上海交通大学硕士学位论文

通过AR游戏提升
自闭症儿童的情绪识别能力

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AR GAME FOR IMPROVING EMOTION RECOGNITION IN CHILDREN ON THE AS

ABSTRACT

This study explored the concept of a hands-free augmented reality (AR) game for children on the autism spectrum, in particular on the improvement of emotion recognition skills. At present, 1 in every 59 children in the US and 40 in every 10 thousand children in China are diagnosed with autism spectrum (AS). These stats have risen in recent years, and as such, much research has been devoted to AS and developing tools to aid individuals on the spectrum. For children, toys play an essential role in their development, and research has been conducted on developing toys and games for children on the AS. Some of this research has already taken into account AR games and emotion recognition, but not so much together and none with consideration of a hands-free concept, meaning that all pre-existing research has limited the motor capability of children while playing these games. Thus, this study focused on hands-free AR, and in contribution to the small amount of research in emotional development, the game focuses on improving emotion recognition.

For this study, participants consisted of 6 neurodivergent children. Participants could not all be children on the AS due to the difficulty of forming relations with schools and the limited availability among the students. However, in this case, having 6 neurodivergent children allowed for insight on varying levels of emotion recognition dissimilar to neurotypical children. Apart from surveys to test their skills in emotion recognition before and after playing the game, the game itself was designed for generating monsters with various facial expressions, conveying one of five basic emotions. It was prototyped and used by the participants between the two sessions. The game included both monsters and virtual humans to familiarize the children with different versions of the same expression. Changes, such as sound and the scaffolding rules for emotions and faces, were made to the prototype following the first session, based on the insights of the children's teachers.

The results of this study suggest that agency is a factor of engagement. Between the first and second sessions, children were more engaged when they could pick up the mechanism and use, or control, on their own, meaning less adult interference. All of the children that responded to the post-test questionnaire (five of six) indicated that the game was fun, and they would play again, one of which in the second session, even asked to play the game again following immediately after. With the ease of use, the child had no problem setting it up themselves. While engaging, the game was only played once. One

child, following the use of the game, was able to match all emotions to an expression, and another was able to draw all of their portrayals of the emotions. There did not appear any negative effect among the participants. Still, with a small sample size and only playing the game once, any improvements observed in the children's ability to recognize emotions or certain expressions are not absolute.

KEY WORDS: Augmented Reality (AR), Educational games, Autism Spectrum (AS), Emotion recognition skills, Interactive learning environments

通过 AR 游戏提升自闭症儿童的情绪识别能力

摘要

本研究探索了为自闭症儿童开发无手操作的增强现实技术（AR）游戏的概念，专门用于提升他们的情绪识别能力。目前，在美国，每 59 名儿童中就有 1 名被诊断为自闭症谱系障碍，而在中国，每 1 万名儿童中就有 40 名。近年来，该等数据还在不断攀升，同时也有大量的关于自闭症谱系障碍和开发用于帮助自闭症儿童的工具的研究。对于儿童来说，玩玩具在他们的成长过程中扮演了重要的角色。因此，已有许多关于为自闭症儿童开发玩具和游戏的研究，并且一些研究已经将 AR 技术和情绪识别考虑在其中，但是多数研究未考虑加入无手操作的概念，即所有的现有研究均受限于儿童玩游戏时的动手操作能力。因此，本研究致力于利用无手操作的 AR 技术，并且本研究开发的游戏关注于提升情绪识别能力，用于研究情感成长。

本研究的参与者由 6 名有神经多样性症状的儿童组成。由于和相关学校建立联系以及寻找自闭症儿童作为参与者的实际困难，参与者并不全都是自闭症儿童。但是，由 6 名有神经多样性症状的儿童使得本研究能够从多个层面观察具有神经性症状儿童的情绪识别能力的不同。除了使用问卷调查测试这些参与者在玩游戏前和玩游戏后的情绪识别能力，该游戏本身被设计为通过选择可以表达 5 种基本情绪的不同基本面部表情来创造怪兽形象。该游戏同时包括怪兽和真实的人类形象来让儿童熟悉不同版本的同一种表情。第一轮测试后，笔者根据这些儿童的教师的观察意见对游戏原型做了例如添加游戏音效和逐步增加情绪和表情选择难度的游戏规则等变更。

本研究的结果显示，是否有第三方协助是影响参与度的重要因素之一。根据第一轮和第二轮测试的比较，参与测试的儿童们在他们能够自行选择游戏机制并且使用或控制游戏时，即在更少成人干扰的情况下，会表现出更高的参与度。5 名参与测试结束后问卷调查的儿童均表示该游戏很有趣并且希望再次玩该游戏，其中 1 位甚至在测试结束后立即要求再次玩该游戏。而得益于其易玩性，该儿童可以毫无障碍地自己设置和启动该游戏。其中 1 名儿童在玩过该游戏后能够将全部情绪与相应的表情匹配，而另 1 名则能够自己画出所有情绪的图像。在本游戏的测试

中没有参与者表现出受到了任何负面的影响，但鉴于测试样本较少且游戏测试次数有限，本研究尚无法确认该游戏对于儿童情绪识别能力或某些表情的识别能力的提升。

关键词：增强现实（AR）、教育性游戏、自闭症谱系障碍（AS）、情绪识别能力、交互学习环境

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1. INTRODUCTION

1.1 Context

Autism, otherwise known as autism spectrum (AS), is a developmental condition characterized by difficulties with social interaction, repetitive behaviors, speech, and nonverbal communication, affecting children and adults to similar degrees between east and west (Sun et al., 2019). In China, it affects 40 in every 10 thousand children younger than two years old (Wang et al., 2018). In the U.S., as of 2019, it is predicted to affect 1 in every 59 children, yet in 2000, it was estimated to affect 1 in every 150 (Baio et al., 2018). Aside from the research about the nature of AS, there are studies on the ways and means to assist children on the Autism Spectrum (AS). As AS is a developmental condition, part of the research is on the development of toys that will aid children on the AS in developing the essential skills they will need as adults.

1.2 Importance of Research

Toys and other objects accessible within a child's environment can affect their development. Toys, among other items, may not stunt their development. However, the effect can lead directly to positive outcomes, such as the cultivation of their motor and cognitive abilities, or indirectly to negative outcomes, such as a lack of material bonding or the inability to sustain focus for more extended periods. At present, the notion of toys for children on the AS remains an unusual circumstance. To determine suitable toys requires research by parents, rather than venturing into or browsing any toy stores. While children on the AS can interact with and make use of any regular toy, toys explicitly designed for their particular condition and circumstances will more likely aid in the development of essential life skills with the added assurance of its purpose, instead of merely by chance.

One skill children can develop through playing with toys that is not often associated is emotion recognition. Yet, Pacella and López-Pérez (2018) and Sabatin (2015) have shown that toys and games can develop abilities such as the regulation and identification of emotion. Arya (2009) found that individuals with autism have difficulty understanding the emotional state expressed by another. Taking into account that toys can aid the development of emotion identification, it is not without reason to believe that children on the AS may benefit from a toy or game designed to improve emotion recognition.

1.3 Statement of Intent

Although there have been augmented reality (AR) games designed for children on the AS in research, the AR relies on intentional manipulation as in holding a device to play the game. Such a method demands both mental and physical engagement, which can vary from child to child. Since all previous studies rely on the use of a handheld device for AR, this study will focus on a hands-free setup. This study thus investigates the response of children on the AS towards a hands-free AR game, as well as the development of skills in emotion recognition, an often-unassociated benefit that toys and games can lead to in child development.

1.4 Research Questions

Q1. How would children on the autism spectrum respond to a hands-free augmented reality game?

Previous studies using AR games for children on the AS all use handheld devices to render the game, all finding that the AR was engaging and got the children's attention. However, having to hold the device for delivering the AR in some manner can be limiting to the child's ability to interact with the game. Augmented reality is the superimposition of digital images or elements on one's view of the real world, forming a composite view. The studies on AR for children on the AS have shown this to be of great benefit to them, yet with the inherent limitation of holding a device, as in a cell phone or tablet, or being grounded to a device, such as a laptop, the child's capacity for action or reflection becomes constrained to the area and function of the device. In this study, the instrument responsible for conveying the augmented reality will stand apart from the child, allowing more active use of their hands and a broader view. Playing through the use of artifacts, each child will be studied for their reception to the experience. It is suspected that with a more comprehensive range and the tactile feedback of the game artifacts, a child on the AS will be more receptive and engaged.

Q2. How would a hands-free AR game for children on the autism spectrum affect skills in emotion recognition?

There have been games developed in studies of children on the AS focusing on social, communicative and vocabulary skills (Guerra and Furtado, 2013; Machado, Moraes and Nunes, 2009; Zakari, Ma and Simmons, 2014), some even focusing on emotion recognition (Almeida et al., 2019; Boutsika, 2014; Fernandes et al., 2011; Guerra and Furtado, 2013). However, as noted previously, the interaction was limited in

all cases, given the setup of the device. As such, in investigating children's response to a hands-free AR game, this study will focus on the effect it could have on emotion recognition. Children participating in this study will be assessed for their ability to identify and communicate the basic emotions before and after use of the game, thus determining if there was an effect.

1.5 Background

Approximately one percent of children are diagnosed on the autism spectrum (Sun et al., 2019) with greater representation among boys than girls (Goldstein and Naglieri, 2014). It appears as a set of behaviors manifesting to varying degrees that will accompany them throughout the whole of their lives. This condition is neither temporary nor curable. Symptoms usually appear in the early stages of life (Granpeesheh et al., 2015). As these aspects of autism can influence the rest of their lives, it is imperative to adjust the surrounding environment to ease their development. According to Kenny (2016), some people related to the AS do not usually acknowledge it as a disease or disability but more so as a different way of experiencing life with the only problem being to inhabit a world ill-prepared for them. A neurotypical world where people follow some rules and customs is bearable to most, yet not everyone, which sets up barriers they only disappear when interacting with other people on the spectrum.

Autism manifests in different ways. These manifestations are not only harmful in the present life of the child but also, in the future, affecting academics and their social lives. According to the DSM-5 (APA, 2013), there are two categories of diagnostic criteria: deficits in social communication and interaction, and restricted or repetitive patterns of behavior, interests, or activities. Table 1 shows the main diagnostic criteria presented by DSM-5 for identifying behaviors symptomatic of AS.

Another peculiarity of people on the AS is the inability to form a whole global picture in mind when receiving the parts defined by Gestalt principles (Shah and Frith, 1993). This inability is part of what causes the deficits listed in Table 1. Having a distorted mental picture derived from one's senses that cannot be made sense of or understood overwhelms a person on the spectrum, causing the need to take a break from the sensory world, either through isolation or producing self-stimulation that will nullify other sensory information. Further research on this topic would not only improve the lives of people on the AS but also those of their families, friends, and teachers, among others, in their environment. As such, tools are needed to help them overcome their difficulties and aid caregivers in adapting.

Table 1 Main diagnostic criteria

Deficits in social communication and interaction	• Social-emotional reciprocity (e.g. inappropriate approach, failure to initiate or maintain conversations). • Nonverbal communication (e.g. failure to maintain eye contact, misunderstanding of body language or gestures) • Understanding and cultivating relationships (e.g. inadaptability to social contexts, difficulty to make friends or engage in imaginative play).
Restricted, repetitive patterns of behavior, interests or activities	• Repetitive speech, use of objects or movements. • Inflexibility to change, strong adherence to patterns or routines. • Strong fixation on interests, extreme in intensity or focus. • Hyper- or hypo-reactivity to sensory input.

1.5.1 Role of Play in Development

The elementary stages of life are fundamental in the development of basic skills and tools necessary for living in the world. This growth is possible given the unique sensitivity children and toddlers show and experience during this period. It is thus crucial to provide an environment rich in experience and diversity that allows them to explore, discover, feel safe and grow, and gain knowledge and skills that will benefit them their whole lives, provided this environment remains healthy and happy (Britto et al., 2017).

One means of providing this learning-friendly environment is through play. Playing has beneficial effects later on in development. It helps children to interact with the surrounding world, exploring this and themselves, discovering how their bodies work, and developing what they can do. As toys are the principal implements of play, it is clear the urgency in ensuring access to the appropriate toys that will maximize such gain (Dauch et al., 2018). Not only are there benefits, but it is desirable in preventing different kinds of disorders or illnesses later on in adulthood. During this period of extraordinary openness to the world, the seeds of various types of misfortunes that will affect healthy development can be seeded. Circumstances resulting in these misfortunes can be reduced if the child is provided an adequate social environment. Dolls, action figures, balls, video games, building blocks, smartphones, and more are several of thousands of options

available for parents and caregivers to bring children joy and happiness. However, problems arise when the toy or device given to the child is solely for entertainment. Not only does it not educate them, but it may destroy their capacity to develop a fully-functioning brain. Thus, it is essential to analyze this ecosystem and provide a clearer idea of what are the aspects of toys that affect children in the development of their brains and bodies.

Playing with the appropriate toys can aid development in childhood (Mikolajewska et al., 2015). Promoting interest in the arts and related disciplines has been shown to have a firm connection with the progress of creativity towards proper critical thinking (Topoğlu, 2014; Wechsler et al., 2018). This is not solely a matter of helping children to develop their imaginations; it affects their future, helping them to become problem solvers capable of making their own decisions. A matured imagination will assist them in both their personal and professional lives and can help children with exceptional situations to control and minimize the effects on their daily lives (Crespi et al., 2016).

In the study of toys and child development, part of the focus has been on the importance of toys and the objects in a child's environment on their progress. A child must advance through the proper stages from infant and toddler to child, and therein acquire the essential skills and knowledge to adapt to the world (Piaget and Inhelder, 1998). Several studies have investigated the potential impact of surrounding objects and have proven their influences on proper development (Alexander, Wilcox and Woods, 2008; Britto et al., 2017; Chang and Yeh, 2015). The quality and suitability of toys available to children also need to adapt (Dauch et al., 2018; Benjamin, 2010) as different kinds of toys train different types of abilities, such as construction materials for enhancing motor and cognitive ability and symbolic play to improve the senses (Chang and Yeh, 2015). There is also proof that through playing with toys and games, capabilities such as emotional development, the regulation and identification of emotion, and independence can advance (Pacella and López-Pérez, 2018; Sabatin, 2015).

1.5.2 Purpose of Toys

In the initial stages of life, toys help children develop necessary motor and communication skills. Kids build and strengthen muscles through such actions as holding and throwing these toys, and learn to communicate feelings and needs through the objects they interact with. Later on, they may learn to live in a community by sharing their toys and using them in the company of other children. In this state, they will observe the world, understand it in their way, and seek to express themselves by emulating what they see (Mikolajewska et al., 2015).

Some may refute the widespread belief in children's crazy and limitless imaginations, but this does not mean children do not have any creativity and that this should not be encouraged. The problem is the ambiguous definition of creativity, given a broad range of possibilities on how to define it. Lane describes children as skeptical (Lane et al., 2016), which is not necessarily a bad quality to have. A skeptical mind is more receptive to judging the world and investigating its possibilities. Such a mind does not believe what it encounters and questions it instead.

Most developments in children's cognitive abilities occur during the stage that Piaget calls the sensorimotor stage (1998). At around seven months of age, children will start remembering. Mobility allows them to explore and interact, which, combined with memory, will result in the first signs of symbolic language. By the age of four, children will demonstrate the ability to develop explanations to incongruent problems by imagining an alternative reality (Richards and Sanderson, 1999), and there are also behavioral patterns children will adopt early in life that will be hard to modify later on in adolescence or adulthood.

One of the main touchpoints in the matter of suitable child development is toys. Kids play to learn. They explore, touch, break and copy what they see, and the more they learn, the more sophisticated their games can get, which requires more attention for scanning the world and finding the information needed to achieve their goals. Such focus is difficult to maintain in an over-stimulating environment. Children need to play in different ways, to try different uses and iterate to fully attain the potential of any given toy. Research has shown, however, that this variety is less common in a room overloaded with toys (Dauch et al., 2018). This excessive availability causes children to switch from one toy to another too frequently, thereby lacking a fruitful relationship with any particular object. Patience and the ability to focus for more extended periods can be useful for the rest of their lives.

1.5.3 Application of Augmented Reality

Augmented Reality (AR) is a rendering technology that allows real-time interaction between the immediate environment and virtual elements, manifesting as computer-generated images overlapping the real-world sensory information. Though it is a relatively new technology, there are already some positive results from experiments showing its use for educational purposes. Two examples are the AR Educational Magic Toys and CPR-training in school (Semeraro et al., 2017; Yilmaz, 2016). Generally, AR with kids brings back positive feedback as they liked the magical effect of combining the real world with virtual elements beyond the screen (Yilmaz, 2016). Children also appreciated the ease of use and the possibility of instant feedback (Semeraro et al., 2017).

Probably one of the aspects of AR that helps in these applications is how it focuses the attention of the user, allowing for more in-depth involvement with the content (Malaquias, Malaquias and Hwang, 2018).

