Master's thesis

2022

Suraj De

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

Master's thesis

Suraj De

Exploration of human attitude towards social robots during simple non-digital game

June 2022

NTNU
Norwegian University of Science and Technology

NTNU
Norwegian University of Science and Technology

NTNU
Norwegian University of
Science and Technology

Exploration of human attitude towards social robots during simple non-digital game

Suraj De

Masters in Applied Computer Science
Submission date: June 2022
Supervisor: Deepti Mishra
Co-supervisor: Yavuz Inal

Norwegian University of Science and Technology
Department of Computer Science

Acknowledgement

My heartfelt gratitude goes to my supervisors, **Deepti Mishra** and **Yavuz Inal**, for their unwavering support, academic and expert guidance, and constant feedback during the course of this arduous research project.

Finally, I must express my very profound gratitude to my family and friends for their unconditional moral support and continuous encouragement throughout the process of writing this thesis. Thank you.

Suraj De

Abstract

The introduction of robots into modern civilization has changed the way machines function. With humans, they are no longer in a master-slave relationship. With the introduction of social robotics, these artificial creatures are now capable of standing on an equal footing with humans. Robots have advanced in a variety of fields, including medicine, industry, gaming, and others. As a result, it is critical that we build a stable environment in which both people and robots may thrive. People, on the other hand, have begun to detest robots as they take their position in this human community. Unemployment as a consequence of robots taking jobs exacerbates the negative effects. As a result, in order to develop a healthy ecosystem, it's critical to understand how people feel about robots now and in the future. From a game perspective, this study attempts to investigate this mentality by questioning the unique components of cooperative and competitive characteristics. Individuals' emotional data is collected throughout games, and trends are analyzed to develop a link between competitive and cooperative modes. The notion of cooperative and competitive modes coexisting is supported by significant and confident results obtained from experimental user research. The notion of cooperative and competitive modes coexisting is supported by significant and confident results obtained from experimental user research. Deeper investigation of this subject in the future will lead to a greater understanding of human attitudes toward robots, assisting us in achieving world-wide stability.

Contents

Figures

Tables

Code Listings

Chapter 1

Introduction

1.1 Topic

Social Robotics has started to mould the industrial perception over the past few decades. Since the time of robotic usage to complete essential tasks, deemed harmful or dangerous, the perception of these systems has constantly been changing [1, 2]. This could be attributed to the growing research in increasing intelligence factor in Robots to grow the relationship formed in simple human robot interactions. In the recent years, researchers have been trying to highlight this communication viewpoint from both the robotic and the human side, towards one another. This research aims to motivate the study into these exchanges, looking to provide an idea of how a human mind perceives the presence of a robot in a social setting, like playing a game [3]. Taking on this issue will essentially provide window into understanding if negative emotions of competition could induce a positive behaviour in human understanding or collaboration aspect could generate competitive aspects to increase human efficiency in various modes of work.

The specific viewpoint investigated in this study is an ever-expanding area of social robotics. The original ideology of making robot efficient enough to provide assistance to a human, has been altering towards stabilizing this balance of disparity between human and robot in a general setting. With the shift in applications of robots from strictly industrial standpoint to a more casual environmental approach, the primary belief of robots being in a mission directed setting has changed quite extensively [4]. Researches in the past decade have looked into how these artificial entities could be used to provide comfort and companionship in various aspects. From having Robotic receptionists [5], to becoming gameplay partner [6], public exposition of these morphed intelligent systems has created more research opportunities to understand and improve upon the behavioural pattern of this dynamic as an integral part of social robotics. However, to improve this interaction balance, it is key that this exchange is not treated as a one-way street [7]. This primarily made the researchers increase their effort to look into the other side of this communication chain, that is the human outlook on robots. Human perception of robots could present huge impact on how well an intelligent system is accepted into the society. To take this into consideration, a considerable thought has to be poured into how the media influences the perception of humans towards Robots. The impact of the various online outlets undoubtedly forms the baseline for individuals who have not interacted with robots in any setting. Countering the negative effects in such instance would be to use a similar medium for raising awareness and in dominant terms, alter the perception.

Usage of games has been one such area to highlight the robotic upliftment. Although the current gaming phenomenon has been in the digital sector, the prevalence of board games and physical sports still has a strong impact in reducing the negative impacts of the community. From a psychological standard, a key part of playing games is to be part of the social world and making acquaintances. In recent times, this is further supported by the increase in number of multiplayer games. However, with the increasing risk of game addictions [8], the exploration of safer gameplays look towards offline and board game situations to provide a secure alternative. But keeping the multiplayer aspect in mind, it is often hard to find a partner to dedicatedly play games with. Hence, the significance of robot as social partners increases quite many-fold.

This research study aims to clear out the negative impressions and provide a friendly outlook to revise these baseline perceptions using the method of gameplay. It also takes interest in creating a relationship pattern of the negative and positive perceptions in human beings towards robot. Finally, it aims to extend the foundation of previous researches in exploring this field to highlight any possibilities of reinforcing behaviour to suit the human needs from robotic society.

1.2 Keywords

Human-Robot Interaction, Gaming, Competition perspective, Cooperation perspective, Social Robotics

1.3 Problem Description

This research study will aim to focus on providing comments to the issues gathered from the literature.

The primary work done in early social robotics is to understand the dynamic complexity of human robot interaction from a general standpoint. Since the past decade, this has shifted to making robots in tune with the human conditioning of issues and problems. To achieve that in higher regard, experimentations have been conducted to take in the human side of perception. The environmental conditions for these researches have also vastly varied from a more private setting in a lab to public setting in museums, restaurants and other areas. Even the nature of these researches has undergone mutation from a technological viewpoint in terms of industrial applications to a more social outlook like basic interaction and playing games. However, the focus on this balance has mainly been in either the competitive aspect or the cooperative aspect from an interaction standpoint. The key to addressing this dynamic would be to understand the nature of relationship that exists between the two aspects.

This inevitably leads this research to focus on initially building a simple sample of the two aspects of contention and partnership, to establish a connection and if one is influential on the other. The medium being used is a simple game of trash can basketball which takes the fun aspect and combines it with the human emotional aspect towards the artificial entities. The research study, thus, has been conducted as a motivation for exploring the solution prospect for the problem stated above.

1.4 Justification, Motivation and Benefits

The dynamic of understanding between a human and robot has undergone substantial change in the past few years. Up until recent years, the aim for robotic assessment was to make it efficient enough to justify human purposes. This can primarily be traced back to the laws set by science fiction writer Asimov [7] which presented a master-slave sort of relationship between the two beings. However, with changes in time and development of newer technologies (especially artificial intelligence), the push towards building a self sufficient human independent being has been heavily progressed. Today, it could be safely said that newer laws of robotics are in works[8]. This shift in ideologies has greatly helped in making the society strive for the balance between human beings and robots in every capacity.

With the increase in researches to understand this equilibrium point, the idea to raise the interaction mode between human beings and robots have risen as well. Social robotics now primarily aims to focus on the communication between humans and robots, as partners[9]. Many studies have focused on how effective this communication could be perceived from either side, with some finding basis on stronger rapport leading to better connections [6]. It does however ultimately comes down to how much effort can be put in stabilizing this communication spectrum between human and robot. Changes in robotic awareness have already started to make it possible for these systems to converse, play games or even pass judgements on human activities. The problems addressed by this research will enable us to dive a bit deeper into the psyche of human intellect, understanding and perhaps predicting how humans will behave towards robots in near future.

1.5 Research Questions

Human perception of robots has been extensively researched by previous studies, which is why this study is not aimed at stating just the perception area in itself. Instead, the focus would be to explore this perception area from a gaming viewpoint taking human robot interaction in question. More specifically taking a hard look at the nature of emotions displayed by humans towards robot during a fun activity. These feelings generated by players would be put into two context of competition and collaboration, to have a clearer understanding of emotional approach displayed by humans. This will be studied on the following series of research questions to safely regulate a possible answer towards the conjecture of human perception towards robots:

- *In what way does the cooperative and competitive aspect tend to influence the human attitude towards social robots?*

- *What is the nature of dynamic between cooperative and collaborative modes between human and robot from a gaming aspect?*

1.6 Contributions

This research study primarily contributes to the focused field by expanding and elaborating the previous dealings in understanding the mode of human perception towards robots in a gamified environment. In terms of gameplay, taking the game of trash can basketball to engage players in a confrontational as well as co-operational environment, takes a small break from the various researches in the digital medium. In a way, it focuses on how the daily activities like a simple throwing of a paper ball to a target, could affect the human psyche when there is a robotic system involved. The data potentially will assist in creating a baseline for complex tasks being accomplished by human and robots as an individual to team unit.

The complete implementation is open and available for everyone who is interested in utilizing it for similar or other research problems. Additionally, the data collected will be provided in a similar manner to hopefully form the basis for future theories to be verified.

1.7 Outline of Chapters

To properly understand the usage of each entity in the environmental setup of this gaming ecosystem of human and robot, a section detailing out the various technologies and concepts in play, is necessary. Chapter 2 comprises of the previous researches being done in the area, specifically how each individual mode of competition and collaboration has been targeted, along with a dive into the studies done to understand the connection between the two. It will also showcase the various technologies and concepts involved with this study in terms of the humanoid robot in play. Chapter 3 aims to list out the design progression for the study, listing out the various involved parameters kept in mind during the process. Chapter 4 details the entire implementation, in terms of the iterations it took to reach the final stage of execution. Chapter 5 takes the collected data to present preliminary and trend analysis. Chapter 6 takes the results and analysis done in previous chapter to articulate the notion of how effective the inferences are towards the research questions (1.5). Chapter 7 concludes the work and looks upon potential future work to further advance the field.

Chapter 2

Background

2.1 Related Work

This section deals with the past work in the area of social robotics and how its effect could tip the scales between a positive and negative scenario for the acceptance of robotics in the future.

2.1.1 Social Robotics

The obligation of keeping up with rapid technological advancement, which is molding the practicalities of our lives every second, has fallen largely on the present period. Work simplification has become the standard in society, with the primary goal of decreasing human effort. This way of thinking has resulted in the recent robot revolution. Originally, robots were intended to minimize the amount of energy expended by humans on physically demanding professions, but times have changed dramatically. Robots have progressed from being a mechanical substitute for a worker to a more human-like "artificial organism" capable of doing tasks beyond anyone's imagination. As a result, the ability of robotic entities to coexist with human society has risen. Today's robots are capable of dancing [9], strolling hand in hand [10, 11], playing a musical duet [12, 13], and functioning as a team with humans[14], demonstrating their progress in a more social context. This has given rise to the discipline of social robotics [15–17], which largely focuses on the human-robot interaction component. In this setting, the primary goal of robotic entities is still to complete tasks by reducing human effort; nevertheless, robots' role is no longer that of slaves to human masters, but rather that of partners.

2.1.2 Human Influence

This, on the other hand, makes us wonder about the impact of the human population on this developing community of artificial animals. Robots may now accomplish activities without the need for human intervention thanks to a shift in design and programming standards from specific task-based labor to wider intelligence-based functionality. The same intelligence qualities, on the other hand, may hinder a robot from performing a job it deems is impossible. If a robotic mind's reasoning process determines that a task is difficult, it may refuse to perform it in the future, pushing towards a lazy attitude [18]. These negative traits might be the result of a robot absorbing human emotions and temperament.As a result, the major goal would be to protect robotic perception from this negative[19]. However, understanding the baseline of existing emotions, which is a reflection of the human race, is critical to replacing bad feelings from future technologies. As a result, it's critical that we concentrate on learning how humans interact with robotic technology. From a different standpoint, it's also critical to comprehend human perceptions of these robots[20] in order to determine how effectively they'll be welcomed into society. Currently, the scale of comprehension is skewed to the positive and negative ends of the spectrum. While robots are making it simpler for people to perform difficult and risky activities, they are also causing a employment shortage in the industry [21]. While robots are being portrayed as smart, sentient beings in order to appeal to society's youth, the question of whether or not they are hazardous looms. The continual debate over how humans see the robotic world alters the future topography of its growth.

2.1.3 Human Perspective

The key to understanding the source of this problem is to have a fundamental grasp of how people see robots. The main source of this knowledge is online media for the general public who have never interacted with a robot [22, 23]. However, it is crucial to consider whether viewpoint of real-life encounter[24] is more significant than knowing about them through a movie[25]. It is simple for those who have never seen a robotic being to view robotic systems in a bad light. Putting their admiration for these entities aside, the thought of them being hazardous sends them into a panic mode. We live in a dilemma where, on the one hand, we want the robots to be more functional and engaging, yet the higher the quality, the greater the risk factor [26]. In a nutshell, it mirrors how people see a robot. While some people see these artificial robots as friends and collaborators (a cooperative state), others see them as a potential threat in the future (competitive state).

2.1.4 Cooperation and Competition

This conflict between cooperative and competitive nature has always existed in the human psyche. The existence of these characteristics contributes to society's advancement. However, any of these might collide in terms of its principles. Competitive conduct, for example, is invariably accompanied with negative consequences [27]. Competition has been demonstrated to establish an aggresive baseline of emotions [28, 29], but cooperative components lessen the argument - anger - aggression cycle. Previous studies have attempted to examine the impact of these characteristics in order to determine the function they play in society. To test the context of these features, Biance et al.[30] performed simulated interactive activities in teams. They discovered that a competitive structure aids team performance in independent activities, whereas a cooperative structure aids performance development in interdependent tasks. John et al.[31] go into further detail about this link, claiming that both cooperative and competitive structures have favorable benefits on motivation and performance when used in a systematic way. As a result, the interaction between these features becomes increasingly vital to understand in the long term. Carla et al.[32], for example, investigate this dynamic by employing CGS (Cultural Group Selection) to claim that competition across cultural groups tends to improve cooperation in the long run. Overall, this stabilizing balance of collaboration and rivalry might be a key factor in developing a healthy foundation for human-robot coexistence.

2.1.5 Gaming and Robotics

Gaming is a rapidly growing application area for social robots. In recent years, games have gone beyond the domain of physical fitness to a more digital one. In terms of graphical quality, performance, and other things, video games are always improving [33]. Despite the fact that this innovation affects the vast majority of the world, many areas of the globe still have restricted internet connection and are thus more likely to profit from the offline capabilities [34]. Chess, Catan, Ludo, and other board games continue to be popular across the world. As a result, there are instances when there aren't enough others to enjoy this gaming experience with. The role of gaming buddy has been taken over by robotic devices [35–37]. However, when robots begin to fill this job, questions about cooperative and competitive characteristics, as well as their inter-dynamic interplay, arise. There has been a lot of research on measuring these attributes separately and how they relate to gaming. Axelrod et al. [38] used the prisoner's dilemma game to state that cooperation based on reciprocity may begin in an asocial environment, prosper while engaging with a variety of different methods, and resist invasion once completely established. Jennifer Wirt [39] analyzed the increase of learning in Olympiad Students from a competition aspect with positive results. Dolgov et al.[40] explores the competitive and cooperative aspect implications on social aspects through the usage of gameplay scenario involving Wii Sports. With researches focused on linking the robotic world with the two attributes [41, 42], the dynamic between the traits continue to be explored.

Understanding the motivation and past research in this field is crucial to apprehend the contributions being provided in this research. The next section delves into the concepts and technology utilized in conducting the study, which are required to follow the implementation and outcomes described in succeeding chapters.

2.2 Concepts and Technologies

To get a clearer idea of the experiment being done to properly implement the user study, it is key to understand certain initial concepts regarding each part. Associated technologies and corresponding concepts are provided in this section. This just provides a basic idea of each part involved in the experiment. Further designs and implementations to combine the concepts together will be explained in the chapter 4.

2.2.1 Technologies

This involves the technological aspects being used in the experiment. The following key features were imperative in conducting a successful implementation.

Humanoid Robot

A humanoid robot resembles a human in appearance and behavior. The design might be for practical purposes, such as interacting with human tools and the environment, or for research purposes, such as investigating bipedal walking. In general, humanoid robots have a torso, a head, two arms, and two legs, while some may just replicate a section of the body, such as the upper body. Some humanoid robots feature human-like heads with eyes and lips. The humanoid robot being used for this experiment is the one provided by Softbank Robotics[43] called Pepper Robot (fig: 2.1).

Figure 2.1: Pepper Robot

Pepper Robot

Pepper (fig: 2.1) is the world's first social humanoid robot able to recognize faces and basic human emotions. Pepper was optimized for human interaction and is able to engage with people through conversation and his touch screen. Currently, it is being used all over the world in businesses and schools. Companies all over the world have adopted pepper to welcome, inform and guide visitors in a unique and captivating way.

Naoqi Python API

NAOqi is the name of the primary software that runs on the robot and controls it. SoftBank utilizes this programming framework to program robots like NAO and Pepper. It addresses difficulties like parallelism, resources, synchronization, and events that arise often in robotics. This framework allows for homogeneous communication (motion, audio, and video) across modules, as well as homogeneous programming and data interchange. It was chosen over Choregraphe to exploit the ability to create coding structures from scratch instead of relying on inbuilt functions.

2.2.2 Functionalities - Robot

This section gives a brief idea about the various functionalities which will be necessary usages during the experiment. It will also describe instances, where these structures could be utilized.

Inverse Kinematics

The application of kinematic equations to determine the motion of a robot to attain a desired location is known as inverse kinematics. A robotic arm in a production line, for example, needs accurate mobility from a beginning location to a target position between bins and manufacturing machines to execute automated bin selection. In this experiment, inverse kinematics will be used to move the robot to specific areas and in creating the throwing motion. The values for the throwing motion will be calculated by hit and trial, while the motion computations will be determined mathematically in chapter 4. Using the moveTo function in "ALMotion" API, the movements will be choreographed according to necessity. For the throwing aspect, the primary joints in usage would consist of "Rshoulderpitch" which is the joint for shoulder, "RWristyaw" which is the rotational aspect of the wrist joint and "Rhand" to grab and release the ball when provided.

Lasers and Sensors

Pepper robot has many sensors around its body. For instance, Pepper's legs are equipped with a variety of sensors, including two ultrasonic transmitters and receivers, six laser sensors, and three obstacle detectors. These sensors provide it information about the distance between close objects (up to a range of 3 meters) and help it avoid unforeseen accidents. Using the "ALMemory" API, the data from the sensors can be acquired for calculation and analysis purposes. The sensors to be used in this experiment are:

- *Hand Sensors:* The left hand and right hand sensor could be used in decision making sections.

- *Head Sensors:* The head sensors could also provide more options for pepper to keep track of the progress of the experiment.

- *Laser sensors:* The laser sensors from peppers legs could be useful in checking distance. Effective cone for pepper's laser sensor is 60 degrees.

- *Sonar sensors:* The sonar sensors could also be used in checking out the distance. Effective cone for pepper's sonar sensor is 60 degrees.

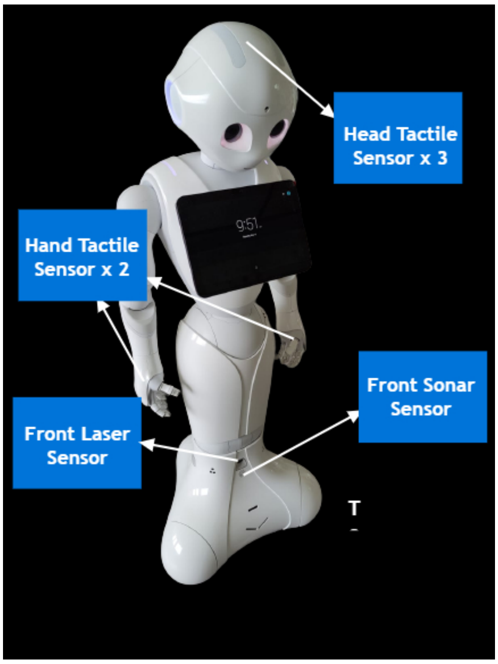


Figure 2.2: Pepper Robot Sensors Used in the experiment

Animated Speech

The normal conversation of pepper can be replaced to a more animated take to have it gain interaction points with the players of the experiment. This can be done using the "ALAnimatedSpeech" API. There are tons of inbuilt settings for animation, ranging from 'explain', 'shortbow', 'excited' and more. The common syntax for the animated speech code is as follows:

```
anim_service = session.service("ALAnimatedSpeech")
anim_service.say("Hi There, ^start(animations/Stand/Gestures/Hey_1) Player!")
```

Code listing 2.1: Animated Speech syntax

Chapter 3

Methodology

This chapter describes the process of how the study was designed, delving into the intricacies of each piece and providing an overview of how the research was conducted. The effort that went into setting up the environmental, user and other parameters will be discussed individually in the sections that follow.

3.1 Study Setup

This section delves into the research parameters, including how the studies were conceived and set up. It also explains which parameters were necessary for the study to be helpful.

3.1.1 Study Motivation

The goal of the study was to look at the link between cooperation and competitiveness in the human mind and how it can influence how people see robots. With a strong interest in robotics and a penchant for gaming, this research looked like the ideal approach to cross all of those boundaries. Explorations into this dynamic have been going on for a long time, according to preliminary study, and it has recently begun to affect the social robotics industry as well. The research questions outlined in (section 1.5) focus on this topic of inquiry, generating a lot of attention. The interest of learning how the entire paradigm existing inside society and could effect the future of human-robot peaceful coexistence is why this study is significantly important.

3.1.2 Preliminary Decisions

Before the experiment and study could be carried out, a few key decisions on how the entire research should be set up had to be taken. The parts that follow go through these decisions and how they relate to the implementation section.

Game Selection

Since the medium of this research was social robotics, specifically gaming, the selection of game become a very crucial task. The goal was to find a game that was simple to learn and play without making the participants strain to recall the rules. Complex digital games were rejected in this regard since they needed additional screen adjustments. With a non-digital game in mind, the options were limited to basic games like connect4, ludo, or games that required more physical exertion, such as table tennis. After much thought, trash can basketball (fig: 3.1) was chosen since the rules essentially consisted of tossing a ball into a bucket from a distance.

(a) Trash-can and paper balls

(b) People playing Trash-can basketball

Figure 3.1: Trash-can Basketball

Mode Selection

Because the entire research is based on the two features of collaboration and competitiveness, they have to be characterized using a trashcan basketball game as a model. As a result, the following regulations were established:

- *Cooperation Game:* In their turns, the two players (human and robot) would each take five shots. The total number of successful hits by the team would be calculated at the end of the round. The outcome was deemed a win for the team if the total was seven or more. The team would be defeated if the total was fewer than seven.

- *Competition Game:* In their turns, the two players (human and robot) would each take five shots. The player with the most successful hits at the conclusion of the round would be named the winner. If the two players' total scores were equal, the tiebreaker session would begin.

- *Tiebreaker:* The tiebreaker section would be built in to cope with the situations where the scores of robot and human are equal in the competition mode. In this, the human player will get to nominate one player (either themselves or the robot) to take one shot. If a successful hit happens, the throwing player wins the game. However, if the throwing player misses the shot, the opponent wins automatically.

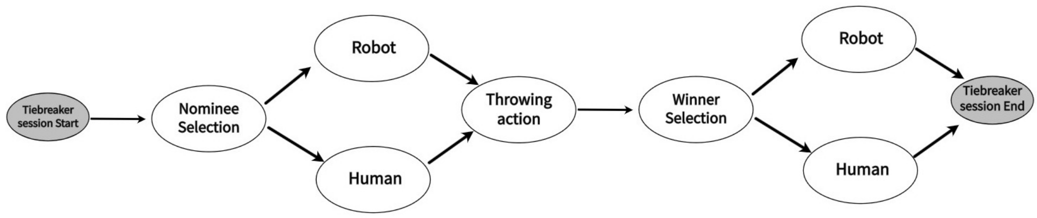


Figure 3.2: Tiebreaker section for competitive mode

Gameplay modes

The sequence of throws was the difficulty that arose after the choice of modes. The two modes were then broken into the following groups to address this issue:

- *Cooperate + Robot:* This mode represented the section of games where the first phase of gameplay would be cooperation session and the second phase, competition session. The selected order of throwing was robot first and human second in this instance.

