



## **VIRTUAL REALITY FOR SOCIAL ATTENTION TRAINING**

**IN-ON            WIRATSIN**

**A PROJECT SUBMITTED IN PARTIAL  
FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE  
BACHELOR OF ENGINEERING IN COMPUTER ENGINEERING**

**FACULTY OF ENGINEERING & INTERNATIONAL COLLEGE  
MAHIDOL UNIVERSITY  
2017**

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Computer Engineering Project  
entitled  
**VIRTUAL REALITY FOR SOCIAL ATTENTION TRAINING**

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**VIRTUAL REALITY FOR SOCIAL ATTENTION TRAINING**

was submitted to the Faculty of Engineering & International College,  
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In-on Wiratsin

## VIRTUAL REALITY FOR SOCIAL ATTENTION TRAINING

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### ABSTRACT

Social attention skills are important for development in children. Learning social skills is difficult for autistic children. Perceptions of autistic children are different from normal children. One obstacle for most autistic children is communication impairment. It negatively affects relationships, perceptions and understanding. Many therapies have tried to deal with autistic symptoms. Examples include electric shock, holding therapy and applied behavior analysis (ABA). ABA uses careful observation to reinforce the correct behavior. Also, Virtual Reality (VR) technology can excel some limitations of original ABA. The ABA therapy and VR technology will be used. Virtual Reality for Social Attention Training (VR-SAT) project is intended to improve social attention skills in autistic children. The project requires effective software, including Blender 3D, Mixamo and Unity. The project will present a group conversation of avatars to user. It will detect head movement and gaze behavior. If a user shows correct behavior, a reward will be given. This project allows users to feel secure in learning social attention skills. There are five participants involved in the experiment. The result showed that all participants have higher score after using VR-SAT for a period of time which refers to the improvement of social attention skill.

**KEYWORDS:** Virtual Reality/ Social Attention/ Autistic/Applied Behavior Analysis

65 pages

## CONTENTS

	<b>Page</b>
<b>BIBLIOGRAPHY</b>	<b>I</b>
<b>ACKNOWLEDGEMENT</b>	<b>II</b>
<b>ABSTRACT</b>	<b>III</b>
<b>CONTENTS</b>	<b>IV</b>
<b>LIST OF TABLES</b>	<b>VI</b>
<b>LIST OF FIGURES</b>	<b>VII</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Introduction	1
1.2 Objective	4
1.2.1 Examining the effect on using VR for autistic children	4
1.2.2 Addressing limitations of previous VR interventions	4
1.3 Project Scope	5
1.3.1 Condition of correct eye contact	5
1.3.2 Four different VR scenes	5
1.3.3 User's head movement tracker	5
1.4 Expected Results	6
<b>CHAPTER 2 LITERATURE REVIEWS</b>	<b>7</b>
2.1 Theoretical Research	7
2.2 Related Work	10
<b>CHAPTER 3 METHODOLOGY</b>	<b>12</b>
3.1 System Component	12
3.2 Main Features	14
3.2.1 Gaze's behavior tracker	14
3.2.2 Interactive avatars	15
3.3 Main Tools	16

## CONTENTS (CONT.)

	<b>Page</b>
3.3.1 Blender	16
3.3.2 Mixamo	16
3.3.3 Unity 5.6.2f	16
3.3.4 Android device	17
3.3.5 VR headset	17
3.4 Project Design	18
3.4.1 User interface	18
3.4.2 Virtual scenes	22
3.4.3 Animation in Unity	24
3.4.4 Implement C# script	26
3.4.5 Gaze's behavior tracking	27
<b>CHAPTER 4 RESULT AND EVALUATION</b>	<b>29</b>
4.1 Experiment Setup	29
4.2 Experiment Design	31
4.3 Experiment Result	36
4.4 Questionnaire Result	43
4.4.1 Guardian's Questionnaire	43
4.4.2 Participant's Questionnaire	44
<b>CHAPTER 5 CONCLUSION</b>	<b>46</b>
5.1 Discussion	46
5.2 Conclusion	46
5.3 Limitation	47
5.4 Future Work	47
<b>REFERENCE</b>	<b>48</b>
<b>APPENDICES</b>	<b>51</b>
Appendix A	51

**LIST OF TABLES**

<b>Table</b>	<b>Page</b>
4.1 Four days experiment design	36
4.2 Guardian's questionnaire	43
4.3 Participant's questionnaire	44

## LIST OF FIGURES

<b>Figure</b>		<b>Page</b>
1.1 A communication impairment in autistic children		1
1.2 Patient is testing on VR device		2
1.3 Virtual classroom project from UC Davis		3
1.4 Virtual reality therapy for autistic children		6
3.1 Top view of supermarket scene in Unity		12
3.2 Play mode of supermarket scene in Unity		12
3.3 Head mounting around axes of device		13
3.4 GVR pointer reticle		14
3.5 GVR pointer reticle interaction		14
3.6 Talking avatar in supermarket scene		15
3.7 Blender software		16
3.8 Mixamo software		16
3.9 Unity software		16
3.10 Android 4.4 KitKat		17
3.11 VR headset Shinecon		17
3.12 Four buttons display on Main Menu		18
3.13 After choose PLAY go to Scene Selection		18
3.14 Four scenes from VR-SAT		19
3.15 OPTIONS for language selection		19
3.16 ABOUT US-1		20
3.17 ABOUT US-2		20
3.18 Scene Selection Menu		21
3.19 PutOnVR scene with 20 seconds countdown		21
3.20 All four scenes from VR-SAT		22
3.21 Graph showing the number of avatars, level of distraction noise		23
3.22 Animation in Unity diagram (1)		24
3.23 Animation in Unity diagram (2)		24

**LIST OF FIGURES (CONT.)**

<b>Figure</b>		<b>Page</b>
3.24	Animation in Unity diagram (3)	25
3.25	Pseudo-code of avatar's animation	26
3.26	user gaze behavior on the correct field of view	27
3.27	Hit condition	27
3.28	User ignore talking avatar, gaze behavior out of the field of view	28
3.29	Miss condition	28
4.1	PDQ Questionnaire	29
4.2	Evaluation questionnaire for participant	30
4.3	Evaluation questionnaire for participant's guardian	30
4.4	Testing on participant	31
4.5	Display output in VR mode	31
4.6	Scene 1 Day 1	32
4.7	Scene 2 Day 1	32
4.8	Scene 1 Day 2	33
4.9	Scene 2 Day 2	33
4.10	Scene 3 Day 3	34
4.11	Scene 4 Day 4	34
4.12	Scene 3 Day 4	35
4.13	Scene 4 Day 4	35
4.14	Result chart for Day 1	37
4.15	Result chart for Day 2	38
4.16	Result chart for Day 3	39
4.17	Result chart for Day 4	40
4.18	Result chart for the longest holding eye contact period	42
A.1	PDQ result (1)	51
A.2	PDQ result (2)	52
A.3	PDQ result (3)	53

A.4	PDQ result (4)	54
A.5	PDQ result (5)	55
A.6	Guardian's questionnaire result (1)	56
A.7	Guardian's questionnaire result (2)	57
A.8	Guardian's questionnaire result (3)	58
A.9	Guardian's questionnaire result (4)	59
A.10	Guardian's questionnaire result (5)	60
A.11	Participant's questionnaire result (1)	61
A.12	Participant's questionnaire result (2)	62
A.13	Participant's questionnaire result (3)	63
A.14	Participant's questionnaire result (4)	64
A.15	Participant's questionnaire result (5)	65

## CHAPTER I

### INTRODUCTION

#### 1.1 Introduction

Social attention is an interest in people. We can communicate our interest and attention with others in society. It helps us to build up relationships. Social attention skills are important for children. They develop this skill to build up and maintain relationships with friends and family [1]. It affects children's perceptions, relationships and understanding. It also contributes to social competence for children in school. Social attention is a fundamental skill in social development. It affects social learning. Examples include language development, social cognition, and social competence [2]. Most children can learn social skills by themselves, they can observe the behavior of their parents and teachers. They observe their parents and teachers behavior. They can generalize this skill in daily life. Learning social skill is difficult for autistic children.



**Figure 1.1:** A communication impairment in autistic children [3]

The perceptions of autistic children are different from normal children. As shown in Figure 1.1, one obstacle for autistic children is communication impairment. Most autistic children avoid making eye contact, it causes extreme stress for autistic children [4]. For over sixty years, many therapists and doctors have created autism treatments to deal with this problem. Some of them failed, while some are not effective enough [5].

Presently, the most effective autism therapy is Applied Behavior Analysis (ABA). The therapist uses strategy of behavioral observation followed by positive reinforcement [6]. However, ABA therapy also has some limitations that can be developed with virtual reality technology. Recently, projects have been created based on the original ABA therapy integrated with VR technology. In Figures 1.2 and 1.3 show examples of virtual reality for eye conditioning in autism and virtual classrooms for developing social skills in autistic children [7].



**Figure 1.2:** Patient is testing on VR device [8]



**Figure 1.3:** Virtual classroom project from UC Davis [8]

The purpose of this project is to create a VR device to improve social attention skill in autistic children. This project requires Blender, Mixamo and Unity software programs for creating a virtual environment. It also uses a VR headset with built-in head tracker. The VR-SAT is intended to develop social attention skills in autistic children. This project allows users to experience real-life scenarios in a safe virtual environment. Users will be able to utilize the skills in real world. With a better social attention skill, autistic children will have an opportunity to build up and maintain good relationships with other people in society.

The VR-SAT project was inspired from my own personal experiences with autistic children for over five years. Since 2011, I have joined the ACT youth orchestra band as a principle musician (cellist) and that was the first times when I had an opportunity to expose my experience into the world of autism. Apart from being a cellist in the orchestra band, I also had to conduct a cello class. I had six of middle school students in my class and one of them is diagnosed with autism. It was obviously for me to see that the twelve years old boy with autism demonstrated social attention skill deficits. For instance, he often used repetitive language, or rocked his hand back and forth for the whole time, and when he played cello he often struggled with rhythm of the song. I later realized that staying focused is very difficult for autistic children. This challenge was truly driven me to come up with the strategy to enhance motor skill for this autistic boy. For two months, I spent two hours of everyday doing rhythm training with him, I gave out two wooden plates one for him and one for me, I used a drum stick to hit to the wooden plate to make the rhythm 4/4 starting with a very slow tempo, then I will allow him to hit his wooden plate and try to catch up with my tempo, until he can reach to the same tempo as mine, then I will speed up a bit faster. This training (which later I called it as the rhythm in rehabilitation) showed that it indeed positively affected on the boy's motor skill, he can played cello much better than the previous.

Although I had a little succeed in improving the boy's motor skill, but it is apparently that a very serious issue that concerned me the most was his social attention deficit skill. To illustrate, whenever we had a conversation, he always looked away, and avoided making eye contact or any gaze behavior with all of his conversation partner.

From the failure of social attention skill, it does negatively affect the way he learn, perceive, relate and understand things that occurred. I had discussed with some therapists about his symptom and they suggested that an Applied Behavior Analysis (ABA) therapy was the most effective therapy for children with autism. However, in Thailand the ABA therapy was not so popular and there is only a few number of children who ever been through this therapy. Therefore, this point triggers me to think about what if we can have ABA therapy by using virtual reality technology, so it will provide benefits in terms of having a convenient safer learning situation with controllable input stimuli that we can designed for each particular children.

## **1.2 Objective**

The virtual reality for social attention problem project, intended to cover a range of improving social attention skills in autistic children by using virtual reality technology, objectives aims to enhance children to pay attention and can keep an eye contact with other persons while having a conversation.

