies. They are short stories constructed to mention, interpret, and reflect on social situations that individuals with autism are not good at. Social stories can improve autism children' social skills through combination of visual and verbal cues. They supply a visual support at each step in specific social behavior so the child can minimize those factors identified as potentially confusing during interaction to provide accurate information and describe appropriate responses.

Social stories have also been proved effective in teaching greeting skills to individuals with autism [6]. The research successfully taught a girl and a boy, they all with autism, how to share and greet peers. The researchers found an increase in greetings and sharing by the participants. Another research also certified the effect of social stories used to instruct how to greet family children with friendly behaviors by an autistic patient [2].

Augmented reality (AR) is a technique that devotes to extend the physical world with digital information [7]. Superimposing digital contents onto the real world, we can view and even interact in time with virtual messages, characters or other information that have three-dimensions in the real-life environment. Although AR technologies have not been a novel issue, they still keep a broader development space for autism treating. Preliminary researches have shown positive adoption and beneficial effects of AR technologies in general cognitive rehabilitation [8] and psychological disorder treatment [9]. The potential of augmented reality to be

applied to the autism intervention and be connected to social stories are full of diverse possibility.

We aims to provide a tool using augmented reality and social stories for therapists, special education teachers or even parents to help children on the autistic spectrum learn the social skills of greeting. There are some reasons why AR technologies may assist children with autism to establish improved social skills with social stories. Augmented reality supports various forms of social stories by creating easy-to-operate simulative social situations that the children with autism are familiar with. According to certain social story, virtual avatars will show correct social behaviors on the specific social stage through different motion and sound in the real world. AR technologies also have the strength to offer three-dimensions image or animation, which is more real than conventional 2D image or video. Besides, using tangible tools as AR markers completely avoids the use of a computer screen. Individuals with autism can move, change or combine different markers to get an immediate feedback effect on AR image which corresponds to different social story. AR technologies may bring benefit opportunities beyond professional social stories therapeutic contexts. Our objective is that develop a new way to interpret social stories for demonstrating an improvement of attraction and enhancing effects of social skills training among children with autism through importing advanced augmented reality technology.

This is a preliminary study of a new AR social stories training system design. In the research, we chose "greeting" as a template from numerous social behaviors. The reasons are that we would like to find an appropriate social situation that is common and basic in autism community and has had many existing social story scripts; as a result, we can test more children with autism under the same story and gather or modify story scripts more easily, so the pilot study may work efficiently and the data we get can be compiled or analyzed with the same view.

2 Related Works

Individuals with autism and their caregivers consider social skills as the primary domain where they need support from technology [10]. Several attempts have been made to know not only are software and technologies well received among individuals with autism, but research also supports the effectiveness of computer-based training for teaching a variety of skills to those with autism. Some examples such as using virtual avatars like "Baldi" [11] to teach autistic children language skills with a virtual head or applying virtual environment as a tool to improve social skills under the situation where subjects with autism want to find a seat to sit [12]. Besides, tangible interface is also a technique that enables autistic patients to control the system in an intuitive way and provide immediate haptic feedback during the interaction, which was used to encourage social communication in "Augmented Knight's Castle [13]."

Although augmented reality technology has played important roles of assisting individuals with autism in some studies, there has been relatively little research into potential possibilities of AR in social stories training for children with autism. For what concerns for using AR as a mediate tool when treating autism, some works has been offered in literature. Zhen et al. [14] described an augmented toy set to enhance the ability of pretend play for autistic children. Its operations are similar to our approach, but we have animated effects in addition to static displays. Mosoco [15] is a mobile assistive application that connects AR technologies with visual supports to help autistic children practice social skills. Our work shares similar ideas of increasing comprehensions of social skills by using visual presentations, but we have more selective contents to face different problems by changing different social story. Alessandrini et al. [16] introduced an audio-augmented paper to support the process when using social stories intervention for low-functioning autism children. The issue about social stories is the same compared with our study, but the target behind is different. Our work devotes to use AR technologies to create a new form of social stories other than puts the focus on the caregivers.