Several experiments have checked the suitability of AR for children on the spectrum. Results have shown there was an improvement in levels of participation and interaction as long as there was an increase in the focus of the children on the AS performing the task (Alakärppä et al., 2017; Lee et al., 2018; Odom et al., 2003). AR catches their attention and reminds them to engage with the task in hand, allowing them to overcome their difficulties in interaction. Reality is unpredictable. Mistakes and their consequences can overwhelm an infant on the AS. This unpredictability is reduced in a virtual environment. This ability to practice in an error-free environment, where one can repeat or do over to correct mistakes and receive instant feedback, is part of the benefits of AR (Benton et al., 2012). Research has already shown that creating simple and clear goal-oriented games can help in the process of adaption for children on the AS (Benton et al., 2012). Also, adapting technology to the child lessens the gap between neurotypical (NT) and neurodivergent (ND) worlds, which can give the child a sense of control, or empowerment (Alakärppä et al., 2017; Benton et al., 2012).

Over the last few years, there have been many experiments utilizing AR for AS. In general, the feedback has been positive. The need for physical interaction and attention to actions and objects has proven to be therapeutic for children on the AS, as observed on their own or with friends and family helped them to socialize and communicate with others as noted in the adventure game by Malinverni (Malinverni et al., 2017). Other uses of AR have been directed toward the training of social skills and interaction, such as in the videos of AR concept maps created by Lee and their colleagues (2018) to help children on the AS understand the bigger picture of their social environment and the relationships among them. In an experiment by Bhatt, De Leon, and Al-Jumaily (2014) encouraged higher levels of concentration using AR, increasing the chances of improving the social skills being trained. All of the games and toys in these experiments were very carefully designed and focused mostly on the goals of benefitting the children (Cunha et al., 2016). Other trials using AR have sought to create natural interactions within the virtual world, either through AR or with humanoids (Lakshmiprabha et al., 2014; Miskam et al., 2014).

1.5.4 Emotion Recognition

Research has shown that individuals with autism fail to understand the emotional state expressed by another person (Arya, 2009). Adolescents with high-functioning AS have subtle deficits in the processing of facial expression and emotional interference, and

aside from exhibiting errors in recognition, they make stronger positive or negative emotional connections with expressions than individuals without AS (Liu et al., 2018). This makes the identification of complex emotions a specific marker of high-functioning AS (Sachse et al., 2014). Detecting the gender, age or mood from a person's face in fractions of seconds is impossible (Kennedy and Adolphs, 2012; Atul and Anurag, 2014) and despite being attentive, children with AS are unable to understand the information presented to them (Assumpção et al., 1999). Matsuda, Minagawa and Yamamoto (2015) found there was no difference in the gaze behavior between children with on the AS and children of typical development toward non-speaking static facial expressions. The data at present suggested no difference either in looking at the picture of a facial expression. This would be important, provided that aversion or directness of gaze assists the speed of identification of an emotion for neurotypical children (Adams and Kleck, 2005; Akechi et al., 2009). Whether gaze is direct or averted is also observed to affect the perception of the emotion's intensity (Graham and LaBar, 2007; Sander et al., 2007). However, it has been shown that the direction of gaze did not affect the speed for children on the AS, meaning less of the spontaneous integration of eye gaze direction and communicative intent (Akechi et al., 2009). Studies have shown that individuals with autism demonstrated impairment in recognition of negative emotions as in anger (Lindner and Rosén, 2006), sadness (Boraston et al., 2007), and fear (Pelphrey et al., 2002; Wallace, Coleman and Bailey, 2008). Confirming these previous studies, Tell, Davidson and Camras (2014) found that children with AS had a more significant impairment in the recognition of fear, as well as a trend for sad expressions, in which they were less accurate at identifying sadness with direct eyes, also rating expressions with direct eyes or 50 percent as more intense than typical-developing children.

Bölte and their colleagues (2006) found that individuals with HFAS benefit from affect recognition training with gains in facial affect recognition in autism associated with higher activation in brain areas that participate in the compensatory facial processing network. Grossard and their colleagues (2017) posited that more attention should be given to game design and the development of a specific framework for the type of serious game that would challenge and engage. For the training of social skills, games are up-and-coming. In agreement, Pacella and López-Pérez (2018) proposed that games could be extremely beneficial to children with HFAS as they may not only improve skills in emotion recognition but also in the regulation of interpersonal emotions. However, games like Tough-Emotions from Special iApps which shows images of random facial expressions (Fernandes et al., 2011) or Emotions from Grasshopper Apps which presents photos of real people with various facial expressions, requiring a child to identify emotions by associating the same images, lack interactivity (Winoto, Cao and Tang, 2017). It has been shown that not only can games be adapted from the treatment

techniques of Image Exchange Communication System, Applied Behavior Analysis and Treatment and Education of Children with Autism and Communication (Guerra and Furtado, 2013; Boutsika, 2014), but adapting these treatment techniques into games and incorporating them into the learning process can result in considerable development in school (Seletos, 2012). In terms of emotion recognition, Almeida and their colleagues (2019) made a role-playing game called ALTRIRAS for associating basic emotions with the corresponding facial expressions. As in an adventure game, children collect items (parts of facial expressions) and must use these collected items to assemble the requested facial expression in a challenge, as well as gather emotions for a character they are training called emotion. As noted by Almeida and their colleagues in designing and selecting the emotions for their game, being able to recognize the basic emotions is essential for the understanding of more complex emotions (Assumpção et al., 1999).

2. METHODOLOGY

2.1 Participants

The students participating in this experiment were recruited from Luwan Special Education School (卢湾辅读实验学校) in Shanghai for two sessions, three children each. There were six participants in total. Four of the children were on the AS, whereas the other two were neurodivergent. Following the first session, three teachers were consulted for their opinions and feedback on the game.

2.2 Referent

For this experiment, the AR game presented to participants was a prototype. It consisted of two subgames: Create A Monster and Guess the Emotion. The full concept is shown in the next chapter, 3. GAME CONCEPT. In short, children are given 15 cards featuring shapes, colors, and facial expressions on a cartoon character. For Create A Monster, children pick one of each type of card, showing it to the AR device, which then generates the image of a monster based on the shape, color, and facial expression provided. For Guess the Emotion, children are shown a monster and must identify the monster's expressed emotion, presenting their guess as one of the five cards for facial expressions. The latter game, Guess the Emotion, has scaffolding, meaning that there are levels of difficulty. In the first level, the child is shown the monster they created in Create A Monster with either one of two expressions. At the fifth and final level, a child may be shown either any random monster or human with any one of the five expressed emotions.

2.3 Apparatus

The experiment was performed on a tablet running a prototype of the AR game, set up in a small room allocated by the school. The room had one door to another classroom that was used as a waiting room for the other participants, as well as two windows, one opening to the aforementioned waiting room and the other facing the school's playground. During the experiment, the playground was empty. Figure 1 shows the setup of the room where the test took place.

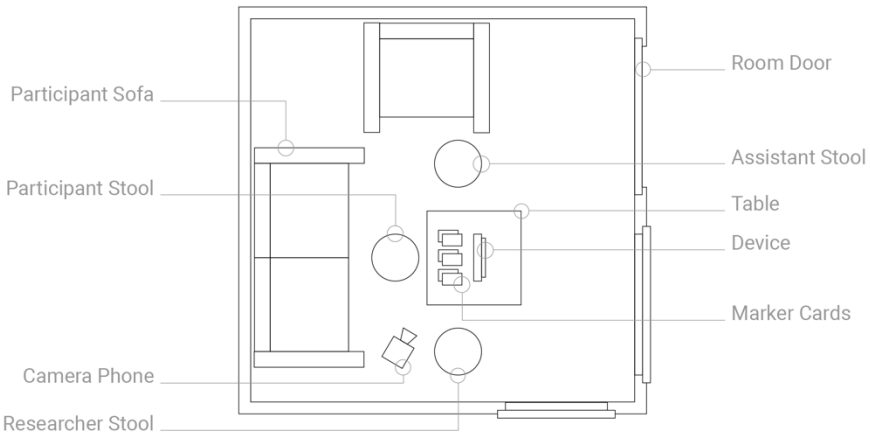


Figure 1. Experiment Room Setting

Participants could choose whether to sit on the stool or sofa in the room. The table would then be moved accordingly. The materials for the experiment would be set up and laid out on the table. The device showing the game prototype would be set up to face the participant with the cards laid out between the participant and the device, as shown in Figure 2. A cell phone was set on a tripod set beside the researcher to record the session, capturing their hands, the cards, and the screen. Given that it was AR, the participant's face would be reflected on the screen.

Figure 2. Tablet computer setup: device, participant and cards

Divided into three stages, students filled out a pre-test questionnaire determining their current skill level in emotion recognition, played the game, and then filled out a post-test questionnaire to assess any differences and their impression of the experience playing the game. Table 2 shows each stage of this test and the tasks each phase consisted

of. As observed, the steps to follow in every stage of the experiment were established according to the objectives above: collecting data on emotion recognition abilities before and after, following the game logic as scaffolding entails, and gathering information about the experience. Due to the specific circumstances of children on the AS, the assistant provided indications or help as needed. Also, the duration of tasks was adjusted, or tasks were skipped if necessary, to ensure the well-being of the participant.

Table 2 Experiment stages and tasks

Pre-Test	Game	Post-Test
Question 1: Can you draw this	Introduction to the cards	Question 1: Can you draw this
Question 2: Please, draw lines from emotions to faces	Introduction to Tutorial game [Session 2]	Question 2: Please, draw lines from emotions to faces
Question 3: What are their emotions	Tutorial game (free play) [Session 2]	Question 3: What are their emotions
Question 4: What are their emotions (markers) [Session 2]	Introduction to Create a Monster game	Question 5: Please, fill out this table about the game
	Create a Monster game (free play)	Question 6: Would you do it again
	Introduction to Guess the Emotion game	Question 7: Was it… fun/boring
	Guess the Emotion game (free play)	Question 8: Was it… easy/hard

For the teacher feedback, the teachers were given a demo of the game, in which they could engage with the equipment while providing comments and suggestions. Afterward, they then filled out a survey.

2.3.1 Equipment

For the experiment, necessary items consisted of the device for presenting the game prototype, two decks of cards, an android phone, and a tripod. The device was a Microsoft Surface Pro 3, running the game using Play Mode in Unity through the Vuforia Unity AR engine. There were two decks of cards, consisting of 15 cards each, printed on 300 gsm cardstock.

2.3.2 Materials

The pre-test questionnaire was conducted as a series of tasks to ascertain a child's preliminary understanding, or familiarity, with the emotions presented in the game. As such, the tasks of the pre-test questionnaire consisted of recognizing emotions in different ways. There were four tasks in total.

In Question 1: Can you draw this, participants were asked to draw faces showing particular emotions, namely sadness, happiness, anger, surprise, and fear. Figure 3 shows

the form for completing this task. The purpose of this question was to analyze the given representations according to EMFACS and the use of its action units and to compare between pre-test and post-test versions of this task.

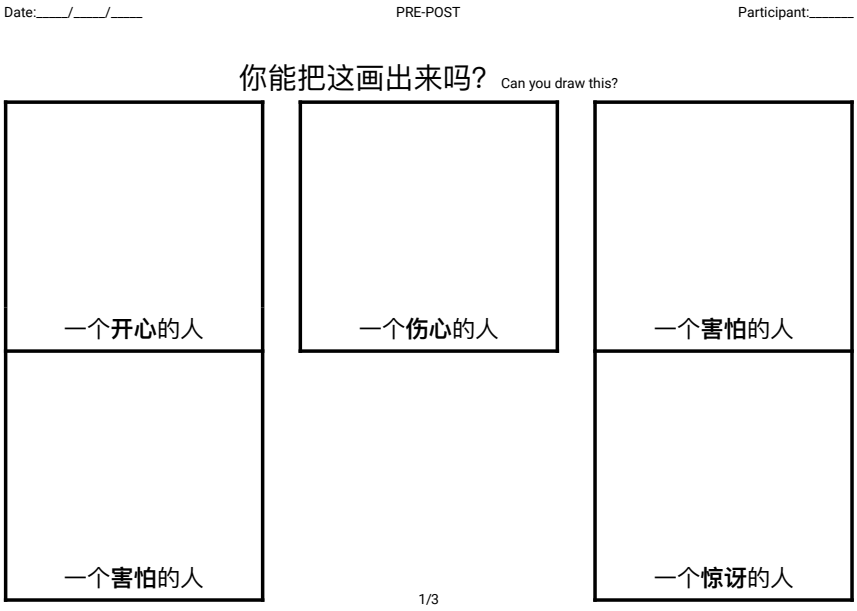


Figure 3. Question 1 of the Pre-test Questionnaire: Can you draw this?

In Question 2: Please draw lines from emotions to faces, participants were presented with five human faces taken from the Japanese Female Facial Expression (JAFFE) database (Figure 4). The faces expressed the basic emotions of anger, sadness, surprise, happiness, and fear. To indicate which face shown which emotion, they were to draw lines connecting the image of the face to the emotion word it corresponded to.

In Question 3: What are their emotions, participants were again presented the faces obtained from the JAFFE database (Figure 5). Instead of five, though, this time, there were six faces, including a neutral face, which acted as a control and was ignored when counting the right answers. For this task, the participant was expected to either write the corresponding emotion word in the box under each face or to answer orally, so that the assistant could write down their response.

Figure 4. Question 2 of the Pre-test Questionnaire: Please draw lines from emotions to faces

Following the first session of the experiment, given the changes to the markers made according to the teachers' suggestions, the fourth question was added. In Question 4: What are their emotions, participants were presented with five new illustrations taken from the emotion markers (Figure 6). This checked whether children understood the emotions they were being shown, provided the style used in the game.

Following the time spent playing the game, the post-test questionnaire used the same questions, except for Question 4, for comparison with the pre-test questionnaire. To gain participant feedback, the post-test survey included several more questions about the experience of playing the game. Thus, in total, the post-test questionnaire had eight questions.

In Question 5: Please fill out this table about the game, participants were presented with a Smileyometer (36), an adaptation of the Likert Scale using emoticons to represent the five possible answers: Awful, Not very good, Good, Really good, and Very good. The participants were to indicate a degree of likability for each aspect of the game: Create a Monster, Guess the Emotion, Monsters, Humans, Colors, and Cards. The form of this question is shown in Figure 7.

Figure 5. Question 3 of the Pre-test Questionnaire: What are their emotions

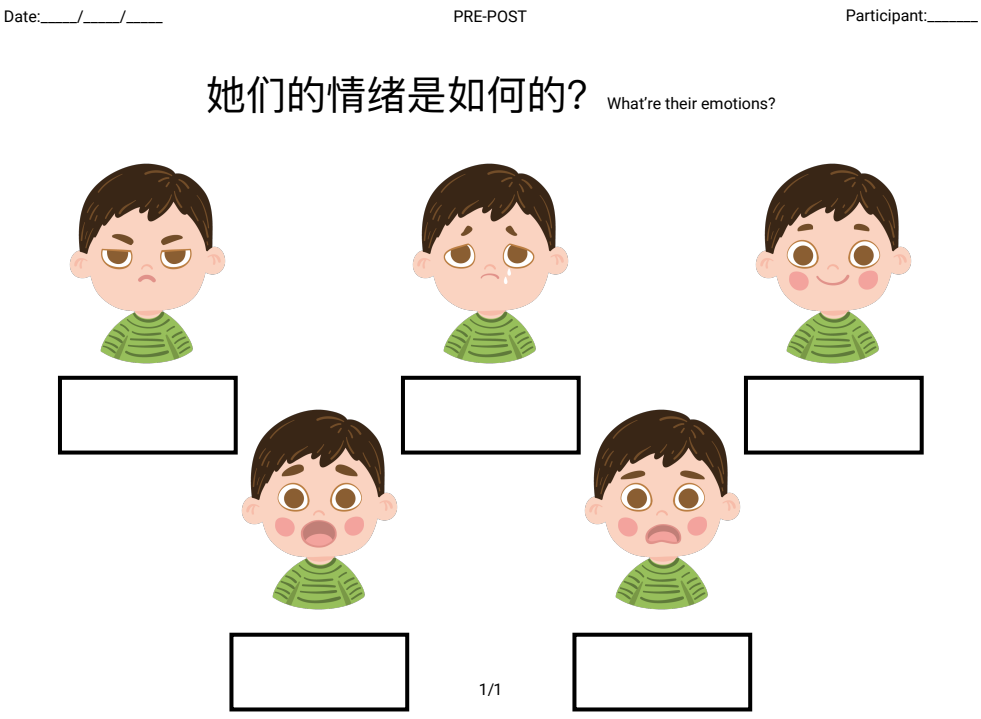


Figure 6. Question 4 of the Pre-test Questionnaire: What are their emotions (markers)

Date:____/____/____ CHILD Participant:_____

请回答有关游戏的下表： Please, answer this table about the game:

	糟糕 Awful	不是很好 Not very good	好 Good	很好 Really good	非常好 Very good
怪兽工厂游戏 Create a monster game					
情绪猜猜猜游戏 Guess emotions game					
怪兽 Monsters					
人 Humans					
颜色 Colors					
卡片 Cards					

1/2

Figure 7. Question 5 of the Post-test Questionnaire: Please fill out this table about the game

In Question 6: Would you do it again, based on Again-Again, proposed by Read (36), participants were presented with different tasks from the game and were asked to indicate if they would play it again, maybe or not. In Question 7: Was it fun or boring, the participants were given the options of answering fun or boring regarding the two games presented in the prototype. For Question 8: Was it easy or hard, the participants were given a similar question to Question 7 but with different options. Given the same topic, items 6, 7, and 8 were asked together (Figure 8). These questions were intended to gain insight into whether the children enjoyed playing the games.