### **1.2.1 Examining the effect on using VR for autistic children**

The purpose of this Virtual Reality Social Attention Training project (VR-SAT) was to observe and examine the effect on using virtual reality for children with social attention disorder, including children with autism spectrum disorder (ASD) for learning their social communication skill in daily life, mainly focusing on learning how to keeping eye and make a gaze behavior contact with other persons.

### **1.2.2 Addressing some limitations of previous VR interventions**

The VR-SAT was designed to address some of the limitation of previous VR interventions by providing social attention training that can be used in children between ages seven to fifteen years old using varying contexts and complexity of social scenarios, therefore the VR-SAT is possible to customize the virtual environment to the specific profile and learning style of each user.

## 1.3 Project Scope

The Virtual Reality Social Attention Training (VR-SAT) involves the use of virtual reality for social attention on social skills for autistic children, therefore the subject group is the children between ages of seven to fifteen who cannot keep an eye contact while having a conversation with other persons.

### 1.3.1 Condition of correct eye contact

In the virtual world of VR-SAT if the user did not pay attention with the avatar then the avatar the score will be deducted and if the avatar still not get attention back in the limit time then the avatar will slowly faded away, and will appear again when it gets attention from the user, this strategy will remind the user to always look at the person's face and make a proper gaze-behavior while talking with others.

### 1.3.2 Four different virtual reality scenes

Four scenes will be created for users to experience the real life scenarios, each scene will have different numbers of avatar and different level of distractions. The four scenes consist of park, restaurant, supermarket and classroom.

### 1.3.3 User's head movement tracker

The VR-SAT will track the user's head movement in three planes, which are up or down, left or right and an angle, and for those three planes information we can tell that where exactly the user is looking at in the virtual world.

## 1.4 Expected Results

VR-SAT is intended to improve social attention skills in autistic children. The design of the project is based on the positive reinforcement strategy of ABA therapy (see Figure 1.4). The project allows users to feel secure in learning social skills in the real world. Users can practice the skills until they become proficient [7]. As a result, they can utilize the skills in real world. The VR-SAT project will be a training tool to improve social attention skills in autistic children.



**Figure 1.4:** Virtual reality therapy for autistic children [9]

## **CHAPTER II**

### **LITERATURE REVIEW**

Children with autism spectrum disorder have deficits in the development of social skills. They experience issues in understanding social circumstances and utilizing social abilities to interact and communicate with others. As a result, to develop the chances for these children to learn proper social interaction skill and perform appropriate behaviors, various therapies have been suggested in many studies, including the parentectomy, lysergic-acid-diethylamide, and electric shock therapy, auditory therapy, holding therapy and applied behavior analysis.

#### **2.1 Theoretical Research**

Focusing on the early literature, the evolution of social attention treatment for autism. According to the scientific journal in 2002, back in 1950 Bettelheim, leader of the University of Chicago's Orthogenic School for Disturbed Children, trusted the cause for a mental imbalance symptoms in autism was the parents, particularly the mother. As a result of this conviction he created parentectomy, he removed the kids from the guardians for a very long period of time. However, it wound up plainly evident after Bettelheim's suicide that his previous successful result had been distorted. Bettelheim's incredible examples of overcoming adversity ended up involving kids that weren't really extremely introverted. He had created many outcomes and had no genuine preparing in therapy. In spite of the fact that, obviously Bettelheim's treatment was in all actuality unsuccessful there were still some psychoanalytic advisors who kept on following his thoughts.

After the failure of Parentectomy, in 1960's scientists examined the use of a serotonin restraining drug (LSD-25) as a treatment for social attention in autism. The thought behind using medications to treat autism based on the idea that an autistic symptom is an identity, so the medications are intended to adjust the individual's perception state [10]. Although some were agreed to use LSD to treat autism, but at that

time many researches came out to oppose that using LSD was seen as abusive to the patients. Therefore in the late of 1968 medication treatment with LSD had rapidly reduced. Although from the observation from this medication treatment showed the positive result, the child who received LSD tended to be happier and easily exposed themselves to engage with the social attention, but there is a controversial treatment about the symptoms of autism which is still unknown.

A medical journal in 1975 reported the result of an electric-shock-therapy in autistic children demonstrated many positive results. An electric-shock-therapy was used as punishment for unwanted behaviors. When the subject occupied with an undesirable behavior, the subject got an electric-shock to diminish the frequency of that behavior, the electric-shock is painful but it is not at a perilous level. According to the study of Lichstein and Schreibman [11], the electric-shock-therapy can help to increase positive behavior and decrease negative behavior with negligible side-effects, they saw an expansion in social attention behavior after the treatment. After his study was published, many believed that the positive side-effect of this treatment exceeded the negative side-effect.

In 1982, an Auditory Integration Training (AIT) was first created by a group of French therapists, the treatment is implied the auditory-sensitivity that many autistic children suffer from based on the belief that these sensitivities to various sound waves can trigger and cause different behaviors and learning issues. Although, the AIT has had some successful results in treating a patient with autism during the past time, however this treatment still needs more empirical research behind it, before it is used universally [12].

In 1999, Martha Welch a famous research specializing in child development was developed the holding treatment (psychodynamic treatment) to treat autism in autistic children who cannot make any gaze-behavior with their conversation partner, with the strategy to restrain the child's behaviors by using physical methods and force the child to make eye contact with the adult. The theory behind this treatment is based on two concept. In the first place is the possibility that an autism symptoms depends on an aggravation in the relationship between parents and kids which also can related back to

the key concept of Parentectomy in 1960's. The second one is that this aggravation in gaze-behavior in autistic child can be forcefully settled when a child is physically controlled by an adult or an instructor [13]. According to Child Myths: Holding Therapy and Autism, this treatment additionally does not have observational confirmation behind it yet and is not utilized routinely [14].

Applied Behavior Analysis (ABA) therapy was first developed by Ivar Lovaas since the 1960's, in the book Applied Behavior Analysis (2009) stated that this therapy is seen as the best and the most effective therapy for children with autism, and also currently has the most research behind it [15]. The focuses of ABA are on teaching motor skills, social skills, and reasoning skills in children with autism. The ABA therapy uses careful observation of the child's behaviors followed by positive reinforcement. To clarify, when the child does the correct behavior then they will receive something that they find rewarding, such as, a sticker, a candy or a toy. The theory behind this therapy is to figure out what triggers an undesired behavior and what reinforces the behavior, then afterwards the parents or therapists can stop the trigger and the reinforcement. When the result showed that the appropriate behavior happens it is reinforced. Based on the concept of the reinforcement for the good behaviors and the removal of the reinforcement for the undesired behaviors, even with the trigger the child will figure out to behavior properly [6]. In general, the ABA therapy will conduct in a one-on-one setting in a small room, it is crucial for the children to receive particular fully attention, so that the programs are conducted particularly for each individual [16].

Although, these aforementioned therapies aimed to treat the symptoms of deficits in the development of social skills, but the most notable indicators is a deficit in eye contact. Researchers suggested that eye contact serves a significant social function and language acquisition skill for children. Furthermore, studies showed that poor eye contact ability can provide negative effects in educational gains and perceptions of autistic children. Therefore, later studies tried to cope with the eye contact conditioning.

Presently, with the ABA therapy in order to teaching eye contact many suggest using prompts. In general there are two types of prompts: (1) A gesture prompts, such as, signaling towards the eye or putting the piece of food that is interest to the child (2)

Physical prompts, such as, manually guiding the child's head so that it is oriented toward the therapist. However, there are some limitation for these approaches, one such limitation is that it is very difficult to eliminate or fade out the prompt while the child continue to hold the eye contact with it, which can be shown that the child pay more attention to prompt than the therapist's eye. The research suggested that when the prompts are directly embedded in stimuli then the child can perform better. Later studies suggested the solutions which can overcome the intrusiveness of the prompts, the first one is augmented reality system, using a VR headset with a stereo video feed. This approach can hold the benefit of the prompt driven system. However, the limitation of the augmented reality system refers to the providing appropriate environment in the reality that can directly affect to the result of the program.

Therefore, the VR-SAT project proposes to overcome these disadvantages by using virtual reality system instead. The child will wear the VR headset and see the whole virtual world with the group of avatars, then with the eye contact conditioning in the VR-SAT the child will learn an appropriate gaze behavior with the conversation partner.

## 2.2 Related Work

At the present, virtual reality technology has proliferated in therapy for autistic children. In 1997, Strickland research team has designed virtual reality crossing road training program as a tool for treatment of autism based on the useful benefits of VR technologies in terms of controllable input stimuli, safer learning situation, individualized treatment and a primarily visual and auditory world. In 2013, Cai research team has developed a Virtual Dolphinarium for autistic children, which allow them to interact with the virtual dolphins and learn communication skills through hand gesture. The University of North Carolina was first developed the game called Astro-Jumper, which allows autistic children to interact with the game by using their own physical developments to avoid virtual flying objects toward them, this game helps the children in developing dexterity and motor skills.

Later researchers have designed a virtual reality for social cognition system aimed at training autistic children. This was a considerable work in that it altogether expands social intellectual measure in principle, emotion recognition, as well as real life social skills. While these previously mentioned related works contribute substantially to the therapy for autistic children, however none of them address a deficit in eye contact in these children. Until the researcher team from Vanderbilt University attempted to condition eye contact in autistic children by establishing a virtual storyteller to guide their focus on their conversation partner. In 2014, Wang research team has designed the project called “Eye Contact Conditioning in Autistic Children Using Virtual Reality Technology” based on the prompt techniques, the child’s attention will follow the prompt as it is removed from the face defeating the aim as it detracts the child’s attention from the conversation partner.

Since 2009, Mundy researcher team at the UC Davis M.I.N.D Institute has developed virtual reality social cognition training for children with autism, aim to enhance social and emotional regulation skills that will help them to learn and generalize these skills in real life. The Mundy virtual world was established as a small classroom with a group of avatars, each avatar will start to interact with the child one by one, the child has to look at a particular avatar and if the child show the gaze behavior deficit in eye contact, then the avatar will faded away. However, in Mundy virtual world only presents the visualization not including the auditory, to complete the program, a therapist or a conversation partner is required. Moreover, with the limitation of the level of virtual reality technology in that time, the customization for the program is also limited and not flexible. And also with the hardware, the old system requires the high performance personal computer and better quality of VR headset to run the program.

## CHAPTER III

### METHODOLOGY

#### 3.1 System Component

VR-SAT will be developed to improve social attention skills in autistic children. We create a VR device using software programs and VR headset with built-in head tracker device. This project uses Blender and Mixamo software programs for creating 3D models. It requires Unity program to create virtual scenes. The project (see Figure 3.1 and 3.2) also requires a VR headset and android smartphone to run.

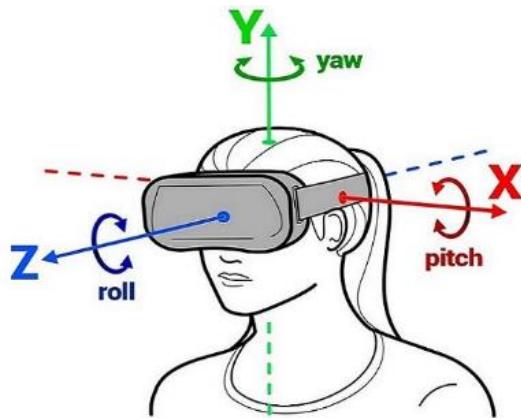


**Figure 3.1:** Top view of supermarket scene in Unity



**Figure 3.2:** Play mode of supermarket scene in Unity

We set and we run the program. Avatars will present a situation to the child as part of group conversation. Each avatar will have its own interaction. One avatar at a time will talk.