- *Competition + Robot:* This mode represented the section of games where the first phase of gameplay would be competition session and the second phase, cooperation session. The selected order of throwing was robot first and human second in this instance.

- *Cooperate + Human:* This mode represented the section of games where the first phase of gameplay would be cooperation session and the second phase, competition session. The selected order of throwing was human first and robot second in this instance.

- *Competition + Human:* This mode represented the section of games where the first phase of gameplay would be competition session and the second phase, cooperation session. The selected order of throwing was human first and robot second in this instance.

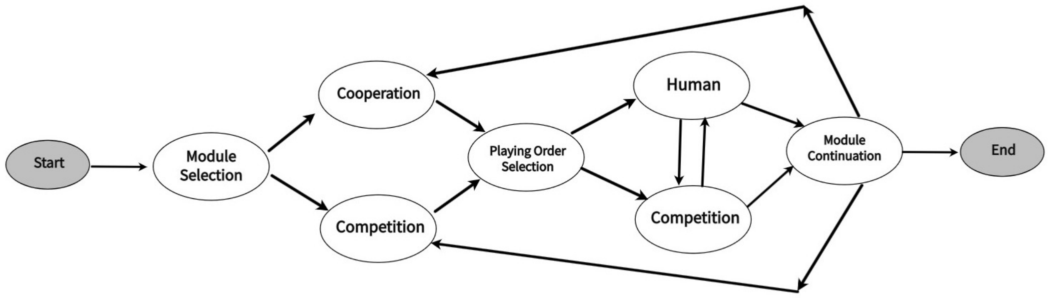


Figure 3.3: Flow of Gameplay of all modes

3.1.3 Flow of the experiments

With the stage set, it was time to lay down the flow of experiment. After careful considerations, this was how the study was decided to take place:

- *Introduction session:* The purpose of this step was to communicate the experiment's motivation and outline to the participant. It was also utilized by the participant to address any queries they had about the specifics of the task at hand. During this time, the user would also be given the data collecting booklet. This phase was decided to have a time limit of around 5 minutes.

- *Interaction time with Pepper Robot:* A one-minute window was set for participants to engage with pepper separately. This phase was placed in the flow for persons who had never interacted with a robot before, in order to lessen and eliminate any shyness or fear that could have arisen during the gameplay session.

- *Pre-experimentation questionnaire:* At this point, the participants would be directed to complete a 15-question brief questionnaire and a preliminary emotion assessment section in the booklet to create a baseline of abilities and preferences, as well as their present emotional state. This phase would have a time limit of roughly 4 minutes.

- *First phase of experiment:* This was the first gameplay session between human and robot. This might be either the competitive or collaborative side, depending on the preferred mode. The manner of play also determined the order of throws for the game. The time limit for this session was set at 5 minutes.

- *Mid-experimentation questionnaire I:* This level consisted of just recording the participant's current feeling on the next emotion assessment in the booklet. It was intended to represent the player's emotional transformation during the course of the initial gaming. This phase had a time limit of 2.5 minutes.

- *Second phase of experiment:* This was the second time a person and a robot played together. This phase would be used to continue with the remaining aspects of gameplay, based on the mode chosen at the start of the experiment. The throws were made in the same order as in the first part of the experiment. This section was decided to have a time limit of 5 minutes.

- *Mid-experimentation questionnaire II:* This step would be used to register the participant's current feeling on the next emotion assessment questionnaire in the booklet. This component of the emotion reading phase, like the previous one, was suggestive of the emotional shift for the second stage of game, and maybe a mixture of the first and second stages. This phase had a time limit of 2.5 minutes.

- *Post-experimentation Questionnaire:* At this point, the participants would be asked to take a few minutes to relax and reflect on their experiences throughout the experiment before setting their final emotion. This section would have a 10-minute time limit.

- *Short Interview:* The final stage would be a brief interview with a few questions on the study's findings and how they feel about the modes in general. A 20-minute interview session was scheduled.

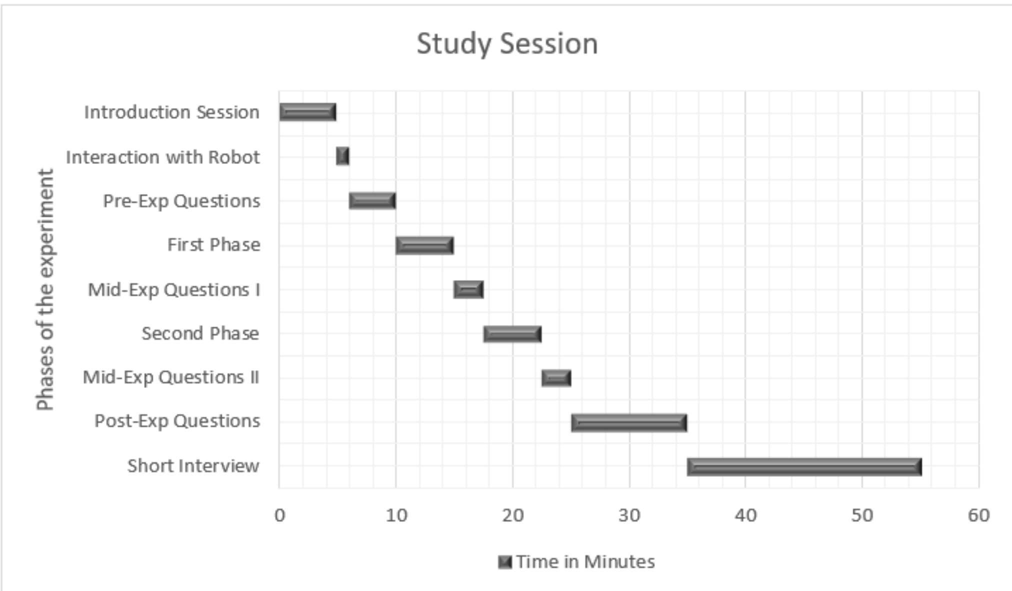


Figure 3.4: Duration of each session

The score was to be recorded on Pepper's breast tablet after each round of games. Pepper would then announce the score to the rest of the room. The opponent's turn would be subsequently completed, and the score, once again, recorded on Pepper's tablet.

3.1.4 Measures and Materials

The substantial stuff to be considered for the study is listed out in this section:

- *Demographics:* The age range for the participants was set to be in 20-30 range. Each category was meant to hold atleast 1 male and 1 female participant.

- *Emotion Scale:* Measurement of emotions was done using the Self-Assessment Manikin (SAM) scale [44]. The scale (fig: 3.5) contains three separate bars to measure the following aspects of emotion:
    - *Valence:* This is used to measure the positive and negative feel of the emotion.
    - *Activation:* This is used to measure the calmness and excitement factor of the emotion.
    - *Control:* This is used to measure the confidence/domination meter of the emotion.

  The scale contains 5 representations on each bars indicative of the feeling at the moment. Along with it, there is a number line ranging from 1 to 9. The participant can indicate their emotions on either of the two places.

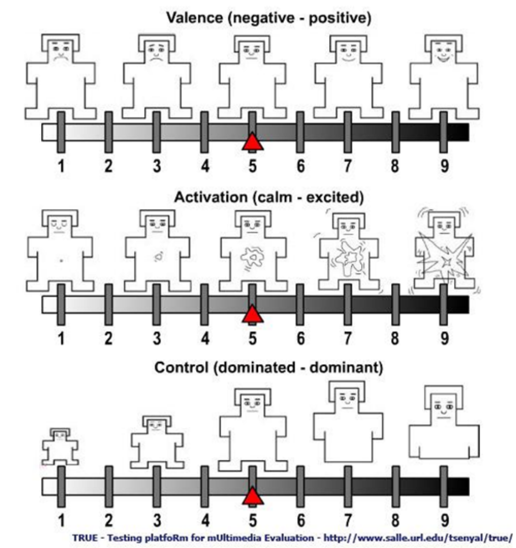


Figure 3.5: Self-Assessment Manikin scale

- *Pre-interview Questionnaire:* The pre-interview questionnaire was a 15-item form along with one set of emotion scale. The questionnaire can be found in Appendix A. The form was primarily set to assess the past experience of player in the following matters:
  - Preference of games: Digital or physical
  - Preference of modes in general games/sports: Cooperation or Competition
  - Trash Can Basketball
  - Humanoid Robot
  - Experiment understanding

3.1.5 Environment Parameters

To conform to the robot's technological concerns, the study was set up at NTNU, Gjøvik's VR Lab. The lab was divided into the following main sections::

- *Gameplay Area:* The primary gaming area would occupy the majority of the lab's size, to give people freedom to explore the entire area whenever they liked.

- *Introduction and Interview Area:* The conversation space was set up with a circular table and two seats (fig: 3.6). This arrangement was utilized to present the experiment's first introduction information as well as to conduct a brief interview session following the experiment.

Figure 3.6: Introduction and post-interview area

- *Score Recording Area:* The game's rules, details on the experiment's flow(fig: 3.8), and the scoring (fig: 3.7) were all written on the lab's white board. This allowed the player to focus on enjoying the game rather than constantly calculating the score.

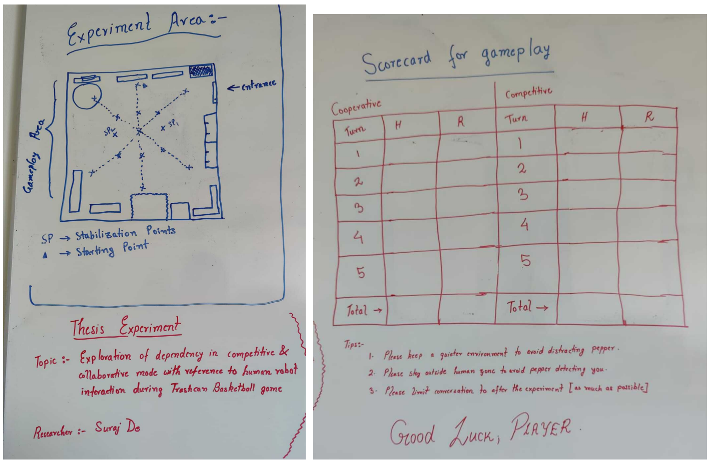


Figure 3.7: White Board - Area and Scoreboard

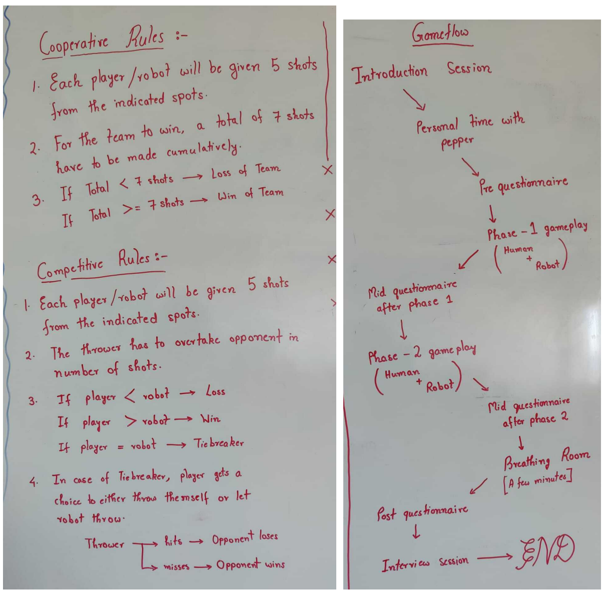


Figure 3.8: White Board - Rules and GameFlow

Chapter 4

Implementation

The principal implementation option was impacted by numerous elements involved in establishing an ambiance appropriate to have a significant quantity of gaming in order to keep the engagement level high while not making it appear too simple as a game of trash can basketball is. The criteria used to build up each element also handled how the major section of the investigation would be carried out. This section outlines how the design and implementation phases turned out in terms of the environment, robotic kinematics and other functionalities. After two independent phases of design and execution, the final version of the implemented setup was completed. The next sections go through each iteration in detail, as well as how future iterations improved on the preceding ones.

4.1 Iteration I

The first iteration of the development phase was devoted to establishing the experiment's fundamental layout. This involved putting up a skeletal structure of the core capabilities that should be employed and how the gaming will be carried out. The preliminary knowledge gained from using the humanoid robot was crucial in determining which functionality could be completed in the allotted period. Because the optimization was intended after building a basis for the implementation, the time period for executing the experiment was ignored at this stage.

4.1.1 Environment Design

The location of the player and robot was a key factor to consider while designing the arrangement. The first draft created was a circular base area with five places arranged in a pentagonal aspect on the area's edges for the original iteration. This would be the playing field, with the five points representing the places from which the players (human or robot) would throw (fig: 4.1).

The purpose of the pentagonal appearance was to keep players from becoming accustomed to the identical sight of the bucket in the middle. This meant that after each shot, each player had to shift to a different spot and adjust to the distance and

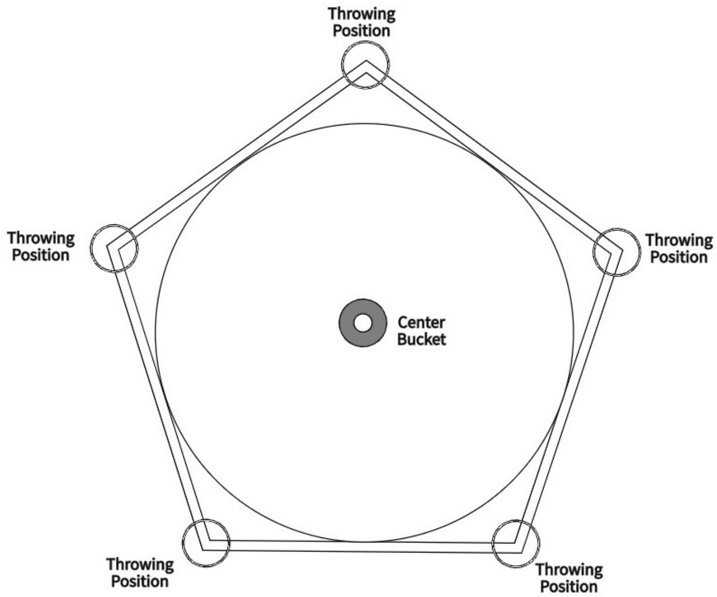


Figure 4.1: Pentagonal Area for the Gameplay

angle. Because the location was maintained constant throughout the experiment, the lighting and any lingering noises from the environment changed with each position.

4.1.2 Environment Implementation

The initially modest experiments in the inverse kinematics area using the humanoid robot pepper enabled the implementation of the throwing property. The movement was controlled via the *ALMotion* for locomotion API from Softbank Robotics, utilizing the function *moveTo*. The key problem here was to figure out how to determine the motion's trajectory.

Because *ALMotion.moveTo* operated on these two parameters, the first step in creating this trajectory was to separate the distance being traveled and how it will rotate. Despite the fact that the first instinct was to make pepper go in a circle pattern via each location, the decision was made to simplify the process by focusing just on straight passage between two spots. This resulted in a pentagonal movement with breaks at each point, rather than a circular movement (fig: 4.2).

For the rotational aspect, the movement was divided into two parts:

- **Vision Adjustment from Bucket Towards Movement (V_{BTM}):** This included the rotation of the robot from the direction of bucket towards the movement line.

- **Vision Adjustment From Facing position Towards Movement (V_{FTM}):** This included the rotation of the robot from the direction of the robot cur-

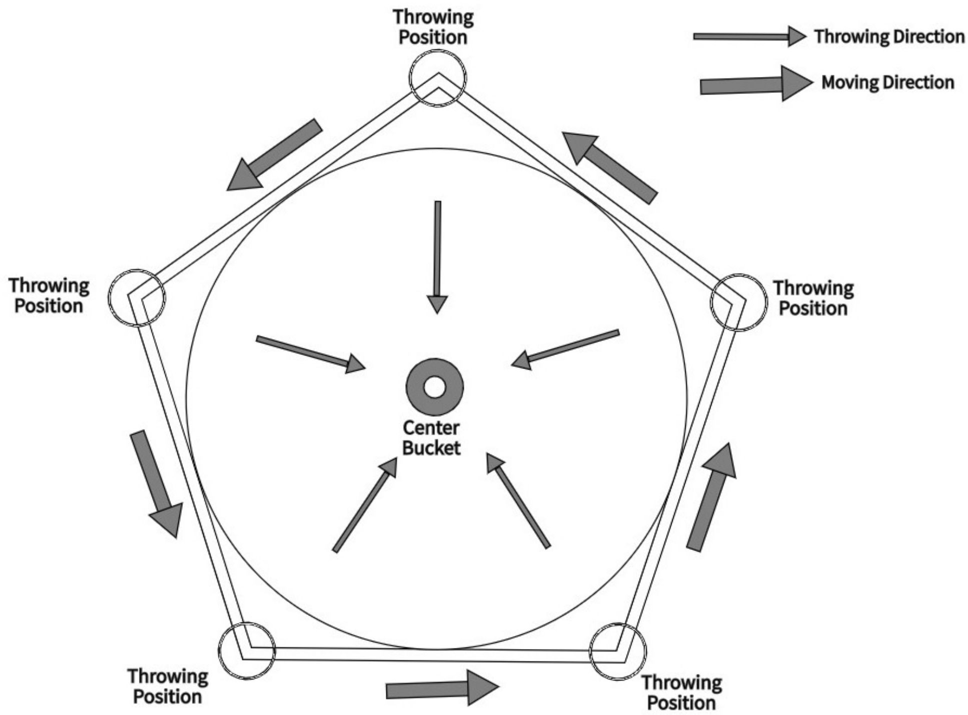


Figure 4.2: Player (Human + Robot) movement along the pathway

rently facing towards the movement line.

.

For this experiment, the values of V_{BTM} and V_{FTM} (fig: 4.3) were decided using the angles associated with the pentagon.

$$\text{The internal angle of a pentagon} = 108°.$$
$$V_{BTM} = (108/2)° = 54°$$
$$V_{FTM} = (180 - 108)° = 72°$$
$$\text{For each movement from the facing direction to the bucket,}$$
$$\text{the angle} = (V_{FTM} + V_{BTM}) = 126°$$

Trigonometric functions were utilized to compute the distance to be covered in the straight moving portion, maintaining the length from the bucket center to each corner of the pentagon constant at 1.5 meters (an assumed value of convenience). Using the above-mentioned angles,

$$\text{Distance} = 1.5 * \sin(\ (360/5)/2\ °) = 1.5 * \sin(36°) = 0.88 \text{ metres}$$

Taking the above values into consideration, the final programmatic approach was scripted out to:

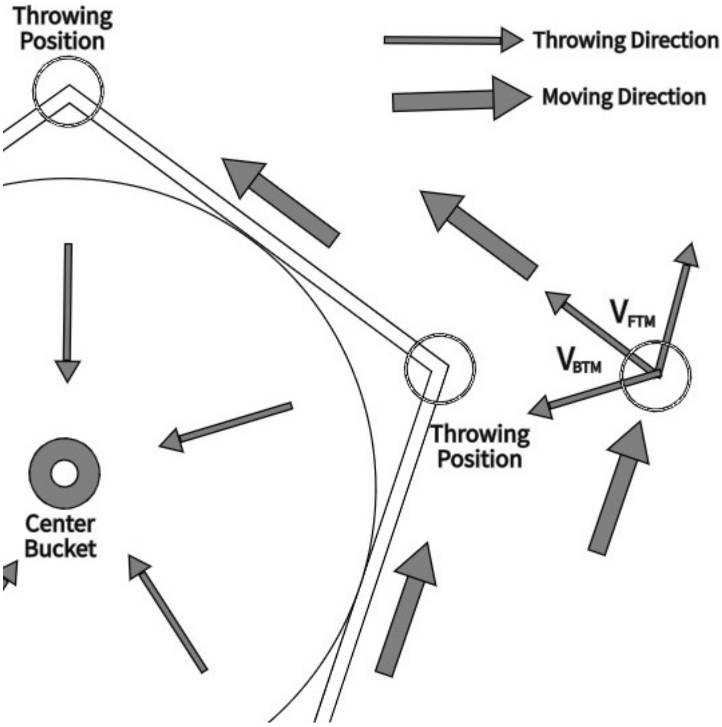


Figure 4.3: V_{BTM} and V_{FTM} for a throwing position

1. Starting position facing the bucket
2. Move clockwise by $V_{BTM} = 54°$
3. Move straight 0.88 metres
4. Move anti-clockwise by $V_{BTM} + V_{FTM} = 54° + 72° = 126°$
5. Throw the ball
6. Repeat Steps 2-5 four more times
7. End at the final position facing the bucket

4.1.3 Demonstrated Testing

The implementation was evaluated for a proper flow once the elements to travel the path and toss towards the bucket were completed. Following the testing findings, a sample demonstration session was planned to better understand the defects and improvements in the present experimentation cycle. The following are some of the points that were highlighted:

- *Easy gameplay:* Due to the nature of short distance between the bucket and throwing point, human players were having no difficulty in scoring shots.

- *Inertial errors:* Due to the complexity in creating the angles, the inertial changes in robots movement pattern were erratic. This made it harder to resolve in between the experiment.

- *Center Bucket:* Because of the variations in the robot's distance, the bucket in the middle (which acted as the garbage can in the game) was picked as a regular rectangular trash bin, which caused complications. It was, however, in favor of human players' inability to adapt to a single throw motion.

4.2 Iteration 2

The second iteration of the development phase focused on increasing the efficiency of the applied settings and implementing any necessary improvements based on the previous iteration's suggestions. To make the improvements, each capability was examined separately from both a programmatic and a player engagement perspective.

4.2.1 List of improvements

The focus of this phase was to list out all the new changes that could be done in the experiment. The following points were the key elements to focus on:

- *Gameplay difficulty:* To set a slightly difficult tone for the human players, the distance between the center bucket and the throwing player needed to be varied based on robot and human participant.

- *Throwing ball:* The usage of one paper ball meant picking the same one up and waiting at the next position for the throw. This made the participants feel pressured in doing more physical activity.

- *Angular adjustment:* The angles needed to be changed to create a simpler mode of calculation for adjustments whenever needed and possible.

- *Center Bucket:* The bucket used needed to be replaced by an uniform container to adjust any variation problems arising for the robot.

- *Distraction parameters:* With the current setup of paper ball moving around and being picked up, the awareness factor of the robot was getting triggered quite often. Thus, the distraction elements of the robot had to be reduced to a great deal to undergo a smoother play.

4.2.2 Environmental Design Changes

The original skeleton design was based on a pentagonal form, which made calculating angular values and distances complicated and difficult. To address this problem, the entire design was reworked to a simpler hexagonal form (fig: 4.4).

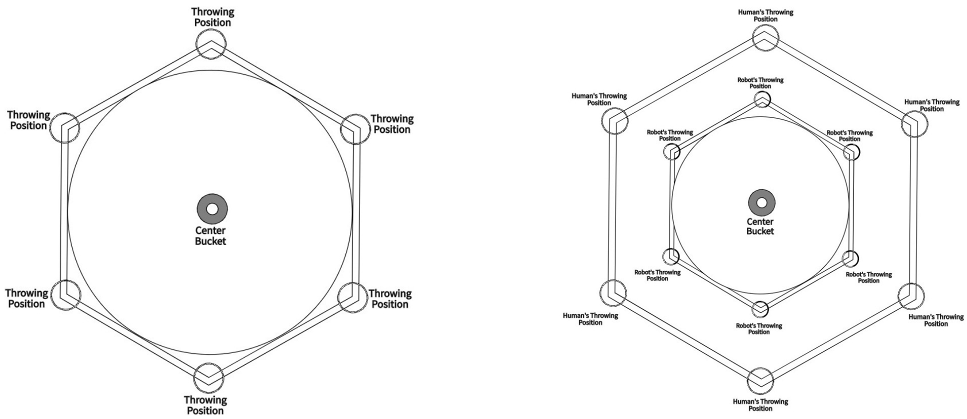


Figure 4.4: Hexagonal Pathway Designs

In addition, the hexagonal pathway for the robot would be different from that of a person. Because the robot's distance from the bucket was not an issue in the prior iteration, the original distance was maintained this time as well. The distance was extended for the human pathway to offer the player a sense of effort and challenge while playing the game. As a result, the arena took on a concentric hexagonal form. One location was preserved as the beginning point in this new pattern, but the other five were used as throwing places (fig: 4.5).