Apart from the questionnaires for the children participating in this experiment, another survey was needed for the teachers or experts (Figures 9-11). The point of this survey was to obtain expert feedback on the games' suitability for the specific needs of children on the AS using a set of Likert Scale questions.

The questions on this survey were divided into four parts: Game adaption, Create A Monster experience, Guess the Emotion experience, and the game experience. The first part consists of Questions 1 through 9; the second part, Questions 10 to 12; the third part, Questions 13 to 18; and the last part was covered in Questions 19 to 26.

Date:____/____/____ CHILD Participant:_____

你会吗再玩一次? Would you do it again?	不会	也许	会
怪兽工厂游戏 Create a monster game			
情绪猜猜猜游戏 Guess emotions game			

这个是... Was it...?	好玩吗? Fun	无聊吗? Boring
怪兽工厂游戏 Create a monster game		
情绪猜猜猜游戏 Guess emotions game		

这个是... Was it...?	简单吗? Easy	困难吗? Hard
怪兽工厂游戏 Create a monster game		
情绪猜猜猜游戏 Guess emotions game		

2/2

Figure 8. Question 6, 7 and 8 of the Post-test Questionnaire

Date:_____/_____/_____ CARER-GAME Participant:_____

说明 DIRECTIONS

本问卷旨在衡量您对于这些游戏的看法，以及孩子的游戏体验。请阅读每个说法，并根据所描述的同意或不同意的标准进行回答：

This questionnaire is designed to measure your appreciation about the game and the child experience. Read each of the statements and answer them in terms of your agreement or disagreement as described:

如果你极其不同意该说法，请圈0 If you strongly disagree with the statement, circle the 0.
如果你不同意该说法，请圈1 If you disagree with the statement, circle the 1.
如果你对该说法持中立看法，请圈2 If you have a neutral opinion about the statement, circle the 2.
如果你同意该说法，请圈3 If you agree with the statement, circle the 3.
如果你极其同意该说法，请圈4 If you strongly agree with the statement, circle the 4.

答案无对错，请勿在完成本问卷时跳过任何问题。 谢谢!

There are no right or wrong answers. Please **do not skip any question** when completing this questionnaire. Thank you.

- 孩子姓名: Child's name _____
- 孩子生日: Child's Date of Birth _____
- 您与孩子的关系 请圈出合适的选项

How are you related to the child? Please circle the appropriate response):

母 Mother　父 Father　监护人 Guardian　其他: _____ (请指明) Other: (please specify)

	极不同意 Strongly Disagree	不同意 Disagree	中立 Neutral	同意 Agree	极其同意 Strongly Agree
该游戏中所出现的技术问题，不利于用户体验 The game attracts the child's attention	0	1	2	3	4
该游戏操作十分简单 The game is easy to use.	0	1	2	3	4
该游戏适合儿童 The game is adequate for the child's profile	0	1	2	3	4
该游戏可以帮助提升依靠脸部表情理解他人情绪的能力 The game can help improve the ability of understanding other people's emotions by their facial expression	0	1	2	3	4
该游戏对于孩子而言是有趣的 The game is interesting for the child	0	1	2	3	4

1/3

Figure 9. First part of the Expert Questionnaire given to teachers

Date:_____/_____/_____ CARER-GAME Participant:_____

	极不同意 Strongly Disagree	不同意 Disagree	中立 Neutral	同意 Agree	极其同意 Strongly Agree
该游戏吸引孩子注意 The game attracts the child's attention	0	1	2	3	4
孩子在玩游戏时看上去乐在其中 The child appears to have fun while playing the game	0	1	2	3	4
AR环境的使用改善了孩子的体验 The use of the Augmented Reality environment improves the child's experience.	0	1	2	3	4
孩子看上去享受与AR环境进行互动 The child appears to enjoy interacting with the Augmented Reality environment.	0	1	2	3	4
游戏"怪兽工厂"有助于将体验私人化 The "Create Monster" game helps personalise the experience	0	1	2	3	4
游戏"怪兽工厂"对于孩子而言是容易理解且上手的 The "Create Monster" is easy to understand and play by the child	0	1	2	3	4
孩子看上去乐于根据其选择来创造新怪兽 The child appears to enjoy creating a monster according to their choices.	0	1	2	3	4
游戏"情绪猜猜猜"对于孩子而言是容易理解且上手的 The "Guess Emotions" game is easy to understand and play by the child.	0	1	2	3	4
孩子看上去享受根据其选择来猜测角色的情绪 The child appears to enjoy guessing the character's emotions according to their choices.	0	1	2	3	4
为了孩子学会如何玩该游戏，"情绪猜猜猜"适当地提升其难度 The "Guess Emotions" game increases its difficulty appropriately for the child to learn how to play.	0	1	2	3	4
孩子可轻易理解"情绪猜猜猜"中怪兽的情绪 The emotions of the monsters in the "Guess Emotions" game are easily understood by the children.	0	1	2	3	4
孩子可轻易理解"情绪猜猜猜"中虚拟人的情绪 The emotions of the virtual humans in the "Guess Emotions" game are easily understood by the children.	0	1	2	3	4
"情绪猜猜猜"游戏引导孩子理解正确的回答 The "Guess Emotions" game guides the child to understand the right answer.	0	1	2	3	4

	极不同意 Strongly Disagree	不同意 Disagree	中立 Neutral	同意 Agree	极其同意 Strongly Agree
该游戏节奏太快了 The pace of the game is too fast.	0	1	2	3	4
该游戏太无聊了 The game is too boring.	0	1	2	3	4

2/3

Figure 10. Second part of the Expert Questionnaire given to teachers

Date:_____/_____/_____ CARER-GAME Participant:_____

	极不同意 Strongly Disagree	不同意 Disagree	中立 Neutral	同意 Agree	极其同意 Strongly Agree
该游戏是基于直觉的 The game is intuitive.	0	1	2	3	4
该游戏吸引孩子注意 The game attracts the child's attention.	0	1	2	3	4
该游戏太难了 The game is too difficult.	0	1	2	3	4
在游戏中所使用的颜色过于刺激了 The colours used in the game are too stimulating.	0	1	2	3	4
该游戏太简单了 The game is too easy.	0	1	2	3	4
该游戏过于刺激了 The game is too stimulating.	0	1	2	3	4

Figure 11. Third part of the Expert Questionnaire given to teachers

2.4 Procedure

Following the three stages, the pre-test questionnaire was filled out. During Question 1, all participants were able to draw either some or all of the faces but needed help from the assistant in reading out the written instructions. The task stopped when finished or if a problem occurred, such as taking too long or not paying attention. For Question 2, the children still needed the guidance of the assistant as most would not draw the lines between the faces and emotion words on their own. This proved to be harder than other tasks and was thus skipped in the post-test in Session 1 and altogether in Session 2. While Question 3 also required guidance from the assistant to complete, it was doable. When Question 4 was added for Session 2, it did not present too much difficulty.

For the second part of the experiment, the play stage, the participants were given the game to play with, receiving guidance when necessary, playing for some amount of time until they were told to stop. In the first session, the assistant explained the difference between markers regarding the shapes, colors, and emotions. Still, in the second session, this was taken care of by the Tutorial Game, which allowed the children to learn the meaning of the cards through the prototype. Thus, the Tutorial Game was only introduced and played during the second session. None of the participants of the second session showed any problems with the Tutorial Game.

In playing the game, participants first played the Create A Monster game. The explanation for this game was based on pointing out the three different kinds of cards they could use, and if needed, it would be indicated to them what kind of cards they needed to use at any moment or shown an example of how to use the game. When the monsters were created, most participants did not interact with the screen, so the assistant

had to accept or reject the monster for them upon asking the participant. Following the Create A Monster game, for Guess the Emotion, the participants were only to use the five cards with facial expressions and explained as necessary on how to answer. All participants understood relatively quickly how to play this subgame. Only one participant had to skip it as they needed to terminate the experiment before becoming too exhausted. The rest of the participants played the game up to the last level and then were asked to stop for the post-test questionnaire.

For the post-test questionnaire, some of the participants had to skip some of the initial tasks repeated from the pre-test questionnaire, meaning the first through third questions, to ease the process. On Question 5, the participants were assisted by the assistant in filling out the table. Most of the participants would point to the emoticon or write their responses. Then the assistant would take notes when advised. For Questions 6 to 8, the assistant wrote down the answer for all of the participants. Only one of the participants abstained from answering Questions 6 through 8 regarding the Guess the Emotion game.

After the first session with the children, their teachers were surveyed and interviewed, gathering their insights on the game and children they are familiar with. The interview was conducted in an open conversational manner with the help of the assistant for translation. The teachers shared their points of view on the game, provided comments and suggestions from the practices they usually use in their classes with children on the AS. The interview and survey could not be conducted following the second session as no teacher was available.

2.4.1 Intersession Changes

Given preliminary analysis following the first session and the commentary from the teachers, the game was modified to include the effect of the improvements in the results of the second session. Revisions implemented consisted of changing the illustration style of the cards, redesigning the scaffolding—or level system—of the game, adding voice and sound effects, as well as minor changes to the monsters. Before the first session, the cards for facial expressions presented illustrations based on Twemoji from Twitter. Some of the teachers mentioned that in class, usually, the pictures they use to represent emotions are cartoon figures. Thus, they suggested utilizing this kind of design to improve the understandability of the cards since the children would be more familiar with the latter style. The cards for emotions were thus updated with graphics based on Pikisuperstar, taken from Freepik.

The first system for the game's scaffolding was updated to include all emotions from the beginning and, at the final level, show only the virtual human faces. Suggestions

indicated that it would be beneficial to redesign the level system to give more control to the child and to dispense emotions gradually. Therefore, the logic between levels was adapted with virtual humans appearing from level two and emotions appearing increasingly, starting with only two and increasing up to five as the levels increase. A means of switching levels was also made available on the screen, showing the current level and offering the possibility of jumping to the next or previous level.

To avoid sensory overload, the game was initially designed without sound effects or voice, relying only on visual and text prompts. However, during the first session, participants showed little responsiveness to the game, needing help from the assistant. Teachers also thought that such elements would help engage the children and aid those with reading difficulties. Hence, part of the revisions included the addition of auditory messages and sound effects to guide the children and help them understand what was happening in the game.

Lastly, there were comments on the faces of the monsters, indicating that some details could confuse. For instance, blue eyes could be confused with tears, and teachers usually represented sad faces with tears. On this basis, some minor revisions were made to the monsters' faces.

2.5 Variables

From the questionnaires administered to child participants and observations, this study tracks their responses and any changes in the skill of emotion recognition between before and after playing the game. Notes and observations of their personal experience provide the children's perception of the games, particularly in the dimensions of fun and ease of use. These can be interpreted as appeal and interest.

Apart from the child participants, comments from their teachers and survey results can provide a qualitative measure of the suitability of this study for children on the AS.

3. GAME CONCEPT

3.1 Design Parameters

Since children on the AS do not follow the same developmental path as NT children, it is not appropriate to categorize them solely by age. Other aspects, such as their ability to speak and read, should also be taken into account. In general, the AR game in this study was targeted at children on the AS in school, approximately 6 to 12 years of age. In designing an AR system, all the usual precautions of any design project should be taken into account, and aside from the general requirements in designing for children, as in safety, age suitability and appeal, children on the AS require even more caution. Furthermore, this project tries to avoid the usual limitations that other AR settings imply by releasing the need of carrying the device and presenting it as an interaction with the screen instead of through the screen. This way the participant can interact freely with the marker cards and explore in a more natural way as they would play with other traditional games or toys. Research has suggested some features to consider in addressing these requirements: equilibrium, adaption, predictability, attention, scaffolding, and clean design.

3.1.1 Equilibrium

Even knowing that video games can help children on the AS to feel less lonely and to have more friends, this still comes with the condition of fair use, meaning to play only around an hour per day (Sundberg, 2018). Another mistake to avoid is the oversimplification of tasks. When gamifying any educative process, the flow needs to be flexible and straightforward, but the benefits may decrease if too simple (Malinverni et al., 2017).

3.1.2 Adaption

Several researchers, as in Khan, Tahir, and Raza (2013) or Walsh and Barry (2008), have offered sets of guidelines for adapting visual interfaces for the individual needs of subjects on the AS. This noted, any adaption provided should increase the degree of a player's attention and encourage interaction, to improve the target skills of the experiment (Baker, 2000; Carter, 2001). It is thus essential to keep in mind that while designing a game, a carefully designed and focused approach will ensure the most benefit (Cunha et al., 2016), as well as the provision of the option for a player to personalize or

adapt a game to their tastes (Yusoff, 2010). This can mean adjusting functions, such as duration, order, and progression.

3.1.3 Predictability

Individuals with autism find real-life social interactions to be stressful and intimidating, given their unpredictable and judgmental nature. In virtual reality, both visual and auditory stimuli can be controlled and gradually increased as the child becomes more familiar and comfortable with the provided environment (Bernardini, Porayska-Pomsta and Smith, 2014).

3.1.4 Attention

Any game should include an element of surprise to draw and maintain the attention of a child. It should invite interaction and exploration, leading to the discovery of new things (Malinverni et al., 2017). Aside from maintaining a child's attention, having elements of surprise can also help to prepare children on the AS for change and slowly expose them to chaotic, or uncontrollable situations. However, it is important that while drawing their attention to avoid color palettes with excessively intense colors so that a child will not experience sensory overload (Walsh and Barry, 2008). Pastel tones can be used instead (Vogel, 2008).

3.1.5 Scaffolding

There is a benefit to having some adaptability to the different levels of function in games (Grossard et al., 2017). Among children on the AS, some have less developed capabilities than others. A game should thus discriminate between none of them.

3.1.6 Clean Design

The visual presentation of a game needs to be very clean and straightforward to avoid distractions and direct a child's attention to its functional components. This means that navigation should be step-by-step with only one thing to do at a time and to contain all information needed on the same page to avoid causing a child any difficulty in discerning the whole idea (Walsh and Barry, 2008; Fage et al., 2019). As such, distracting stimuli should be avoided. Apps need to have a very simple user interface with little to no use of words to improve their appeal to a population that can often process information better visually than visually. The presence of excess words can make them more easily distracted by irrelevant visual stimuli (Hourcade et al., 2013).

3.2 Emotional Facial Action Coding System

Whereas emotion recognition comprehend a vast concept and it is impacted by contextual elements, some simplification is conducted for training purposes. This reduction includes the selection of basic emotions to begin with the teaching as long as some classification that helps in the understanding. Thanks to the Emotional Facial Action Coding System, otherwise known as EMFACS, an emotion can be divided into combination of simple items easing the comprehension.

EMFACS is a categorization of human facial movements in action units (Friesen and Ekman, 1983). As seen in Figure 12, the combinations of several of these action units represent different emotions. For example, according to EMFACS, the happiness emotion is shown in a face by the use of the action units 6 (cheek raiser) and 12 (lip corner puller).

Action Unit	FACS Name
1	Inner brow raiser
2	Outer brow raiser
4	Brow lowerer
5	Upper lid raiser
6	Cheek raiser
7	Lid tightener
12	Lip corner puller
15	Lip corner depressor
20	Lip stretcher
23	Lip tightener
26	Jaw drop

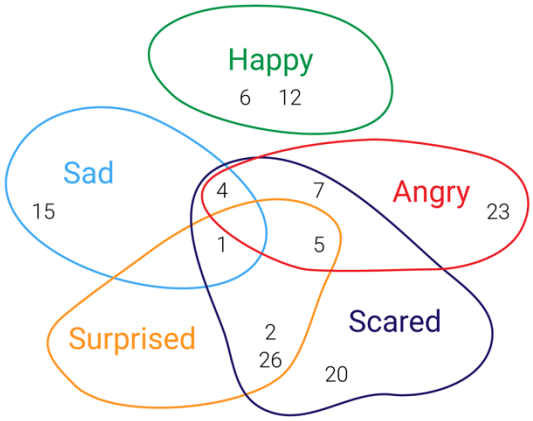


Figure 12. Action units from EMFACS and their relationship with the emotions in the game

EMFACS was used to design the faces of the monsters used in this game (Figure 13). It was also used in analyzing Question 1 of the questionnaires.