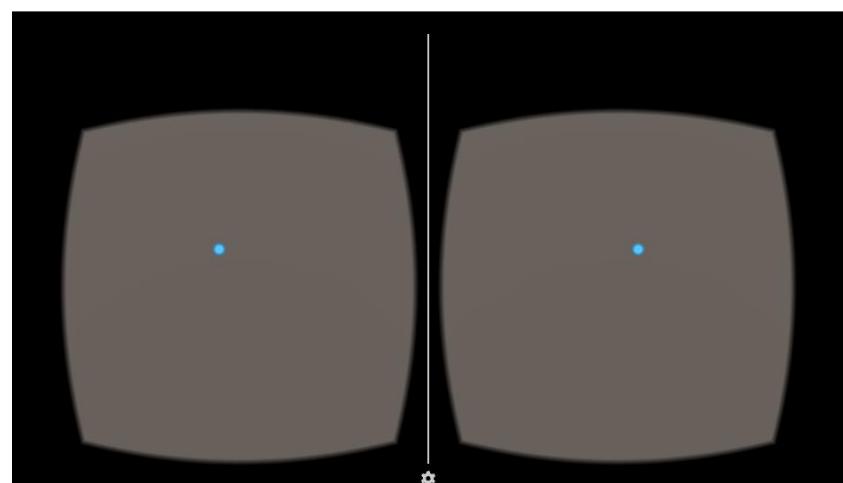
**Figure 3.3:** Head mounting around axes of device [10]

VR-SAT will detect the head movement and gaze behavior of a user (see Figure 3.3). If the user shows correct behavior, pays attention and makes eye contact, a score will be given as a reward. If the user shows wrong behavior or loss of attention, the score will be deducted. Interaction in the virtual world can be increased to maintain individual attention. A program evaluation form will be used to measure the effectiveness. The recorded score for each participant can show the progress, if it shows a higher score after using VR-SAT for a period of time. Therefore, the VR-SAT project will seize the opportunities to address the wider and more flexible in program customization, including the adjustment of the number of avatars and the virtual environment, with the easy and convenient to use in hardware. The software of the VR-SAT can run on the PC or laptop and also on the smartphone that support the software.

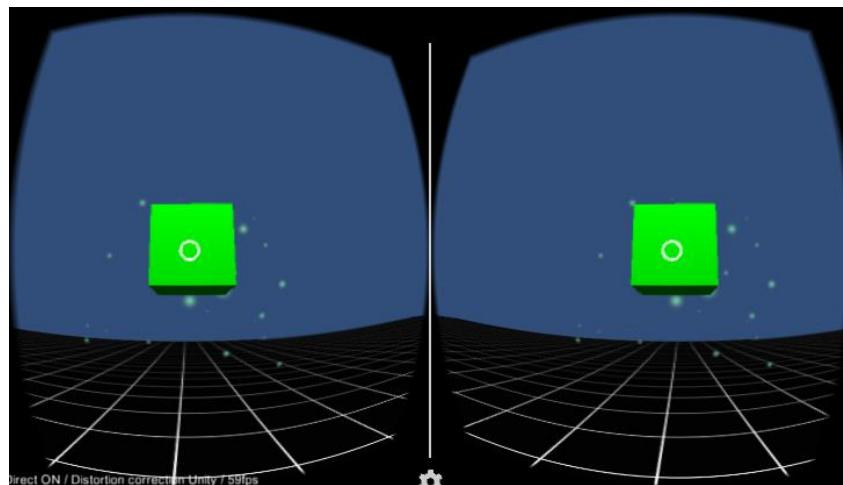
## 3.2 Main Features

### 3.2.1 Gaze's behavior tracker

Imported Google Virtual Reality (GVR) and Software Development Kit (SDK) for Android v1.150.0 and use GVR Reticle Pointer set Main Camera as its parent. The user head movement ant the reticle pointer will work together when the program run in VR mode (see Figure 3.4 and 3.5).



**Figure 3.4:** GVR pointer reticle



**Figure 3.5:** GVR pointer reticle interaction [11]

### 3.2.2 Interactive avatars

The conversation and gesture of avatars will be changed according the behavior of the users during the runtime (see Figure 3.6).

1. eye contact hit the correct spot: animation is “talking”
2. user ignore the avatar for few second: animation is “sad”
3. the avatar was ignore for a long time: avatar faded away



**Figure 3.6:** Talking avatar in supermarket scene

### 3.3 Main Tools

#### 3.3.1 Blender

The three-dimensional (3D) Blender is a free open-source 3D computer graphics software, very effective for creating visual effects, animated films and 3D models.



**Figure 3.7:** Blender software [19]

#### 3.3.2 Mixamo

Mixamo's 3D animation software allows users to create characters and get customize 3D characters.



**Figure 3.8:** Mixamo software [20]

#### 3.3.3 Unity 5.6.2f

Unity is a cross-platform game engine developed by Unity Technologies, which is primarily used to develop both three-dimensional and two-dimensional video games and simulations for computers, consoles, and mobile devices.



**Figure 3.9:** Unity software [21]

### 3.3.4 Android device

For VR mode that will be exported from Unity must support VR mode and need an Android device running Android 4.4 'Kit Kat' (API level 19) or higher and a Cardboard viewer.



**Figure 3.10:** Android 4.4 KitKat [22]

### 3.3.5 VR headset

VR headset that will be used in this project must have comfortable headband and the weight about 0.3 kilogram (see Figure 3.11).



**Figure 3.11:** VR headset Shinecon [23]

## 3.4 Project Design

### 3.4.1 User interface

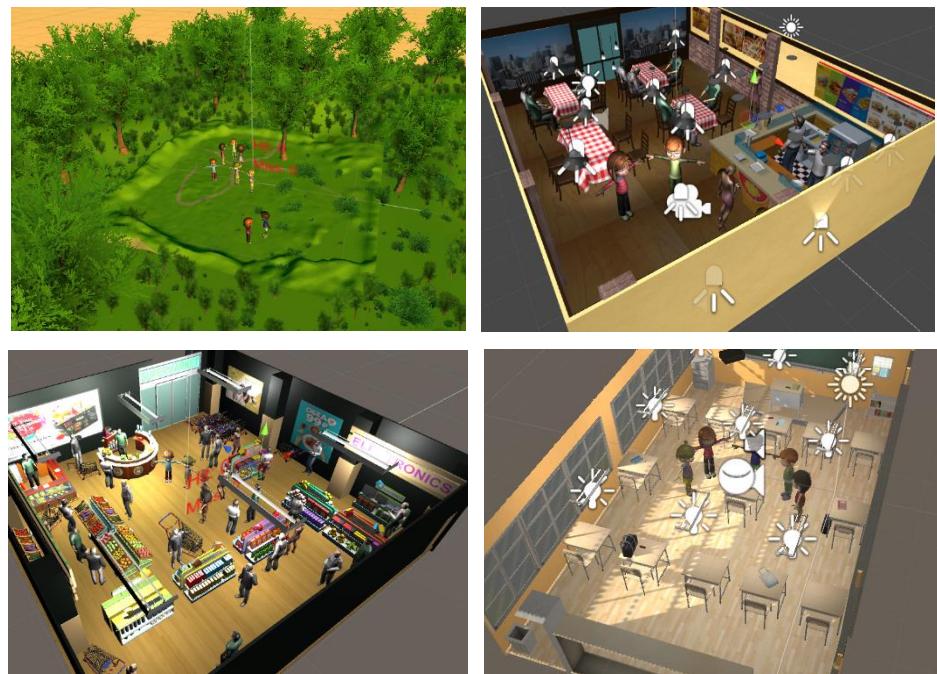
Display in 2D user interface, along with the soundtrack background. User can choose PLAY to select the particular scene and start, or can choose OPTION to select the language for audio (in Thai or English) then choose scene and start. ABOUT US will describe the purpose of VR-SAT and how it works. After users choose the scene to start then the PutOnVR will display, and user will have 20 seconds to set up the VR headset (see Figure 3.12 to 3.19).



**Figure 3.12:** Four buttons display on Main Menu



**Figure 3.13:** After choose PLAY go to Scene Selection



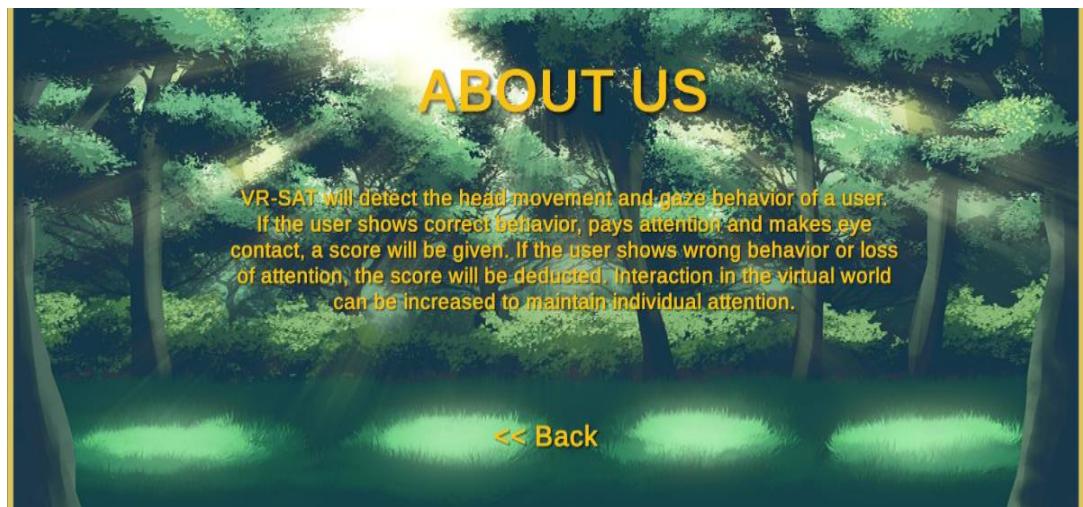
**Figure 3.14:** Four scenes from VR-SAT



**Figure 3.15:** OPTIONS for language selection



**Figure 3.16:** ABOUT US-1



**Figure 3.17:** ABOUT US-2



**Figure 3.18:** Scene Selection Menu

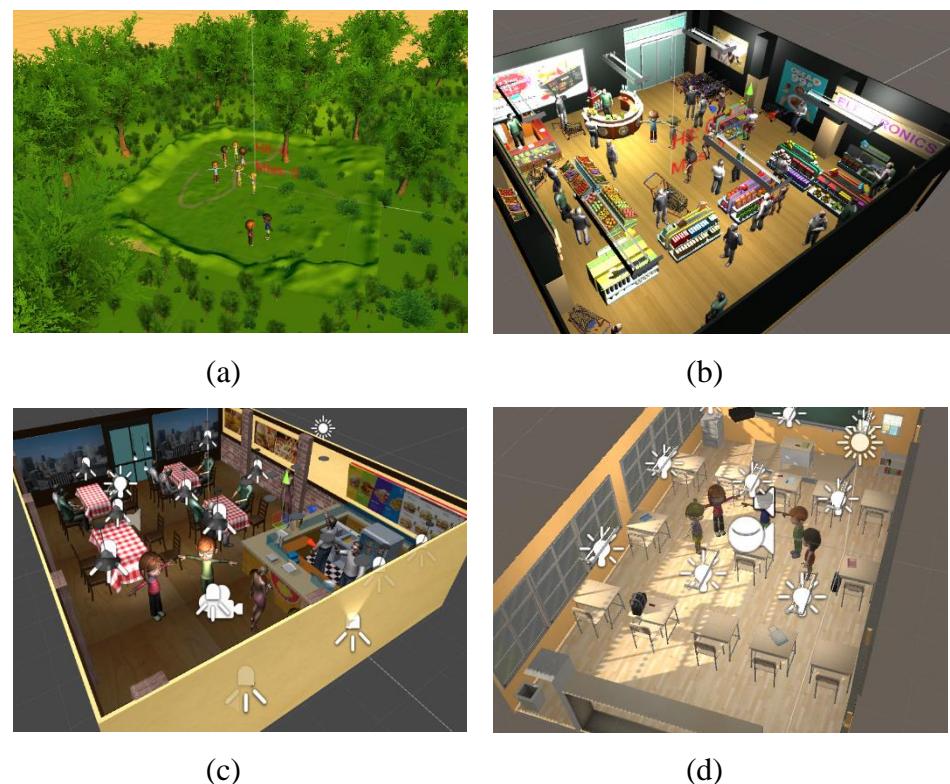


**Figure 3.19:** PutOnVR scene with 20 seconds countdown

Menu scene will display as 2D mode, after user start the scene then the countdown 20 seconds will start to prepare to display next scene in VR mode.