Four more paper balls were made in addition to the preceding one and put near each throwing location. Taking the ball and shifting to the next position promptly after each throw lowered the amount of distraction generated. To preserve a consistent structure in the center to toss towards, the bucket was altered to an almost circular garbage can. The bucket chosen featured a hard flat surface on one side that partially covered the open region, increasing the challenge for people and robots.

4.2.3 Environment Implementation

The hexagonal pattern of mobility for people and robots was the major focus of this iteration's execution. This meant that each distance had to be calculated to a specific degree of accuracy. To accomplish so, the first step was to examine the height of the person. Pepper robots stand 120 cm tall when fully extended, although human height may vary widely. As a result, the average height was estimated in cms from 5 feet to 6.5 feet to produce an approximation of the height factor. It was around 174 cms in length. As a result, the final length to consider is 174-120 cms = 54 cms.

The distance between robot and bucket was kept at 54 * 2 = 108 cms
The distance between human and bucket was kept at 54 * 4 = 216 cms.

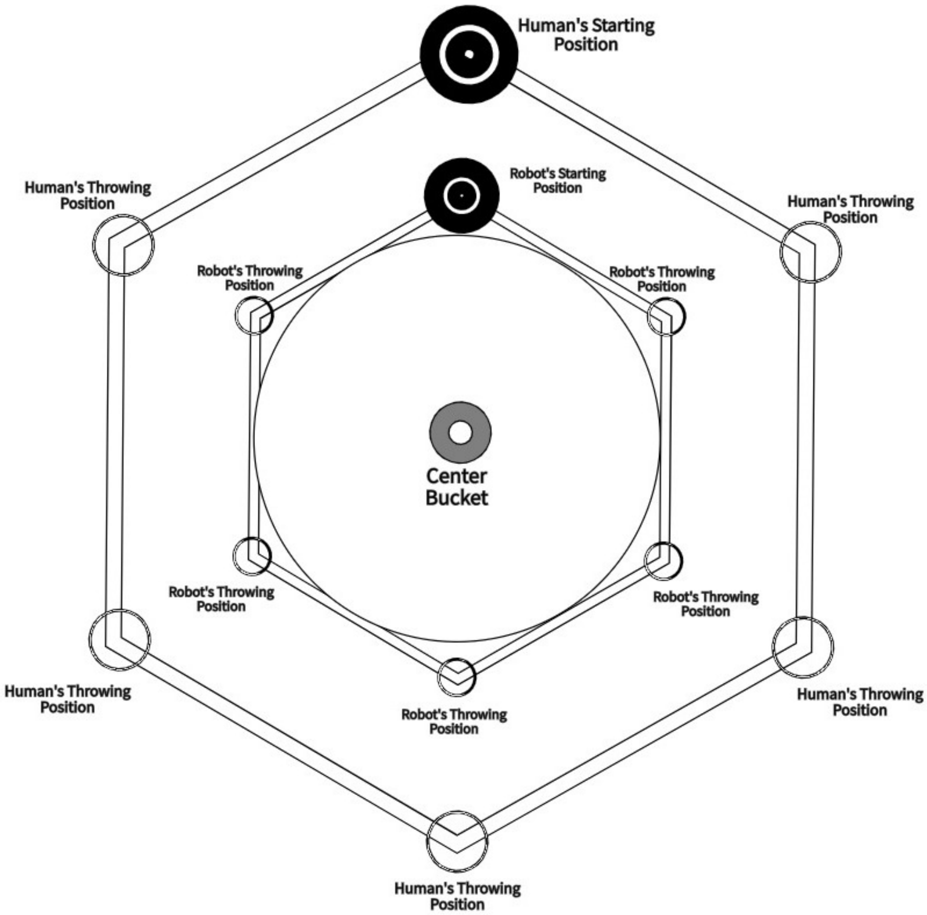


Figure 4.5: Hexagonal Pathway with starting points

The next course of action was to do the angular calculations like in (4.1.2),

The internal angle of a hexagon = 120°.
V_{BTM} = (120/2)° = 60°
V_{FTM} = (180 - 120)° = 60°
For each movement from the facing direction to the bucket(fig: 4.6),
the angle = (V_{FTM} + V_{BTM}) = 120°

For the straight movement section, lengths for robot and human needed to be calculated separately. Taking the above distances between each entity,

robotic distance = 1.08 * sin((360/6)/2 °) = 1.08 * sin(30°) = 0.54 metres
human distance = 2.16 * sin((360/6)/2 °) = 2.16 * sin(30°) = 1.08 metres

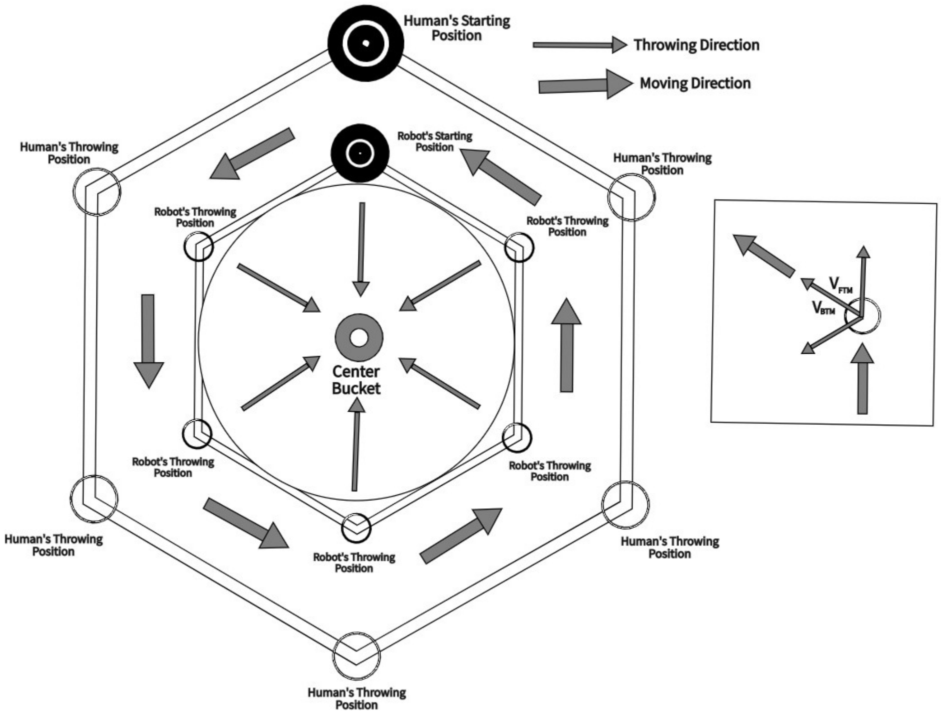


Figure 4.6: V_{BTM} and V_{FTM} for a throwing position

This time, the final programmatic approach for the robot was scripted out to be:

1. Starting position facing the bucket
2. Move clockwise by $V_{BTM} = 60°$
3. Move straight 0.54 metres
4. Move anti-clockwise by $V_{BTM} + V_{FTM}$= 60° + 60° = 120°
5. Throw the ball
6. Repeat Steps 2-5 four more times
7. Move clockwise by $V_{BTM} = 60°$
8. Move straight 0.54 metres
9. Move anti-clockwise by 120°
10. End at the final position facing the bucket

Animated scripts were utilized with the *ALAnimatedSpeech* API to make the interaction between human players and robots more natural. In addition, the code now included a few sensor usages. The left-right hand sensors specified options at certain stages, while the head sensors signaled the start of games. The *ALMemory* API was used to perform this.

4.2.4 Demonstrated Testing

Each new capability was subjected to sample testing, just as it had been in the previous round of development. These test results were shown to the supervisory audience once again for flaws and difficulties. As part of this iteration's improvement considerations, the following points were highlighted:

- *Lack of Animations*: The added animations were not enough to keep the engagement active.

- *Errors in movement*: Due to the lack of position correction, the movement was problematic. The robot was taking breaks and moving around showing problems with judgement on where the ball should be thrown.

- *Distractions*: The robot was getting quite distracted due to surrounding sounds or people talking at times. This made the whole experiment stop or go in a wrong direction.

- *Throwing action*: The throwing part was causing issues with being late to and having to wait for quite sometime to take the ball and then throw properly.

4.3 Final Iteration

The last development iteration concentrated on building the final version of the experiment, which included as many capabilities as feasible for the experiment. The previous iteration's upgrades and ideas were taken into consideration to ensure that all possible enhancements were considered.

4.3.1 List of improvements

The final list of improvements to include any key elements of change to be done is as follows:

- *Position Correction:* The position of the robot needed to be fixed for the throwing to go smoothly in a perfect order.

- *Animation Content:* The number of animations needed to be increased to a greater number.

- *Mode creation:* The experiment hinged upon having four modes in play.
    1. Cooperation 1st and Human 1st
    2. Cooperation 1st and Robot 1st
    3. Competition 1st and Human 1st
    4. Competition 1st and Robot 1st

These modes needed to be built within the programming parameters for correct data to be submitted.

- *Tablet Usage:* Tablet usage would be quite useful in keeping the engagement of players high.

4.3.2 Environmental Design Changes

To allow the use of positioning checks, the hexagonal design had to be altered to an octagonal model for the robot. The walkway was turned into an octagonal space within an octagonal construct (without two corners) with a bucket in the center(fig: 4.7).

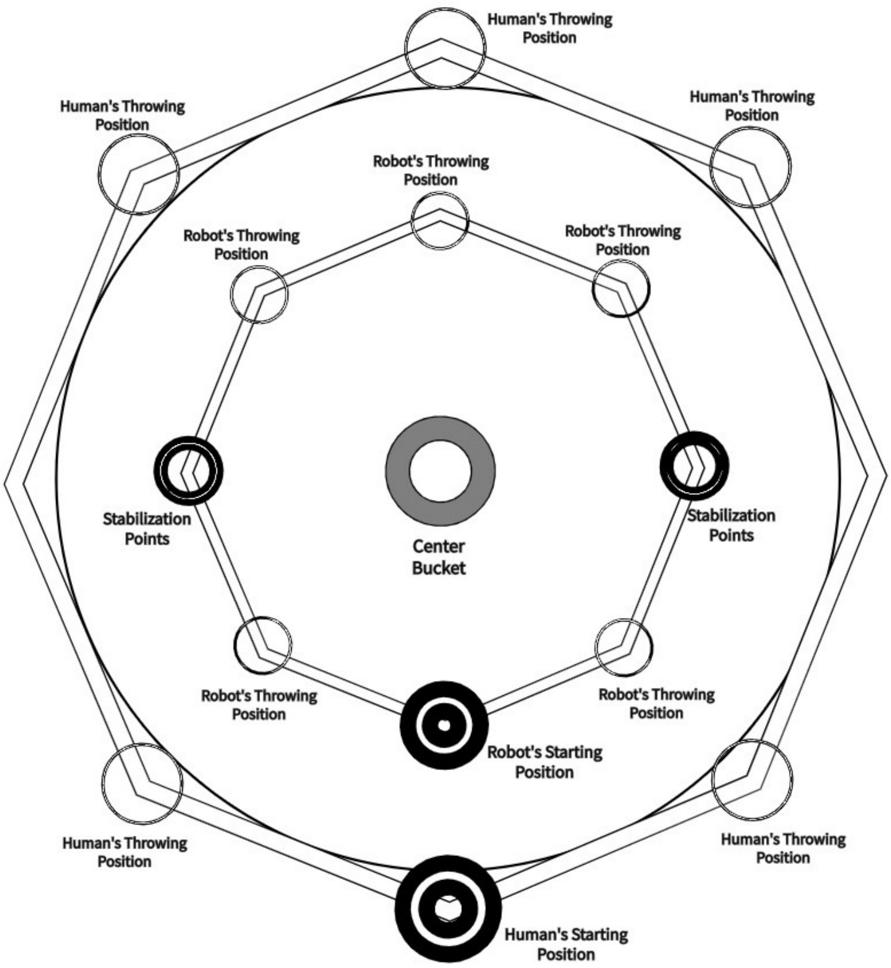


Figure 4.7: Final Pathway Design

Positional adjustments would also have to be developed, and they would be a significant implementing element for the development's final stages. The bucket's distance had to be modified based on the robot's base and the bucket's diameter. The mode section was an important aspect of the implementation since it allowed the data to be separated into the four categories and each section's analysis to be done separately.The throwing part needed to be reworked as well, in order to simplify the arm action. In addition, the tablet on the robot's chest needed to be included in the experiment. To avoid the experiment becoming boring for the player, the amount of animation used had to be significantly increased.

4.3.3 Implementation - Environmental Adjustments

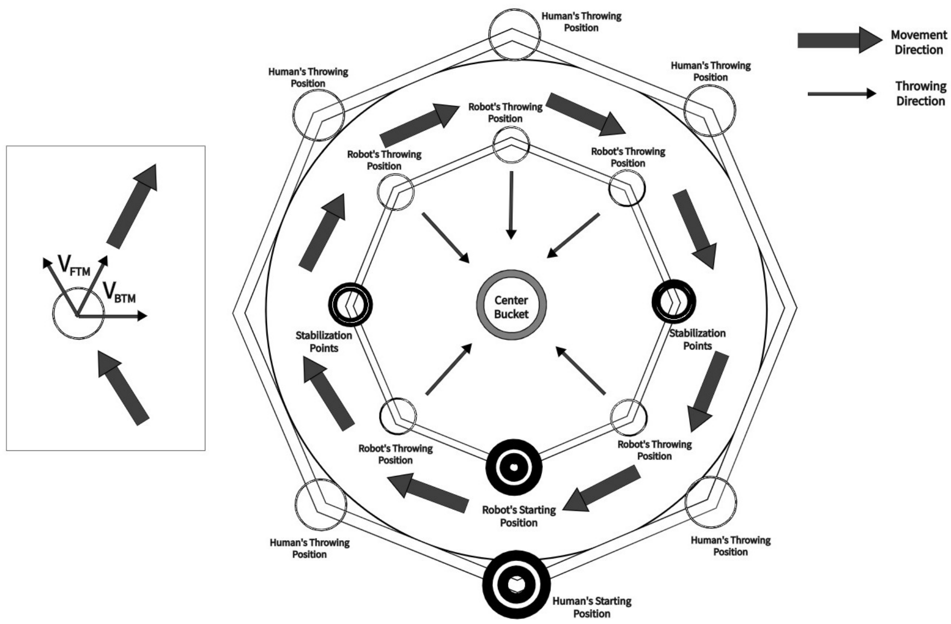


Figure 4.8: Throwing and locomotion map

To calculate the exact distance between pepper and the bucket, the following parameter values were acquired:

The diameter of the bucket used in the center = 32 cms
The radius of the bucket used in the center = 16 cms
Base length of pepper robot = 42 cms

Taking pepper's base to be an equilateral triangular structure, the distance from peppers Centre of Gravity (in the standing posture) to the outer face = 13 cms

The total distance from the center of the bucket to Pepper robot's CG = 13 + 16 + 81 cms = 110 cms

Here, 81 cms is the distance from pepper robot to the bucket. This length (previously calculated) as 108 cms was reduced down to (54 * 1.5 = 81 cms) due to the limitation of pepper's throwing range.

The exact distance between human and the bucket was calculated to 216 + 16 = 232 cms.

The octagon for the robot and the octagon for the human player were designed using these lengths. Throws had to be done once in each quadrant, keeping the perpendicular to the beginning axis as the robot's *stabilizing line* (on these places, no tossing occurs, but the robot adjusts itself further to get a better idea of the track). The third throw would be made on the same axis but in the opposite position as the first. Each area was taped off, keeping a distance of 1.1 meters from the center (fig: 4.7).

The human throwing locations were marked 2.32 meters from the center, on the same lines as the robotic throwing sites.

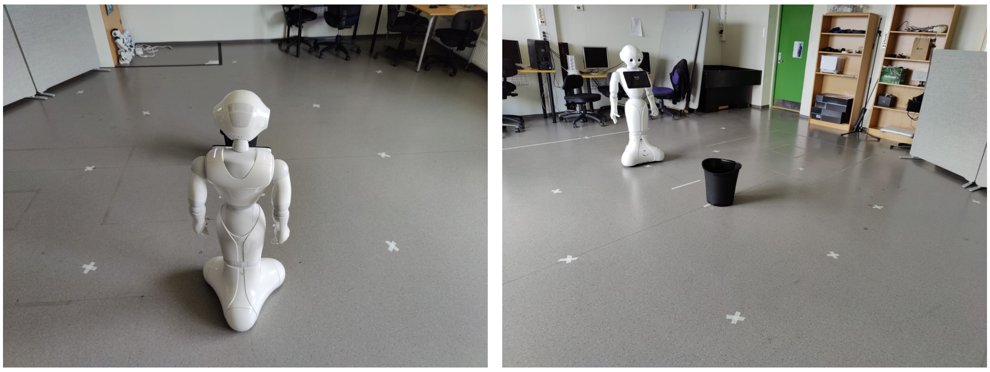


Figure 4.9: Location Identification Using Tapes

4.3.4 Implementation - Position Correction

Pepper's position has to be adjusted in two segments, the x and y axes. Picture recognition techniques were avoided due to the time it took to verify each batch of images for the bucket and the inability to alter image parameters since they were very dependent on lighting conditions. Peppers system used a mix of sonar and laser sensors to generate the capability.

Pepper was programmed to walk back and forth till it reached a length of 1.1 meters in order to alter the longitudinal parameter from bucket (with a variance of 0.05 metres).

```
# lengthwise position adjustment using SONAR sensor

    setspace = 1.1  # length to be adjusted
    diff = 5.0  # maximum length to detect
```

```
    while abs(diff) >= 0.05:
        senseval = sensor_service.getData(
            "Device/SubDeviceList/Platform/Front/Sonar/Sensor/Value")

        # slowly reducing the distance to match adjustment length
        diff = setspace - senseval - 0.001

        print("difference is " + str(diff))

        # performing the movement with length adjusted above
        motion_service.moveTo(-diff, 0, 0)
```

Code listing 4.1: lengthwise position adjustment

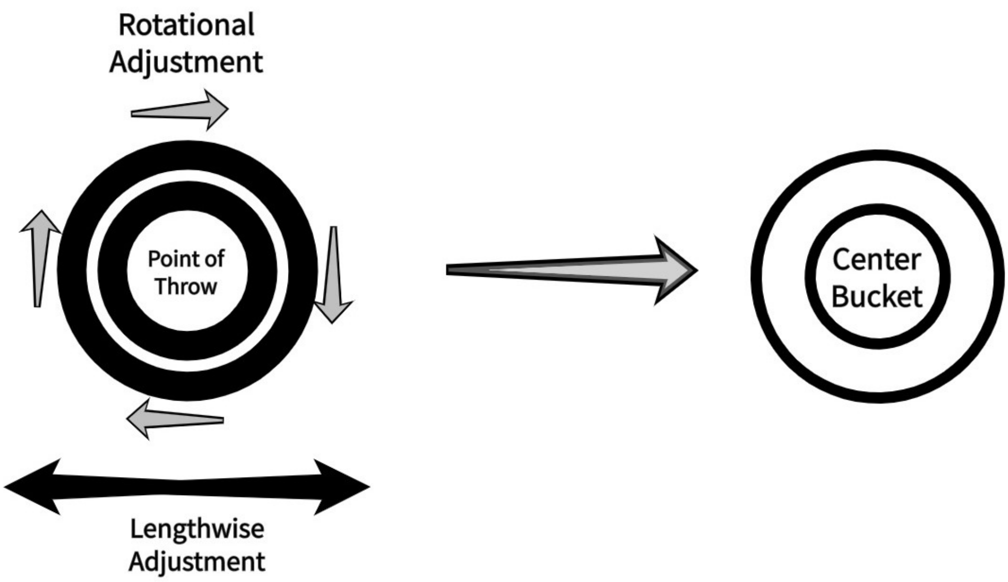


Figure 4.10: Position Correction for Robot

Pepper was given an angular rotation to alter the sideways parameter from bucket. In each iteration, the robot would revolve 10° and use its front laser to locate the bucket. The straight segmentation lasers would capture the bucket at roughly the 1 meter mark if the bucket was kept at a distance of 1.1 meters. The floor function was utilized on the 7th, 8th, and 9th segmentation of the lasers to evaluate if the length is appropriate for a bucket to be present in front, in order to have the freedom of variations.

```
 # rotational position adjustment using SONAR + Laser

def position_correction(sensor_service, motion_service):
    moveM = 0
    correct = False
    sensValue = 1.25
```

```
    floorValue = 1

    while not correct:
        sensa = sensor_service.getData("Device/SubDeviceList/Platform/Front/Sonar/Sensor/Value")
        if moveM == 101:
            # increasing length to adjust robots detection range for next set
            print "increasing sensing length"
            sensValue = sensValue + 0.25
            floorValue = math.floor(sensValue)
        if moveM == 240:
            print "unable to confirm right location"
            break
        else:
            for sensing in range(7,10):  # sensing on the 7th, 8th and 9th segments of Laser
                sega = sensor_service.getData("Device/SubDeviceList/Platform/LaserSensor/Front/Horizontal/Seg0" + str(sensing) + "/X/Sensor/Value")
                segb = sensor_service.getData("Device/SubDeviceList/Platform/LaserSensor/Front/Horizontal/Seg" + (str(sensing + 1) if (sensing + 1 > 9) else "0" + str(sensing + 1)) + "/X/Sensor/Value")

                # bucket sensing using a low occurring parabolic pattern
                if sensa < sensValue and math.floor(sega) <= floorValue and math.floor(segb) <= floorValue:
                    correct = True
                    break
            if not correct:
                # performing the movement to check next set of segments
                turningmovement(motion_service, 1)
            moveM = moveM + 1

def turningmovement(motion_service, multiplier):
    theta = math.pi/18 #  10 degree adjustment
    motion_service.moveTo(0, 0, -theta * multiplier)
```

Code listing 4.2: rotational position adjustment

To provide the robot more latitude in detecting the bucket and then modifying the length at which the throw might make a good shot, the position adjustment order was retained at sideways first and then lengthwise (fig: 4.10).