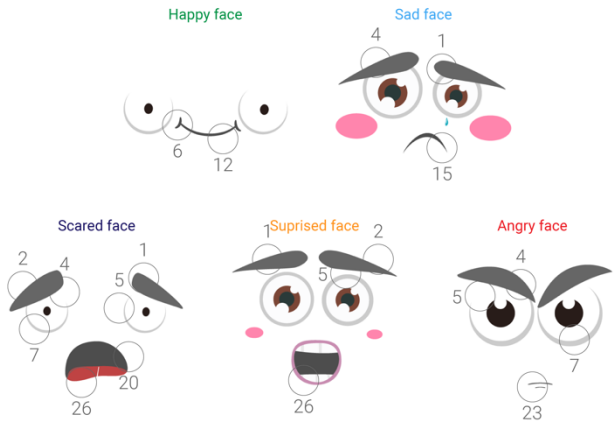


Figure 13. Use of EMFACS in design monster faces

3.3 Development Process

The process for developing this project followed the principles of Munari's design method (2018) and agile development (Martin, 2002). First, an in-depth research study was conducted, following the concepts of games for education and child development. These added to other concepts, as in technology and healthcare, leading to a focus on children on the AS. Reviewing relevant literature and products presently offered in the market, the team thus focused on augmented reality as the tool for improving the experience of children. The problem of this research was, therefore, defined as the need for a tool to enhance children's skills in emotion recognition. Data was then collected and analyzed, contributing to the draft and conceptualization of this project's game idea.

Part of the novelty of this game is its hands-free concept, taking away the need to hold the device. This setup is partially based on the OsmoTM set from Tangible Play Inc. and allows the child to interact with the objects of the game using their hands, rather than solely through a camera and screen. While designed for use with the given markers, AR system, and game of this experiment, the setup can serve as the basis for numerous tasks and activities.

With the concept formed and entering the development phase, the game was developed over a continuous series of short cycles, no less than two weeks each, where the prototype of the game was prepared, reviewed, and tested in several ways, which included group meetings and usability tests.

3.4 Markers

Initially, there were only five different markers, each possessing an organic form and presenting shape, emotion, and color at the same time. Since the AR engine could

not recognize them though, different styles of visual codes were tried—textures, dot matrices, and ring codes, among others. Figure 14 shows the front and back of the original markers; the front conveying the emotion and the back showing a visual code.

Maintaining the original organic form, however, made holding the markers difficult. Thus, the markers were converted to rectangular cards, which would include the visual code on the front, as in Figure 15. This way, the markers were more comfortable to hold without covering too much of the image, so that the AR engine could still recognize them.

Following a discussion with the professors from the Takemura Lab, another concept was tried for the markers. This resulted in a new set consisting of fifteen markers, where each one only served one purpose at a time (Figure 16). As such, it was expected that understanding of each card's concept would be more natural. The new set split cards into three categories, shape (produced as abstractions of the shapes of the monsters), color (the main colors that the monsters can appear in), and emotion (the five emotions that the monsters will express), with five each. For the visual code, each card was given a unique dot matrix for detection by the AR.

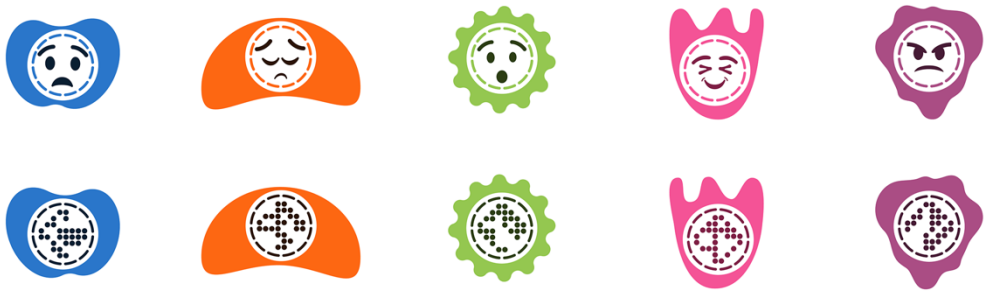


Figure 14. The original markers

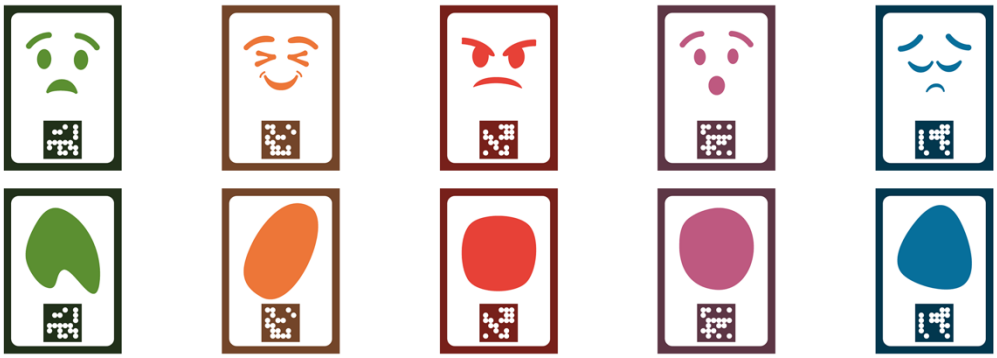


Figure 15. Markers as rectangular cards with visual code beneath either a fade or shape

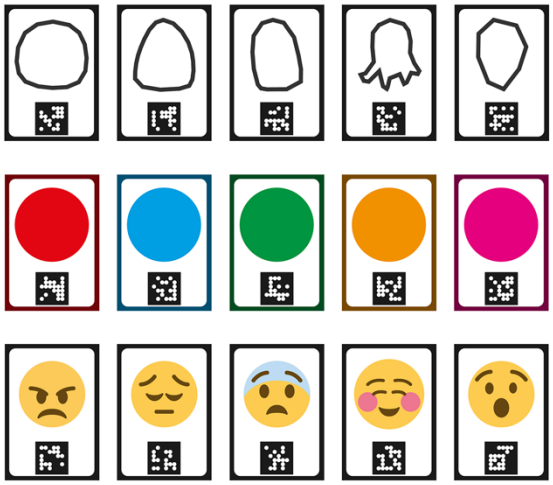


Figure 16. Set of markers, where each card served only one purpose—shape, color or emotion

The last set used abstractions of possible shapes for the monsters and simple circles to convey the available colors in the game. The emotions were represented with emoji, using the open-source set, Twemoji, from Twitter. However, the faces were modified later.

Following the first session in this experiment, provided the teachers' suggestion to change the emoji into cartoon people as that might be more familiar and thus more accessible for the children to understand. Cartoon people illustrations are usual in the materials that teachers use in their classes, according to their comments, as books, flash cards and other games. The markers showing emotions were adjusted accordingly to the illustrations shown in Figure 17. These illustrations were based on designs from Pikisuperstar at Freepik.

Figure 17. Cartoon people showing the different emotions in the game

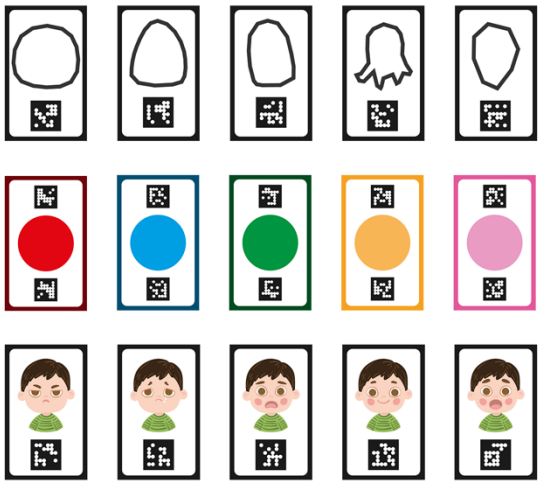


Figure 18. Final set of marker cards

The final set of markers, or cards, is shown in Figure 18. Exemplary of the changes mentioned, the set consists of fifteen cards, split between three categories—shape, color, and emotion—with five cards for each category.

3.5 Characters

The game for this project presents two contrasting kinds of characters: monsters and virtual humans. The monster characters are generated in the subgame, Create A Monster, and then used to learn different emotions in the second subgame, Guess the Emotion. Virtual humans are only used in Guess the Emotion to increase the difficulty.

3.5.1 Monsters

The original design of the monsters, shown in Figure 19, was based on models from Vectortwins at Freepik, which were modified for this experiment. With the first versions of the markers, monsters were created from combinations of three from the five available without consideration of the order. This resulted in ten possible combinations or unique monsters.

Figure 19. First version of monsters

A child would show the first marker, then based on the marker, an organic abstract shape with the same color would appear on the screen. With the second marker, a combination of the shapes and colors would appear. Given the third and final marker, a monster would be formed, possessing all three colors of the presented markers with some resemblance to the shapes. This sequence can be seen in Figure 20.

Provided the emotions, every monster from this set had five versions. Each version expressed one of the emotions in the game, such as the monsters in Figure 21.

When the markers were changed so that each card only expressed one feature, the design of the monsters changed accordingly. Figure 22 shows the new monsters upon completion of the creation sequence.

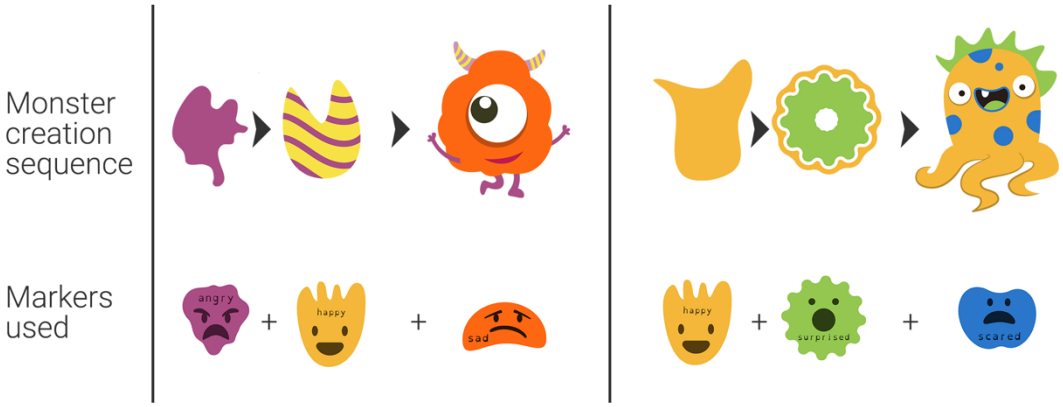


Figure 20. Monster creation sequence with original five markers

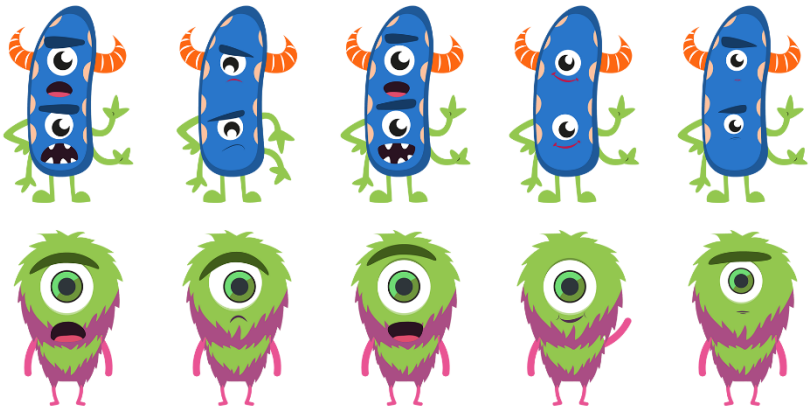


Figure 21. Five variations on two monsters according to emotions

Figure 22. Monsters for new markers where each card served only one purpose

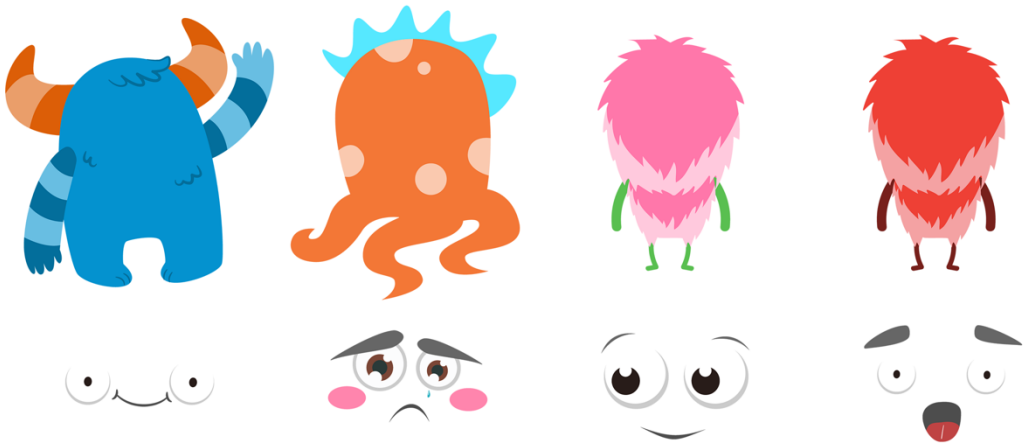


Figure 23. Monster bodies and faces separated, resulting in 125 possible combinations and 375 different facial styles

The new monsters were given body-independent characteristics. In other words, the face and body of the monster were separated from one another (Figure 23). Five monster bodies and three styles of faces were designed based on the previous set. There were five versions to each body shape, corresponding with the five possible colors the body could be.

Given the separation of color, shape, facial expression, and style, the sequence of creation also changed. First, a child chooses a shape, then a color, and lastly, an emotion, as shown in Figure 24. During this process, the screen reflects the sequence. The style of the face is randomly assigned, however, to maintain some degree of surprise and anticipation regarding the look of a monster.

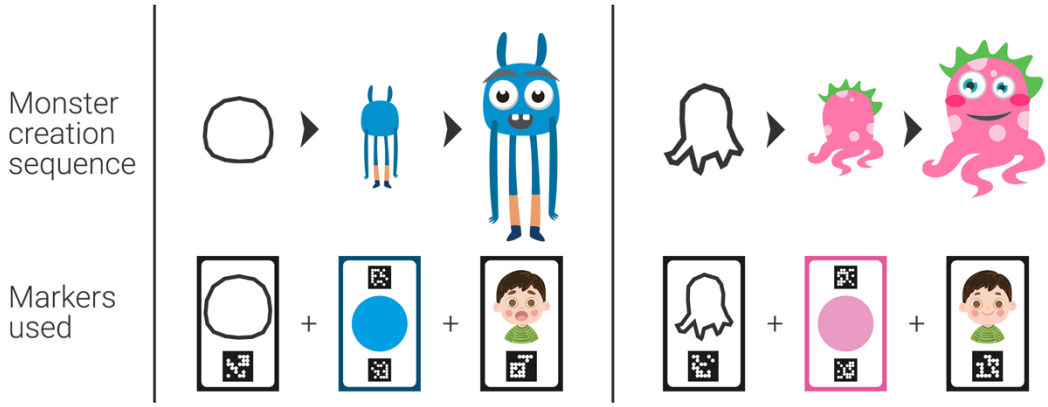


Figure 24. Generation sequence for creating a monster

3.5.2 Virtual Humans

Figure 25. Virtual humans

The virtual humans used in Guess the Emotion were taken from among the ones stored in the Facial Expression Research Group Database created by Aneja and their colleagues (2016). As shown in Figure 25, these computer-generated pictures of faces represent the different emotions needed in the subgame, varying across several characters.

3.6 Visuals and Components

3.6.1 User Interface

The chosen color palette used in this game, shown in Figure 26, follows the recommendations of the studies mentioned above (Walsh and Barry, 2008; Vogel, 2008). None of the colors used have a saturation value above 50 percent, and the use of the colors follows a consistent logic. White is used for titles, orange for general buttons, and green for positive messages and buttons such as “Yes” and “This.” Yellow is used for neutral prompts and buttons such as the undo and “Use another card,” whereas red is used for the back button and negative answers.

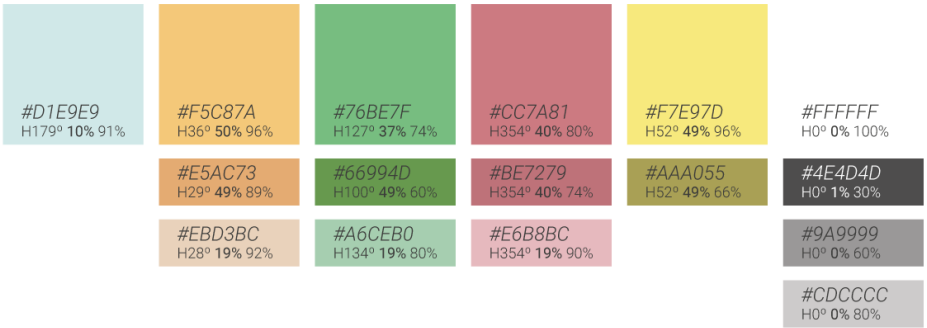


Figure 26. Color palette

The interface for this game is simple, with as few elements as possible (Figure 27). All necessary information is contained to a single page at any given time so that a child need not scroll or switch between pages. Features for switching between levels were provided to allow a sense of control on the situation. Examples of this are the back and undo buttons, which were available at any time.