3 Method

For bringing out AR contents, we have to prepare a conventional social story text in advance. Our social stories text version about greeting referred to several websites of different autism associations [17, 18] and a book written by Carol Gray [19], who is the initiator of social stories. The greeting issue we wanted to solve can divide into three parts: (1) greeting with parents, (2) greeting with friends, (3) greeting with strangers, so we created three stories for each other. The all stories we edited will be tested simultaneously to teach children with autism different social behaviors when they greet to different people. In our social stories, we had the social skills lessons as below:

(1) Greet with parents: say hi or hello, kiss, and give a hug.
(2) Greet with friends: say hi or hello, wave, look at face, and call name.
(3) Greet with strangers: say hi or hello, ask names, introduce self, shake hands, and nod head.

Once we have story texts, the next thing for transforming them into AR versions is to do an analysis. We followed some guidelines according to the developer Carol Gray [19] to find used sentence types in our social stories. Four sentence types will be needed especially. They are: (1) descriptive sentence, (2) perspective sentence, (3) affirmative sentence, and (4) coach sentence (suggested responses for the audience, responses for his or her team, and self-coaching statements.) The descriptive sentences usually have the most information to construct an AR story. It is not all social stories have all types of sentence, but the descriptive sentence type is required certainly. Table 1 shows the four sentence types below.

Table 1 Four sentence types that we need to use involved in a social story

Sentence type	Function	Example
Descriptive	Objective statements of fact or the information that "everyone knows"	Most of the time my friends will say hi or wave to me when they see me
Perspective	Describe the thoughts, feelings, and beliefs of other people	Saying hi to friends is fun! People like me when I say hello
Affirmative	Enhance the meaning of surrounding statements	Everyone say hi to friends when they see them
Coach	Guide the behaviour of the audience or the members of team	When I see my friend I will try my best to wave or say hi

Table 2 A framework that transforms a social story into AR version

Sentence type	Relevant "wh" factors	AR social stories elements
Descriptive	What is happening?	Scripts
	Where a situation occurs?	Background
	When a situation occurs?	Background
	Who is involved?	Model
Perspective	Why should I do?	Narration
Affirmative		
Coach	How should I do?	Scripts

We also have to define "5W1H" questions to apply for the contents of AR versions. It means what, where, when, who, why, and how. The six questions can be answered by studying the four sentence types above. After this process, we can correspond the answers to the elements used to build a full AR social story. The relations between correspondences are given in Table 2. By operating this framework, we got useful elements for creating our "greeting" AR social stories as Table 3.

After we have known the elements needed in our AR system through the framework. In this part we will describe the design of the AR system in details. We would like to use a tangible approach for controlling the displays of AR animations. Marker-based tracking that is commonly used in AR applications can achieve our

Table 3 Three greeting AR social stories elements

Social situation	Story elements
Greet with parents	A home background, two 3D models (autistic child and Mom or Dad), story scripts and a piece of narration sound recording
Greet with friends	A school background, two 3D models (autistic child and friend), story scripts and a piece of narration sound recording
Greet with strangers	A community background, two 3D models (autistic child and stranger), story scripts and a piece of narration sound recording