4.3.5 Implementation - Throwing action

The throwing motion was changed to make a basic approach of the right hand reaching back to grab the ball and then tossing the ball over the head. The wrist-yaw maintained the hand in line for receiving and releasing the ball, while the shoulder-pitch values were mostly changed for the throw.

```

    def throwing(motion_service):
        names = list()
```

```
        times = list()
        keys = list()

        names.append("RShoulderPitch")
        times.append([6, 8, 8.27, 8.9])
        keys.append([1.8, -1.8, 0.1, 1.5])

        names.append("RWristYaw")
        times.append([5, 6, 8.1])
        keys.append([-1.8, -1.8, -1.1])

        names.append("RHand")
        times.append([3, 8, 8.29])
        keys.append([1.8, -1.8, 1.8])

        motion_service.angleInterpolation(names, keys, times, True)
```

Code listing 4.3: Throwing action

4.3.6 Implementation - Tablet Service

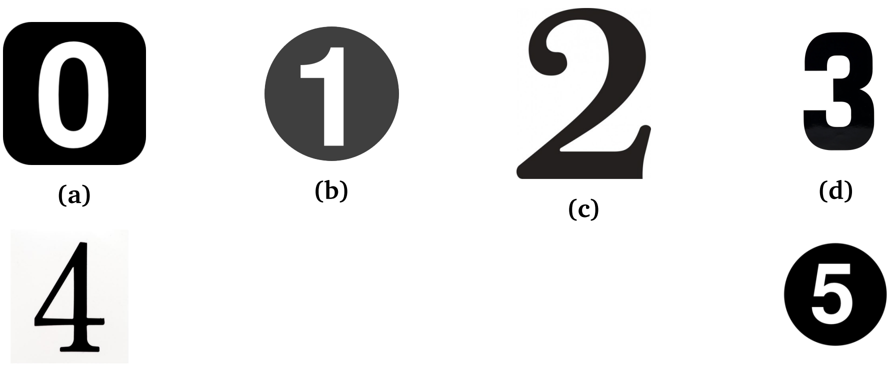
Pepper's tablet provided a way for pepper to keep track of the score. The *ALTabletService* API provided this feature. Numbers from "0" to "5" would appear on the tablet (fig: 4.11), controlled by two sensors:

- Hand sensor: This provided the option to the user to move to the next score.
- Head sensor: This provided the option to the user to lock in the score.

```
# selection of score using the hand and head sensors

def scoreRecord(session):
    anim_service = session.service("ALAnimatedSpeech")
    tablet_service = session.service("ALTabletService")
    sensor_service = session.service("ALMemory")

    # animated speech to make the robot more engaging with the players
    anim_service.say("Please tell me what the score is.")
    anim_service.say("To register score,")
    anim_service.say("Tap my head, if the number on the tablet is the score.")
    anim_service.say("Tap my left hand, to go to the next number!")

    next = 1
    tablet_service.hideImage()
    time.sleep(1)
    while True:
        scoreSelect(session, next - 1)
        headsense = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
        handsense = sensor_service.getData("Device/SubDeviceList/LHand/Touch/Back/Sensor/Value")
        if handsense == 1.0:
            next = next + 1
```

```
            time.sleep(1)
        elif headsense == 1.0:
            hit = next - 1
            break
        if next == 7:
            # rotational counter for the scores in case of miss
            next = next - 6

    tablet_service.hideImage()
    miss = 5 - hit

    return hit, miss

def scoreSelect(session, count):
    tablet_service = session.service("ALTabletService")

    # images of numbers for players visual engagement
    if count == 0:
        tablet_service.showImage("http://clipart-library.com/img1/146629.png")
    elif count == 1:
        tablet_service.showImage("http://clipart-library.com/images/8TEb8o57c.png")
    elif count == 2:
        tablet_service.showImage("http://clipart-library.com/data_images/425459.jpg")
    elif count == 3:
        tablet_service.showImage("http://clipart-library.com/images/8cGbedjKi.jpg")
    elif count == 4:
        tablet_service.showImage("http://clipart-library.com/images/8TzrxdAGc.jpg")
    elif count == 5:
        tablet_service.showImage("http://clipart-library.com/img1/188853.png")
```

Code listing 4.4: Score Selection



(a) (b) (c) (d) (e) (f)

Figure 4.11: Numbers displayed on the tablet

4.3.7 Implementation - Mode usage

The code was segregated into modules to allow players to choose the sequence in which they will be playing the games. This was done to establish the mode usage (3.1.2) for accumulation of categorized data. Pepper would make a few hello words before prompting the option. The choice provided was based on user input and was checked using two "if" conditions. They were:

- *First selection:* The first "if" condition checked for the validity of player choosing the right number for cooperative and competitive 1st gameplay. Number for selection of competitive 1st: 1, number for selection of cooperative 1st: 2.

- *Second selection:* The second "if" condition checked for the validity of player choosing the right number for human and robot 1st order gameplay. Number for selection of robot 1st: 1, number for selection of human 1st: 2.

4.3.8 Implementation - Tiebreaker Functionality (3.1.2)

The tiebreaker functionality was implemented using a system of sensors in two steps:

Step 1: The player nominates either themselves or the robot to take the deciding shot. This is done by giving the player choice to:

- *Tap Left Hand:* The left hand sensor of the robot is used to designate the robot as the tiebreaker nominee.
- *Tap Right Hand:*The right hand sensor of the robot is used to designate the player as the tiebreaker nominee.

Step 2: The player signals the robot on who achieved the victory. This is done by giving the player choice to:

- *Tap Left Hand:* The left hand sensor of the robot is used to designate the human as the winner of tiebreaker session.
- *Tap Right Hand:* The left hand sensor of the robot is used to designate the robot as the winner of tiebreaker session.

4.3.9 Implementation - Animated Speech (2.2.2)

Pepper's speech was accompanied by animations throughout the experiment. This was to make it more interactive to the human perception and not let the robots action seem monotonous. This was made possibly by using *ALAnimatedSpeech* API.

4.3.10 Integrated Implementation

Integration of all the functionalities involved addition of code section followed by series of tests in the following manner:

- Individual functionalities were retested in an isolated capacity to ensure the code was serving the right purpose.

- These code segments were added onto the skeleton program and retested as to see if there are any faulty connections.

- The entire code was retested after addition of every major functionality in its entirety.

- Additions of waiting time or conditional halt was added based on the assessed duration of code and necessity in the flow of the program.

4.3.11 Demonstrated Testing

The finished code was displayed to the supervisory audience once more after the lengthy retesting procedure in order to improve on any last-minute alterations or points that may be influenced by real-life experimentation. The following are some of the most common responses:

- *Distraction:* Owing to the high sensitivity of pepper to detect faces, sound and other stimuli, there was an issue with the entire movement scheme of pepper throughout the arena. Since pepper tracks movements with its whole body, the path followed by the robot gets altered at certain points.

- *Joint stiffness:* During the roundabout movement of pepper in the arena, there are cases when the robot gets stuck and delays its actions by a bit.

- *Random Scoring:* Pepper's scoring pattern was different each time the testing was performed.

- *Long strolls:* There would be certain instances when the robot would walk towards a specific direction other than the buckets direction for a long duration.

4.4 Maintenance Measures

The issues recognized at the end of final iteration were adjusted to the following measure:

- *Distraction:* The distraction issue was resolved by decreasing the maximum range of sensing done by pepper to 2 cms and reducing sound sensitivity to 0.09. This helped pepper to avoid sensing any person or object during the experiment. However, the case in which pepper notices a person, could still be problematic. Hence, the tracking feature was limited to just the "head" instead of "bodyrotation".

```

life_service2 = session.service("ALPeoplePerception")
life_service4 = session.service("ALSoundDetection")
life_service3 = session.service("ALBasicAwareness")

life_service2.setMaximumDetectionRange(0.02)
life_service4.setParameter("Sensitivity", 0.09)
life_service3.setTrackingMode("Head")

```

Code listing 4.5: Distraction Reduction by Reducing Awareness sensing

At the end of experiment, the parameters were reset to the default values.

```

life_service2.setMaximumDetectionRange(3.5)
life_service4.setParameter("Sensitivity", 0.9)
life_service3.setTrackingMode("BodyRotation")

```

Code listing 4.6: Reseting paramters to default values

- *Joint Stiffness:* The usage of the stabilizing points and position correction helped reduce the effects of this stiffness to a certain degree. Positional adjustment was done before and after each throw and movement, allowing better accuracy of traversing the right pathway.

- *Random Scoring:* Since the nature of gameplay warrants that players should enjoy the experience, the scoring unpredictability was kept untouched.

- *Long Strolls:* This resulted due to peppers sensors being unable to detect the bucket infront of it in a certain time interval. Due to the succeeding adjustment of length from the bucket, pepper was sensing the external environment leading to the lengthy movements in a random direction. This was adjusted by varying the sonar sensing option of pepper during rotation after a certain time period.

4.5 Procedure for the study sessions

The steps of the procedure during each study session are as follows:

- A booklet was prepared before the arrival of the participant. The participants number was filled out along with date and time. This was done to avoid breach of anonymity at any point of the experiment. The scoreboard was cleared to allow the next participant to come for the experiment.

- On coming to the experiment, first the participant was seated at the introduction area and preliminary stuff was explained. Once the explanation was done (which roughly took around 2 minutes), the booklet was forwarded to them to check out the data collection section. Meanwhile, pepper would be placed at the starting location on the track in the "sleep" mode to avoid distractions from the conversation happening around it.

- Next course of action was directing the participant to pepper for the personal time. During this period, the researcher was also interacting with the participant in case they asked any questions, regarding the experiment or pepper. This took roughly around 1 minute.

- At this point, the participant was instructed to fill up the pre-experimentation questionnaire. The researcher stood close as to be available to answer any questions, yet distant enough to not cause any issues in the collected data. This took around 1 minute. On completion, they were moved to the starting position on the track

- After this, as the participant was made to stand on the track, the now-player was explained the soft voice and distance rule (keeping a distance of 2.5 metres from pepper to avoid it detecting any human being). The player was also asked if they are willing to play the available mode. The available mode was picked based on the balancing scenario of each category described in 3.1.2. This roughly takes a minutes time.

- With a final check of all the things (IP address, mode selection, etc), the player was directed to keep the score if Robot had first play. The player also got an option to hand the ball to the robot at each position.

- As the experiment starts, the assigned mode was selected on the system and according to it, the first game was played. This took around 5 minutes for the complete human and robot turns.

- Next, the player was directed to fill up the mid-experiment questionnaire. While the player was filling in their data, check were made on the proper continuation of the experiment. This took around 1 minute.

- Then, the second game ensued with both robot and human taking turns. This took about 5 minutes as well for the completion.

- After the completion of the experiment, the player was directed back to the sitting area for the remaining phases. They had to first fill in the second mid-experiment questionnaire. This took about 1 minute.

- Once the mid-experiment questionnaire 2 is filled out, the now-participant was instructed to relax and reflect upon the experiment in its entirety. They were given 5 minutes, but they insisted on moving to the next phase around the 2 minutes mark.

- Then they were instructed to fill up the post-experiment questionnaire section at this point. When they had finished filling the questionnaire, chocolates (one for participating and one if they won against the robot) were provided to them in exchange of booklets. This experiment conclusion section lasted for about 2 minutes.

- Following this, the interview session started, wherein the participants were asked various questions to register data off of their normal ideas and thoughts. This took around 7 minutes and the whole session ended there.

A week's period was kept for the whole data collection session. Taking out the holidays in the middle of the week, everyday roughly 3 people visited in an average. Many of the participants contacted a few days before the experiment to set their date and adjust for any clashes. To maximize the flow of data, an extra week was kept in case of any issues or problems. After the days experiments, the data would be digitized in excel sheets and stored in the researchers personal laptop, while the physical copies were stored in a secure location.

4.6 Issues and Restrictions

During the week of experimentation, the following difficulties arose.:

- *Low Participant Count:* Exams for students began on May 10th, 2022, making students apprehensive to physically visit the VR Lab for the experiment. Furthermore, the physical presence made it difficult for people to visit the institution just for the purpose of participating in an experiment, resulting in a low number of participants.

- *Lighting Conditions:* Due to the heating of coils, the lights inside the lab made a buzzing sound for a short period, distracting the robot throughout the experiment. Furthermore, the outdoor lighting conditions fluctuated during the day, making it difficult to maintain a consistent atmosphere.

- *Room and equipment availability:* For security reasons, the network connection to Pepper had to be made with a university-issued laptop, therefore its availability was critical. Furthermore, because other students were working on projects and theses on the Pepper robot at the same time, a plan had to be devised that balanced the arriving participants, the robot, and laptop availability.

Chapter 5

Results and Analysis

This chapter will layout the results and their interpretations of the study conducted in chapter 3. The raw data is presented in the appendix along with the interview question and answers from the session.

5.1 Preliminary Results

The following data presented depicts the connection of various aspects of gameplay and emotion. The values represented have been taken from the data collected during the pre-experiment phase (**pre-exp**), mid-experiment phase after first gameplay (**mid-exp 1**), mid-experiment phase after second gameplay (**mid-exp 2**), post-experiment phase (**post-exp**). The values were recorded on the **Self-Assessment Manikin (SAM) scale** by participants after each phase.

5.1.1 Modes vs Emotion

This part defines the results of collected data in relation to the modes defined in (). The values are represented in terms of each aspect of the SAM scale: Valence, Activation and Control.

Cooperation first (COOP1) and Human first (H1): This mode of gameplay was configured to have the cooperation gameplay first and then the competitive gameplay. The order of throws was decided to be human participant first and then the robot. Three players opted to play this mode of gameplay:

- Player 1 (emotional progress indicated with blue in graph)
- Player 9 (emotional progress indicated with orange in graph)
- Player 10 (emotional progress indicated with green in graph)

Table 5.1 shows the emotional data of the players, distributing the data into the three categories of Valence (fig: 5.1), Activation (fig: 5.2) and Control (fig: 5.3).

	Player	Pre-exp Phase	Mid-exp Phase-1	Mid-exp Phase-2	Post-exp Phase
Valence	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	1	6	7	8	7
	9	6	7	7	7
	10	7	5	7	5
	Average	**6.33**	**6.33**	**7.33**	**6.33**
Activation	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	1	3	6	8	7
	9	5	5	5	4
	10	7	5	5	5
	Average	**5.00**	**5.33**	**6.00**	**5.33**
Control	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	1	7	6	7	7
	9	5	7	5	5
	10	5	5	5	5
	Average	**5.67**	**6.00**	**5.67**	**5.67**

Table 5.1: Emotion Values for Coop1 H1

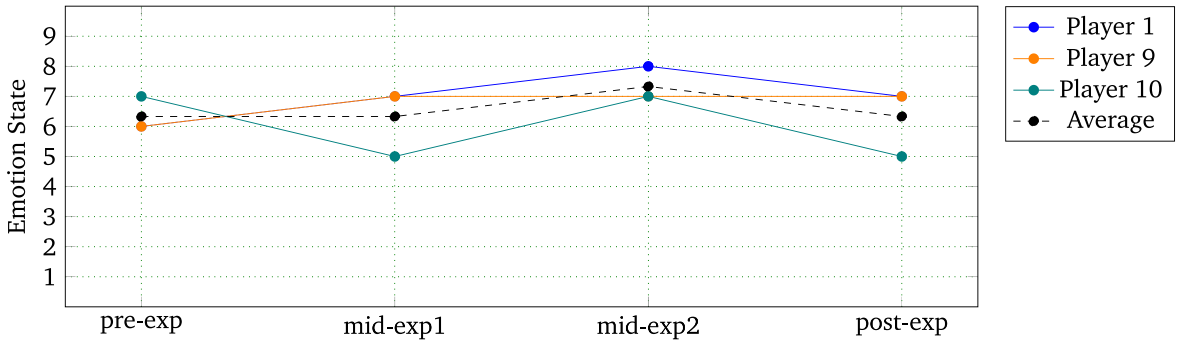


Figure 5.1: Valence Emotion Graph Coop1 H1

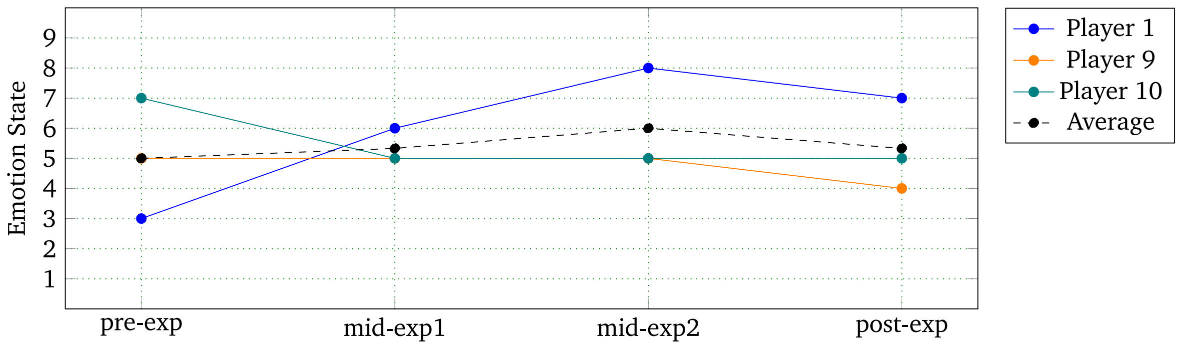


Figure 5.2: Activation Emotion Graph Coop1 H1

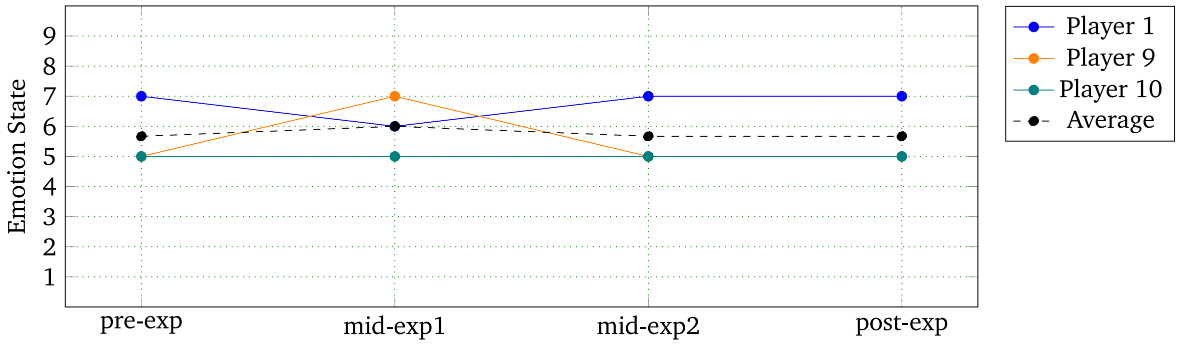


Figure 5.3: Control Emotion Graph Coop1 H1

As we can see from table 5.1, there is no change in Valence for the first game session (cooperation). However, there is a positive increase in the second (competition) session. For the activation section, there is a constant growth of excitement as each of the sessions progress. Control (confidence) area gets a boost for the cooperation game but dips during the competition game, indicating that there was a loss in confidence for the player when playing against the robot. This trend is also indicated in the graphs above corresponding to each player and the emotional aspect.

Cooperation first (COOP1) and Robot first (R1):

This mode of gameplay was configured to have the cooperation gameplay first and then the competitive gameplay. The order of throws was decided to be robot first and then the human participant. Three players opted to play this mode of gameplay:

- Player 3 (emotional progress indicated with blue in graph)
- Player 11 (emotional progress indicated with orange in graph)
- Player 12 (emotional progress indicated with green in graph)

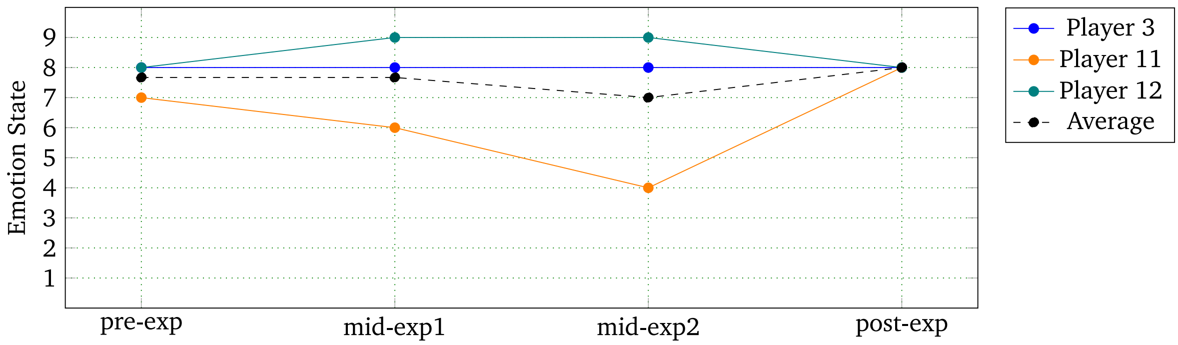


Figure 5.4: Valence Emotion Graph Coop1 R1

	Player	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
Valence	**3**	8	8	8	8
	11	7	6	4	8
	12	8	9	9	8
	Average	**7.67**	**7.67**	**7.00**	**8.00**
Activation	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	3	8	7	8	7
	11	8	8	3	2
	12	8	9	9	9
	Average	**8.00**	**8.00**	**6.67**	**6.00**
Control	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	3	6	6	6	6
	11	9	7	5	6
	12	8	9	9	9
	Average	**7.67**	**7.33**	**6.67**	**7.00**

Table 5.2: Emotion Values for Coop1 R1

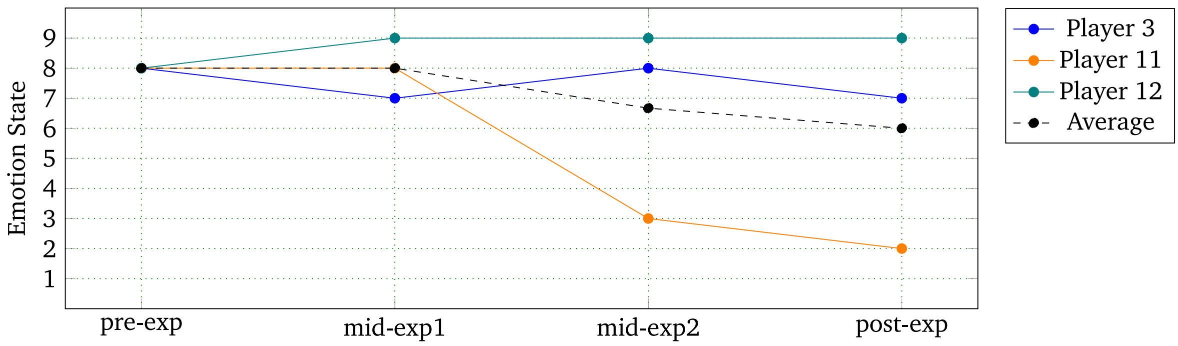


Figure 5.5: Activation Emotion Graph Coop1 R1

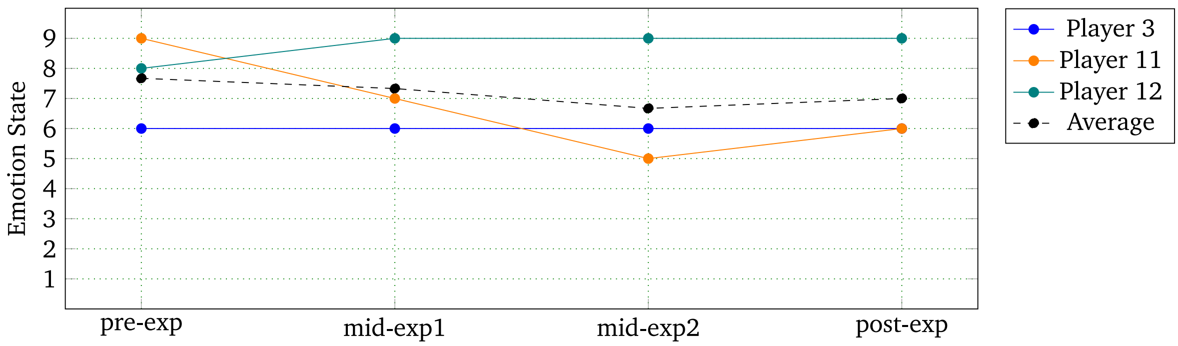


Figure 5.6: Control Emotion Graph Coop1 R1

As we can see the from the table 5.2, there is no change in valence (fig: 5.4) for the cooperation mode of play but the competition mode of play sees a decreasing trend. For the activation aspect (fig: 5.5), the excitement level stayed the same for the cooperation section, but it was reduced by a good amount for the competitive section. There is also reduction in confidence level(fig: 5.6) for the player in every session of the gameplay.