### 3.4.2 Virtual scenes

Four scenes will be created for users to experience the real life scenarios, each scene will have different numbers of avatar and different level of distractions. The four scenes consist of park, restaurant, supermarket and classroom (see Figure 3.20 and 3.21).



**Figure 3.20:** All four scenes from VR-SAT

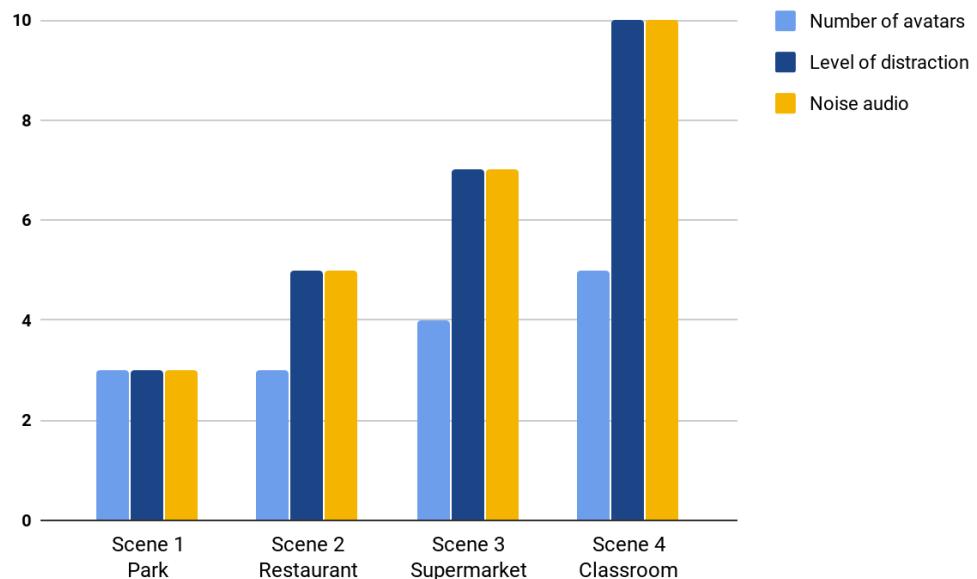
The purpose of the study is to create the virtual environment that can create the situation of group conversation and allow autistic children to practice social attention skills. The study will track the user's head movement in three planes, which are up/down, left/right and an angle, and for those three planes information we can tell that where exactly the user is looking at in the virtual world.

**Scene 1 Park:** This scene consists of three avatars and NPC standing around with the peaceful natural ambient noise, as shown in Figure 3.20(a).

**Scene 2 Restaurant:** This scene consists of three avatars and NPC sitting around with the jazz music ambient noise, as shown in Figure 3.20(b).

**Scene 3 Supermarket:** This scene consists of four avatars and NPC walking around with the heavy ambient noise engine or gossip, as shown in Figure 3.20(c).

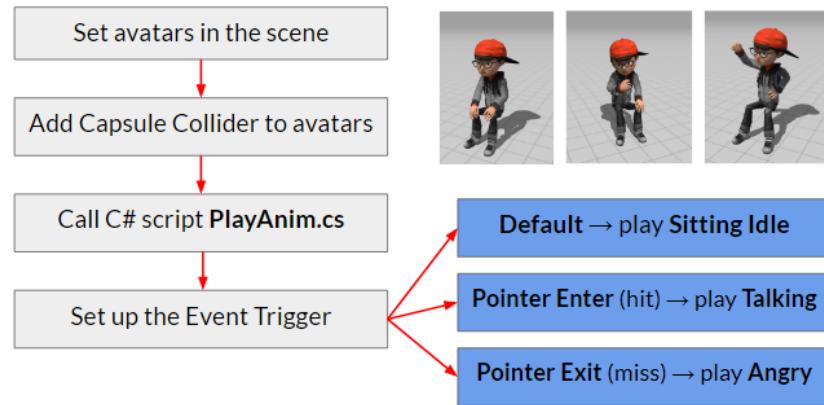
**Scene 4 Classroom:** This scene consists of five avatars and NPC playing around with the chaos ambient noise, laughing or shouting or yelling, as shown in Figure 3.20 (d).



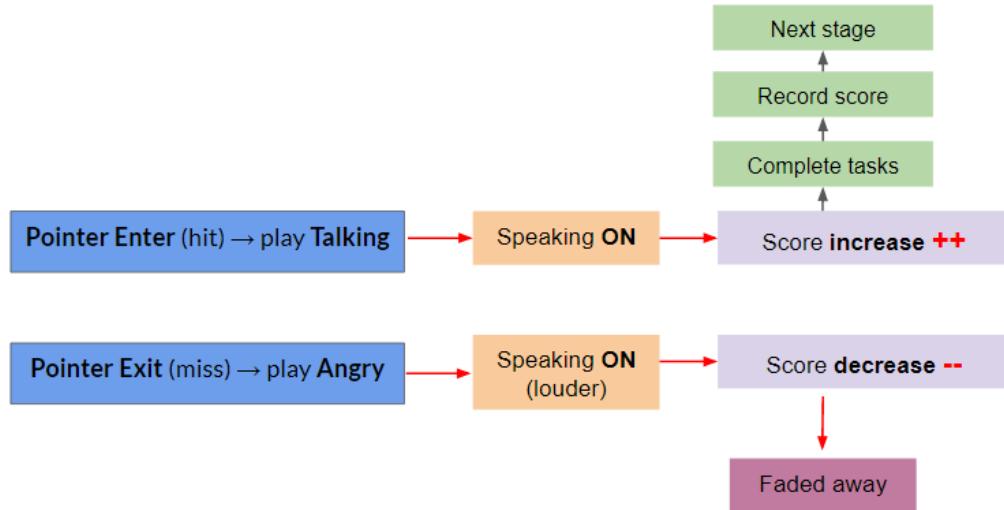
**Figure 3.21:** Graph showing the number of avatars and level of distraction noise

### 3.4.3 Animation in Unity

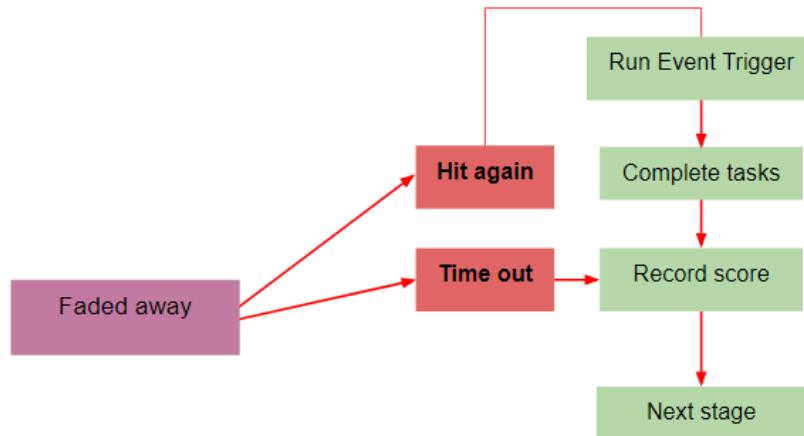
The interaction of avatar was set according to below diagram as shown in Figure 3.22 to 3.24.



**Figure 3.22:** Animation in Unity diagram (1)



**Figure 3.23:** Animation in Unity diagram (2)



**Figure 3.24:** Animation in Unity diagram (3)

The 3D sphere without mesh will be placed at the position of avatar's head, this sphere will random its position from one avatar to another avatar, and the event trigger will be assigned, 'Pointer Enter' event avatar will play 'Talk' animation and 'Pointer Exit' event avatar will play 'Sad' animation. For other cases avatar will play 'Idle' animation.

When user ignore talking avatar for a long period of time until it reached time limit, then the talking will faded away and if user notice and pay attention back then the avatar will reappear again, but if user still ignore the talking avatar until reached the time limit of the scene then the scene will forcefully end.

### 3.4.4 Implement C# script

In each scene of VR-SAT consists of several C# scripts, each scripts will call different GameObject randomly. List of main C# scripts that used in the project, as follow:

1. Script for menu: MainMenu.cs
2. Script for controlling avatars: AvatarControl\_Scen.cs
3. Script for counting score: Score\_Scene.cs
4. Script for timer: Timer.cs
5. Script for switching between 2D and VR mode: VRYesPlease.cs

Pseudocode of avatar's animation and score condition as shown in Figure 3.25.

---

#### Algorithm 1 Pseudo-code of Avatar's Animation

---

```

1: procedure AVATARCONTROL( $n$ )       $\triangleright$  Let  $n$  be the number of avatars.
2:   Generate set of avatars  $A \leftarrow \{a_1, a_2, \dots, a_n\}$ .
3:    $hit \leftarrow 0$ 
4:    $miss \leftarrow 0$ 
5:   for  $i \leftarrow 0$  to  $n$  do
6:     Set  $timer$  to 0.
7:     while  $timer < 60$  seconds do
8:       if User looks at the  $a_i$  then
9:          $a_i$  talks to the user.
10:         $hit \leftarrow hit + 1$ 
11:       else
12:          $a_i$  shows the feeling down face animation to the user.
13:          $miss \leftarrow miss + 1$ 
14:       end if
15:       Increase  $timer$ .
16:     end while
17:   end for
18: end procedure

```

---

**Figure 3.25:** Pseudo-code of avatar's animation

### 3.4.5 Gaze's behavior tracking

The VR-SAT will track the user's head movement in three planes, which are up or down, left or right and an angle, and for those three planes information we can tell that where exactly the user is looking at in the virtual world. VR-SAT also used the Google VR Reticle Pointer to detect the gaze behavior of user. To clarify, VR-SAT has the field of view that user must look at and it can check from user's gaze behavior that it is hit or miss.



**Figure 3.26:** user gaze behavior on the correct field of view



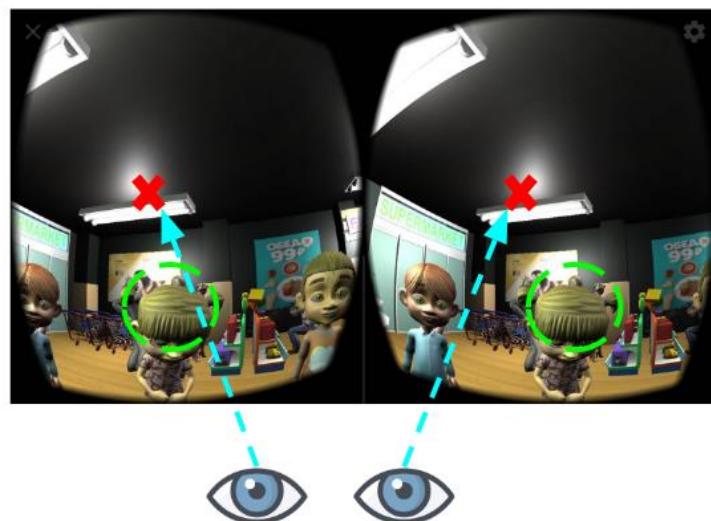
**Figure 3.27:** Hit condition

As shown in Figure 3.26 and Figure 3.27, the green circle is the field of view that user must look, and the red cross is position where user is looking at. If the red cross

is inside the green circle imply that user is looking at the correct spot, which refers to the hit condition the hit score will be increased.