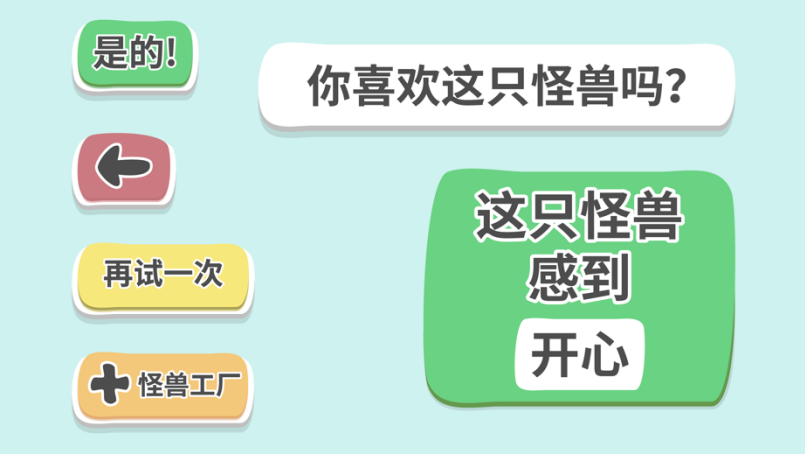


Figure 27. User interface

3.6.2 Voice and Sound Effects

Auditory feedback was added after the first session of the experiment, given the recommendation from the teachers. With sound, the game can attract children's attention and interest, as well as help those who have problems reading as in Figure 28. The encouraging voice, matched with a positive message on the screen, serves to empower the child, helping them to enjoy the game and focus longer.

Written message: *Show a card to choose the monster's color*

Written message: *This monster's emotion is happiness*

Figure 28. Auditory messages at different stages of the game

3.7 Prototype

In sum, the game of this project is a hands-free AR system aimed at improving the emotion recognition skills of children on the AS. The system for the game consists of a touch-screen device with a front-facing camera and a deck of cards (markers) for children to use and present to the camera, as in Figure 29, acting as the mode of interaction.

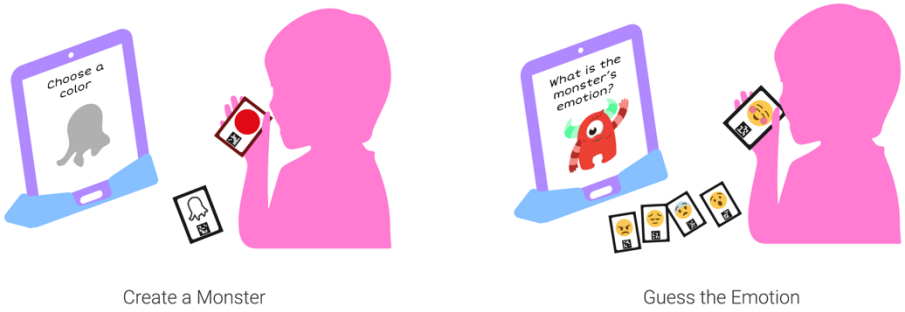


Figure 29. Example of the prototype's AR setup, where a child can be seen playing with the game.

Scaffolding appears in the game as the three modes of play, Tutorial Game, Create A Monster and Guess the Emotion, and the levels of difficulty in Guess the Emotion. When starting the game, only the Tutorial Game and Create A Monster would be available as there would be no monster stored. After having played Create A Monster, though, the third mode, Guess the Emotion, would appear, as well as the last monster saved. This difference in the UI can be seen in Figure 30.

Figure 30. Available modes

3.7.1 Tutorial Game

After the first session of this experiment, a Tutorial mode, or subgame, was added that would allow the children to s. In this mode, children only needed to raise a card. The AR system would detect the card and show a 3D object associated with the card on the screen. These 3D objects would appear to be floating over the raised card, as in Figure 31, and would differ with each category.

Figure 31. Tutorial game

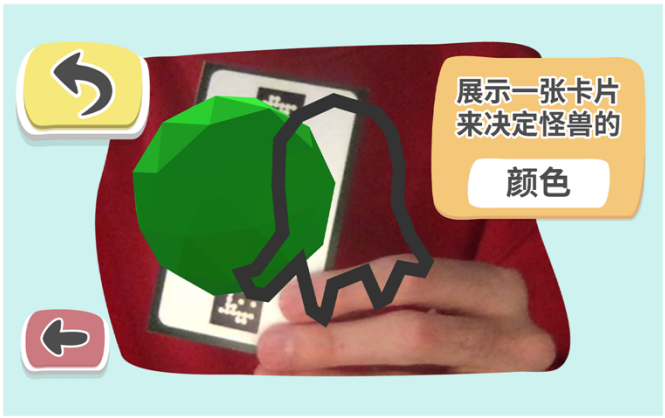
For shapes, a 3D representation of the shape would appear. For colors, a spherical shape would appear, colored according to the raised color card. For the emotion markers, an enlarged version of the illustration on the card would appear. At the same time as rendering a 3D object, a sound would be produced at the detection of the card. This sound was a beep. In the case of color or emotion cards, the system would state the meaning of the card. With the Tutorial mode, children could become familiar not only with the cards but also the concept of and manner of interacting with the game.

Scanning the codes on Figure 31 an explanatory video[1] of this stage can be found.

3.7.2 Create A Monster

In this mode or subgame, using the markers, children can create a monster. The combination of different pieces detected by the system would generate a monster according to the characteristics of the chosen markers presented, namely by color and shape, as in Figure 32.

[1] Link to the video: https://pan.baidu.com/s/1gqePYOJiXYN45Uz3cKoFww (password: kqsm)
Alternative link: https://ia801402.us.archive.org/29/items/guess-the-emotions-game/animations-tutorial-mac.mp4



Written message: *Show a card to choose the monster's color.*

Figure 32. Create A Monster

This mode allows children to familiarize themselves with the concept of the monster and faces. Seeing the generation of the monsters in response to personal choice also relates the world view with its parts, and by creating their monsters, children can thus personalize the experience of this game.

Scanning the codes on Figure 32 an explanatory video[2] of this stage can be found.

3.7.3 Guess the Emotion

For this subgame, a character—either a monster or virtual human—would be displayed on the screen, presenting one of the emotions (Figure 33). The child would then have to guess which emotion the character is expressing. To answer, they would hold up whichever of the five markers for the emotion they thought it was.

[2] Link to the video: https://pan.baidu.com/s/.18TsJwv4sBcYwXA_4RoM0TQ (password: 21db)
Alternative link: https://ia801402.us.archive.org/29/items/guess-the-emotions-game/animations-create-mac.mp4

Written message: *You are right! The monster is happy. / Next / Level*

Figure 33. Guess the Emotion

At first, this subgame only uses two of the emotions and the monster created by the child in Create A Monster. As the child answers more correctly, the level of difficulty increases with the game showing more of the emotions and more kinds of monsters, alternating with the virtual humans. As seen in Figures 33 and 34, this mode has five levels of difficulty.

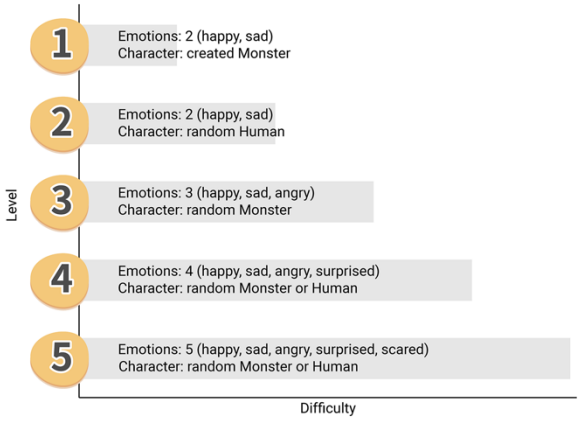


Figure 34. Levels of Guess the Emotion

Scanning the codes on Figure 33 an explanatory video[3] of this stage can be found

[3] Link to the video: https://pan.baidu.com/s/1owd_SaA4SraJfj5zJu0cnA (password: nzic)
Alternative link: https://ia601402.us.archive.org/29/items/guess-the-emotions-game/animations-guess-mac.mp4

3.7.4 Source Material

To be specific, the prototype uses the Vuforia AR engine to recognize and identify the markers. The game was made using Unity 3D and was run in Play Mode during the experiment. For the markers, the emoji used before were Twemoji from Twitter (twemoji.twitter.com), which, as aforementioned, were exchanged for the cartoon illustrations from Pikisuperstar at Freepik (www.freepik.com/pikisuperstar). The monsters were based on designs from Vectortwins at Freepik (www.freepik.com/vectortwins). The virtual humans were taken from the Facial Expression Research Group Database, otherwise known as FERG-DB (Aneja et al., 2016). Upon the incorporation of sounds, the voice messages were generated using the online platform, TTSmp3 (www.ttsmp3.com), using the engine provided by Amazon Polly. Sound effects were taken from the AllSounds library (www.theallsounds.com).

For reference, the setup of this game was, as aforementioned in 3.3 Development Process, based on the OsmoTM set from Tangible Play (www.playosmo.com).

4. RESULTS

4.1 Preliminary Tests

During the research and development stage, the game was continuously tested through different methods, as in a demo trial and user observation. Two of these methods included a more structured arrangement and provided some remarkable insights for the game. Once a usable prototype had been refined, a usability test was performed in the Takemura Lab at Osaka University. Seven participants took part in the experiment, all of which were students of the university. While these subjects were not among the target users of this study, the purpose of this test was to determine general problems with the usability of the game and to determine whether the emotions were recognizable among neurotypical users. Professor Takemura recommended the the participants could not belong to the main target group at this stage due to the difficulties of recruiting this specific profile in Japan, simplifying and speeding up the development process.

The most common remark was that the scared and sad faces were the most difficult to recognize. As seen in Figure 35, participants did not correctly identify the sad and scared faces more than fifty percent of the times these faces appeared in the game. Alongside other results indicating a need for the improvement of different emotions and the markers, several changes were made to the illustrations, markers, and the design of the facial styles, particularly the use of two eyes in all-new versions.

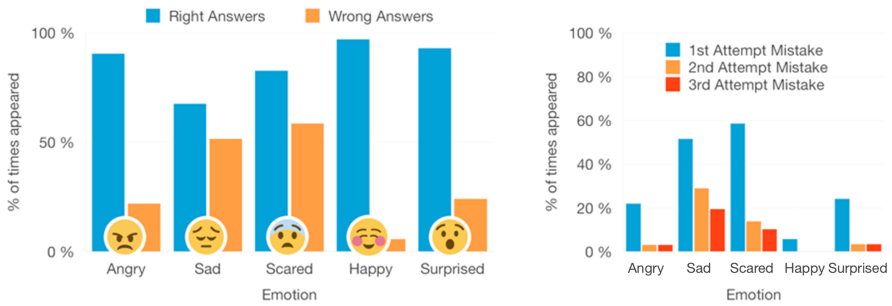


Figure 35. Right and wrong answers per emotion and attempt

Following the implementation of the changes, the modifications were tested with an online survey distributed mainly among students of Shanghai Jiao Tong University. The aim of this survey was to validate the changes in the display of emotion on the faces of monsters and the markers. Given the results of the study, the changes were found to be appropriate, showing that the new designs reduced the problems in distinguishing between scared and sad faces.

4.1 Session One

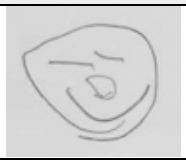
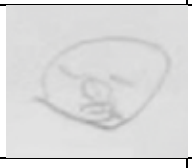
The first session of the experiment took place on 2019 Oct. 28. Three students of the school were recruited to participate, two of which were on the AS and one who was also neurodivergent but not on the AS. To indicate the session and refer to participants anonymously, the three participants for the first session are assigned to as P1-1, P1-2, and P1-3.

4.1.1 Pre-test Questionnaire

4.1.1.1 Question 1: Can you draw this?

P1-2 was not able to work on this task, whereas P1-1 and P1-3 were able to draw four faces each, as shown in Table 3. Note that neither P1-1 nor P1-3 drew an angry face for this question.

Table 3 Session 1. Pre-test Questionnaire. Question 1. Participant Answers

Participants		**P1-1**	**P1-3**
Happy face			
Action units	6	Yes	Yes
	12	Yes	Yes
Sad face			
Action units	1	Yes	No
	4	No	Yes
	15	Yes	No
Scared face			
Action units	1	No	Yes
	2	No	Yes
	4	Yes	Yes
	5	No	Yes
	7	No	No
	20	Yes	Yes
	26	Yes	Yes

Participants		P1-1	P1-3
Surprised face			
Action units	1	Yes	Yes
	2	Yes	No
	5	Yes	Yes
	26	Yes	Yes
Angry face		-	-
Action units	4	-	-
	5	-	-
	7	-	-
	23	-	-

The happy and surprised faces used the most action units from EMFACS to be used by both participants in their drawings. For the happy face, both participants drew faces with the two action units for identifying a happy face, while for the surprised face, P1-1 used all four action units, and P1-3 used three of the four. Meanwhile, sad and scared faces varied between participants. For the sad face, P1-1 included two of three action units, while P1-3 included only one. Then for the scared face, P1-1 used three of the seven action units, and P1-3 used six.

4.1.1.2 Question 2: Please draw lines from emotions to faces

Table 4 Session 1. Pre-test Questionnaire. Question 2. Participant Answers

Participants	P1-1	P1-2	P1-3
Happy face	Right	Wrong	Right
Sad face	Right	Wrong	Wrong
Scared face	Right	Right	Wrong
Surprised face	Right	Right	Right
Angry face	Right	Right	Right
CORRECT	**5 / 5**	**3 / 5**	**3 / 5**

For this task, only P1-1 matched all faces correctly. P1-2 and P1-3 both incorrectly matched the sad face with P1-2 mistaking it for the happy face and P1-3 mistaking it for the scared face.

4.1.1.3 Question 3: What are their emotions?

As P1-2 was unable to complete Question 1, this question was also skipped in favor of proceeding to the next part of the experiment. Table 5 shows the answers from P1-1 and P1-3.

Table 5 Session 1. Pre-test Questionnaire. Question 3. Participant Answers

Participants	P1-1	P1-3
Happy face	Wrong	Right
Sad face	Wrong	Right
Scared face	Right	Right
Surprised face	Right	Right
Angry face	Wrong	Right
CORRECT	**2 / 5**	**5 / 5**

When describing the emotions, P1-1 could only describe two of the five correctly, whereas P1-3 managed to tell all of them.

4.1.2 Post-test Questionnaire

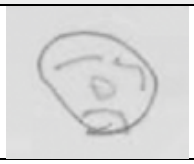
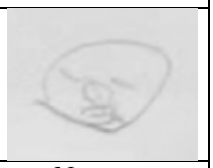
For the post-test questionnaire, P1-1 only completed Question 1, having to skip the other review questions, namely 2 and 3, due to lack of concentration. P1-2 and P1-3 could not complete any of the review questions, either due to a lack of remaining time or problems with concentrating. For Questions 5 through 8, P1-2 gave no response, whereas the assistant aided P1-1 and P1-3 in filling out the tables.

4.1.2.1 Question 1: Can you draw this?

In the use of the EMFACS for depicting emotion, P1-1 had the most problems with the scared face, which is considered one of the most complex.

Table 6 Session 1. Post-test Questionnaire. Question 1. Participant Answers

Participants		P1-1
Happy face		
Action units	6	Yes
	12	Yes

Participants		P1-1
Sad face		
Action units	1	Yes
	4	No
	15	Yes
Scared face		
Action units	1	No
	2	No
	4	Yes
	5	No
	7	No
	20	Yes
	26	Yes
Surprised face		
Action units	1	Yes
	2	Yes
	5	Yes
	26	Yes
Angry face		-
Action units	4	-
	5	-
	7	-
	23	-

4.1.2.2 Question 5: Smileyometer

The responses from the first participant, P1-1, seem to follow a diagonal pattern.

Table 7 Session 1. Post-test Questionnaire. Question 5. Participant Answers

Game Aspect	Awful	Not good	Good	Really good	Very good
Create A Monster			P1-3	P1-1	

Game Aspect	Awful	Not good	Good	Really good	Very good
Guess the Emotion					P1-1, P1-3
Monsters			P1-1	P1-3	
Virtual humans		P1-1	P1-3		
Colors	P1-1		P1-3		
Cards		P1-1		P1-3	
Game Likability	**1**	**2**	**4**	**3**	**2**

4.1.2.3 Questions 6-8

Table 8 Session 1. Post-test Questionnaire. Questions 6-8. Participant Answers

Question	Would you do it again?			Was it?			
Answers	**No**	**Maybe**	**Yes**	**Boring**	**Fun**	**Hard**	**Easy**
Create A Monster	P1-1		P1-3		P1-1, P1-3		P1-1, P1-3
Guess the Emotion		P1-1	P1-3		P1-1, P1-3		P1-1, P1-3

Both participants, meaning P1-1 and P1-3, found both modes of the game to be fun and easy. However, P1-1 indicated that they would no play Create A Monster again and maybe would play Guess the Emotion.