Cooperation first (COMP1) and Human first (H1): This mode of gameplay was configured to have the competition gameplay first and then the cooperative gameplay. The order of throws was decided to be human first and then the robot participant. Three players opted to play this mode of gameplay:

- Player 5 (emotional progress indicated with blue in graph)
- Player 8 (emotional progress indicated with orange in graph)
- Player 13 (emotional progress indicated with green in graph)

Table 5.3 shows the emotional data of the players, distributing the data into the three categories of Valence (fig: 5.7), Activation (fig: 5.8) and Control (fig: 5.9).

	Player	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
Valence	**5**	9	9	7	7
	8	7	8	8	8
	13	9	8	5	5
	Average	**8.33**	**8.33**	**6.67**	**6.67**
Activation	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	5	5	5	5	5
	8	1	3	4	4
	13	9	6	5	3
	Average	**5.00**	**4.67**	**4.67**	**4.00**
Control	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	5	7	4	8	8
	8	9	7	9	9
	13	9	9	9	9
	Average	**8.33**	**6.67**	**8.67**	**8.67**

Table 5.3: Emotion Values for Comp1 H1

Table: 5.3 shows no change in valence for the competitive aspect of the gameplay, however there is a declining trend for the cooperative game. The excitement decreases towards calming nature for the competitive aspect and stays same for the cooperative section. For the confidence section, there is a strong decline during the competitive gameplay, and a strong rise in confidence for the cooperative section.

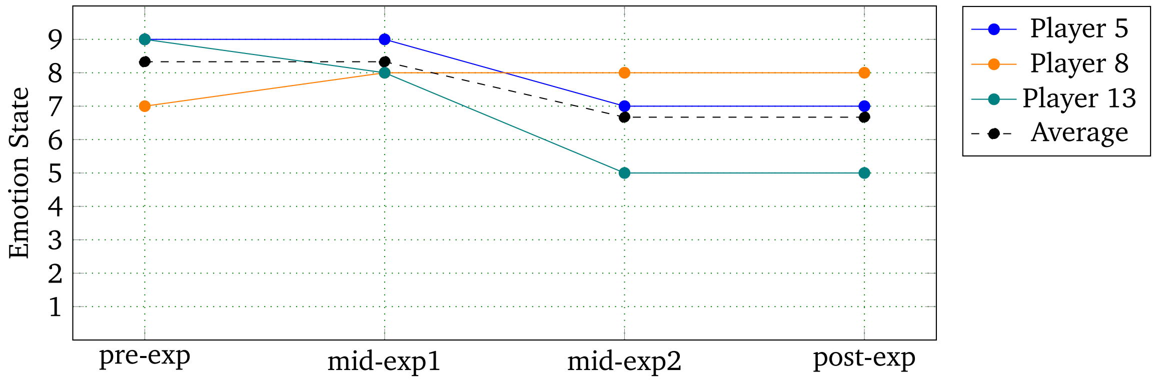


Figure 5.7: Valence Emotion Graph Comp1 H1

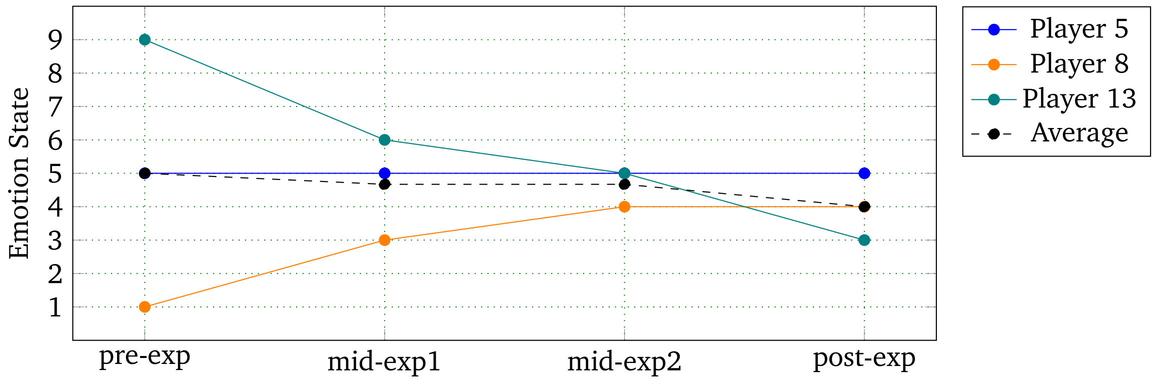


Figure 5.8: Activation Emotion Graph Comp1 H1

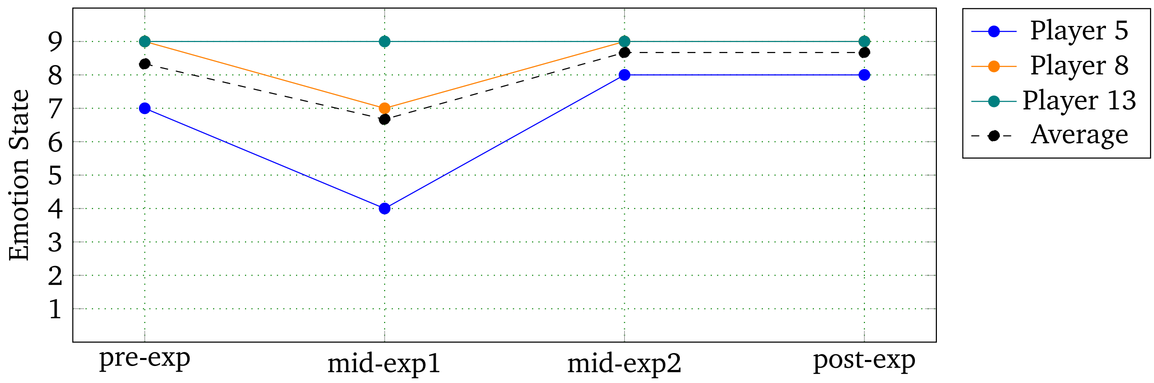


Figure 5.9: Control Emotion Graph Comp1 H1

Competition first (COMP1) and Robot first (H1): This mode of gameplay was configured to have the competition gameplay first and then the cooperative gameplay. The order of throws was decided to be robot first and then the human participant. Three players opted to play this mode of gameplay:

- Player 2 (emotional progress indicated with blue in graph)
- Player 6 (emotional progress indicated with orange in graph)
- Player 7 (emotional progress indicated with green in graph)

Table 5.4 shows the emotional data of the players, distributing the data into the three categories of Valence (fig: 5.10), Activation (fig: 5.11) and Control (fig: 5.12).

	Player	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
Valence	**2**	8	9	9	7
	6	8	8	9	8
	7	6	7	8	8
	Average	**7.33**	**8.00**	**8.67**	**7.67**
Activation	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	2	9	9	9	9
	6	7	7	8	7
	7	4	7	8	7
	Average	**6.67**	**7.67**	**8.33**	**7.67**
Control	*Player*	*Pre-exp Phase*	*Mid-exp Phase-1*	*Mid-exp Phase-2*	*Post-exp Phase*
	2	9	9	9	9
	6	9	8	7	9
	7	6	6	6	6
	Average	**8.00**	**7.67**	**7.33**	**8.00**

Table 5.4: Emotion Values for Comp1 R1

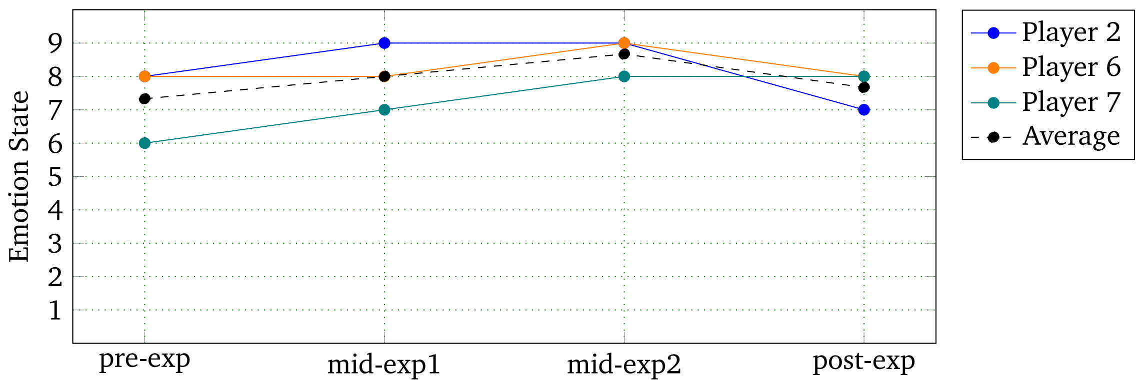


Figure 5.10: Valence Emotion Graph Comp1 R1

As we can see in the table 5.4, the valence meter goes upward throughout the gameplay sessions. The excitement level follows the same trend, however, the confidence aspect of the participant shows a steady decline with each gameplay. These trends are also indicated in the graphs provided above.

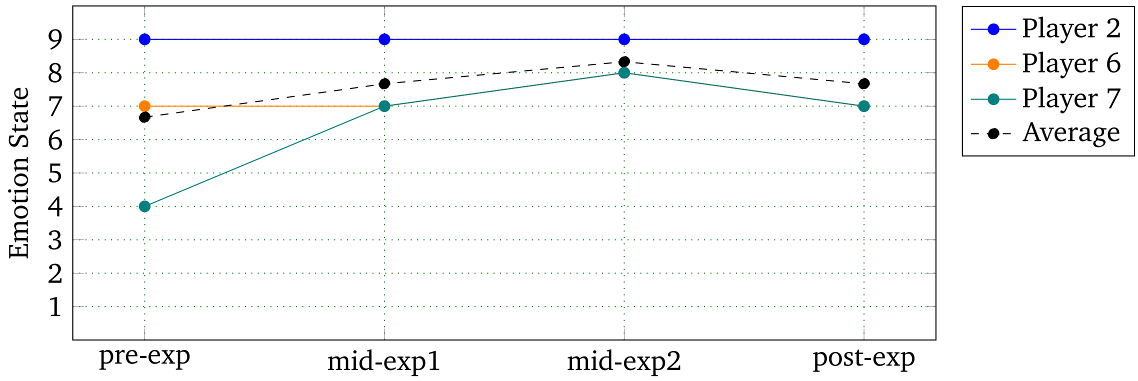


Figure 5.11: Activation Emotion Graph Comp1 R1

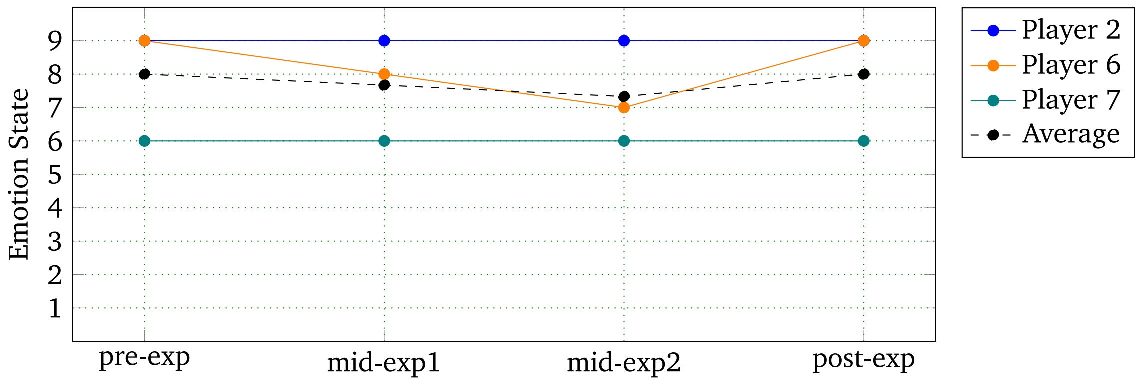


Figure 5.12: Control Emotion Graph Comp1 R1

5.1.2 Modes - Preference of Gameplay

This part defines the results of collected data in relation to the change in status of preferred mode of play. In other words, it shows if the participant's state of mind towards the competitive and cooperative aspect has been affected by the experiment.

From the table 5.5, we can see that for the cooperative 1st with human playing 1st and the competitive 1st with robot going 1st, the final state for the participants show a heaviness towards the competitive aspect, while conversely the other two modes of play are cooperative heavy in nature. We can also notice that seven out of twelve people have not changed their mindset and the majority of participants decided to stick with the cooperation mode in the end.

Player	*Mode*	*Initial Choice*	*Final Choice*	*Status Change*
1	Coop1 H1	Cooperation	Competition	Yes
9	Coop1 H1	Cooperation	Cooperation	No
10	Coop1 H1	Cooperation	Competition	Yes
Preference	**Coop1 H1**			**Competition Heavy**
3	Coop1 R1	Cooperation	Competition	Yes
11	Coop1 R1	Competition	Cooperation	Yes
12	Coop1 R1	Cooperation	Cooperation	No
Preference	**Coop1 R1**			**Cooperation Heavy**
5	Comp1 H1	Cooperation	Cooperation	No
8	Comp1 H1	Cooperation	Cooperation	No
13	Comp1 H1	Cooperation	Cooperation	No
Preference	**Comp1 H1**			**Cooperation Heavy**
2	Comp1 R1	Competition	Competition	No
6	Comp1 R1	Cooperation	Cooperation	No
7	Comp1 R1	Cooperation	Competition	Yes
Preference	**Comp1 R1**			**Competition Heavy**

Table 5.5: Dominant Preference of Game Aspect

Player	*Mode*	*Team Play*	*Human Play*
1	Coop1 H1	Lost	Won
9	Coop1 H1	Lost	Won
10	Coop1 H1	Lost	Won
3	Coop1 R1	Lost	Won
11	Coop1 R1	Lost	Lost
12	Coop1 R1	Won	Won
5	Comp1 H1	Lost	Lost
8	Comp1 H1	Lost	Lost
13	Comp1 H1	Lost	Won
2	Comp1 R1	Lost	Lost
6	Comp1 R1	Lost	Won
7	Comp1 R1	Lost	Lost

Table 5.6: Gameplay Results

5.1.3 Modes - Results of Gameplay

This part defines the results of collected data in relation to the results of the games played by the participant. The detailed result has been attached with the interview session for each player in Appendix C.

Table 5.6 shows the results of the participants in the team play (playing with the robot) and human play (playing against the robot). It can be seen that the team of robot and participant manage to secure a win in only one instance. For the competitive aspect, the robot managed to beat the human players five out of twelve time, speaking for the close stats of win-lose factor in the human-robot games.

5.1.4 Modes - Tiebreaker Choice

This part defines the results of collected data in relation to the choice the participants would have made if the game went to a tiebreaker session. Most of the participants were on the binary spectrum of win-lose scenario, so considering the gameplays they witness, the idea of who they would pick for a sudden death situation in a future game, was quite interesting to explore.

Player	*Mode*	*Tiebreaker Choice*
1	Coop1 H1	Human
9	Coop1 H1	Robot
10	Coop1 H1	Human
3	Coop1 R1	Robot
11	Coop1 R1	Human
12	Coop1 R1	Robot
5	Comp1 H1	Robot
8	Comp1 H1	Robot
13	Comp1 H1	Human
2	Comp1 R1	Human
6	Comp1 R1	Robot
7	Comp1 R1	Robot

Table 5.7: Tiebreaker Choice

The tiebreaker functionality (3.1.2) was invoked by only one participant. However, the answers for future choices for all participants is shown in table 5.7. Although being pretty evident that there is a variety of choices being made for the categories, it is interesting to note that three modes (coop1 R1, comp1 H1, comp1 R1) showed a heavy inclination towards selection of robots for the tiebreaker situation.

5.2 Trend Analysis

This section uses the emotion values from the preliminary results to assess positive, negative or neutral trends, analyzing possible connections between the categories listed above. The players list table holds the number of the participant, considered for that specific category. And in the trending tables,

- +ve = represents a positive growth of the emotion being reflected.
- -ve = represents a negative shrinking of the reflected emotion.
- - = represents a neutral stance in the matter due to inconclusive evidence from the data.
- X = represents lack of data for the specific segment.

5.2.1 Performance vs Emotion

Table 5.9 shows the trend of the emotions for the players, segregated into their corresponding category of gameplay results.

Results	**Team Won**	**Team Won**	**Team Lost**	**Team Lost**
	Player Won	**Player Lost**	**Player Won**	**Player Lost**
Player List	12	X	1,9,10,3,13,6	11,5,8,2,7

Table 5.8: Players List for performance

Trend Table for Performance vs Emotion:

Results	**Team Won**	**Team Won**	**Team Lost**	**Team Lost**
	Player Won	**Player Lost**	**Player Won**	**Player Lost**
Valence	-	X	-ve	+ve
Activation	+ve	X	-ve	-
Control	+ve	X	-	-ve

Table 5.9: Trend Table for Performance vs Emotion

From the trend table (5.9), we can see that there is a significantly positive emotion being generated when the player loses in both the cooperative and competitive mode. However, there is a negative emotion being generated when the team loses but the player wins the game against robot. For the excitement factor, we can see the positive trend for the category of both team and human player winning case, which is similar to the confidence meter. There is a lack of excitement generated during the team's loss along with a general trend of declining confidence levels.

5.2.2 Tiebreaker situation (Choice vs Emotion)

Table 5.11 shows the trend of the emotions for the players, segregated into their corresponding category of tiebreaker choices, answered during the interview session after the game.

Tiebreaker Choices	**Human**	**Robot**
Player List	1,10,11,13,2	9,3,12,5,8,6,7

Table 5.10: Players List for Tiebreaker Choice

Trend Table for Tiebreaker situation (Choice vs Emotion)

Tiebreaker Choices	**Human**	**Robot**
Valence	-ve	+ve
Activation	-ve	+ve
Control	-ve	+ve

Table 5.11: Trend Table for Tiebreaker situation (Choice vs Emotion)

From the trend table (5.11), we can observe the negative aspects of the emotional reading being the cause for human choices in the tiebreaker situation, while the positive aspects making players choose robot for future instances of tied games.

5.2.3 Results of Gameplay and Tiebreaker Choice vs Emotion

Table 5.13 shows the participants' emotional tendency, broken down into their respective categories based on games outcomes and tiebreaker selection. The trend is taken independently, without any influence from the individual comparisons of the categories as prepared previously.

Results	**Team Won**		**Team Won**		**Team Lost**		**Team Lost**	
	Player Won		**Player Lost**		**Player Won**		**Player Lost**	
Tiebreaker Choice	**H**	**R**	**H**	**R**	**H**	**R**	**H**	**R**
Player List	X	12	X	X	1,10,13	9,3,6	11,2	5,7,8

Table 5.12: Player List for Results of Gameplay and Tiebreaker Choice

From the trend table (5.13), it can be seen that the most positive trend in terms of the overall emotion, comes when the team result matches the individual player result, with the tiebreaker selection being robot. Conversely, the most negative trends comes about when the team loses irrespective of the competitive aspect. It is also interesting to note that keeping inconclusive evidence aside, selection of robot is always accompanied by positive emotions, while selection of human stems from negative emotions with less excitement and low confidence.

Results	**Team Won**		**Team Won**		**Team Lost**		**Team Lost**	
	Player Won		**Player Lost**		**Player Won**		**Player Lost**	
Tiebreaker Choice	**H**	**R**	**H**	**R**	**H**	**R**	**H**	**R**
Valence	X	-	X	X	-ve	+ve	-	+ve
Activation	X	+ve	X	X	-ve	-ve	-ve	+ve
Control	X	+ve	X	X	-	-	-ve	+ve

Table 5.13: Trend Table for Results of Gameplay, Tiebreaker Choice and final choice of mode vs Emotion

5.2.4 Results of Gameplay and Tiebreaker Choice vs Emotion

Table 5.15 shows the participants' emotional tendency, broken down into their respective categories based on games outcomes, tiebreaker selection and their choice of mode at the end of experiment. These calculations are also independent of the previous segments of individual comparisons. Here **CP** represents the cooperative aspect of gameplay and **CT** represents the competitive part. The selection of participants for this data, specifically relating to the choice of gameplay is taken from the interview sessions.

Results	**Team Won**				**Team Won**				**Team Lost**				**Team Lost**			
	Player Won				**Player Lost**				**Player Won**				**Player Lost**			
Tie Choice	**H**		**R**		**H**		**R**		**H**		**R**		**H**		**R**	
Final Mode Choice	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**
Player List	X	X	12	X	X	X	X	X	13	1,10	9,6	3	11	2	5	7

Table 5.14: Player List for Results of Gameplay, Tiebreaker Choice and Final Choice of Mode

Results	**Team Won**				**Team Won**				**Team Lost**				**Team Lost**			
	Player Won				**Player Lost**				**Player Won**				**Player Lost**			
Tie Choice	**H**		**R**		**H**		**R**		**H**		**R**		**H**		**R**	
Mode Choice	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**	**CP**	**CT**
Valence	X	X	-	X	X	X	X	X	-ve	-ve	+ve	-	+ve	-ve	-ve	+ve
Activation	X	X	+ve	X	X	X	X	X	-ve	+ve	-ve	-ve	-ve	-	-	+ve
Control	X	X	+ve	X	X	X	X	X	-	-	-	-	-ve	-	+ve	-

Table 5.15: Trend Table for Results of Gameplay, Tiebreaker Choice and Final Choice of Mode vs Emotion

From the trend table (5.15), it can be seen that even through there is an even distribution of positive and negative feelings about the players opting for cooperative mode in future, the competitive mode is tied to the negative emotion more. It can also be seen that there is a tendency for people to get less enthusiastic during the cooperation game, while getting more excited for the competitive games. A buildup of confidence also results in people picking the cooperation mode.

Chapter 6

Discussion

The field of robotics has been steadily expanding throughout time. The era of robots being programmed to do certain tasks is coming to an end. Artificial intelligence has paved the way for robots to develop consciousness, allowing them to become more human-like. This change in the machine era has sparked debate about how humans and robots will live in the future. Everyone is affected by the good and bad repercussions of their life in some manner. As a result, it is reasonable to assume that robots are here to stay, raising the question of whether the human population will be able to fully embrace them in the future. Establishing the nature of human knowledge of robots is, thus, a critical step in resolving this question. Real-life encounters between humans and robots are increasingly promoted in this area. However, consequences such as increased unemployment as a result of robots' engagement in industry make it difficult to determine if humans regard robots as collaborators or competitors. The findings of this study go a step further in looking at this relationship via the lens of a game.

6.1 Competitive and cooperative dynamic

The findings of this study provide simple indication of how a robot is seen as a gaming companion. The interest that exists in the human mind about communicating with a robot is revealed in interviews with participants in this study. People want to see more of this robot in action because of their lack of familiarity with it. This is supported by statistics demonstrating the players' favorable views about playing with the robot in the future, even when they lose in versus bouts. However, it was fascinating to observe how the players' competitive spirit was heightened as a result of the robot's improved performance. In terms of enthusiasm, the findings in 5.15 reveal that instances in which a player wins a game against a robot tends to lessen excitement and boost tranquility, leading them to choose cooperative gameplay in future iterations. Another important point to consider is that competitive gaming is favored in situations when there is a spike in enthusiasm, such as when a team loses. In other circumstances, witnessing the robot perform successfully boosts the players' confidence, encouraging them to continue playing with the robot. Taking all of these aspects into account, there is a significant amount of negative and positive feedback skewing towards both competitive and cooperative modes. As such it is difficult to ascertain the superiority of any mode over the other from the perspective of a human mind.