**Figure 3.28:** User ignore talking avatar and gaze behavior out of the field of view



**Figure 3.29:** Miss condition

As shown in Figure 3.28 and Figure 3.29, the green circle is the field of view that user must look, and the red cross is position where user is looking at. If the red cross is outside the green circle imply that user is not looking at the correct spot, which refers to the miss condition the miss score will be increased.

## CHAPTER IV

### RESULT AND EVALUATION

The VR-SAT project aims to create a VR device to improve social attention skills in autistic children. The project was designed based on the original ABA therapy integrated with VR technology. In virtual environment users are able to learn and practice their social skills, including paying attention to their conversation partner and have the proper gaze behavior with their conversation partner.

#### **4.1 Experiment Setup**

This project requires Psychological Development Questionnaire (PDQ), as shown in Figure 4.1. PDQ will be used to find experimental group. This questionnaire is designed to help physicians and parents describe child's psychological development. If the PDQ score is below 15 then will be classified as an experimental group, but if the PDQ score is higher than 15, then will be classified as a general group.

The Psychological Development Questionnaire (PDQ-1)						
<b>Please complete the following sentence by circling the word which accurately describes your child</b>						
<b>My child...</b>						
1 points or gesture to show interest or get attention		never	rarely	sometimes	often	
2 has usual responses to sound		never	rarely	sometimes	often	
3 smiles or makes regular eye contact with others		never	rarely	sometimes	often	
4 responds to name when called		never	rarely	sometimes	often	
5 shows interest in children at play		never	rarely	sometimes	often	
6 pays attention while having a conversation with others		never	rarely	sometimes	often	
7 can hold eye contact with conversation partner		never	rarely	sometimes	often	
8 enjoys doing "sawasdee" (Wai) or "handshake"		never	rarely	sometimes	often	
9 relates to others by gesturing, talking or changing expression		never	rarely	sometimes	often	
10 laughs when other laugh		never	rarely	sometimes	often	
never = 0 rarely = 1 sometimes = 2 often = 3						
total _____		<input type="checkbox"/> Group 1 (0-15) <input type="checkbox"/> Group 2 (15-30)				

**Figure 4.1:** PDQ Questionnaire

After user used VR-SAT, the questionnaire for participants and guardian will be given to evaluate the efficiency. Questionnaire will be given to participants and their guardian and the scope of questionnaire will cover behavioral observation and device aspect (see Figure 4.2 and 4.3).

VR-SAT Evaluation Questionnaire																																															
<b>Personal Information</b>																																															
Type:	Participant																																														
Age:	_____																																														
Gender:	Male / Female / Other																																														
		YES	OKAY																																												
		NO																																													
<table border="1"> <tr> <td>1</td> <td>I think paying attention towards others is very important.</td> <td></td> <td></td> </tr> <tr> <td>2</td> <td>I am happy while training with VR-SAT.</td> <td></td> <td></td> </tr> <tr> <td>3</td> <td>I pay attention and concentrate while using VR-SAT.</td> <td></td> <td></td> </tr> <tr> <td>4</td> <td>I want to use VR-SAT again.</td> <td></td> <td></td> </tr> <tr> <td>5</td> <td>If I continue with VR-SAT, I will have better social attention skills</td> <td></td> <td></td> </tr> <tr> <td>6</td> <td>(paying attention and making eye-contact while having conversation).</td> <td></td> <td></td> </tr> <tr> <td>7</td> <td>I think VR-SAT is good for my friends who have social attention problems</td> <td></td> <td></td> </tr> <tr> <td>8</td> <td>I can use device easily.</td> <td></td> <td></td> </tr> <tr> <td>9</td> <td>I like the virtual environment in VR-SAT.</td> <td></td> <td></td> </tr> <tr> <td>10</td> <td>I see the differences between each stage.</td> <td></td> <td></td> </tr> <tr> <td>11</td> <td>I can understand the instruction easily.</td> <td></td> <td></td> </tr> </table>				1	I think paying attention towards others is very important.			2	I am happy while training with VR-SAT.			3	I pay attention and concentrate while using VR-SAT.			4	I want to use VR-SAT again.			5	If I continue with VR-SAT, I will have better social attention skills			6	(paying attention and making eye-contact while having conversation).			7	I think VR-SAT is good for my friends who have social attention problems			8	I can use device easily.			9	I like the virtual environment in VR-SAT.			10	I see the differences between each stage.			11	I can understand the instruction easily.		
1	I think paying attention towards others is very important.																																														
2	I am happy while training with VR-SAT.																																														
3	I pay attention and concentrate while using VR-SAT.																																														
4	I want to use VR-SAT again.																																														
5	If I continue with VR-SAT, I will have better social attention skills																																														
6	(paying attention and making eye-contact while having conversation).																																														
7	I think VR-SAT is good for my friends who have social attention problems																																														
8	I can use device easily.																																														
9	I like the virtual environment in VR-SAT.																																														
10	I see the differences between each stage.																																														
11	I can understand the instruction easily.																																														
Comment: _____ _____																																															

**Figure 4.2:** Evaluation questionnaire for participant

VR-SAT Evaluation Questionnaire			
<b>Personal Information</b>			
Type:	Participant's guardian		
Age:	_____		
Gender:	Male / Female / Other		
1. Have your child received any ABA therapy before?		YES	NO
<b>Behavioral Observation</b>			
2. Social attention skill is very important for children development		agree	neutral
3. Your child is enjoy while using VR-SAT		disagree	no comment
4. Your child cooperates well with VR-SAT			
5. You will encourage your child to train with VR-SAT again			
6. If your child uses VR-SAT for a period of time, he/she will have better social attention skill			
7. You think that VR-SAT can develop social attention skill in autistic children			
<b>Device Aspect</b>		agree	neutral
8. User interface is easy to use		disagree	no comment
9. Virtual environment is appealing enough			
10. The distraction level for each stage is appropriate			
11. The instruction for practicing social attention skill is understandable			
Comment: _____ _____			

**Figure 4.3:** Evaluation questionnaire for participant's guardian

## 4.2 Experiment Design

According to the agreement with participant's family, their names and identities participants remain secret, and the result from the experiment will be used for educational purpose only. Participants will be set to play two scenes per day for four days, and the score will be recorded to compare for each day (see Figure 4.4 and 4.5).



**Figure 4.4:** Testing on participant



**Figure 4.5:** Display output in VR mode

For Day 1 participants will be trained to use VR-SAT first, and demonstrate how to use VR-SAT and instruction properly. Participant start with the first scene Park and take a break for ten minutes, then continue the second scene Restaurant (see Figure 4.6 and 4.7). After that participant will be asked to answer the questionnaire. The questionnaire will be given to both participants and their guardians.



**Figure 4.6:** Scene 1 Day 1



**Figure 4.7:** Scene 2 Day 1

For Day 2 participants will do the same routine as Day 1, start with the first scene Park and take a break for ten minutes, then continue the second scene Restaurant (see Figure 4.8 and 4.9). After that participant will be asked to answer the questionnaire. The questionnaire will be given to both participants and their guardians. After that we will record the score and compare the result.



**Figure 4.8:** Scene 1 Day 2



**Figure 4.9:** Scene 2 Day 2

For Day 3 participants will play different scenes, participant start with the first scene Supermarket and take a break for ten minutes, then continue the second scene Classroom (see Figure 4.10 and 4.11) and answer the questionnaire after testing.



**Figure 4.10:** Scene 3 Day 3



**Figure 4.11:** Scene 4 Day 4

For Day 4 participants will do the same routine as Day 3, participant start with the first scene Supermarket and take a break for ten minutes, then continue the second scene Classroom (see Figure 4.12 and 4.13) and answer the questionnaire after testing.



**Figure 4.12:** Scene 3 Day 4



**Figure 4.13:** Scene 4 Day 4

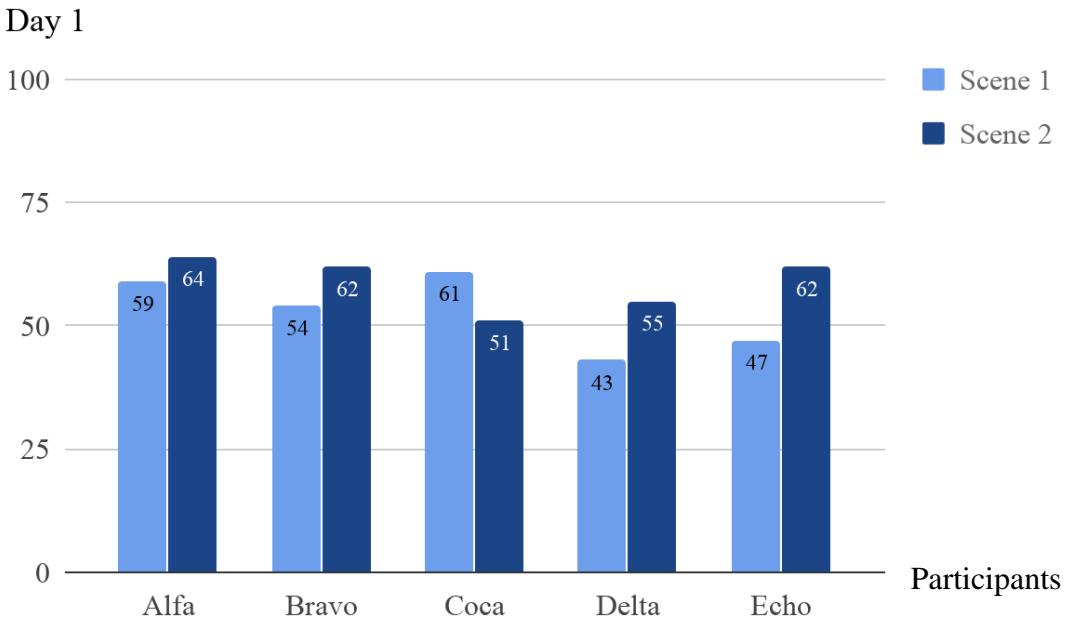
### 4.3 Experiment Result

There are five participants involved in the experiment, all participants have PDQ score below 15. All participants are autistic children at the age between seven and fifteen, three male and two female participants. According to the agreement with the participant's families, their name and identity will keep secret and all five participants will be assigned alias name as Alfa, Bravo, Coca, Delta and Bravo. All participants that included in this experiment have zero experience with VR technology before. All participants will be set to play two scenes per day for four days, and the score will be recorded to compare for each day. Four scenes in VR-SAT was created to have different distraction levels, including noise and number of avatars. Therefore, after testing we can see and compare the performance of participants for each day.