4.1.3 Participant Observations

4.1.3.1 Participant 1 (P1-1)

On the pre-test questionnaire, P1-1 spent 34 seconds drawing the faces for Question 1. The assistant helped them to take notes on Questions 2 and 3. During the play portion, P1-1 was given an explanation of Create A Monster first before using the cards to create their first monster. After the first monster was created, the assistant directed them into creating another. There were some problems when P1-1 presented the back of the cards to the camera. P1-1 created only two monsters, taking 68 and 67 seconds. They did not use the undo button at any time while playing Create A Monster but neither tried to interact with the screen. Following Create A Monster, P1-1 was given an explanation of Guess the Emotion. P1-1 played this game for 7 minutes and 51 seconds. Since time was limited and the child was reacting slowly, Guess the Emotion was accelerated to the last level to test them on the virtual human faces. On the post-test questionnaire, P1-1 only completed the first question in the review portion due to a lack of concentration. With help from the assistant, they answered Questions 5 through 8 regarding the experience of playing the game.

4.1.3.2 Participant 2 (P1-2)

On the pre-test questionnaire, P1-2 did not do either Question 1 or 3, and the assistant helped them fill out Question 2. For the first half of the play portion, P1-2 was given an explanation of the three kinds of cards with the assistant showing them how to create a monster. Then the screen was restarted for them to try. P1-2 held the cards too close to the screen, causing detection problems, and sometimes, they held up the wrong type of card, not following the proper sequence for monster creation. This required guidance from the assistant to correct. When the first monster was finished, P1-2 continued raising cards to the camera, so the assistant had to ask if they liked the monster. They gave no response, so "Try Again" was selected to play Create A Monster again. P1-2 thus created a second monster, but given the demonstration by the assistant, they had three monsters to choose from. However, at this point, P1-2 lost focus on the experiment and stopped responding to either the game or assistant. As such, P1-2 also did not participate in the post-test questionnaire.

4.1.3.3 Participant 3 (P1-3)

On the pre-test questionnaire, P1-3 spent 108 seconds on drawing the faces for Question 1. While they realized how to do Question 2 on their own, they needed help from the assistant on taking notes for Question 3. During the play portion, P1-3 was given a step-by-step demonstration of Create A Monster, then tried it themselves without incident. Once they had their monster, the assistant directed them to Guess the Emotion. Without needing much explanation, P1-3 started to play and interacted with the screen as required. They played Guess the Emotion for 4 minutes and 13 seconds, reaching the top level, before being asked by the assistant to stop. Due to a lack of concentration, P1-3 skipped the review portion of the post-test questionnaire but was aided by the assistant in filling out Questions 5 through 8 regarding the experience of playing the game.

4.1.4 App Log

The number of times every marker was used per participant in Create A Monster was calculated as in Figure 36. The happy emotion marker was the most used, chosen by all three participants, whereas the angry emotion marker was not used at all.

Table 9 Session 1. Response times for decisions using the markers.

Action Performed	Average Time (sec)
Shape marker detection	10.5
Color marker detection	13.8

Emotion marker detection	13.5
Create A Monster actions (average)	**12.6**
Right answer (1st try)	7.7
Right answer (2nd try)	17.2
Right answer (3rd try)	2
Right answers (average)	9.6
Wrong answer (1st try)	12.3
Wrong answer (2nd try)	7.8
Wrong answers (average)	10.7
Guess the Emotion actions (average)	**10.1**

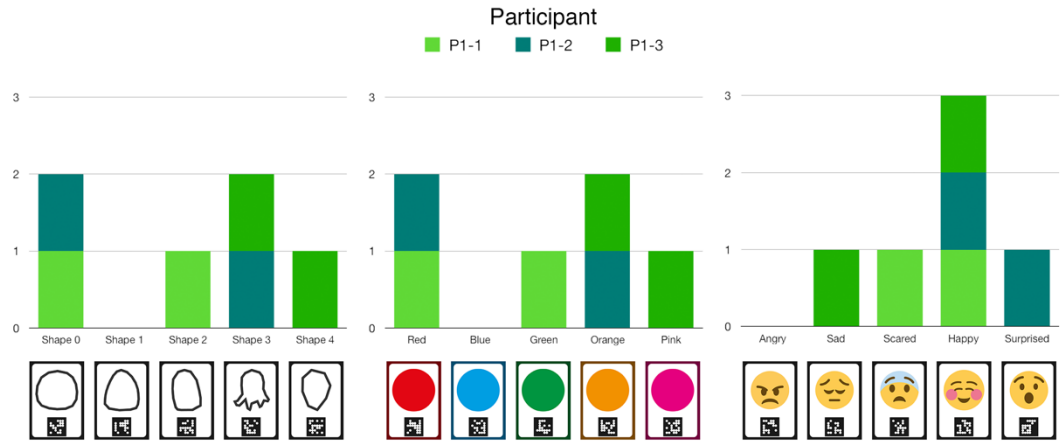


Figure 36. Session 1. Markers used per participant in Create A Monster.

In Guess the Emotion, P1-1 had the same number of hits and mistakes on the first attempt, whereas P1-3 had twice as many hits than errors on the first attempt but made more mistakes on the second attempt (Figure 37).

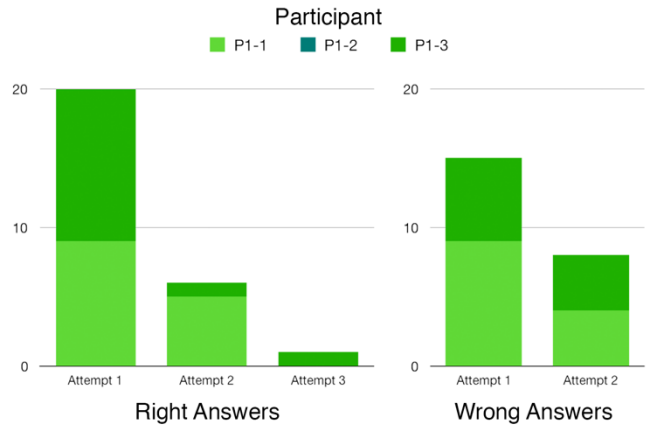


Figure 37. Session 1. Right and wrong answers per attempt and participant.

Disaggregating responses in Guess the Emotion, shown in Figure 38, P1-1 made the most mistakes on the angry face, while for P1-3, most of their mistakes were on the surprised face.

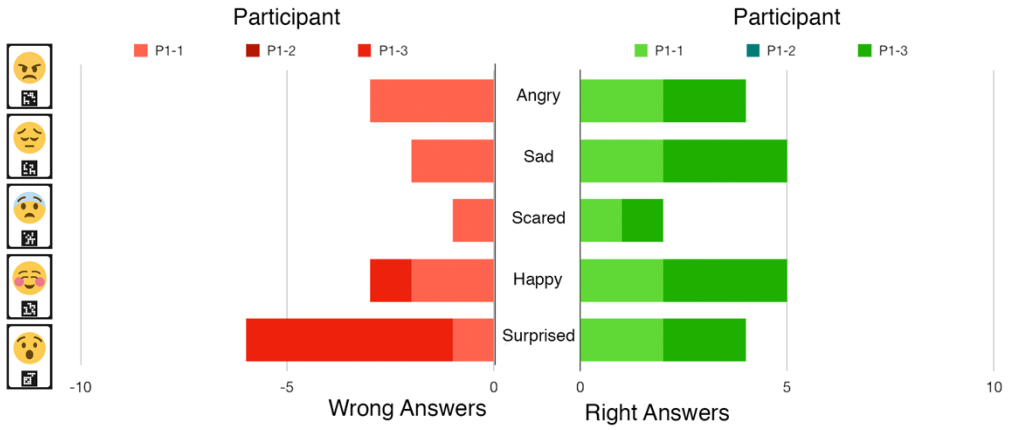


Figure 38. Session 1. First attempt. Right and wrong answers per emotion and participant.

Looking at the evolution of answers for different emotions in Figure 39, the scared face was only identified correctly in two attempts (trying two different markers) for all instances. In contrast, all the rest reached the latter stages at least once, where the participants were prompted to reply a yes-no question about the respective emotion using the touch screen.

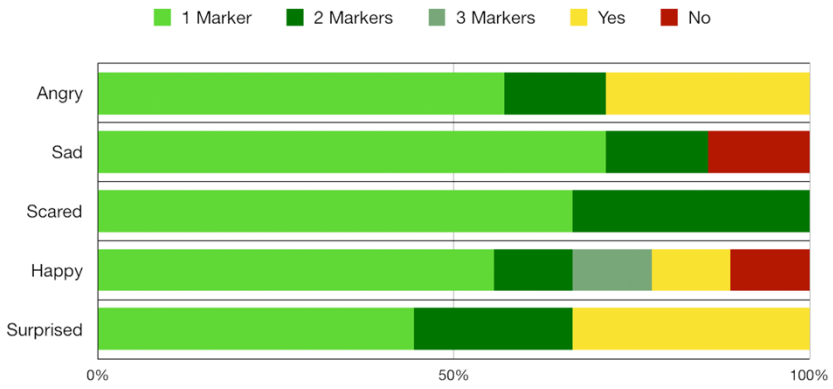


Figure 39. Session 1. Evolution of answers per emotion in Guess the Emotion.

Comparing the data between monsters and virtual human faces as in Figure 40, the same trend applies. In this session, though, human faces only appeared in the last level, making this data limited.

Figure 40. Session 1. Comparison between monsters and virtual humans in the evolution of answers per emotion.

Table 10 Session 1. Final results of modes.

Mode	Count	P1-1	P1-2	P1-3
Create A Monster	Monsters saved	2	2	2
	Markers used	6	10	6
	Wrong markers used	0	4	0
Guess the Emotion	Characters played	19	-	17
	Markers used	30	-	24
	Maximum score	14	-	13

In sum, as shown in Table 10, P1-1 and P1-3 played similarly. Both created two monsters and had similar scores in Guess the Emotion. Since P1-2 did not play Guess the Emotion, their results cannot be compared in the second half of Table 10.

4.1.5 Expert Insights

Three teachers were interviewed in an open conversational format in Chinese, with the assistant translating their suggestions and comments. As teachers were not interviewed in the second session, teachers are referred to as T1, T2, and T3.

4.1.5.1 Teacher 1 (T1)

T1 commented that the concept of the game was interesting and useful for the needs of children on the AS. They also pointed out that not only children on the AS receive classes in emotion recognition but also the rest of the students in their special education school so that it could be useful to others as well. They did, however, note that the lack of sound made it seem like something was missing from the game. When it was explained that this was intentional to avoid sensory overload, T1 recommended trying some simple sounds and messages to make the game more appealing. They also noted that in class, the basic emotions are happy, sad, angry, and surprised, which are usually expressed with cartoon boys and girls.

4.1.5.2 Teacher 2 (T2)

T2 also stated that the concept of the game was interesting for the unique needs of children on the AS. On observation of the game and monsters, they noted that the eyes of some of the monsters might be confusing as blue eyes might give the impression of tears. A child would then the face is sad even when it is not. Following this remark, T2 pointed out that the sad faces would be clearer to understand if the faces included some tears, as in the illustrations generally used in the classroom for teaching emotion recognition.

When asked about the comment on sound by T1, T2 agreed that it seemed to be something missing in the game. They added that happy voice messages would make the children more engaged and find the experience more enjoyable, also adding an element of surprise. Apart from the appearance and sound, T2 commented on the levels system, suggesting a scaffolding of the emotions, rather than having them all appear from the beginning and adding some more explicit way of seeing the progress. They also said that allowing children to switch between the levels would be an interesting add-on.

4.1.5.3 Teacher 3 (T3)

As with the other two, T3 agreed that the concept of the game was interesting for addressing the needs of children on the AS. However, distinguishing the emotions on the markers with emoji was hard. They explained that the emotion markers were hard for the

children to understand and recommended changing them to more realistic cartoon images similar to those typically used in their classrooms. They also remarked that the virtual human faces could seem scary.

4.1.5.4 Expert Survey

None of the questions were skipped in the expert survey, and there did not appear to be any problems answering. According to the study, none of the teachers considered the game to present any remarkable technical issues. As seen in Figure 41, for game adaption, the teachers mostly agreed. However, none of the three was neutral on the ease of the game, its likelihood of improving the ability to recognize emotions on others' facial expressions, and the use of AR to enhance children's experiences. In the least, as in answer to Question 9, if the child appeared to enjoy interacting with the AR, all three agreed that the children seemed to enjoy it.

Figure 41. Expert survey. Questions 2 through 9 on game adaption. Teacher answers.

For the second part of the survey, shown in Figure 42, addressing the experience of Create A Monster, all of the teachers agreed that this mode, or subgame, helped to personalize the experience. However, they were neutral on the ease of understanding, and one of them was neutral on the observation of whether the child appeared to enjoy this mode

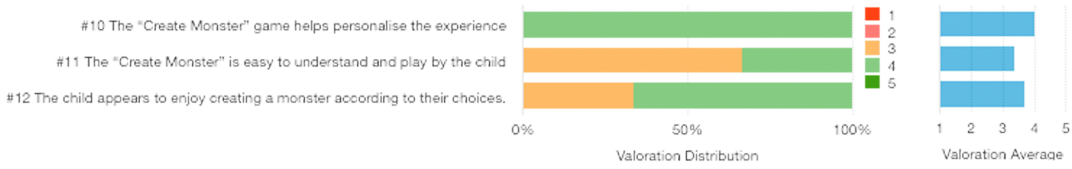


Figure 42. Expert survey. Questions 10 through 12 on Create A Monster experience. Teacher answers.

For the third part of the survey, shown in Figure 43, the teachers were mostly neutral on all questions regarding children's experience in Guess the Emotion. Only one was neutral on if the child appeared to enjoy guessing the emotions. According to their answers, with all three being neutral on the comprehensibility of the emotions of the monsters and virtual humans, it seems Guess the Emotion was harder to understand.

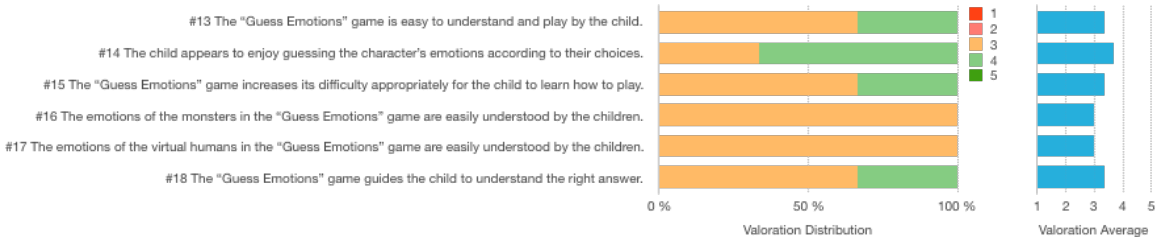


Figure 43. Expert survey. Questions 13 through 18 on Guess the Emotion experience. Teacher answers.

4.2 Session Two

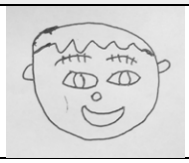
The second session of the experiment took place on 2019 Nov. 2. Three students of the school were recruited to participate, two of which were on the AS and another who was neurodivergent but not on the AS. To indicate the session and refer to participants anonymously, the three participants for the second session are assigned to as P2-1, P2-2, and P2-3.

4.2.1 Pre-test Questionnaire

4.2.1.1 Question 1: Can you draw this?

All three participants worked on this task, but P2-1 and P2-3 were only able to draw two of the five faces each, while P2-2 managed to draw four. Refer to Table 11 for their answers.

Table 11 Session 2. Pre-test Questionnaire. Question 1. Participant Answers.

Participants		**P2-1**	**P2-2**	**P2-3**
Happy face				
Action units	6	Yes	Yes	Yes
	12	Yes	Yes	Yes
Sad face				
Action units	1	No	No	No
	4	Yes	No	Yes
	15	Yes	No	No
Scared face		-	-	-
Action units	1	-	-	-

Participants		P2-1	P2-2	P2-3
	2	-	-	-
	4	-	-	-
	5	-	-	-
	7	-	-	-
	20	-	-	-
	26	-	-	-
Surprised face				
Action units	1	-	No	-
	2	-	Yes	-
	5	-	Yes	-
	26	-	Yes	-
Angry face				
Action units	4	-	No	-
	5	-	No	-
	7	-	Yes	-
	23	-	No	-

For P2-1, the faces drawn for scared, angry, and surprised were discarded as they were copying the faces on the markers. P2-2 drew the scared face without an actual face, so this drawing was not used. As for P2-3, the task was stopped due to problems with concentration. These drawings aside, all three drew a happy face, including both action units. While all drew the sad face, not one used all three action units, and P2-2 did not use any of the ascribed action units. However, all three drew the sad face with tears. For the other two faces, surprised and angry, which only P2-2 drew, both consisting of four action units, P2-2 got three of the four on the surprised face but only one on the angry face.