6.2 Limitations

Results from the experiment may have thrown some light on the dynamic of the two aspects, but it is also important to address that there may be some potential bias in assessing the users initial motivation to participate in the study. The participants list involved students from the Bachelors and Master studies at the university. As a result, given the educational value of the study, students would be naturally inclined to participate [45]. In terms of data, the study's little amount of data may result in a gap in the analysis that can be done. Aside from that, participant remarks about the game being simple and dull raise questions about the game's quality to some level. Despite its flaws in different areas, the research gave a clear insight into the topic under investigation. This enables for the development of confidence that these discoveries will serve as a foundation for future study.

6.3 Practical and theoretical implications

The findings in the research can be summarized into the following:

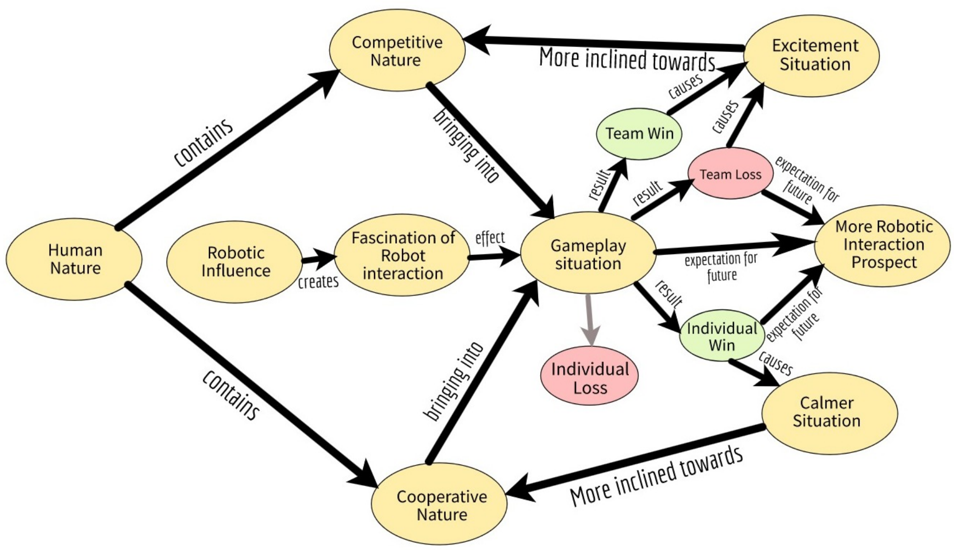


Figure 6.1: Summarizing the research findings

The loop shown above(fig: 6.1) summarizes the research findings by showcasing the observations found in (table: 5.15). Loss has been shown with red while win has been shown with green. The pathways are the inferences taken from the results, except individual loss, which has inconclusive evidence. In short, it depicts the instability existing within the paradigm of these two aspects. It's difficult to argue that one feature of nature is superior than another because anyone may modify the other. Even if the loop is interrupted at some time, other circumstances may cause a shift in human attitudes. As a result, it's safe to say that both of these modes are stuck in an unpredictably stalemate condition. In terms of how people feel about robots, both competitive and cooperative attitudes will coexist in the human psyche for a long time.

The ideas presented in previous researches in the evaluation of the cooperation-competition dynamic, have mainly posited that these two aspects, though individually show signs of being positive and negative based on tasks, are meant to assist each other in the long run [32]. This research provides further evidence to support this claim from the gaming perspective. The cycle of cooperative and competitive nature that exists inside the human psyche may never overcome one another, but it will undoubtedly continue to help one another in the future to enhance the human species.

Chapter 7

Conclusion and Future Work

The focus of this research has been primarily on investigating human attitude towards robots in the context of games. The specific aspect of evaluation was the cooperative and competitive natures, attempting to explore the relationship existing between the two. Although each of these natures, individually tend to create positive and negative feelings in various aspects, the idea of them dominating another is faulty. The research findings show how both of these modes can influence another, creating a deadlock situation. In this context, the whole research was based on the two research question detailed out in ().

In what way does the cooperative and competitive aspect tend to influence the human attitude towards social robots?

Any person's heart is likely to feel both happy and bad emotions as a result of the cooperative and competitive components. These modalities tend to establish a good attitude toward the robot in terms of social robotics. It is clear from the bulk of human statements throughout the data gathering interview session that there is some appreciation for artificial creatures. Even though the robot's gaming abilities can elicit either exhilaration or relaxation, it is still difficult to foresee how the modes would effect a human mind.

What is the nature of dynamic between cooperative and collaborative modes between human and robot from a gaming aspect?

The findings strongly suggest the coexistence of the two aspects within the research area. The looping structure (fig:6.1) clears the outlook to make the observer realize that one exists to fuel the other. Both of the aspects are quite effective in their own right, but its hard to put one above the other. From the human and robot dynamic standpoint, the acceptance ability of robots in the near future will strongly depend on humans ability to take note of this idea.

Future Work

Regarding the improvement of the experiment, the ideas suggested would typically include the conversion of this study from a qualitative exploration to a quantitative research. The low number of participants has impacted the investigation in being unable to assess some areas like the team won and player lost section of the trend analysis. Perhaps the increase of age factor for the research will provide a variance of the data in comparison to the skill level of the participants. Improving the game would be another area where the experiment can be made better. As per the comments of the participants, the game was easy and boring at times. Perhaps the usage of a complex game would pose more of a challenge to the players of the experiment. Interaction of robot can also be updated to make it more engaging, creating a more interesting environment for the participants,

A few comments were towards using second round of gameplays with robots and humans. This provides the basis for extending present study to include the comparison of feeling for robot and human. A second round of gameplay in general would also make the player get used to the conditions, providing better readings in terms of their emotional scale. Some criticized the method of collecting data and it will be possible to increase the engagement factor more with a better questionnaire section.

Bibliography

[1] D. C. Herath, E. Jochum and E. Vlachos, 'An experimental study of embodied interaction and human perception of social presence for interactive robots in public settings,' *IEEE Transactions on Cognitive and Developmental Systems*, vol. 10, no. 4, pp. 1096–1105, 2017.

[2] H. Yan, M. H. Ang and A. N. Poo, 'A survey on perception methods for human–robot interaction in social robots,' *International Journal of Social Robotics*, vol. 6, no. 1, pp. 85–119, 2014.

[3] D. O. Johnson, R. H. Cuijpers, K. Pollmann and A. A. van de Ven, 'Exploring the entertainment value of playing games with a humanoid robot,' *International Journal of Social Robotics*, vol. 8, no. 2, pp. 247–269, 2016.

[4] T. Fong, I. Nourbakhsh and K. Dautenhahn, 'A survey of socially interactive robots,' *Robotics and autonomous systems*, vol. 42, no. 3-4, pp. 143–166, 2003.

[5] M. K. Lee, S. Kiesler and J. Forlizzi, 'Receptionist or information kiosk: How do people talk with a robot?' In *Proceedings of the 2010 ACM conference on Computer supported cooperative work*, 2010, pp. 31–40.

[6] N. D. Bowman and J. Banks, 'Social and entertainment gratifications of videogame play comparing robot, ai, and human partners,' in *2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, IEEE, 2019, pp. 1–6.

[7] A. Z. |. M. N. Office, *How to help humans understand robots*. [Online]. Available: `https://news.mit.edu/2022/humans-understand-robots-psychology-0302`.

[8] A. M. Weinstein, 'Computer and video game addiction—a comparison between game users and non-game users,' *The American journal of drug and alcohol abuse*, vol. 36, no. 5, pp. 268–276, 2010.

[9] F. Tanaka, J. R. Movellan, B. Fortenberry and K. Aisaka, 'Daily hri evaluation at a classroom environment: Reports from dance interaction experiments,' in *Proceedings of the 1st ACM SIGCHI/SIGART conference on Human-robot interaction*, 2006, pp. 3–9.

[10] H.-o. Lim, A. Ishii and A. Takanishi, 'Emotion-based biped walking,' *Robotica*, vol. 22, no. 5, pp. 577–586, 2004.

[11] H.-o. Lim, S.-h. Hyon, S. A. Setiawan and A. Takanishi, 'Quasi-human biped walking,' *Robotica*, vol. 24, no. 2, pp. 257–268, 2006.

[12] J. Solis, M. Bergamasco, K. Chida, S. Isoda and A. Takanishi, 'The anthropomorphic flutist robot wf-4 teaching flute playing to beginner students,' in *IEEE International Conference on Robotics and Automation, 2004. Proceedings. ICRA'04. 2004*, IEEE, vol. 1, 2004, pp. 146–151.

[13] J. Solis, K. Chida, K. Suefuji and A. Takanishi, 'The development of the anthropomorphic flutist robot at waseda university,' *International Journal of Humanoid Robotics*, vol. 3, no. 02, pp. 127–151, 2006.

[14] M. F. Jung, J. J. Lee, N. DePalma, S. O. Adalgeirsson, P. J. Hinds and C. Breazeal, 'Engaging robots: Easing complex human-robot teamwork using backchanneling,' in *Proceedings of the 2013 conference on Computer supported cooperative work*, 2013, pp. 1555–1566.

[15] C. Breazeal, K. Dautenhahn and T. Kanda, 'Social robotics,' in *Springer Handbook of Robotics*, B. Siciliano and O. Khatib, Eds. Cham: Springer International Publishing, 2016, pp. 1935–1972, ISBN: 978-3-319-32552-1. DOI: `10.1007/978-3-319-32552-1_72`. [Online]. Available: `https://doi.org/10.1007/978-3-319-32552-1_72`.

[16] T. B. Sheridan, 'A review of recent research in social robotics,' *Current opinion in psychology*, vol. 36, pp. 7–12, 2020.

[17] S. Šabanović, 'Robots in society, society in robots,' *International Journal of Social Robotics*, vol. 2, no. 4, pp. 439–450, 2010.

[18] S. Kent and N. Patel, 'Artificial intelligence makes computers lazy,' *International Journal of Industrial and Systems Engineering*, vol. 1, no. 4, pp. 519–532, 2006.

[19] A. Sharkey and N. Sharkey, 'We need to talk about deception in social robotics!' *Ethics and Information Technology*, vol. 23, no. 3, pp. 309–316, 2021.

[20] N. Parletta, *Showing what we think about robots*, Sep. 2020. [Online]. Available: `https://cosmosmagazine.com/technology/showing-what-we-think-about-robots/`.

[21] B. Vermeulen, A. Pyka and P. P. Saviotti, 'Robots, structural change, and employment: Future scenarios,' *Handbook of Labor, Human Resources and Population Economics*, pp. 1–37, 2020.

[22] N. Savela, T. Turja, R. Latikka and A. Oksanen, 'Media effects on the perceptions of robots,' *Human Behavior and Emerging Technologies*, vol. 3, no. 5, pp. 989–1003, 2021.

[23] M. Salzmann-Erikson and H. Eriksson, 'A descriptive statistical analysis of volume, visibility and attitudes regarding nursing and care robots in social media,' *Contemporary Nurse*, vol. 54, no. 1, pp. 88–96, 2018.

[24] C. Bartneck, T. Suzuki, T. Kanda and T. Nomura, 'The influence of people's culture and prior experiences with aibo on their attitude towards robots,' *Ai & Society*, vol. 21, no. 1, pp. 217–230, 2007.

[25] L. D. Riek, A. Adams and P. Robinson, 'Exposure to cinematic depictions of robots and attitudes towards them,' in *Proceedings of international conference on human-robot interaction, workshop on expectations and intuitive human-robot interaction*, Citeseer, vol. 6, 2011.

[26] C. Dirican, 'The impacts of robotics, artificial intelligence on business and economics,' *Procedia-Social and Behavioral Sciences*, vol. 195, pp. 564–573, 2015.

[27] M. Deutsch, 'Educating for a peaceful world.,' *American psychologist*, vol. 48, no. 5, p. 510, 1993.

[28] C. A. Anderson and M. Morrow, 'Competitive aggression without interaction: Effects of competitive versus cooperative instructions on aggressive behavior in video games,' *Personality and Social Psychology Bulletin*, vol. 21, no. 10, pp. 1020–1030, 1995.

[29] B. SPANGLER, G. BURGESS and H. BURGESS, *Beyond intractability*, 2007.

[30] B. Beersma, J. R. Hollenbeck, S. E. Humphrey, H. Moon, D. E. Conlon and D. R. Ilgen, 'Cooperation, competition, and team performance: Toward a contingency approach,' *Academy of Management Journal*, vol. 46, no. 5, pp. 572–590, 2003.

[31] J. M. Tauer and J. M. Harackiewicz, 'The effects of cooperation and competition on intrinsic motivation and performance.,' *Journal of personality and social psychology*, vol. 86, no. 6, p. 849, 2004.

[32] C. Handley and S. Mathew, 'Human large-scale cooperation as a product of competition between cultural groups,' *Nature communications*, vol. 11, no. 1, pp. 1–9, 2020.

[33] M. J. Wolf, *The video game explosion: a history from PONG to Playstation and beyond*. ABC-CLIO, 2008.

[34] J. R. Shaffer, *Online and offline gaming social preferences of students*. George Mason University, 2012.

[35] F. Alonso-Martın, V. Gonzalez-Pacheco, Á. Castro-González, A. A. Ramey, M. Yébenes and M. A. Salichs, 'Using a social robot as a gaming platform,' in *International Conference on Social Robotics*, Springer, 2010, pp. 30–39.

[36] P. Jerčić, J. Hagelbäck and C. Lindley, 'An affective serious game for collaboration between humans and robots,' *Entertainment Computing*, vol. 32, p. 100 319, 2019.

[37] S. Zörner, E. Arts, B. Vasiljevic, A. Srivastava, F. Schmalzl, G. Mir, K. Bhatia, E. Strahl, A. Peters, T. Alpay *et al.*, 'An immersive investment game to study human-robot trust,' *Frontiers in Robotics and AI*, vol. 8, p. 139, 2021.

[38] R. Axelrod and W. D. Hamilton, 'The evolution of cooperation,' *science*, vol. 211, no. 4489, pp. 1390–1396, 1981.

[39] J. L. Wirt, *An analysis of Science Olympiad participants' perceptions regarding their experience with the science and engineering academic competition*. Seton Hall University, 2011.

[40] I. Dolgov, W. J. Graves, M. R. Nearents, J. D. Schwark and C. B. Volkman, 'Effects of cooperative gaming and avatar customization on subsequent spontaneous helping behavior,' *Computers in human behavior*, vol. 33, pp. 49–55, 2014.

[41] R. H. Timmerman, T.-Y. Hsieh, A. Henschel, R. Hortensius and E. S. Cross, 'Individuals expend more effort to compete against robots than humans after observing competitive human–robot interactions,' in *International Conference on Social Robotics*, Springer, 2021, pp. 685–696.

[42] T. Nomura, T. Kanda, T. Suzuki and K. Kato, 'Prediction of human behavior in human–robot interaction using psychological scales for anxiety and negative attitudes toward robots,' *IEEE transactions on robotics*, vol. 24, no. 2, pp. 442–451, 2008.

[43] *Pepper qisdk*. [Online]. Available: `https://developer.softbankrobotics.com/pepper-qisdk`.

[44] M. M. Bradley and P. J. Lang, 'Measuring emotion: The self-assessment manikin and the semantic differential,' *Journal of behavior therapy and experimental psychiatry*, vol. 25, no. 1, pp. 49–59, 1994.

[45] E. D. Mekler, F. Brühlmann, A. N. Tuch and K. Opwis, 'Towards understanding the effects of individual gamification elements on intrinsic motivation and performance,' *Computers in Human Behavior*, vol. 71, pp. 525–534, 2017.

Appendix A

Programming Code

This appendix contains the programming code for the whole setup and implementation section. The coding has been done in python language in Pycharm IDE.

```
import qi
import argparse
import sys
import math
import time

def main(session, exploration_file):
    life_service2 = session.service("ALPeoplePerception")
    life_service4 = session.service("ALSoundDetection")
    life_service3 = session.service("ALBasicAwareness")
    life_service2.setMaximumDetectionRange(0.02)
    life_service4.setParameter("Sensitivity", 0.09)
    life_service3.setTrackingMode("Head")
    intro(session)
    life_service2.setMaximumDetectionRange(3.5)
    life_service4.setParameter("Sensitivity", 0.9)
    life_service3.setTrackingMode("BodyRotation")


def intro(session):
    anim_service = session.service("ALAnimatedSpeech")
    sensor_service = session.service("ALMemory")

    anim_service.say("Hi There, ^start(animations/Stand/Gestures/Hey_1) Player!")
    time.sleep(0.5)
    anim_service.say("Welcome to the Experiment. ^start(animations/Stand/Gestures/
     You_1) Hope you enjoy it!")
    time.sleep(1)
    anim_service.say("Please select the assigned mode for the gameplay, Suraj.")
    firstplay = input(" 1 for competitive and 2 for collaborative: ")
    firstplayer = input(" 1 for robot and 2 for human: ")
    if not (firstplay >= 1 and firstplay <= 2) and (firstplayer>= 1 and firstplayer
      <= 2):
        anim_service.say("Unable to start play. Please restart.")
```

```

    resume = 0.0
    anim_service.say("Let's begin then!")
    time.sleep(2)
    if firstplay == 1:
        anim_service.say("^start(animations/Stand/Gestures/You_4) You have been selected for the competitive and then collaborative gameplay.")
        compgame(session, firstplayer)
        time.sleep(2)
        anim_service.say("Please take the time to fill in the mid-experiment questionnaire phase 1")
        time.sleep(60)
        anim_service.say("^start(animations/Stand/Gestures/Explain_3) Please tap my head when you're ready to go for next phase of the experiment!")
        while resume == 0.0:
            resume = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
        coopgame(session, firstplayer)
        time.sleep(2)
        anim_service.say("Please take the time to fill in the mid-experiment questionnaire phase 2")
    elif firstplay == 2:
        anim_service.say("^start(animations/Stand/Gestures/You_4) You have been selected for the collaborative and then competitive gameplay.")
        coopgame(session, firstplayer)
        time.sleep(2)
        anim_service.say("Please take the time to fill in the mid-experiment questionnaire phase 1")
        time.sleep(60)
        anim_service.say("^start(animations/Stand/Gestures/Explain_3) Please tap my head when you're ready to go for next phase of the experiment!")
        while resume == 0.0:
            resume = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
        compgame(session, firstplayer)
        time.sleep(2)
        anim_service.say("Please take the time to fill in the mid-experiment questionnaire phase 2")
    closer(session)

def coopgame(session, firstplayer):
    anim_service = session.service("ALAnimatedSpeech")

    time.sleep(1)
    anim_service.say("Now, we will be going for the cooperative gameplay. ^start(animations/Stand/Gestures/Explain_2) We have to make atleast 7 shots in total.")
    anim_service.say(" ^start(animations/Stand/Gestures/Explain_3) I will try my best to get my 5 shots.")
    if firstplayer == 1:
        anim_service.say("^start(animations/Stand/Gestures/Explain_1) Also, the order of throw, assigned this time is Robot first and Human second.")
        hitr, missr = robo(session)
        hith, missh = human(session)
```

```python
    elif firstplayer == 2:
        anim_service.say("^start(animations/Stand/Gestures/Explain_1) Also, the order of throw, assigned this time is Human first and Robot second.")
        hith, missh = human(session)
        hitr, missr = robo(session)
    anim_service.say("So, the total score is: " + str(hith + hitr))
    time.sleep(1)
    if hitr + hith >= 7:
        anim_service.say(" ^start(animations/Stand/Gestures/Excited_2) We crossed the threshold! Our team won!")
    else:
        anim_service.say("Alas, luck wasn’t on our side. ^start(animations/Stand/Gestures/Explain_3) But, we tried our best and played a good game.")

def compgame(session, firstplayer):
    anim_service = session.service("ALAnimatedSpeech")
    time.sleep(1)
    anim_service.say("^start(animations/Stand/Gestures/Explain_3) Now we will be going for the competitive gameplay.")
    anim_service.say("We both get 5 hits each. ^start(animations/Stand/Gestures/Explain_2) Lets see who scores more shots!")
    anim_service.say(" ^start(animations/Stand/Gestures/Explain_3) I will try my best to get my 5 shots.")
    if firstplayer == 1:
        anim_service.say("^start(animations/Stand/Gestures/Explain_1) Also, the order of throw, assigned this time is Robot first and Human second.")
        hitr, missr = robo(session)
        hith, missh = human(session)
    elif firstplayer == 2:
        anim_service.say("^start(animations/Stand/Gestures/Explain_1) Also, the order of throw, assigned this time is Human first and Robot second.")
        hith, missh = human(session)
        hitr, missr = robo(session)
    if hitr > hith:
        anim_service.say("And that means, the victory is mine! I mean, well done, my fellow player!")
    elif hitr < hith:
        anim_service.say("And that means, you won the game! Great job, my fellow player! Celebration time!")
    elif hitr == hith:
        anim_service.say("And that means, we are tied in score!")
        tiebreaker(session)

def robo(session):
    sensor_service = session.service("ALMemory")
    anim_service = session.service("ALAnimatedSpeech")

    start = 0.0
    time.sleep(1)
    anim_service.say("^start(animations/Stand/Gestures/CalmDown_1) Suraj, can you please confirm if I am at the starting position?")
    while start != 1.0:
        start = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
```

```
    anim_service.say("^start(animations/Stand/Gestures/Excited_1) Great. Thanks!")
    time.sleep(1)
    anim_service.say("^start(animations/Stand/Gestures/YouKnowWhat_1) My visual perception is low. ^wait(animations/Stand/Gestures/YouKnowWhat_1)")
    anim_service.say("^start(animations/Stand/Gestures/YouKnowWhat_1)To understand the flow of game, can I be helped a bit?")
    anim_service.say("^start(animations/Stand/Gestures/Explain_4) After each phase, please select the score on my tablet.")
    time.sleep(2)
    anim_service.say("^start(animations/Stand/Gestures/Enthusiastic_5) Okay, here I go!")
    time.sleep(1)
    hit, miss = movement(session)
    anim_service.say("^start(animations/Stand/Gestures/Explain_4) So my round of throws are over! ^wait(animations/Stand/Gestures/Explain_4)")
    time.sleep(1)
    anim_service.say("Calculating.")
    time.sleep(2)
    anim_service.say("^start(animations/Stand/Gestures/Explain_3) And the results are in:")
    anim_service.say("I have " + str(hit) + "baskets and " + str(miss) + "misses!")

    return hit, miss

def human(session):
    anim_service = session.service("ALAnimatedSpeech")
    sensor_service = session.service("ALMemory")

    resume = 0.0
    time.sleep(2)
    anim_service.say("Its your turn, player.")
    anim_service.say("Please don’t forget to update your score after the game on my tablet.")
    anim_service.say("Thank you and good luck, human.")
    time.sleep(20)
    while resume == 0.0:
        resume = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
    time.sleep(2)
    hit, miss = scoreRecord(session)
    anim_service.say("^start(animations/Stand/Gestures/Explain_4) So your round of throws are over! ^wait(animations/Stand/Gestures/Explain_4)")
    time.sleep(2)
    anim_service.say("^start(animations/Stand/Gestures/Explain_3) Your result is:")
    anim_service.say("You have " + str(hit) + "baskets and " + str(miss) + "misses!")

    return hit, miss

def tiebreaker(session):
    anim_service = session.service("ALAnimatedSpeech")
    sensor_service = session.service("ALMemory")
    motion_service = session.service("ALMotion")