**Table 4.1** Four days experiment design

Day	First scene	Second scene
1	Park	Restaurant
2	Park	Restaurant
3	Supermarket	Classroom
4	Supermarket	Classroom

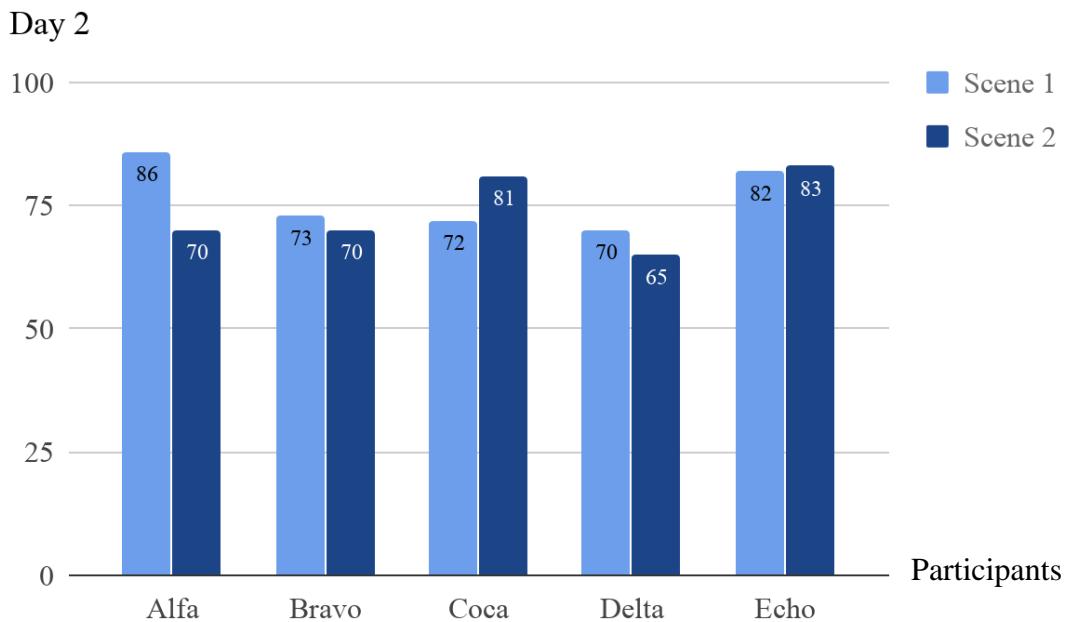
For the result, we stated Park as "scene 1", Restaurant as "scene 2", Supermarket as "scene 3" and Classroom "scene 4". After we observed the participant's performance and recorded all the participant's score, we will compare and discuss the result in further. In Figure 4.14 to 4.17 showed charts that represent the results from five participants.



**Figure 4.14:** Result chart for Day 1

On Day 1, participants will be asked to play scene 1 (Park) and scene 2 (Restaurant). From the experiment on first day, we will observe the behavior of participants and record the score of both scenes and compare to discuss the result further. The result from Day 1 (see Figure 4.14) showed that participants provide good cooperation and interesting to test with VR-SAT. The average score of Scene 1 Day 1 is 52.8 (out of full score 100) while the average score of Scene 2 Day 1 is 58.8. The result from the first day showed that the average score of scene 1 is lower than scene 2, the main reason that can be observed is that all five participants have zero experience with VR technology, so participants may not understand the instruction of VR-SAT for the first time. Also, the participant was explored to the virtual environment (Scene Park and Restaurant) for the first time so they were not aware of the position of talking avatar, however for the other days after participants have seen the scenes before, they tended to have better performance and higher score compared to the first day of experiment. The average score in scene 2 is not supposed to higher than average in scene 1 because scene 2 has high level of distraction (louder sound and more avatars), however all participants seem to feel more comfortable and familiar with scene 2 after playing scene 1. We

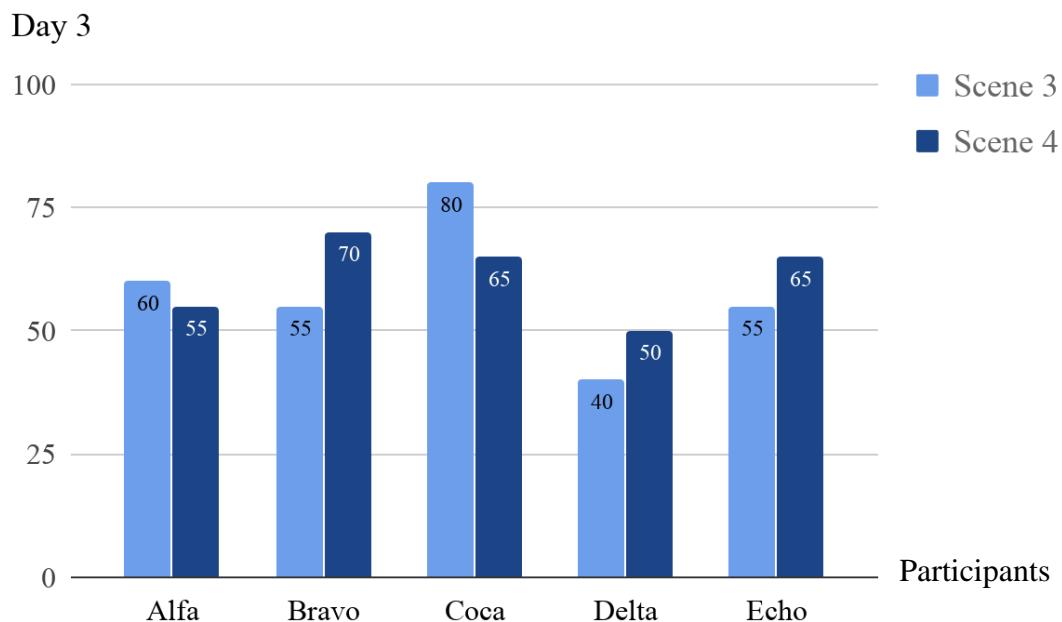
assume that this case occurs due to the cause that all participants have no experience with VR technology before.



**Figure 4.15:** Result chart for Day 2

The result from Day 2 (see Figure 4.15) showed that participants provide good cooperation and interesting to test with VR-SAT. Out of full score 100, the average score of Scene 1 Day 2 is 76.6, while the average score of Scene 2 Day 2 is 73.8. According to the score that shown in the graph, participants have average score in scene 1 higher than average score in scene 2. Based on the purpose of creating four different scenes with different level of distractions, we assume that participants will have better performance and higher score on the scene with less distraction. The scene 1 Park is the scene with the lowest level of distraction, so three are only three talking avatars in the scene with NPC standing around and the ambient noise is the peaceful natural park. Therefore, most of participants tended to have very high score in this scene. On the other hand, in the scene 2, given three taking avatars and lots of NPC sitting and the

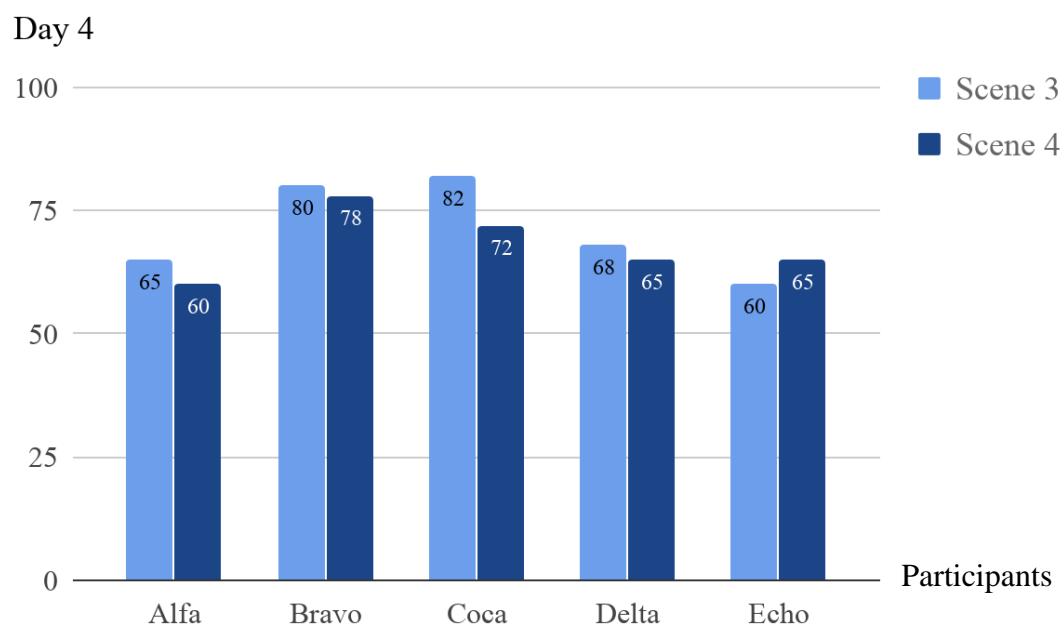
background sound is the louder noise (Jazz music). In scene 2, participants seemed to lack of attention more often when compared with scene 1. In conclusion, the result showed the better performance and higher average score in the scene 1 compared with scene 2.



**Figure 4.16:** Result chart for Day 3

The result from Day 3 (see Figure 4.16) showed that participants provide good cooperation and interesting to test with VR-SAT. The average score of Scene 3 Day 3 is 58 while the average score of Scene 4 Day 3 is 61. Scene 3 and scene 4, participants provided well cooperation and excited to see the new scenes. In scene 3 the scene was set in supermarket with four talking avatars and lots of NPC walking around, and background sound is loud ambient noise (machine and gossips). And in scene 4, the scene was set in the chaos classroom with five talking avatars and NPC playing and running around, the background sound is the loudest ambient noise (screaming, yelling and shouting). The level of distraction for scene 3 and scene 4 is much higher than scene

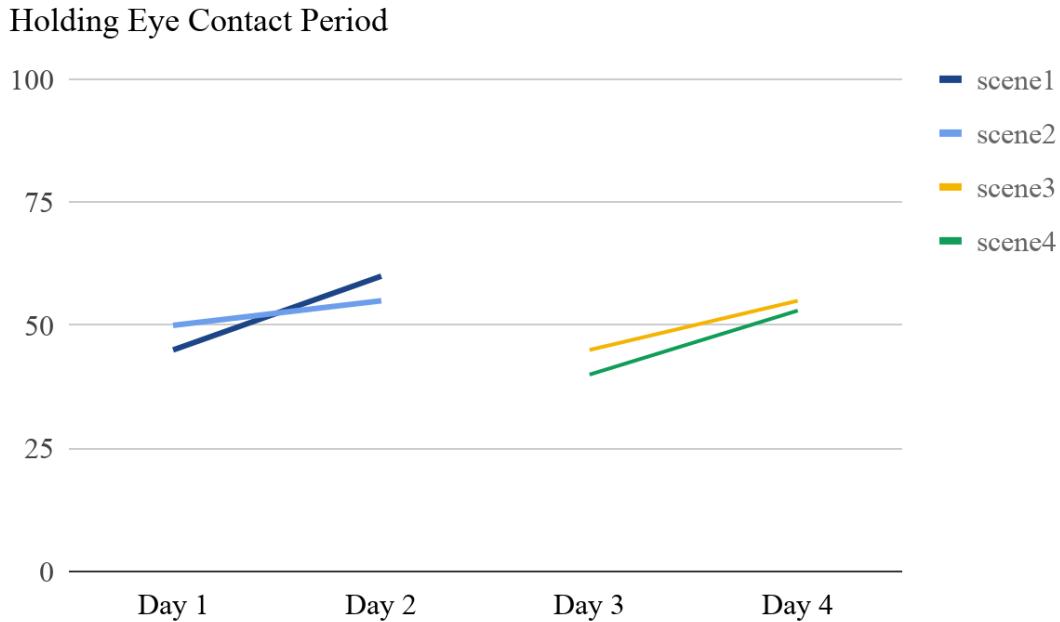
1 and scene 2. Compare the performance and the score of participants, it clearly showed that the score from Day 3 is much lower than Day 1. The main reason that can observe is on Day 3, two new scenes (Supermarket and Classroom) were presented to participants for the first time. Participants still need more time to observe the scene and find the position of talking avatars in the virtual environment. Due to the high level of distraction on scene 3 and scene 4, on scene 3 three participants tended to often lack of attention from talking avatar, while two participant can pay attention on talking avatars longer. However, on scene 4 after participants played scene 3, three participants feel more secure and aware of paying attention at the talking avatars, therefore this group showed the higher score in scene 4 compared to scene 3. But overall of average score of both days not longer than the result from Day 1 and Day 2. And for the experiment on Day 4, we expected to see that after participants have seen the scene 3 and scene 4, their performance and score should be increased.