4.2.1.2 Question 2: Please draw lines from emotion to face

This question was skipped to ease the load on participants.

4.2.1.3 Question 3: What are their emotions?

P2-1 and P2-2 were able to complete this task with the help of the assistant to write down their answers. Due to similar problems encountered with Question 1, P2-3 skipped this question.

Table 12 Session 2. Pre-test Questionnaire. Question 3. Participant Answers.

Participants	P2-1	P2-2
Happy face	Wrong	Right
Sad face	Wrong	Wrong
Scared face	Wrong	Wrong
Surprised face	-	Wrong
Angry face	-	Right
CORRECT	**0 / 5**	**3 / 5**

4.2.1.4 Question 4: What are their emotions?

Using the markers, all participants completed this task but still required the aid of the assistant in recording their answers.

Table 13 Session 2. Pre-test Questionnaire. Question 4. Participant Answers.

Participants	P2-1	P2-2	P2-3
Happy face	Right	Right	Right
Sad face	Wrong	Right	Right
Scared face	Right	Wrong	Wrong
Surprised face	Wrong	Wrong	Wrong
Angry face	Right	Right	Right
CORRECT	**3 / 5**	**3 / 5**	**3 / 5**

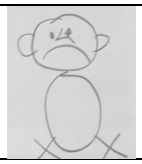
All participants obtained the same number of right answers on this question. While they all misidentified the surprised face, two of them confused it with the scared face, and one confused it with the sad face.

4.2.2 Post-test Questionnaire

For the post-test questionnaire, P2-1 was not able to complete Question 2, and P2-3 did not complete Question 1, due to a lack of time and problems concentrating on the tasks. For these same reasons, Question 5 was only answered by P2-2.

4.2.2.1 Question 1: Can you draw this?

Table 14 Session 2. Post-test Questionnaire. Question 1. Participant Answers.

Participants		**P2-1**	**P2-2**
Happy face			
Action units	6	Yes	Yes
	12	Yes	Yes
Sad face			
Action units	1	Yes	-
	4	Yes	-
	15	No	-
Scared face			
Action units	1	No	-
	2	No	-
	4	No	-
	5	Yes	-
	7	No	-
	20	No	-
	26	No	-
Surprised face			
Action units	1	Yes	-
	2	Yes	-
	5	No	-
	26	Yes	-
Angry face			
Action units	4	Yes	-
	5	Yes	-

Participants		P2-1	P2-2
	7	Yes	-
	23	No	-

P2-1 was able to complete all five faces, while P2-2 only drew one valid face. After drawing this one face, they replicated the drawing for two more emotions, so these drawings were discarded, and the task was stopped. Since P2-3 took too long on this question and tried to copy the faces from the markers in the pre-test, they skipped this question.

Looking at the drawings from P2-1, they used all the action units for the happy face and used most of the action units, missing only one, on sad, surprised, and angry. On scared, though, they only used one of the ascribed action units.

4.2.2.2 Question 2: Please draw lines from emotion to face

This question was skipped to ease the load on participants.

4.2.2.3 Question 3: What are their emotions?

Just as in the pre-test, P2-1 and P2-2 were able to complete this task with the help of the assistant to take down their answers.

Table 15 Session 2. Post-test Questionnaire. Question 3. Participant Answers.

Participants	P2-1	P2-2
Happy face	Right	Right
Sad face	Wrong	Right
Scared face	Wrong	Wrong
Surprised face	Right	Right
Angry face	Right	Right
CORRECT	**3 / 5**	**4 / 5**

Both P2-1 and P2-2 misidentified the scared face, but while P2-1 mistook it for the sad face, P2-2 could not recognize it. Compared to their previous answers in the pre-test questionnaire, P2-1 was able to identify the surprised and angry faces, and P2-2 had one less wrong answer.

4.2.2.4 Question 5: Smileyometer

Due to the lack of time and concentration, P2-2 was the only participant to answer Question 5. Though they were helped by the assistant to fill in the table, looking at the diagonal pattern of their answers, as seen in Table 16, the data is not relevant.

Table 16 Session 2. Post-test Questionnaire. Question 5. Participant Answers.

Game Aspect	Awful	Not good	Good	Really good	Very good
Create A Monster					P2-2
Guess the Emotion				P2-2	
Monsters			P2-2		
Virtual humans		P2-2			
Colors	P2-2				
Cards		P2-2			
Game Likability	**1**	**2**	**1**	**1**	**1**

4.2.2.5 Questions 6-8

For Questions 6 through 8, all participants answered regarding Create A Monster, but P2-1 refused to answer for Guess the Emotion.

Table 17 Session 2. Post-test Questionnaire. Questions 6-8. Participant Answers.

Question	Would you do it again?			Was it?			
Answers	**No**	**Maybe**	**Yes**	**Boring**	**Fun**	**Hard**	**Easy**
Create A Monster			P2-1 P2-2 P2-3		P2-1 P2-2 P2-3		P2-1 P2-2 P2-3
Guess the Emotion			P2-2 P2-3		P2-2 P2-3	P2-2	P2-3

For Create A Monster, all participants answered in the positive for playing it again and finding it fun and easy. Of the two that answered regarding Guess the Emotion, they both would play it again and thought it was fun, but one of them thought it was hard, the other thought it was easy.

4.2.3 Participant Observations

4.2.3.1 Participant 1 (P2-1)

On the pre-test questionnaire, P2-1 spent 2 minutes and 51 seconds drawing faces, but after drawing the first two, they took the sheet for Question 4, showing the illustrations from the emotion markers and started to copy the faces. The assistant tried

to redirect them to the game, but P2-1 insisted on finishing the faces. Once they finished, they were handed the cards and shown the game, starting the Tutorial game. P2-1 spent 1 minute and 20 seconds playing the Tutorial game and used almost all of the cards. When they finished with the Tutorial game, the assistant started Create A Monster. Without explanation, aside from sound indications from the game, P2-1 proceeded to create a monster. After choosing one color, P2-1 continued to raise color codes, and the assistant pressed undo twice. Eventually, P2-1 pressed the back button, exiting the subgame and returning to the menu screen. The assistant restarted Create A Monster, and this time, a monster was successfully generation and approved. P2-1 spent almost 3 minutes in total playing Create A Monster. On Guess the Emotion, P2-1 was directed to play and respond with the emotion markers. They played Guess the Emotion for 4 minutes. Then on the post-test questionnaire, P2-1 was able to draw all five faces. The second question was skipped, and on the third question, P2-1 correctly identified three of the faces. Compared with the pre-test, they guessed the other two faces. For Questions 5 through 8, however, P2-1 would not answer Question 5 and refused to answer Questions 6 through 8 regarding Guess the Emotion.

4.2.3.2 Participant 2 (P2-2)

On the pre-test questionnaire, P2-2 took 2 minutes and 43 seconds to draw the faces for Question 1, drawing all five without any problems. For Questions 3 and 4, the assistant helped them take down answers. Proceeding to the game, the Tutorial game was started, and the assistant showed P2-2 how to interact with the game. P2-2 played the Tutorial game for 58 seconds without any problems. Then, the assistant started Create A Monster. With a brief explanation using the shape cards and showing the steps, P2-2 started to play the subgame. When a monster was generated, the assistant confirmed it and started Guess the Emotion for them. On Guess the Emotion, P2-2 used the cards without any need for a further explanation other than the sounds from the game. However, the AR system malfunctioned for a moment, and the assistant had to restart it to fix the error. After that, P2-2 played the subgame without any further incident, reaching level 5 on their own and playing for 3 minutes and 15 seconds. The game was then stopped to perform the post-test questionnaire. On the post-test questionnaire, P2-2 managed a face. Though they drew more faces, they started to draw the same face for two more emotions and were stopped. On the third question, they identified one more correct face than on the pre-test questionnaire, but the one they got wrong, the scared face, was the same face they had wrong in the pre-test. Although they answered Question 5, their answers were too intentionally picked to be valid, forming a diagonal across the form. They had no problem answering Questions 6 through 8.

4.2.3.3 Participant 3 (P2-3)

On the pre-test questionnaire, P2-3 took 3 minutes for drawing the faces, only finishing three of them. They were stopped to avoid losing time and exhausting the participant. Questions 2 and 3 were skipped due to the lack of time. The assistant thus helped P2-3 answer Question 4. Then, the assistant initiated the Tutorial game for P2-3 to try. After indicating for the participant to raise cards to the camera, P2-3 continued playing for 1 minute and 8 seconds without any further problems. Several times, P2-3 tried to touch the 3D figure that would appear on the screen over the marker. The assistant thus switched the game to Create A Monster. The participant was guided through the creation of the monster and confirmed it, but once on the menu screen, P2-3 tapped on the reset button, erasing the monster generated. They refused to create a new monster, so the assistant started Guess the Emotion. When it started, the participant expressed that they wanted to play and tried to tap on the deactivated buttons of the levels and title panel. They then played Guess the Emotion without further problems, switching cards when mistakes were made. After playing for 2 minutes and 45 seconds, the game was finished, and the assistant performed the post-test questionnaire. On the post-test questionnaire, P2-3 was not able to complete any of the questions in the review portion. They did not answer Question 5, and on Questions 6 through 8, they had no problem answering. Upon finishing the post-test questionnaire, the participant asked to play the game some more. As their teacher had yet to arrive, the assistant allowed them to take the equipment and play freely until their teacher came to pick them up.

4.2.4 App Log

Table 18 Session 2. Response times for decisions using the markers.

Action Performed	Average Time (sec)
Shape marker detection	7.5
Color marker detection	13.8
Emotion marker detection	11.8
Create A Monster actions (average)	**10.9**
Right answer (1st try)	5.1
Right answer (2nd try)	3.5
Right answer (3rd try)	6.0
Right answers (average)	4.7
Wrong answer (1st try)	6.1
Wrong answer (2nd try)	1.4
Wrong answers (average)	4.6
Guess the Emotion actions (average)	**4.7**

The number of times every marker was used per participant in Create A Monster was calculated as in Figure 44.

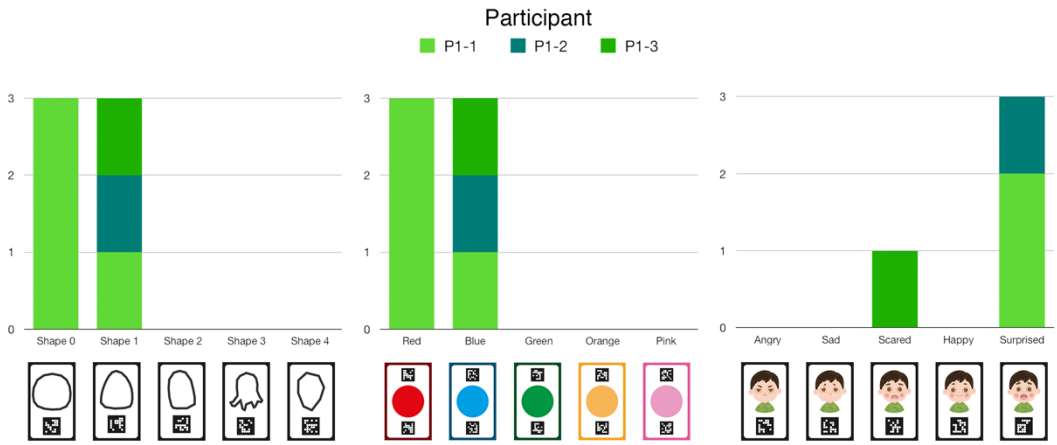


Figure 44. Session 2. Markers used per participant in Create A Monster.

In Guess the Emotion, as seen in Figure 45, P2-1 and P2-2 made the same number of mistakes and hits between their first and second attempts, while P2-3 seemed to make nearly twice as many hits than mistakes on their first attempt. On their second attempt, P2-3 did less overall and seemed to make about the same number of mistakes and hits.

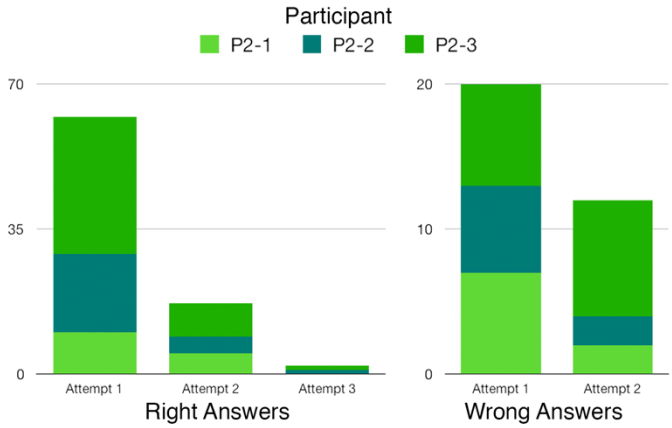


Figure 45. Session 2. Right and wrong answers per attempt and participant.

Disaggregating responses in Guess the Emotion, shown in Figure 46, it can be observed how many right and wrong answers every participant did in their first attempts.

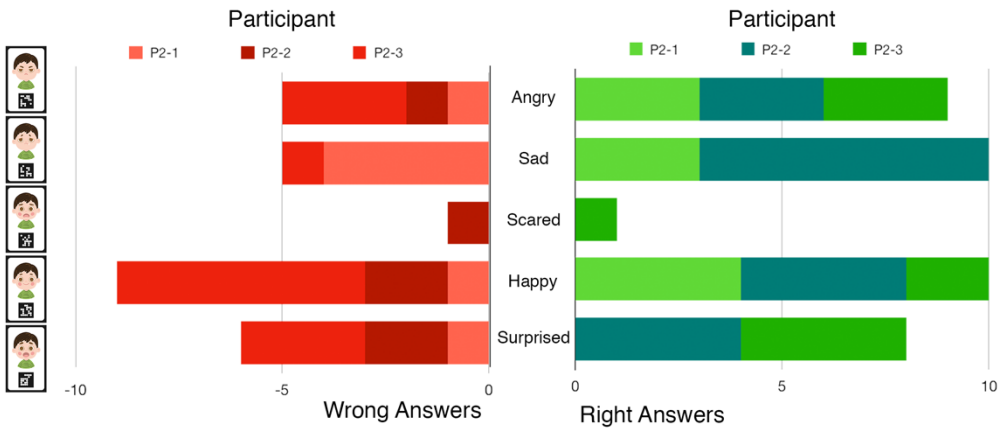


Figure 46. Session 2. First attempt. Right and wrong answers per emotion and participant.

Looking at the evolution of answers for different emotions in Figure 47, all the emotions passed by every stage of the game. It can be noted that the scared faces were guessed right in the first attempt in half of the appearances.

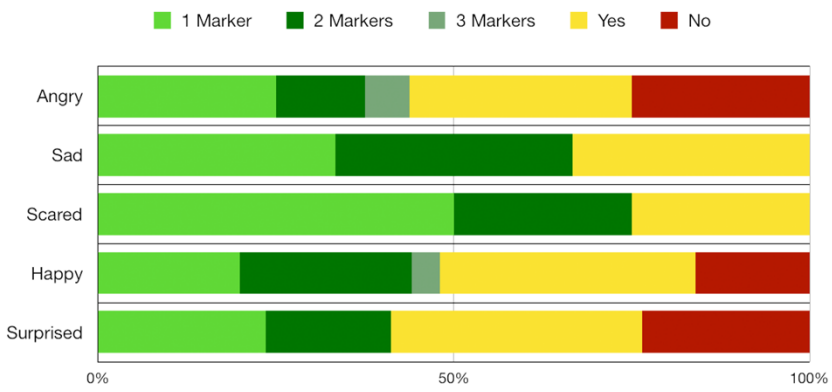


Figure 47. Session 2. Evolution of answers per emotion in Guess the Emotion.

Comparing the data between monsters and virtual human faces as in Figure 48, in all the cases when a virtual human portrayed the emotion, more than half of the instances were guessed right the first attempt. For the monsters, though, the scared emotion was always guessed with the second marker.