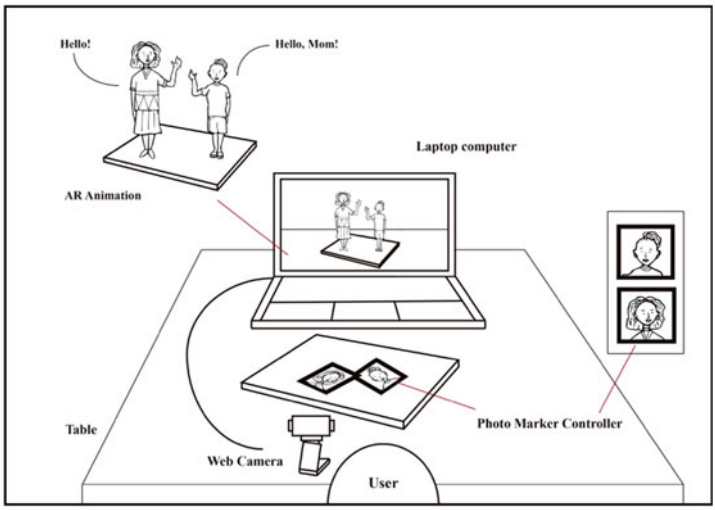

Fig. 1 The AR system diagram

goal and provide a more well understand human-computer interface to children with autism.

The full system includes a laptop computer, a web camera and several markers (see Fig. 1). The system applies photos of autistic patients, parents, friends and strangers to the pictures of markers that are printed on the sheets of paper. A web camera (Logitech Carl Zeiss Tessar HD 1080p) is set nearby the markers to recognize the presence of a sheet. A laptop computer is connected to the web camera via USB. It will distinguish the marker through reading a code assigned to each one which is recorded by the web camera and then call a corresponding 3D figure model to cover the marker on the screen. Besides, different markers can be put together to trigger social stories animations between 3D figure models that the markers represent (autistic child with parents, autistic child with friend, autistic child with stranger.)

4 Results

Our framework displays an effective method to transform a conventional social story text into an AR version. Once it is demonstrated that AR technologies play a positive impact in supporting social stories of children with autism, more contents or social situations could be transformed to enhance the quality of all system. The open framework can also be used and refined by any people. We expect to explore various possibilities between social stories and AR technologies, and encourage sharing ideas of designs for those autistic children who we care about.

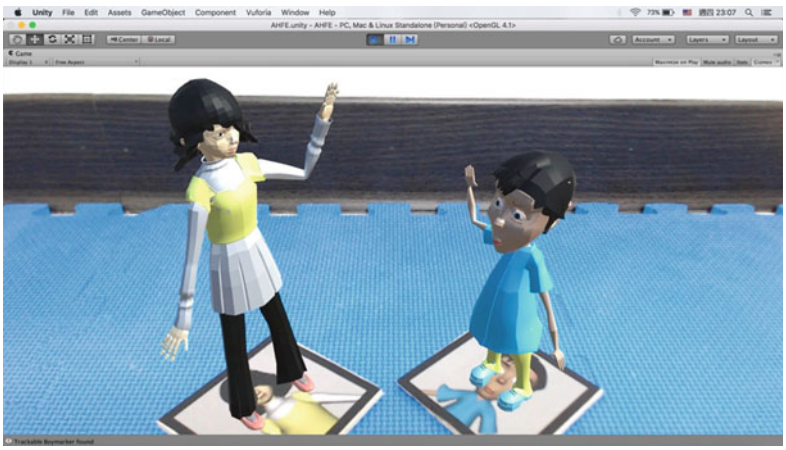

Fig. 2 The prototype screenshot

The prototype reveals a social situation about greeting with Mom for autism children. Figure 2 shows an image that was a screenshot from the view of a web camera. The virtual figure Mom and virtual figure autism child are waving their hands toward each other. Their animated actions are according to prepared social story script (Appendix, A-1) and accompanied by verbal illustration of the story text. The other two greeting social situations that include "greeting with friend" and "greeting with stranger" have the same form but different contents. Choosing appropriate matches of two markers among several different ones corresponding focal social situations is the operation of performing social stories. Children with autism can view social stories composed of animate virtual characters and vocal illustrations repeatedly, and then learn social skills based on their special needs.

Besides, a full user scenario also includes an evaluation that will compare the subject's greeting behaviors before and after the intervention afterwards. A person who is familiar with the autism subject will be invited to participate in the study during the period of intervention to help the evaluation and make subject feel more comfortable in an unfamiliar environment.