**Figure 4.17:** Result chart for Day 4

The result from Day 4 (see Figure 4.17) showed that participants provide good cooperation and interesting to test with VR-SAT. The average score of Scene 3 Day 4 is 71 while the average score of Scene 4 Day 4 is 68. On Day 4, all participants have seen all the virtual environment both Supermarket and Classroom. We expected to see the improvement for paying attention to the talking avatars from all participants. According to the experiment on Day 1 and Day 2, the performance of participants tended to improve and most of participants have higher score after on the second day of testing the same virtual environment. Therefore, the average score from scene 3 is clearly higher than the average score from scene 4. This can emphasized that the distraction level that was shown in the virtual environment can affect the performance of paying attention. The performance from Day 4 showed that participants tended to perform better in the scene with less distraction.

In conclusion, all participants can pay attention at the talking avatar well in the scene with less distraction. The park scene with the lowest level of distraction, three talking avatars, NPC standing around and peaceful natural ambience. Participants have their highest score in this scene on Day 2, when they tested this scene for second round. According to the result on Day 1 and Day 2, we can notice the improvement of participant's performance from Day 1 to Day 2. However, in the scene with high level of distraction like scene 4, participants tended to have difficulty in paying attention on talking avatars. In the scene 4 Classroom (five talking avatars with NPC running around and loud chaos ambience) participants often lack of attention from talking avatars and pay attention on other NPCs in the scene. From the result of four days experiment, we conclude that participants can pay attention well at the talking avatars in the scenes with less distraction (scene 1 and scene 2). And participants more often lack of attention from talking avatar in the scenes with high level of distraction (scene 3 and scene 4).



**Figure 4.18:** Result chart for the longest holding eye contact period

As shown in Figure 4.18 represents the longest time period of holding eye contact in average case for all participants. Result shows the increasing time period of holding eye contact for all scenes. From the result can be concluded that in the scene that have more distraction in terms of number of avatars, noise and distraction level, participants tend to be distracted and cannot hold eye contact or pay attention at the talking avatars comparing to the scene that have less distraction level and less number of avatars.

## 4.4 Questionnaire Result

After testing the questionnaire will be given to participants and their guardian. Purpose of the questionnaire is to ask the participants and their guardian whether they are satisfied with VR-SAT device or not. The questionnaire for the guardian asked about the background information of participant, during the experiment the participant's guardian will be asked to observe the behavior of their child. Examples of the questions in this questionnaire, such as experience of participant about ABA therapy and the performance of the participant during the experiment. Furthermore, the participant's questionnaire will focus on how participant feel while they are using VR-SAT device, examples from the participant's questionnaire, such as, do they happy while using and will they use it again. For the participant's questionnaire, the question will be asked as oral questionnaire and the answer will be recorded because participants are incapable to do writing questionnaire by themselves. The result from questionnaire as shown below.

**Table 4.2** Guardian's Questionnaire

	Agree	Normal	Disagree
Participants never have ABA therapy before	100%	-	-
Social attention skill is very important for children development	100%	-	-
Child enjoys while using VR-SAT	80%	20%	-
Child cooperates well with VR-SAT	60%	40%	-
Encourage the child to use VR-SAT again	60%	20%	20%
If your child uses VR-SAT for a period of time, he/she will have better social attention skill	60%	40%	-
VR-SAT can develop social attention skill in autistic children	20%	60%	20%
User interface is easy to use	100%	-	-
Virtual environment is appealing enough	20%	80%	-

The distraction level for each stage is appropriate	20%	80%	-
The instruction for practicing social attention skill is	20%	80%	-

The result from guardian's questionnaire showed that all five participants (100%) have never received ABA therapy before. And there is 100% agree that social attention skill is very important for development in children. There is 80% of guardians agree that their children are happy while using VR-SAT device and 60% agree that the child provide good cooperation during the experiment. There is 60% agree in terms of encourage their children to use VR-SAT device again. Lastly, 60% agree that VR-SAT can develop social attention skill in autistic children. Focusing on the question about VR-SAT can develop social attention skill in autistic children only 20% agree with this term. Apart from the behavioral observation aspect to the device aspect, there is 100% agree that 2D use interface is very easy to use. About 80% feel normal with virtual environment in VR-SAT.

**Table 4.3** Participant's Questionnaire

	Agree	Normal	Disagree
Pay attention toward others is very important	40%	60%	-
I am happy while using VR-SAT	80%	20%	-
I play attention and concentrate while using VR-SAT	20%	80%	-
I want to use VR-SAT again	80%	20%	-
If I continue with VR-SAT, I will have better social attention skill	40%	60%	-
I think VR-SAT is good for my friend who have social attention problem	-	100%	-
I can use device easily	20%	80%	-

I like virtual environment in VR-SAT	60%	40%	-
I see the difference between each state	60%	40%	-
The instruction is easy to understand	80%	20%	-

For participant's questionnaire, the question will focus on how they feel while they are using VR-SAT. The result from the participant's questionnaire showed that 80% of participants feel happy while using VR-SAT device, whereas 20% feel normal. 80% of participants want to use VR-SAT device again. There is 80% of participants agree that the instruction for playing VR-SAT is easy to understand. And there is 80% agree that the instruction for playing VR-SAT is easy to understand.

## **CHAPTER V**

## **CONCLUSION**

### **5.1 Discussion**

Working on VR-SAT project required a lot of fields of knowledge including virtual reality technology, psychological development in children, theory of autism therapies, and the original applied behavioral analysis. Therefore, VR-SAT was developed based on the concept of original applied behavior analysis integrate with virtual reality technology. The virtual scene was created by Unity software and exported to android device. User can run VR-SAT by using VR headset with android smartphone easily. After testing with all participants, users can pay attention much better and hold longer eye contact at the talking avatars in the scene with less distraction and less noise compare to the scene with chaos situation and louder noise. Result shows that in the scene that have more distraction level and more number of avatars users tend to have lower score compare to the scene with less distraction level and less number of avatars. However, it also has some factors that might effect on the result, such as experience and ages of participants. Lastly, focusing on the limitation of VR-SAT when testing with the user who was classified as severely autistic group, this group has very sensitive sensory and reject to put on VR headset.

### **5.2 Conclusion**

The VR-SAT project is intended to create a VR device to be a training tool to improve social attention skills in autistic children. Several useful features in VR can help children to practice their social attention skills until they become proficient. This allows them to feel secure in learning the skills and with generalizing social attention skills in the real world, attainable with VR technology. Examples include controllable input stimuli and safer learning situations. After using VR-SAT, autistic children can utilize the skills in real world. The project will be a training tool to improve social

attention skills in autistic children, which can help them build and maintain good relationships with their friends and family.

Some features of VR-SAT can be extended to deal with other autistic symptoms. Examples include, impairments of motor skills in autistic children and issues of facial expression understanding. The interaction of avatars in a virtual environment can be increased by using other softwares, such as Maya. The VR headset can connect with loudspeakers to specify a particular audio source and increase the quality of the sound in the virtual world.

### **5.3 Limitation**

Limitation of VR-SAT is the errors that found while building scene from Unity to android device. Another limitation that can be found is the difficulty of VR headset configuration. When testing VR-SAT with participant the VR headset have to adjust manually, and it is very difficult to adjust the VR perspective for each particular user. Another problem is that this version of VR headset cannot be monitoring with another device, so the observers cannot see the performance of users while they are using VR-SAT device. However, we tackle this problem by mirroring the result on Unity again to interpret the score.

### **5.4 Future Work**

For future work, we aim to develop VR-SAT to have more features. For instance, leverage VR headset to be more comfortable and easily adjust for each user, randomization function. To clarify we can extend features of VR-SAT to random between scenes and the level of distraction for each particular user. Monitoring the testing or display the experiment on another device. Additionally, making the virtual scene looks more realistic by adjusting light and more decoration. In terms of hardware, we can attach eye tracking device to detect user's eye contact. Also, in terms of experiment we can conduct experiment with therapist for better performance.

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## APPENDICES

### Appendix A

Questionnaire results from five participant and their guardians.

The Psychological Development Questionnaire (PDQ-1)					
<b>Please complete the following sentence by circling the word which accurately describes your child</b>					
<b>My child...</b>					
1	points or gesture to show interest or get attention	never	rarely	sometimes	often
2	has usual responses to sound	never	rarely	sometimes	often
3	smiles or makes regular eye contact with others	never	rarely	sometimes	often
4	responds to name when called	never	rarely	sometimes	often
5	shows interest in children at play	never	rarely	sometimes	often
6	pays attention while having a conversation with others	never	rarely	sometimes	often
7	can hold eye contact with conversation partner	never	rarely	sometimes	often
8	enjoys doing "sawasdee" (Wai) or "handshake"	never	rarely	sometimes	often
9	relates to others by gesturing, talking or changing expression	never	rarely	sometimes	often
10	laughs when other laugh	never	rarely	sometimes	often
never = 0 rarely = 1 sometimes = 2 often = 3					
total <u>12</u>	<input checked="" type="checkbox"/> Group 1 (0-15) <input type="checkbox"/> Group 2 (15-30)				

**Figure A.1: PDQ result (1)**

The Psychological Development Questionnaire (PDQ-1)				
<b>Please complete the following sentence by circling the word which accurately describes your child</b>				
My child...				
1	points or gesture to show interest or get attention	never	rarely	sometimes
2	has usual responses to sound	never	<b>rarely</b>	sometimes
3	smiles or makes regular eye contact with others	never	<b>rarely</b>	sometimes
4	responds to name when called	never	<b>rarely</b>	sometimes
5	shows interest in children at play	never	<b>rarely</b>	sometimes
6	pays attention while having a conversation with others	never	<b>rarely</b>	sometimes
7	can hold eye contact with conversation partner	never	<b>rarely</b>	sometimes
8	enjoys doing "sawasdee" (Wai) or "handshake"	never	<b>rarely</b>	sometimes
9	relates to others by gesturing, talking or changing expression	never	<b>rarely</b>	sometimes
10	laughs when other laugh	never	<b>rarely</b>	sometimes
never = 0 rarely = 1 sometimes = 2 often = 3				
total <u>11</u>		<input checked="" type="checkbox"/> Group 1 (0-15) <input type="checkbox"/> Group 2 (15-30)		

**Figure A.2:** PDQ result (2)

The Psychological Development Questionnaire (PDQ-1)				
<b>Please complete the following sentence by circling the word which accurately describes your child</b>				
My child...				
1	points or gesture to show interest or get attention	never	rarely	sometimes
2	has usual responses to sound	never	rarely	sometimes
3	smiles or makes regular eye contact with others	never	rarely	sometimes
4	responds to name when called	never	rarely	sometimes
5	shows interest in children at play	never	rarely	sometimes
6	pays attention while having a conversation with others	never	rarely	sometimes
7	can hold eye contact with conversation partner	never	rarely	sometimes
8	enjoys doing "sawasdee" (Wai) or "handshake"	never	rarely	sometimes
9	relates to others by gesturing, talking or changing expression	never	rarely	sometimes
10	laughs when other laugh	never	rarely	sometimes
never = 0 rarely = 1 sometimes = 2 often = 3				
total <u>10</u>		<input checked="" type="checkbox"/> Group 1 (0-15)	<input type="checkbox"/> Group 2 (15-30)	