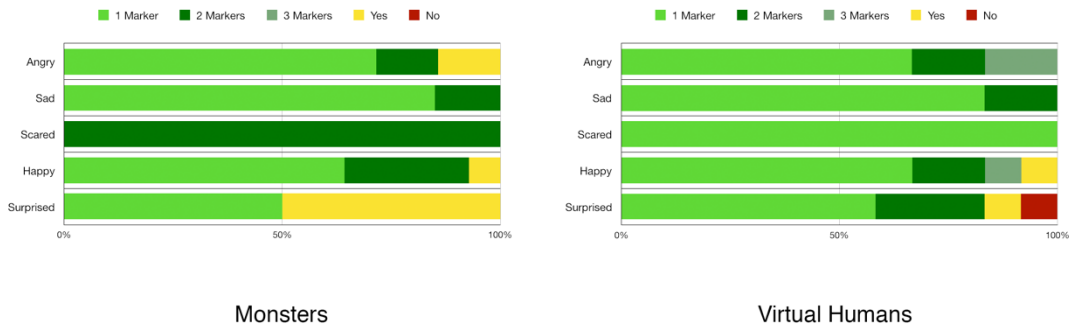


Figure 48. Session 2. Comparison between monsters and virtual humans in the evolution of answers per emotion.

In sum, as shown in Table 19, all the participants used at least nine markers when playing the Tutorial. Also, the three participants, during the test time, played between 18 and 24 characters, scoring a maximum of 80 points (P2-2). P2-3, during the free play time after the test, played with 45 characters, the most played by any of the participants.

Table 19 Session 2. Final results of modes.

Mode	Count	P2-1	P2-2	P2-3 (a)	P2-3 (b)
Tutorial	Markers used	10	9	15	17
Create A Monster	Monsters saved	2	1	1	-
	Markers used	17	3	7	-
	Wrong markers used	5	0	2	-
Guess the Emotion	Characters played	18	27	24	45
	Markers used	25	32	29	35
	Maximum score	36	80	70	61

4.3 Summary

In a review of these results, the most relevant data consists of Questions 1 and 6 through 8 on the pre-test and post-test surveys. As the expert survey was only administered during the first session with significant suggestions being integrated for the second session, it cannot be used for further analysis. Observations provide the general behavior of the participants, yet for the most part, what behavior was observed does not contradict data on the questionnaires. The only observation overall to make is that the

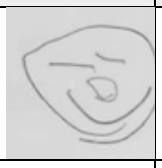
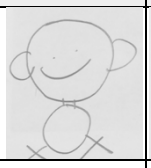
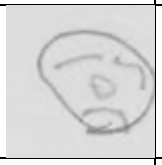
participants of the second session were more engaged than those of the first. To what degree this was affected by the changes is uncertain.

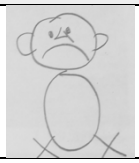
As for the App Logs of either session, it can be observed how the changes realized between them, as suggested by the experts, appear to be welcome by the children. The logs of the second session show an increased amount of interactions and lower response times, as is compared in Table 20.

Table 20 Comparison: Response times for decisions using the markers.

Action Performed	Session 1 Average Time (sec)	Session 2 Average Time (sec)
Shape marker detection	10.5	7.5
Color marker detection	13.8	13.8
Emotion marker detection	13.5	11.8
Create A Monster actions (average)	**12.6**	**10.9**
Right answer (1st try)	7.7	5.1
Right answer (2nd try)	17.2	3.5
Right answer (3rd try)	2	6.0
Right answers (average)	9.6	4.7
Wrong answer (1st try)	12.3	6.1
Wrong answer (2nd try)	7.8	1.4
Wrong answers (average)	10.7	4.6
Guess the Emotion actions (average)	**10.1**	**4.7**

Table 21 Comparison: Question 1. Participant Answers.

		P1-1 (pre)	P1-1 (post)	P2-1 (pre)	P2-1 (post)	P2-2 (pre)	P2-2 (post)
Happy face							
Action units	6	Yes	Yes	Yes	Yes	Yes	Yes
	12	Yes	Yes	Yes	Yes	Yes	Yes
Sad face							-
Action units	1	Yes	Yes	No	Yes	No	-
	4	No	No	Yes	Yes	No	-
	15	Yes	Yes	Yes	No	No	-

		P1-1 (pre)	P1-1 (post)	P2-1 (pre)	P2-1 (post)	P2-2 (pre)	P2-2 (post)
Scared face				-		-	-
Action units	1	No	No	-	No	-	-
	2	No	No	-	No	-	-
	4	Yes	Yes	-	No	-	-
	5	No	No	-	Yes	-	-
	7	No	No	-	No	-	-
	20	Yes	Yes	-	No	-	
	26	Yes	Yes	-	No	-	
Surprised face				-			-
Action units	1	Yes	Yes	-	Yes	No	-
	2	Yes	Yes	-	Yes	Yes	-
	5	Yes	Yes	-	No	Yes	-
	26	Yes	Yes	-	Yes	Yes	-
Angry face		-	-	-			-
Action units	4	-	-	-	Yes	No	-
	5	-	-	-	Yes	No	-
	7	-	-	-	Yes	Yes	-
	23	-	-	-	No	No	-

As seen in Table 21, three participants were able to answer Question 1 in the pre- and post-test questionnaires, one from the first session (P1-1) and two from the second session (P2-1 and P2-2). Regardless of which participant, even looking at the other participants not represented in Table 21, the participants always got the two action units for a happy face. All the sad faces drawn always had tears. Two of the participants from Table 2 still included tears, even though the monsters in the game did not have tears on their sad faces.

On all faces drawn, P1-1 did not show any changes in which action units were used or excluded. However, in the happy face, the smile was smaller but was an open shape rather than a line. For the sad face, the eyes and mouth became open, while the nose was skipped in the latter. Between all the faces drawn by P1-1, this general observation can

be made. During the post-test questionnaire, they drew the faces with open eyes and mouths.

In comparison, P2-1 managed to draw three more representations in the post-test than the pre-test. In all their post-test drawings, they emphasized the mouth, more so than the eyes or brows. For all three participants, the nature of the drawings remained the same between the pre-test and post-test.

In comparing participants between sessions, there were no participants in session 1, who completed Question 3 on the post-test questionnaire, yet two participants in session 2 did. Of these two, both appeared to improve from the pre-test to the post-test. One managed to provide an answer for all five, getting three correct, rather than none, and the other got one more correct on the post-test questionnaire than on the pre-test.

As for the experience of playing the game, Table 22 shows the answers of participants across both sessions. All that answered said the games were fun. Create A Monster was considered easy, and apart from one participant, the other four participants indicated that they would play it again. For Guess the Emotion, one of the four participants that answered found it hard. Another one of the four indicated that they would only maybe play it again, while all the rest affirmed that they would.

Table 22 Comparison: Questions 6-8. Participant Answers.

Question	**Would you do it again?**			**Was it?**			
Answers	**No**	**Maybe**	**Yes**	**Boring**	**Fun**	**Hard**	**Easy**
Create A Monster	P1-1		P1-3, P2-1 P2-2, P2-3		P1-1, P1-3 P2-1, P2-2 P2-3		P1-1, P1-3 P2-1, P2-2 P2-3
Guess the Emotion		P1-1	P1-3, P2-2 P2-3		P1-1, P1-3 P2-2, P2-3	P2-2	P1-1, P1-3 P2-3

5. ANALYSIS

5.1 Response to Hands-free AR

Despite the lack of sound in Session 1, P1-1 and P1-3 found the game to be fun and easy. However, P1-1 expressed a negative in playing Create A Monster again and only a maybe in playing Guess the Emotion again. In comparison, for Session 2, all participants found Create A Monster to be easy and fun, and of the two that answered for Guess the Emotion, while they both found it fun, one found it easy, and the other found it hard. About playing it again, all participants indicated they would for Create A Monster, and for Guess the Emotion, the two that answered indicated they would.

Though it was not included initially to avoid sensory overload, the sounds still seemed to play a part in engaging the children as they were much more engaged in the second session than in the first. Also, it seems some agency, as in the inclusion of the Tutorial game, whether it builds confidence in the mechanism of the game or allows independence, is more engaging. However, between the two sessions, the children mostly found the game to be fun and easy despite the absence of these factors in the first session. The more indicative measure, rather than answers to the survey, was the number of markers used and the fact that at the end of the second session, P2-3 actually played the game after the experiment.

With the setup of this game, children could be more active, handling the cards in their hands and embodying their choices. With agency, simplicity, and controlled levels of difficulty, this may have resulted in more comfort and ease of use. Regardless of whether the child is neurotypical or neurodivergent, the children engaged more with a system that gave them a sense of their agency.

5.2 Effect on Skills in Emotion Recognition

Of the three participants in Session 1, P1-1 was the only one that was able to complete the pre-test questionnaire and at least one part of the review portion in the post-test questionnaire. There was no difference between the action units used, as in which units were included and excluded, in drawing the faces for Question 1. For session 2, P2-1 and P2-2 were able to draw some faces. As noted in 5.3 Summary, regarding all the faces drawn by P1-1, between the pre-test and post-test, the faces were drawn in the post-test with open eyes and mouths. In comparison, P2-1 managed to draw three more representations in the post-test than the pre-test. In all their post-test drawings, they

emphasized the mouth, more so than the eyes or brows. For all three participants, the nature of the drawings remained the same between the pre-test and post-test. While there were no participants in session 1, who completed Question 3 on the post-test questionnaire, two participants in session 2 did. Of these two, both appeared to improve from the pre-test to the post-test. One managed to provide an answer for all five, getting three correct, rather than none, and the other got one more correct on the post-test questionnaire than on the pre-test.

Five of the six participants did not draw an angry face. The only one that did (P2-2) only used three of the four action units ascribed to an angry face by the EMFACS system. Of the 5 participants that drew a sad face, all of them included a tear or tears. None of them used all the action units ascribed to a sad face by the EMFACS system. The most complex facial expression, Fear, was either not drawn or missed most of the action units ascribed by the EMFACS system.

5.3 Discussion

At present, AR and other mixed reality technologies are becoming more popular and thus more prevalent. However, these technologies are usually constrained to the parameters of the device. One of the objectives of this study was to ascertain children's response to a hands-free AR game, particularly of children on the AS. Given it was a game, it was meant to be fun and repeatable. As the results have shown, the children in this study did find it fun and expressed the wish to play again. From observations of the children, agency appears to be a factor of engagement. In the first session, the children were less responsive and had to be guided by the assistant much of the activities. In contrast, children in the second session, given the addition of the Tutorial game and sound effects, were more likely to take the initiative and interact with the game on their own.

In the design and research of games for neurodivergent children, agency may be an essential factor to consider. By agency, one means to what extent a child can pick up the mechanism of the game and use or control it on their own. Increased agency means less adult interference. As Tell and their colleagues (2014) affirmed, ND children rated expressions as more intense than neurotypical children. If size and complexity is a factor in the view of expressions, the view and presence of an adult would affect a child's perception. When the assistant was less involved in the activity, the children were more engaged with the game, and one even expressed that they wanted to play, indicating that the assistant need not intervene anymore.

The objective of this study was not to ascertain the effect of agency but on the possibility of a hands-free AR concept and its effect on fostering and improving emotion

recognition skills. As observed, the hands-free AR concept was engaging, and agency was seen to be a factor of the degree of engagement. For its effect on fostering and improving emotion recognition skills, it is not particularly certain. While some of the participants showed an improvement, one of them capable of matching all emotions to an expression and another drawing out all of their portrayals of emotions, this study can only affirm the potential of this particular game's design in improving emotion recognition skills. In the least, none of the children were affected negatively, yet most showed no change between before and after playing the game.

In a real-world context, a hands-free AR concept may not be as convenient. While it was engaging, the setup required the tablet, a stand, and cards. Parents usually prefer games with less equipment as it means fewer things to keep track of. Such an inconvenience can easily be addressed, presuming the equipment is provided as a set or pack. However, AR technology has yet to reach children as a safe medium. By this, one means that toys are acting like computers and cell phones, which are given more realism and functionality with higher age suitability. AR for children requires the use of an actual tablet or cell phone. Although hands-free AR could be a promising concept for children, here in particular for children on the AS, some manufacturers of AR technologies would have to appear for the adaption of its specifications for children. As previously noted, this study was based on the OsmoTM set from Tangible Play Inc. Yet, even the offerings of Tangible Play are reliant on devices for adults, as in the AR capabilities on tablets and cell phones.

6. CONCLUSIONS

This study explored the concept of a hands-free AR game for children on the autism spectrum, in particular on the improvement of emotion recognition skills. A game designed for generating monsters with various facial expressions, conveying one of five basic emotions, was prototyped and played by six neurodivergent children between two sessions. The game included both monsters and virtual humans to familiarize the children with different versions of the same expression. Changes, such as the addition of sound and modification of the scaffolding rules for emotions and faces, were made to the prototype following the first session. It was notable that one of the teachers interviewed following the first session stated that the eye color of the monsters, mainly blue, might indicate tears, which is a common feature associated with sadness among the children. They also commented that this association was likely to be made due to the children's familiarity as the materials in their classrooms portray sad faces with tears. This makes familiarity and culturally-defined associations factors of emotion recognition.

The results of this study also suggest that agency is a factor of engagement. All of the children that responded to the post-test questionnaire (five of six) indicated that the game was fun, and they would play again, one of which even asked to play the game again following immediately after their session. With the ease of use, the child had no problem setting it up themselves. While improvement was observed in the results, it is not certain if the game itself is the cause.

6.1 Significance

Up to now, numerous studies on games for children on AS, even using AR, have been device-reliant. The interaction of the children was limited to the physical constructs of the device, whether as a controller, mouse, and keyboard, or a touch screen. Limiting the child's physical capacity of interaction may affect how engaging a game is. For an educational game that is preferably designed to entertain and cultivate skill and learning, engagement is an essential factor.

Based on this study, future studies on games for neurodivergent children, not only those on the AS, should take this notion of the degree of agency into consideration. Part of the development of children is agency, as in physical and mental independence. A game that allows for more agency requires the synchronicity of the physical and mental. However, this study was not looking at the factor of agency and its effect on either the response to AR or the improvement of emotion recognition skills.

Regarding previous studies, this study affirms the engaging quality of AR. The children all found the game fun, and most indicated they would play both modes again. For the improvement of emotion recognition skills, the engaging quality of AR likely helped in procuring the benefits of the game, but this notion needs to be validated. However, future studies and projects hoping to affect emotion recognition skills could use the same model, using character faces designed and assessed with EMFACS to measure children's progress. Also, utilizing both animated and realistic elements, such as the monsters and virtual humans, of this game could further improve such skills for children on the AS in particular.

6.2 Limitations

Although a game for emotional development of children on the AS using AR is possible, the data presented here is insufficient to determine its actual effectiveness. Improvement may have been observed in the second session, but these improvements are observed from only two children. A much larger sample would be needed to ascertain the validity of the observed improvement. While it is also crucial that the children found the games easy and fun, that one of the children found Guess the Emotion hard may indicate its potential value.

Another factor affecting the validity of these results, however, is that the form of the questionnaire did not sustain the children's attention. Though it may be considered inevitable, it should not be acceptable, whether with NT or ND children. A lack of engagement is a compromise on results. While the shortage of time was unavoidable, the children's inability to provide answers to questions due to a lack of focus or concentration meant fewer comparisons and indicators for addressing the objectives of this study. It directly resulted in the loss of possibly meaningful data, namely in the immediate assessment of each child's ability to recognize and identify different basic emotions.

As a serious game and as noted by Almeida and their colleagues (2019), children on the AS would likely benefit more if the game was part of a daily routine as in the emotion recognition classes offered at the school where this experiment was conducted. Games are meant to be played several times, and just as there are games for entertainment, there are games for learning and relaxation. A more indicative measure of the efficacy of this game might arise if the experiment had been conducted on a nearly daily basis for a given period of time. This said, one should note the factor of familiarity.

As one teacher pointed out in this study, tears were associated with sadness as the materials the children were exposed to all reinforced this notion. This teacher warned that the blue eyes of the monsters could be associated with tears. In a community or society where having eyes a color other than brown signals a difference, such as racial

or national affiliation, the color of the eyes on artificial entities may more likely cause false impressions. If this experiment took place in Northern Europe, where the variation of eye color is more familiar and expected, this color association would less likely have been a factor. Since this experiment was not considering familiarity and color association, it cannot be surmised to what extent familiarity and color association affected the results.

6.3 Further Study

Due to this experiment's limitations, it is suggested this study be replicated to validate the results before pursuing any enhancement or modification on the parameters and game concept. For the replication, it would be sufficient for the pre-test questionnaire to only consist of the first and fourth questions, and for the post-test questionnaire to only consist of a review of the pre-test's first and fourth, as well as the sixth through eighth. If performed frequently over a period of time, however, the questionnaires need only be conducted twice, and the format need only be contained to the functionality of the game. In other words, incorporate the questionnaire into the design of the game. This would require more cooperation with the school to temporarily incorporate the game into their curriculum, as well as a partial redesign to allow features that support educational administration. Fulfilling these conditions would more likely result in a valid assessment of the game's efficacy in fostering and improving skills in emotion recognition.

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9. PUBLICATIONS

[1] VICENTE LOPEZ TROMPO, D., HAN, T., RATSAMEE, P. and TAKEMURA, H. (2019). An AR Puzzle Application for Improving Emotion Recognition for AS Children. In *Proceedings of the 3rd International Conference on Digital Technology in Education*. Yamanashi, Japan.