5 Conclusion and Discussion

We are currently developing the prototype and accessing to our subjects continuously. The prototype will be an augmented reality social stories system for guiding "greeting" social skills to children with autism. According to different "greeting" social situations, autistic child will be requested to select two appropriate photos (markers) and then watch the screen to view a social story that is showed by those two virtual characters corresponding the photos. Through the research, we expect to

make three main contributions as below, which will benefit the therapeutic or educational setting and researchers from AR or human computer interaction field:

(1) Give conventional social stories an opportunity to get a new style and appearance by introducing AR technologies.
(2) Understand user behaviors, practical effects and hidden deficits when children with autism interact with an AR environment and then form useful design guidelines for future studies.
(3) Raise a framework to support later researchers to transform a conventional social story into AR type social story.

The research is just a pilot study for AR social stories; we still have more ideas in our mind. Several ongoing plans are illustrated below:

(1) We use faces of participants to make the appearances of 3D virtual characters and take pictures for them to produce AR markers. Autism subjects and other people who are participating in the research will have their own photos (markers) and virtual models. Through this design, child with autism can look himself or herself in the AR social stories as a main role. We referred to a research about using masks to augment different facial expressions for assisting children with autism in learning expressions on their faces [20]. The system will be more immersive and attractive to them.
(2) We prepare various backgrounds (home, classroom, etc.) for different social situations. An AR marker that used the background photo triggers a 3D virtual background model and then the characters' markers will be put on the background marker so users can get a view of virtual roles interacting in the virtual background. The social story can fulfill the social situation more closely and enhance immersion.
(3) We plan to give the process of operating the system several new mechanisms. It will be like a game for autism children that they play social stories one after another. A set of AR social stories will be constructed corresponding social deficits of the subject appropriately and be separated into different levels according to the complexity of the social skills that the stories focus on. Children can challenge and practice social skills systematically. The study process will also get more fun and attractive.

A series of usability study will conduct to validate our design and get more information to improve and refine the system. More details about formal evaluation are discussed with several experts and then implemented the new functionalities suggested in the next future.

Appendix: Social Stories

A.1 Greet with Mom

There are many ways to greet someone.

Sometimes I can say, "Hello!" or "Hi!" It's a great way to start a conversation and a good way to make new friends. I love to greet people because it makes me happy; it also makes the other people happy. They smile and respond to the greeting. I can also use sign language to greet someone!

When I see Mommy I can say "Hello!" to her.

Sometimes I can kiss her forehead, or even give her a hug if I want.

Saying hi to Mom is fun and a short hug also means "Hello!" Mom likes it when I greet her.

Most of the time she will say hi or give me a hug back when I greet her, this is a friendly and loving thing.

A.2 Greet with Friends

There are many ways to greet someone.

Sometimes I can say, "Hello!" or "Hi!" It's a great way to start a conversation and a good way to make new friends. I love to greet people because it makes me happy; it also makes the other people happy. They smile and respond to the greeting. I can also use sign language to greet someone!

When I see my friend I will try my best to wave or say hi. When I say hi I can wave or use my words. I can say hi and than the person's name.

Sometimes it is hard to say hello to friends but I will try my best to look at my friend's face and wave or say hi.

Saying hi to friends is fun! People like me when I say hello.

Most of the time my friends will say hi or wave to me when they see me. I can try to say hi and wave back when this happens. Everyone say hi to friends when they see them.

A.3 Greet with Strangers

There are many ways to greet someone.

Sometimes I can say, "Hello!" or "Hi!" It's a great way to start a conversation and a good way to make new friends. I love to greet people because it makes me happy; it also makes the other people happy. They smile and respond to the greeting. I can also use sign language to greet someone!

When I see someone I do not know I could say “Nice to meet you.” or “Hello!” When I say hello to a new friend I will try and remember to ask them their names. I can also tell my new friend my name.

Sometimes I can shake their hands, or wave my hand to say hello. Sometimes I can just nod my head and say hi.

Saying hi to new friends is fun! People like me when I say hello.

Greeting can make people feel good.

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