**Figure A.3: PDQ result (3)**

The Psychological Development Questionnaire (PDQ-1)					
<b>Please complete the following sentence by circling the word which accurately describes your child</b>					
My child...					
1	points or gesture to show interest or get attention	never	rarely	sometimes	often
2	has usual responses to sound	never	rarely	sometimes	often
3	smiles or makes regular eye contact with others	never	rarely	sometimes	often
4	responds to name when called	never	rarely	sometimes	often
5	shows interest in children at play	never	rarely	sometimes	often
6	pays attention while having a conversation with others	never	rarely	sometimes	often
7	can hold eye contact with conversation partner	never	rarely	sometimes	often
8	enjoys doing "sawasdee" (Wai) or "handshake"	never	rarely	sometimes	often
9	relates to others by gesturing, talking or changing expression	never	rarely	sometimes	often
10	laughs when other laugh	never	rarely	sometimes	often
never = 0 rarely = 1 sometimes = 2 often = 3					
total <u>13</u>		<input checked="" type="checkbox"/> Group 1 (0-15)	<input type="checkbox"/> Group 2 (15-30)		

**Figure A.4:** PDQ result (4)

The Psychological Development Questionnaire (PDQ-1)				
<b>Please complete the following sentence by circling the word which accurately describes your child</b>				
My child...				
1	points or gesture to show interest or get attention	never	rarely	sometimes
2	has usual responses to sound	never	rarely	sometimes
3	smiles or makes regular eye contact with others	never	rarely	sometimes
4	responds to name when called	never	rarely	sometimes
5	shows interest in children at play	never	rarely	sometimes
6	pays attention while having a conversation with others	never	rarely	sometimes
7	can hold eye contact with conversation partner	never	rarely	sometimes
8	enjoys doing "sawasdee" (Wai) or "handshake"	never	rarely	sometimes
9	relates to others by gesturing, talking or changing expression	never	rarely	sometimes
10	laughs when other laugh	never	rarely	sometimes
never = 0 rarely = 1 sometimes = 2 often = 3				
total <u>13</u>		<input checked="" type="checkbox"/> Group 1 (0-15)	<input type="checkbox"/> Group 2 (15-30)	

**Figure A.5:** PDQ result (5)

VR-SAT Evaluation Questionnaire				
<b>Personal Information</b>				
Type:	Participant's guardian			
Age:	43			
Gender:	Male	(Female)	Other	
1. Have your child received any ABA therapy before?	YES	NO		
<b>Behavioral Observation</b>	agree	neutral	disagree	no comment
2. Social attention skill is very important for children development	/			
3. Your child is enjoy while using VR-SAT	/			
4. Your child cooperates well with VR-SAT	/			
5. You will encourage your child to train with VR-SAT again	/			
6. If your child uses VR-SAT for a period of time, he/she will have better social attention skill	/			
7. You think that VR-SAT can develop social attention skill in autistic children	/			
<b>Device Aspect</b>	agree	neutral	disagree	no comment
8. User interface is easy to use	/			
9. Virtual environment is appealing enough	/			
10. The distraction level for each stage is appropriate	/			
11. The instruction for practicing social attention skill is understandable	/			
Comment:				

**Figure A.6:** Guardian's questionnaire result (1)

VR-SAT Evaluation Questionnaire				
<b>Personal Information</b>				
Type:	Participant's guardian			
Age:	42			
Gender:	Male	Female	Other	
1. Have your child received any ABA therapy before?		YES	NO	
<b>Behavioral Observation</b>				
2. Social attention skill is very important for children development		agree	neutral	disagree
3. Your child is enjoy while using VR-SAT		/	/	/
4. Your child cooperates well with VR-SAT		/	/	/
5. You will encourage your child to train with VR-SAT again		/	/	/
6. If your child uses VR-SAT for a period of time, he/she will have better social attention skill		/	/	/
7. You think that VR-SAT can develop social attention skill in autistic children		/	/	/
<b>Device Aspect</b>				
8. User interface is easy to use		agree	neutral	disagree
9. Virtual environment is appealing enough		/	/	/
10. The distraction level for each stage is appropriate		/	/	/
11. The instruction for practicing social attention skill is understandable		/	/	/
Comment: _____				

**Figure A.7: Guardian's questionnaire result (2)**

VR-SAT Evaluation Questionnaire				
<b>Personal Information</b>				
Type:	Participant's guardian			
Age:	48			
Gender:	<input checked="" type="checkbox"/> Male	<input type="checkbox"/> Female	/ Other	
1. Have your child received any ABA therapy before?		YES	NO	
<b>Behavioral Observation</b>				
2. Social attention skill is very important for children development	agree	neutral	disagree	no comment
3. Your child is enjoy while using VR-SAT	/	/	/	/
4. Your child cooperates well with VR-SAT	/	/	/	/
5. You will encourage your child to train with VR-SAT again	/	/	/	/
6. If your child uses VR-SAT for a period of time, he/she will have better social attention skill	/	/	/	/
7. You think that VR-SAT can develop social attention skill in autistic children			/	/
<b>Device Aspect</b>				
8. User interface is easy to use	agree	neutral	disagree	no comment
9. Virtual environment is appealing enough	/	/	/	/
10. The distraction level for each stage is appropriate	/	/	/	/
11. The instruction for practicing social attention skill is understandable	/	/	/	/
Comment: _____				

**Figure A.8:** Guardian's questionnaire result (3)

VR-SAT Evaluation Questionnaire					
<b>Personal Information</b>					
Type:	Participant's guardian				
Age:	12				
Gender:	Male	<input checked="" type="checkbox"/>	Female	<input checked="" type="checkbox"/>	Other
1. Have your child received any ABA therapy before?	YES		NO		
<b>Behavioral Observation</b>					
2. Social attention skill is very important for children development	agree	neutral	disagree	no comment	
3. Your child is enjoy while using VR-SAT	<input checked="" type="checkbox"/>				
4. Your child cooperates well with VR-SAT	<input checked="" type="checkbox"/>				
5. You will encourage your child to train with VR-SAT again	<input checked="" type="checkbox"/>				
6. If your child uses VR-SAT for a period of time, he/she will have better social attention skill	<input checked="" type="checkbox"/>				
7. You think that VR-SAT can develop social attention skill in autistic children	<input checked="" type="checkbox"/>				
<b>Device Aspect</b>					
8. User interface is easy to use	agree	neutral	disagree	no comment	
9. Virtual environment is appealing enough	<input checked="" type="checkbox"/>				
10. The distraction level for each stage is appropriate	<input checked="" type="checkbox"/>				
11. The instruction for practicing social attention skill is understandable	<input checked="" type="checkbox"/>				
Comment:					

**Figure A.9:** Guardian's questionnaire result (4)

VR-SAT Evaluation Questionnaire				
<b>Personal Information</b>				
Type:	Participant's guardian			
Age:	49			
Gender:	<input checked="" type="checkbox"/> Male	Female	/	Other
1. Have your child received any ABA therapy before?	YES		<input checked="" type="checkbox"/> NO	
<b>Behavioral Observation</b>				
2. Social attention skill is very important for children development	agree	neutral	disagree	no comment
3. Your child is enjoy while using VR-SAT	<input checked="" type="checkbox"/>			
4. Your child cooperates well with VR-SAT	<input checked="" type="checkbox"/>			
5. You will encourage your child to train with VR-SAT again	<input checked="" type="checkbox"/>			
6. If your child uses VR-SAT for a period of time, he/she will have better social attention skill	<input checked="" type="checkbox"/>			
7. You think that VR-SAT can develop social attention skill in autistic children	<input checked="" type="checkbox"/>			
<b>Device Aspect</b>				
8. User interface is easy to use	agree	neutral	disagree	no comment
9. Virtual environment is appealing enough	<input checked="" type="checkbox"/>			
10. The distraction level for each stage is appropriate	<input checked="" type="checkbox"/>			
11. The instruction for practicing social attention skill is understandable	<input checked="" type="checkbox"/>			
Comment:				

**Figure A.10:** Guardian's questionnaire result (5)

VR-SAT Evaluation Questionnaire			
Personal Information			
Type:	Participant		
Age:	12		
Gender:	Male	Female	Other
	YES	OKAY	NO
1	I think paying attention towards others is very important.	/	
2	I am happy while training with VR-SAT.	/	
3	I pay attention and concentrate while using VR-SAT.	/	/
4	I want to use VR-SAT again.	/	
5	If I continue with VR-SAT, I will have better social attention skills. (paying attention and making eye-contact while having conversation).	/	
6	I think VR-SAT is good for my friends who have social attention problems.	/	
7	I can use device easily.	/	
8	I like the virtual environment in VR-SAT.	/	
9	I see the differences between each stage.	/	
10	I can understand the instruction easily.	/	
Comment: _____			

**Figure A.11:** Participant's questionnaire result (1)

VR-SAT Evaluation Questionnaire					
Personal Information					
Type:	Participant				
Age:	15				
Gender:	(Male) / Female / Other				
			YES	OKAY	NO
1	I think paying attention towards others is very important.		/	/	
2	I am happy while training with VR-SAT.		/	/	
3	I pay attention and concentrate while using VR-SAT.		/	/	
4	I want to use VR-SAT again.		/	/	
5	If I continue with VR-SAT, I will have better social attention skills. (paying attention and making eye-contact while having conversation).		/	/	
6	I think VR-SAT is good for my friends who have social attention problems.		/	/	
7	I can use device easily.		/	/	
8	I like the virtual environment in VR-SAT.		/	/	
9	I see the differences between each stage.		/	/	
10	I can understand the instruction easily.		/	/	
Comment: _____					

**Figure A.12:** Participant's questionnaire result (2)

VR-SAT Evaluation Questionnaire			
Personal Information			
Type:	Participant		
Age:	13		
Gender:	Male	Female	/ Other
		YES	OKAY
			NO
1	I think paying attention towards others is very important.	/	
2	I am happy while training with VR-SAT.	/	
3	I pay attention and concentrate while using VR-SAT.	/	
4	I want to use VR-SAT again.	/	
5	If I continue with VR-SAT, I will have better social attention skills. (paying attention and making eye-contact while having conversation).	/	
6	I think VR-SAT is good for my friends who have social attention problems.	/	
7	I can use device easily.	/	
8	I like the virtual environment in VR-SAT.	/	
9	I see the differences between each stage.	/	
10	I can understand the instruction easily.	/	
Comment: _____			

**Figure A.13:** Participant's questionnaire result (3)

VR-SAT Evaluation Questionnaire			
Personal Information			
Type:	Participant		
Age:	12		
Gender:	Male	Female	Other
	YES	OKAY	NO
1	I think paying attention towards others is very important.	/	
2	I am happy while training with VR-SAT.	/	
3	I pay attention and concentrate while using VR-SAT.	/	
4	I want to use VR-SAT again.	/	
5	If I continue with VR-SAT, I will have better social attention skills. (paying attention and making eye-contact while having conversation).	/	
6	I think VR-SAT is good for my friends who have social attention problems.	/	
7	I can use device easily.	/	
8	I like the virtual environment in VR-SAT.	/	
9	I see the differences between each stage.	/	
10	I can understand the instruction easily.	/	
Comment: _____			

**Figure A.14:** Participant's questionnaire result (4)

VR-SAT Evaluation Questionnaire						
Personal Information						
Type:	Participant					
Age:	10					
Gender:	Male	<input checked="" type="checkbox"/> Female	Other			
				YES		OKAY
				NO		
1	I think paying attention towards others is very important.		/			
2	I am happy while training with VR-SAT.		/			
3	I pay attention and concentrate while using VR-SAT.		/			
4	I want to use VR-SAT again.		/			
5	If I continue with VR-SAT, I will have better social attention skills. (paying attention and making eye-contact while having conversation).		/			
6	I think VR-SAT is good for my friends who have social attention problems.		/			
7	I can use device easily.		/			
8	I like the virtual environment in VR-SAT.		/			
9	I see the differences between each stage.		/			
10	I can understand the instruction easily.		/			
Comment: _____						

**Figure A.15:** Participant's questionnaire result (5)