```

```
    nominee = 1

    anim_service.say("Since we are tied, the rule is that you, a k a the player, get to nominate")
    anim_service.say("either me, the amazing pepper or yourself to take one more shot from the starting location.")
    anim_service.say("If the nominee successfully gets the shot right, they are the winner! Otherwise the opponent wins!")
    anim_service.say("The choice lies with you!")
    anim_service.say("Tap my left hand to indicate me going for the shot, and my right hand to indicate you taking the shot!")
    while True:
        if sensor_service.getData("Device/SubDeviceList/LHand/Touch/Back/Sensor/Value"):
            nominee = nominee + 1
            start = 0.0
            anim_service.say("Okay then, here’s the luck of Pepper!")
            time.sleep(1)
            anim_service.say("^start(animations/Stand/Gestures/CalmDown_1) Suraj, can you please confirm if I am at any of my positions?")
            while start != 1.0:
                start = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
            anim_service.say("^start(animations/Stand/Gestures/Excited_1) Great. Thanks!")
            position_correction(sensor_service, motion_service)
            throwing(motion_service)
        if sensor_service.getData("Device/SubDeviceList/RHand/Touch/Back/Sensor/Value"):
            nominee = nominee - 1
            start = 0.0
            anim_service.say("The stage is all yours! Good luck!")
            time.sleep(10)
            anim_service.say("^start(animations/Stand/Gestures/CalmDown_1) Suraj, can you please tap my head when your turn is done?")
            while start != 1.0:
                start = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
            anim_service.say("^start(animations/Stand/Gestures/Excited_1) Okay then!")
        if nominee != 1:
            break
    time.sleep(2)
    anim_service.say("So, did i win? Please go for right hand if i won, or left hand for my loss.")
    while True:
        touch = 0
        if sensor_service.getData("Device/SubDeviceList/LHand/Touch/Back/Sensor/Value"):
            anim_service.say("Oh well, it was a good game. You deserve the victory!")
            touch = touch + 1
        if sensor_service.getData("Device/SubDeviceList/RHand/Touch/Back/Sensor/Value"):
```

```
            anim_service.say("It was a great game. We tried our best and the better being won! Haha. But truly, well played!")
            touch = touch + 1
        if touch > 0:
            break

def closer(session):
    anim_service = session.service("ALAnimatedSpeech")

    time.sleep(1)
    anim_service.say("^start(animations/Stand/Gestures/BowShort_1) Thank you for participating in the experiment. ^wait(animations/Stand/Gestures/BowShort_1)")
    anim_service.say("Please proceed to the questionnaire and interview area for next steps")

def movement(session):
    anim_service = session.service("ALAnimatedSpeech")
    sensor_service = session.service("ALMemory")
    motion_service = session.service("ALMotion")

    # Throwing and movement

    # Starting position set:
    anim_service.say("^start(animations/Stand/Gestures/Explain_4) I hope I am at the neutral position.")
    time.sleep(1)
    anim_service.say(" Okay, here i go for the throws.")
    time.sleep(1.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    # Over to first throwing position:
    anim_service.say("Let me correct my position before going for the first throw!")
    position_correction(sensor_service, motion_service)
    time.sleep(1.2)
    leftturn(motion_service)
    time.sleep(0.2)

    # 1st throw:
    anim_service.say("Lets get the first throw underway!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    throwing(motion_service)
    time.sleep(1.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    # Over to first frame of reference:
    anim_service.say("Over to my first stability point in the zone.")
    time.sleep(0.2)
    leftturn(motion_service)
    time.sleep(0.2)
    position_correction(sensor_service, motion_service)
```

```
    time.sleep(0.2)

    # Over to second throwing position:
    anim_service.say("Let me correct my position before going for second throw!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    leftturn(motion_service)
    time.sleep(0.2)

    # 2nd throw:
    anim_service.say("Time for the second shot!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    throwing(motion_service)
    time.sleep(1.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    # Over to third throwing position:
    anim_service.say("Let me correct my position before going for third throw!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    leftturn(motion_service)
    time.sleep(0.2)

    # 3rd throw:
    anim_service.say("Halfway there. 3rd shot!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    throwing(motion_service)
    time.sleep(1.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    # Over to fourth throwing position:
    anim_service.say("Let me correct my position before going for fourth throw!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    leftturn(motion_service)
    time.sleep(0.2)

    # 4th throw:
    anim_service.say("Now we are in the end-game. 4th shot!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    throwing(motion_service)
    time.sleep(1.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    # Over to second frame of reference:
    anim_service.say("Over to my second stability point in the zone.")
    time.sleep(0.2)
    leftturn(motion_service)
```

```
    time.sleep(0.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    # Over to fifth throwing position:
    anim_service.say("Let me correct my position before going for final throw!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    leftturn(motion_service)
    time.sleep(0.2)

    # 5th throw:
    anim_service.say("And finally, 5th shot!")
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)
    throwing(motion_service)
    time.sleep(1.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    # Over to starting position:
    anim_service.say("Over to the neutral position!")
    leftturn(motion_service)
    time.sleep(0.2)
    position_correction(sensor_service, motion_service)
    time.sleep(0.2)

    hit, miss = scoreRecord(session)

    return hit, miss

def scoreRecord(session):
    anim_service = session.service("ALAnimatedSpeech")
    tablet_service = session.service("ALTabletService")
    sensor_service = session.service("ALMemory")

    anim_service.say("Please tell me what the score is.")
    anim_service.say("To register score,")
    anim_service.say("Tap my head, if the number on the tablet is the score.")
    anim_service.say("Tap my left hand, to go to the next number!")

    next = 1
    tablet_service.hideImage()
    time.sleep(1)
    while True:
        scoreSelect(session, next - 1)
        headsense = sensor_service.getData("Device/SubDeviceList/Head/Touch/Front/Sensor/Value")
        handsense = sensor_service.getData("Device/SubDeviceList/LHand/Touch/Back/Sensor/Value")
        if handsense == 1.0:
            next = next + 1
            time.sleep(1)
        elif headsense == 1.0:
```

```
            hit = next - 1
            break
        if next == 7:
            next = next - 6

    tablet_service.hideImage()
    miss = 5 - hit

    return hit, miss

def scoreSelect(session, count):
    tablet_service = session.service("ALTabletService")

    if count == 0:
        tablet_service.showImage("http://clipart-library.com/img1/146629.png")
    elif count == 1:
        tablet_service.showImage("http://clipart-library.com/images/8TEb8o57c.png")
    elif count == 2:
        tablet_service.showImage("http://clipart-library.com/data_images/425459.jpg")
    elif count == 3:
        tablet_service.showImage("http://clipart-library.com/images/8cGbedjKi.jpg")
    elif count == 4:
        tablet_service.showImage("http://clipart-library.com/images/8TzrxdAGc.jpg")
    elif count == 5:
        tablet_service.showImage("http://clipart-library.com/img1/188853.png")

def position_correction(sensor_service, motion_service):
    moveM = 0
    correct = False
    sign = 1
    sensValue = 1.25
    floorValue = 1

    # rotational position adjustment using SONAR + Laser

    while not correct:
        sensa = sensor_service.getData("Device/SubDeviceList/Platform/Front/Sonar/Sensor/Value")
        if moveM == 101:
            # increasing length to adjust robots detection range for next set
            print "increasing sensing length"
            sensValue = sensValue + 0.25
            floorValue = math.floor(sensValue)
        if moveM == 240:
            print "unable to confirm right location"
            break
        else:
            for sensing in range(7,10):  # sensing on the 7th, 8th and 9th segments of Laser
                sega = sensor_service.getData("Device/SubDeviceList/Platform/LaserSensor/Front/Horizontal/Seg0" +
                    str(sensing) + "/X/Sensor/Value")
                segb = sensor_service.getData("Device/SubDeviceList/Platform/
```

```
LaserSensor/Front/Horizontal/Seg" + (
                    str(sensing + 1) if (sensing + 1 > 9) else "0" + str(sensing + 1)) + "/X/Sensor/Value")

                # bucket sensing using a low occurring parabolic pattern
                if sensa < sensValue and math.floor(sega) <= floorValue and math.floor(segb) <= floorValue:
                    correct = True
                    break
            if not correct:
                # performing the movement to check next set of segments
                turningmovement(motion_service, 1)
            moveM = moveM + 1

    # lengthwise position adjustment using SONAR sensor

    setspace = 1.1  # length to be adjusted
    diff = 5.0  # maximum length to detect
    while abs(diff) >= 0.05:
        senseval = sensor_service.getData("Device/SubDeviceList/Platform/Front/Sonar/Sensor/Value")
        diff = setspace - senseval - 0.001  # slowly reducing the distance to match adjustment length
        print("difference is " + str(diff))
        motion_service.moveTo(-diff, 0, 0)  # performing the movement with length adjusted above
    print(sensor_service.getData("Device/SubDeviceList/Platform/Front/Sonar/Sensor/Value"))

def leftturn(motion_service):
    time.sleep(1.2)
    theta = math.pi / 18
    motion_service.moveTo(0, 0, 6 * theta)
    walkstraight(motion_service)

def walkstraight(motion_service):
    time.sleep(1.2)
    motion_service.moveTo(1.0, 0, 0)
    rightturn(motion_service)

def rightturn(motion_service):
    time.sleep(1.2)
    theta = math.pi / 18
    motion_service.moveTo(0, 0, -6 * theta)

def throwing(motion_service):
    names = list()
    times = list()
    keys = list()

    names.append("RShoulderPitch")
    times.append([6, 8, 8.27, 8.9])
    keys.append([1.8, -1.8, 0.1, 1.5])

```

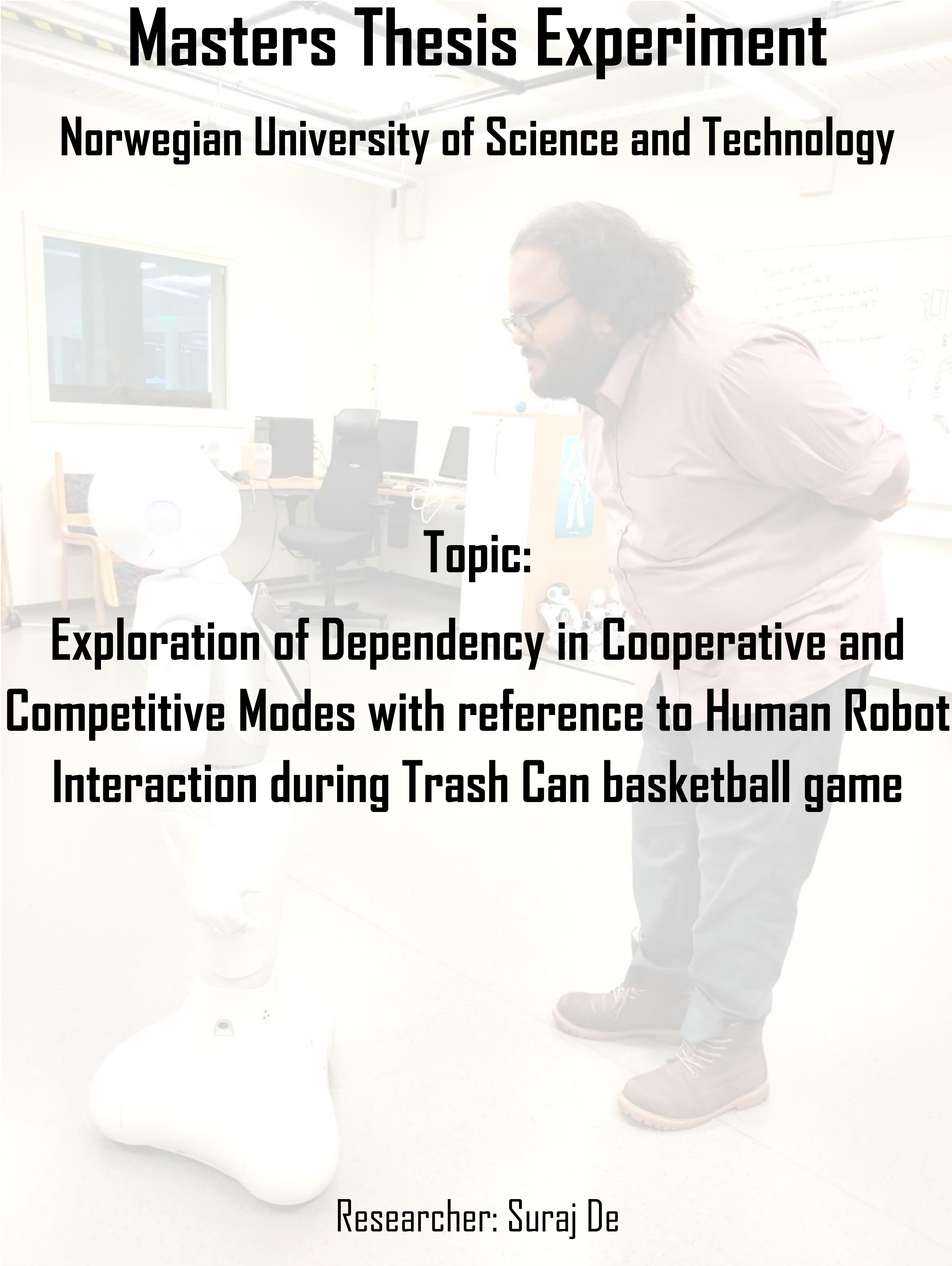
```
    names.append("RWristYaw")
    times.append([5, 6, 8.1])
    keys.append([-1.8, -1.8, -1.1])

    names.append("RHand")
    times.append([3, 8, 8.29])
    keys.append([1.8, -1.8, 1.8])

    motion_service.angleInterpolation(names, keys, times, True)

def turningmovement(motion_service, multiplier):
    theta = math.pi/18
    motion_service.moveTo(0, 0, -theta * multiplier)

if __name__ == "__main__":
    parser = argparse.ArgumentParser()
    parser.add_argument("--ip", type=str, default="192.168.137.186",
                        help="Robot IP address. On robot or Local Naoqi: use
     '127.0.0.1'.")
    parser.add_argument("--port", type=int, default=9559,
                        help="Naoqi port number")
    parser.add_argument("--explo", type=str, help="Path to .explo file.")

    args = parser.parse_args()
    session = qi.Session()
    try:
        session.connect("tcp://" + args.ip + ":" + str(args.port))
    except RuntimeError:
        print ("Can't connect to Naoqi at ip \"" + args.ip + "\" on port " + str(
     args.port) +".\n"
               "Please check your script arguments. Run with -h option for help.")
        sys.exit(1)
    main(session, args.explo)
```

Code listing A.1: Programming Code

Appendix B

Questionnaire booklet

This appendix presents the booklet used to collect data from the participants. The booklet contains sections for the pre-experimentation questionnaire, mid-experimentation questionnaires, post-experimentation questionnaire using the Self-Assessment Manikin (SAM) scale to collect the emotion index for any participant.



Masters Thesis Experiment

Norwegian University of Science and Technology

Topic:

Exploration of Dependency in Cooperative and Competitive Modes with reference to Human Robot Interaction during Trash Can basketball game

Researcher: Suraj De

Supervisor: Deepti Mishra & Yavuz Inal

Session: Jan-May, 2022

Outline:

1. Experiment Introduction . . . .**5 minutes**
2. Interaction time with Pepper Robot . . . .**1 minute**
3. Filling up Short Questionnaire . . . .**4 minutes**
4. First phase of experiment . . . . **5 minutes**
5. Emotion record . . . .**2.5 minutes**
6. Second phase of experiment . . . . **5 minutes**
7. Emotion record . . . .**2.5 minutes**
8. Main Final Questionnaire . . . . **10 minutes**
9. A short interview . . . . **20 minutes**

Total duration of experiment: 55 minutes [approx.]

General Rules of the Gameplay:

For each round, the player (Robot/Human) gets 5 shots to throw paper-ball in the basket from the assigned position in a hexagonal pattern. The aim is to put the maximum number of balls in the bin. There are no general time limitations. However, the overall time of the phase would be tried.

For cooperative matchup:

The maximum baskets that can be achieved is **10 [5 for human, 5 for robot]**.

Passing number of successful baskets is **7**.

Baskets made by Human + Baskets made by Robot = Total hits.

Aim: Reach or cross the Passing number of baskets.

For competitive matchup:

The maximum baskets that can be achieved by each player is **5**

[Either Robot or Human]

Aim: Overtake the opponent by shooting more baskets.

In case of a tie [*Baskets made by Human = Baskets made by Robot*],

Tiebreaker will be played.

Tiebreaker: The human player gets a chance to nominate themselves or the robot for shooting one hoop.

Successful shooting: +1 basket for shooter

Failed shooting: +1 basket for opponent

Note: Each gameplay is preceded and succeeded by small questionnaires to assess the emotional aspect of the player.

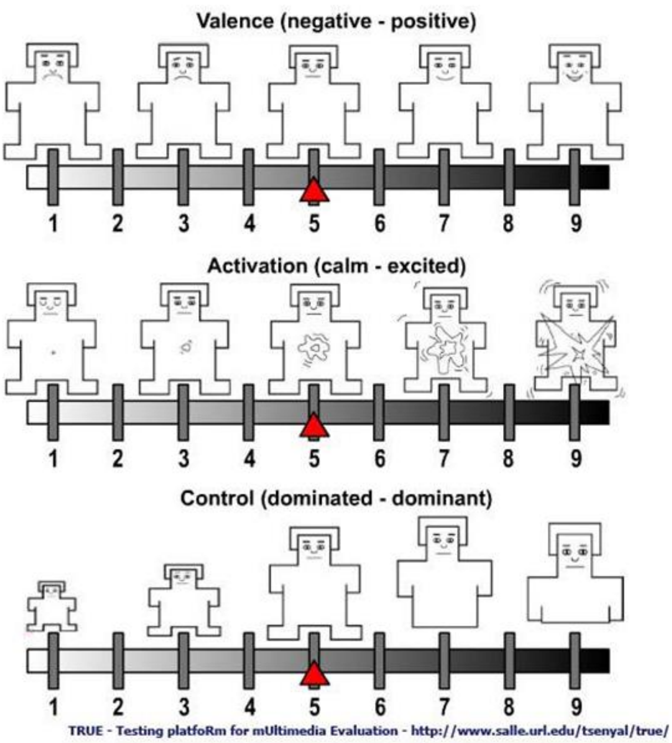
Pre-experimentation Questionnaire

Player Number: ☐ **Date:** ☐ **Time:** ☐

Please answer the questions to the best of your knowledge:

Sl. No.	General Questions	Yes	No
1.	I usually spend my free time playing sports		
2.	I have played more physical sports than digital games		
3.	I prefer competition over cooperation during sports/games		
4.	I prefer cooperation over competition during sports/games		
5.	I have heard about trash can basketball before		
6.	I have played trash can basketball before		
7.	I have interacted with a humanoid robot before		
8.	I have played games with a robot before		
9.	I have played games with robot as a team before		
10.	I have played against robot as a challenger before		
11.	I have understood how the experiment will run		
12.	I have understood that no personal data will be collected		
13.	I have understood the rules of the game		
14.	The one-on-one session with robot was engaging		
15.	The pace of explanation of the experiment was fair		

Emotional State Assessment (Rate your current emotional state)**:**

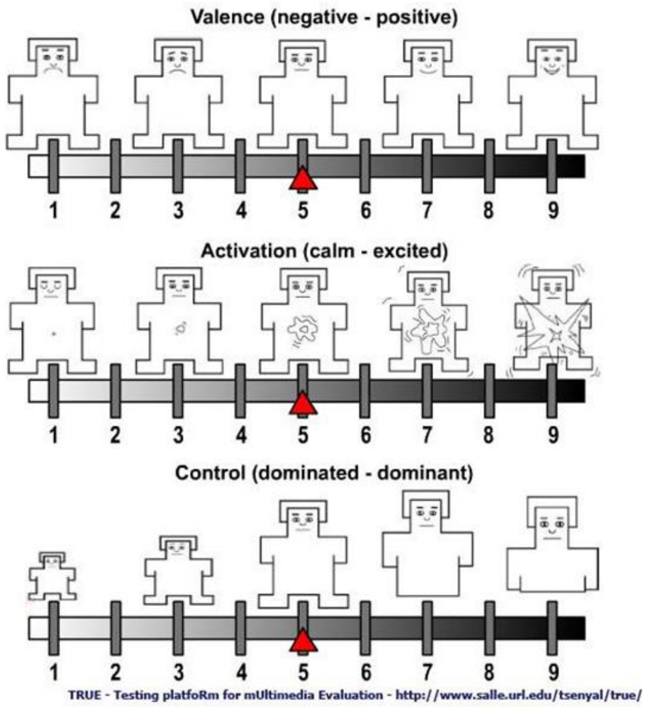


Mid-experimentation Questionnaire

Player: ☐ **First → Cooperative:** ☐ **Competitive:** ☐ **First → H:** ☐ **R:** ☐

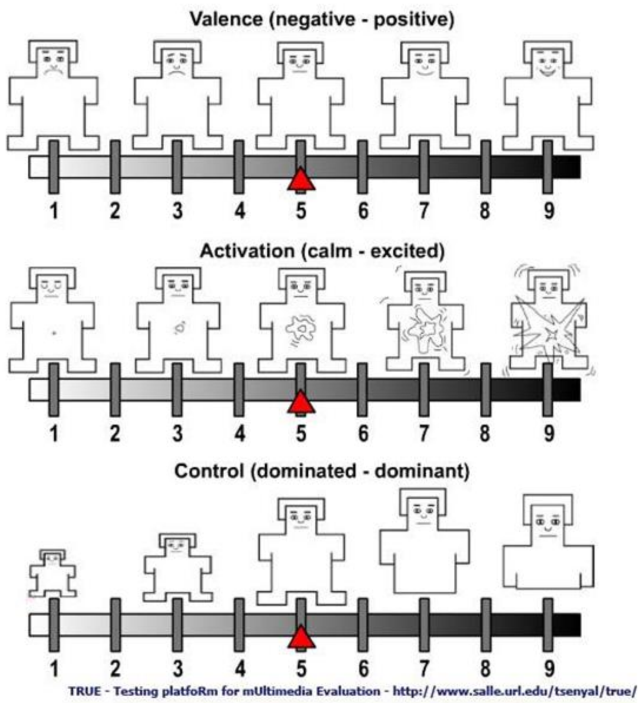
After Phase I:

Emotional State Assessment (Rate your current emotional state)**:**



After Phase II:

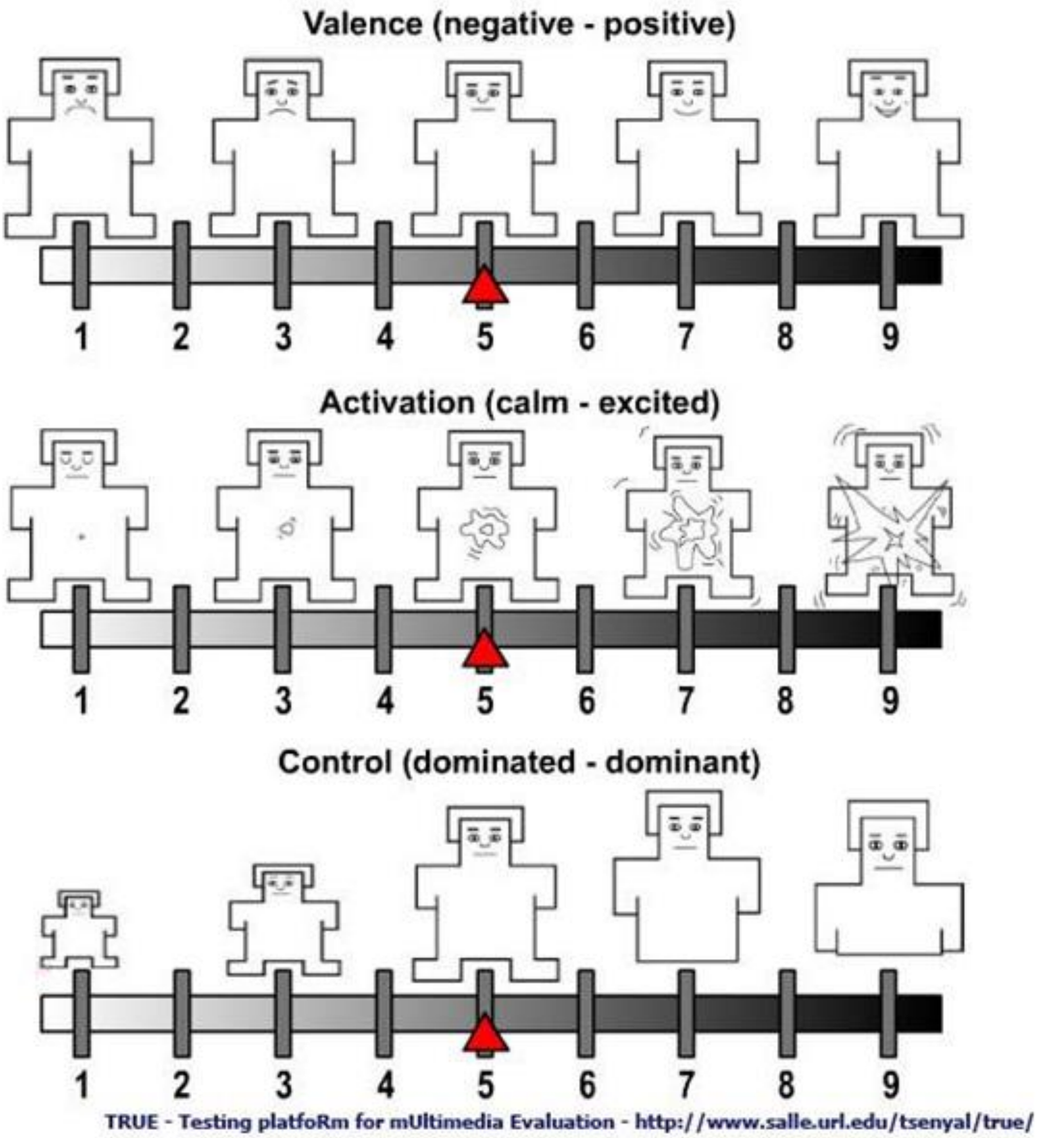
Emotional State Assessment (Rate your current emotional state)**:**

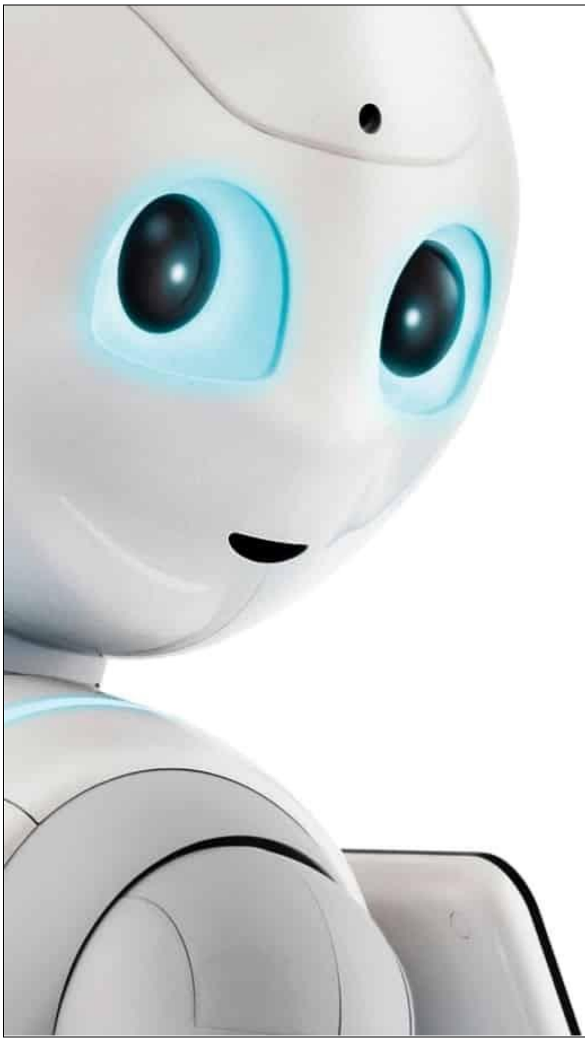


Post-experimentation Questionnaire

Player Number:

Emotional State Assessment (Rate your current emotional state)**:**





Thank you for participating in

the experiment.

Hope you had fun!

-Suraj De

Appendix C

Individual Records

This appendix contains the individual records collected from the participants. Records for each participant has been traced to a graph.

General Records:

	1	2	3	5	6	7	8	9	10	11	12	13
Male	0	1	0	1	1	0	1	1	1	1	1	0
Female	1	0	1	0	0	1	0	0	0	0	0	1
Competitive	0	1	0	1	1	1	1	0	0	0	0	1
Cooperative	1	0	1	0	0	0	0	1	1	1	1	0
Human	1	0	0	1	0	0	1	1	1	0	0	1
Robot	0	1	1	0	1	1	0	0	0	1	1	0
Record Table	C.3	C.4	C.5	C.6	C.7	C.8	C.9	C.10	C.11	C.12	C.13	C.14
Data Graphs	C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8	C.9	C.10	C.11	C.12

Table C.1: General Records Table

C.1 Pre-questionnaire Records

Questionnaires:

1. I usually spend my free time playing sports
2. I have played more physical sports than digital games
3. I prefer competition over cooperation during sports/games
4. I prefer cooperation over competition during sports/games
5. I have heard about trash can basketball before
6. I have played trash can basketball before
7. I have interacted with a humanoid robot before
8. I have played games with a robot before
9. I have played games with robot as a team before
10. I have played against robot as a challenger before

11. I have understood how the experiment will run
12. I have understood that no personal data will be collected
13. I have understood the rules of the game
14. The one-on-one session with robot was engaging
15. The pace of explanation of the experiment was fair

	1	2	3	5	6	7	8	9	10	11	12	13
1	0	0	0	0	0	0	0	0	0	0	1	0
2	1	0	1	1	1	1	0	0	0	0	1	1
3	0	1	0	0	0	0	0	0	0	1	0	0
4	1	0	1	1	1	1	1	1	1	0	1	1
5	1	1	1	0	1	1	0	1	1	1	1	1
6	0	1	1	0	1	0	0	0	1	0	1	1
7	1	1	1	0	0	1	1	0	0	0	1	1
8	1	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1
14	1	0	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1

Table C.2: Introduction Questionnaire Table

C.2 Record tables and Data Graphs for each player

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	6	7	8	7
Activation	3	6	8	7
Control	7	6	7	7
Average	**5.33**	**6.33**	**7.67**	**7.00**

Table C.3: Player 1 Records Table

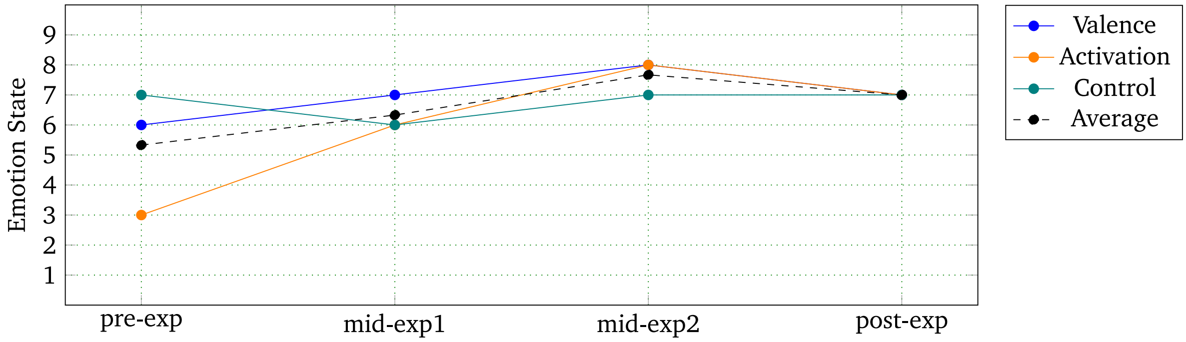


Figure C.1: Player 1 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	8	9	9	7
Activation	9	9	9	9
Control	9	9	9	9
Average	**8.67**	**9**	**9**	**8.33**

Table C.4: Player 2 Records Table

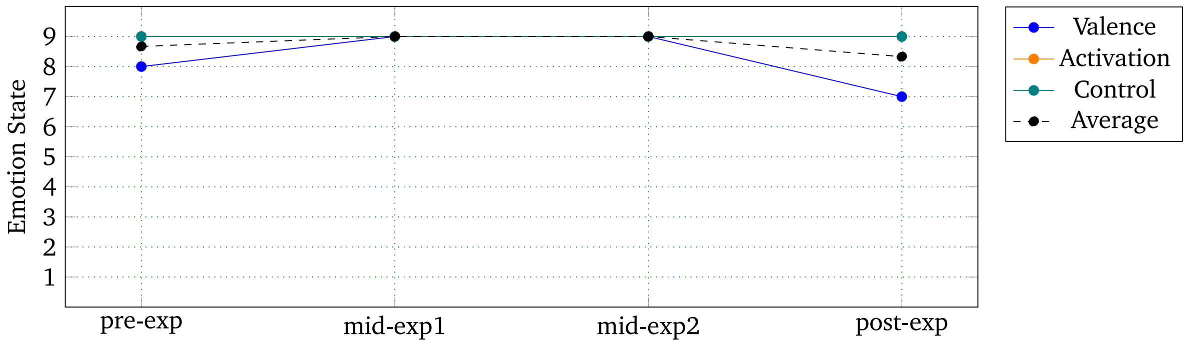


Figure C.2: Player 2 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	8	8	8	8
Activation	8	7	8	7
Control	6	6	6	6
Average	**7.33**	**7.00**	**7.33**	**7.00**

Table C.5: Player 3 Records Table

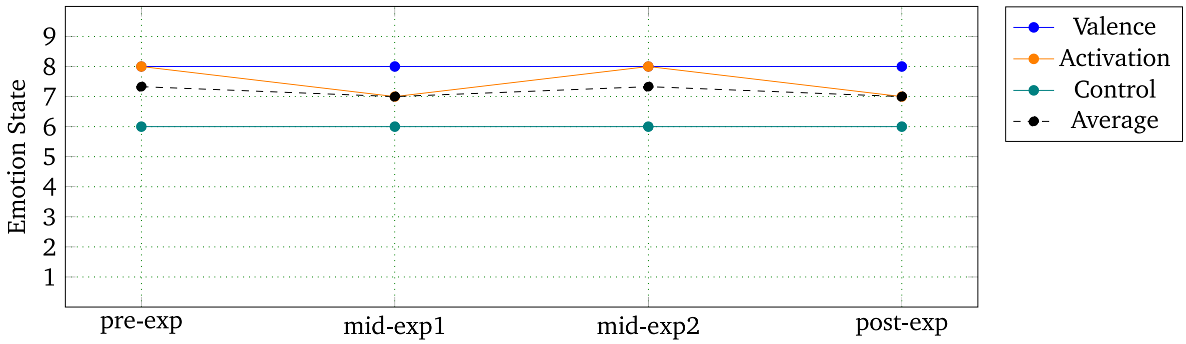


Figure C.3: Player 3 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	9	9	7	7
Activation	5	5	5	5
Control	7	4	8	8
Average	**7.00**	**6.00**	**6.67**	**6.67**

Table C.6: Player 5 Records Table

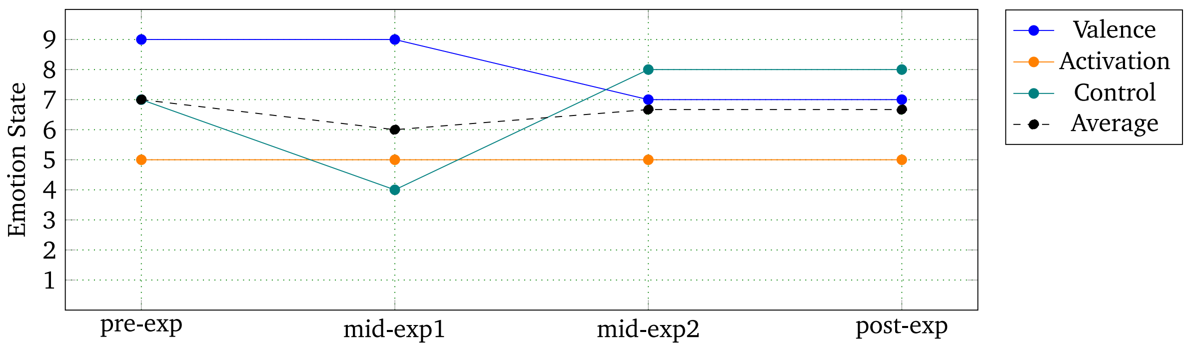


Figure C.4: Player 5 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	8	8	9	8
Activation	7	7	8	7
Control	9	8	7	9
Average	**8.00**	**7.67**	**8.00**	**8.00**

Table C.7: Player 6 Records Table

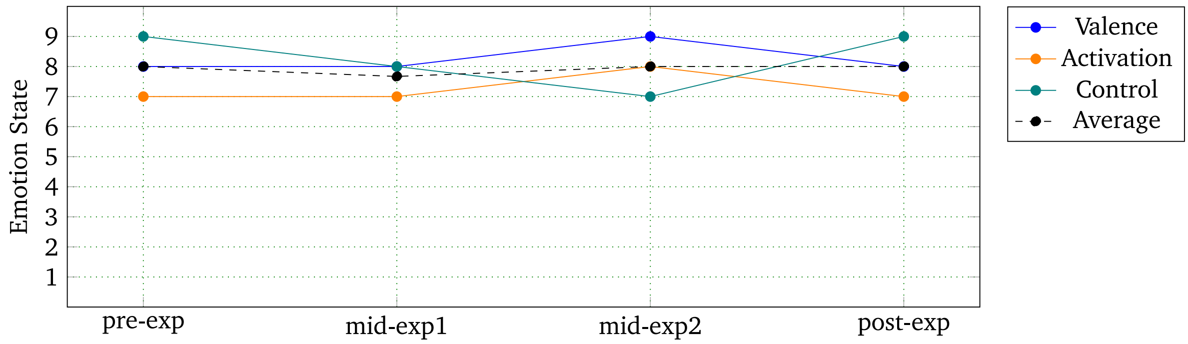


Figure C.5: Player 6 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	6	7	8	8
Activation	4	7	8	7
Control	6	6	6	6
Average	**5.33**	**6.67**	**7.33**	**7.00**

Table C.8: Player 7 Records Table

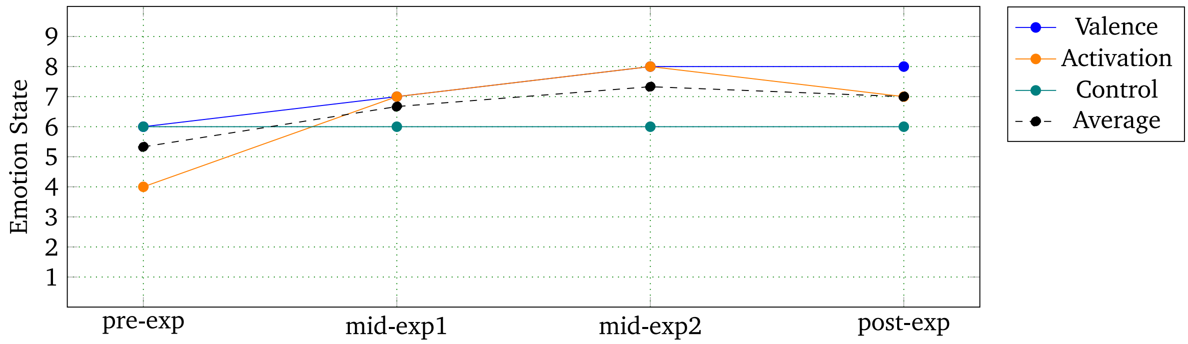


Figure C.6: Player 7 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	7	8	8	8
Activation	1	3	4	4
Control	9	7	9	9
Average	**5.67**	**6.00**	**7.00**	**7.00**

Table C.9: Player 8 Records Table

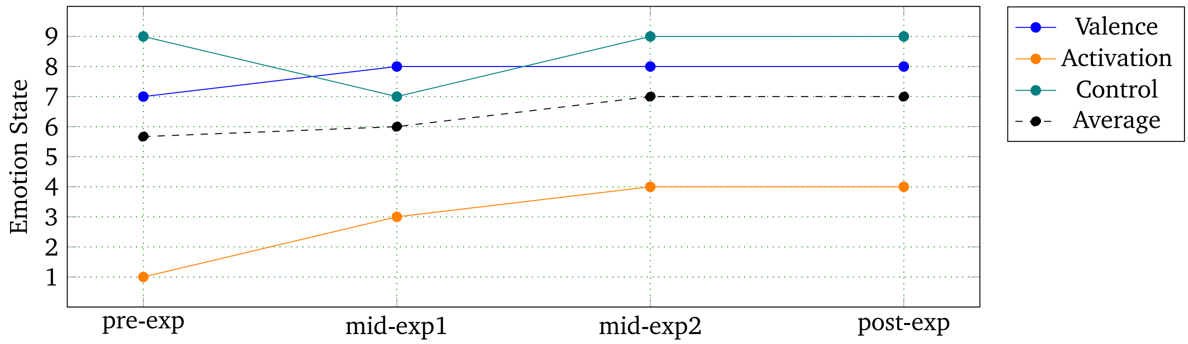


Figure C.7: Player 8 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	6	7	7	7
Activation	5	5	5	4
Control	5	7	5	5
Average	**5.33**	**6.33**	**5.67**	**5.33**

Table C.10: Player 9 Records Table

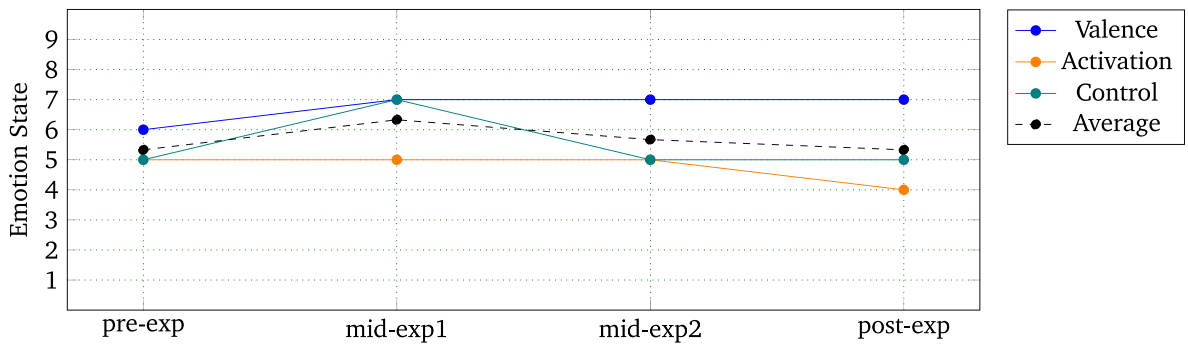


Figure C.8: Player 9 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	7	5	7	5
Activation	7	5	5	5
Control	5	5	5	5
Average	**6.33**	**5.00**	**5.67**	**5.00**

Table C.11: Player 10 Records Table

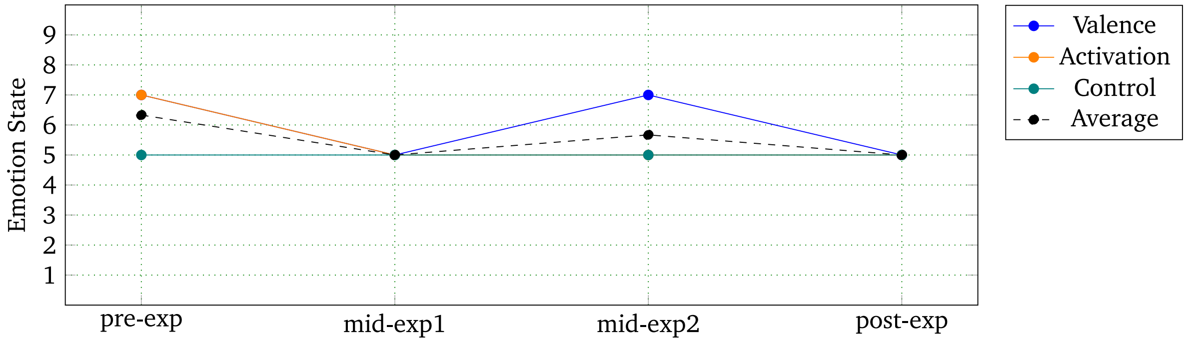


Figure C.9: Player 10 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	7	6	4	8
Activation	8	8	3	2
Control	9	7	5	6
Average	**8.00**	**7.00**	**4.00**	**5.33**

Table C.12: Player 11 Records Table

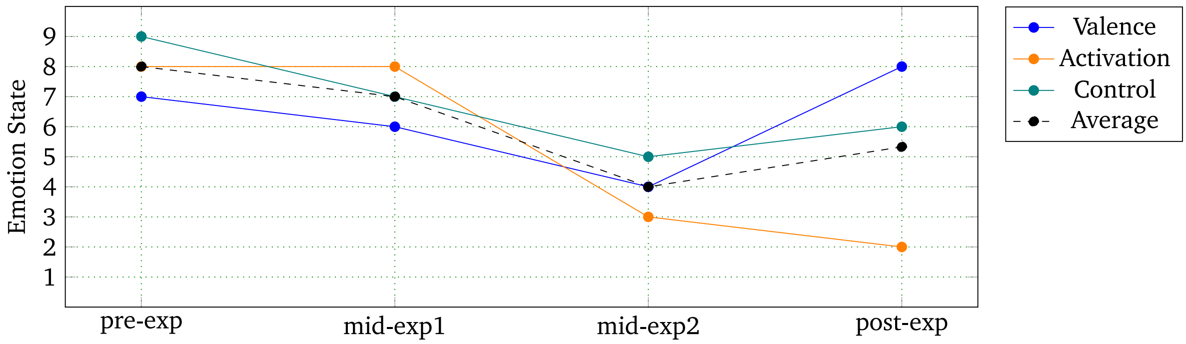


Figure C.10: Player 11 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	8	9	9	8
Activation	8	9	9	9
Control	8	9	9	9
Average	**8.00**	**9.00**	**9.00**	**8.67**

Table C.13: Player 12 Records Table

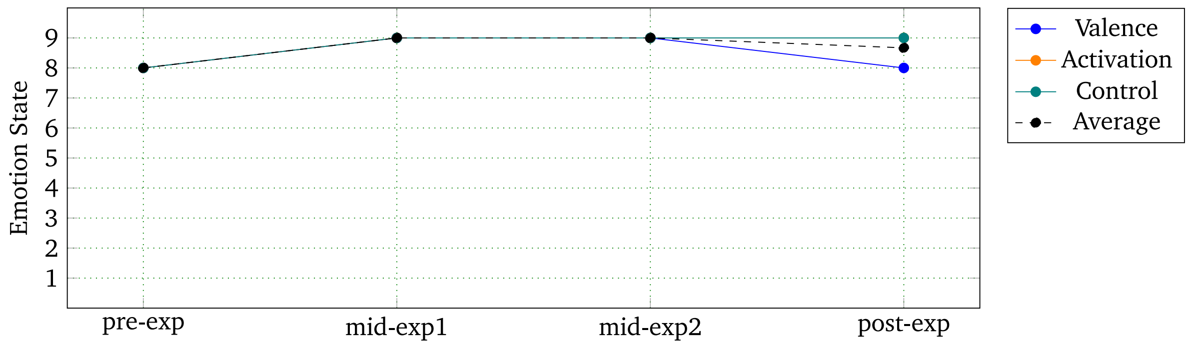


Figure C.11: Player 12 Data

	Pre-exp	Mid-exp1	Mid-exp2	Post-exp
Valence	9	8	5	5
Activation	9	6	5	3
Control	9	9	9	9
Average	**9.00**	**7.67**	**6.33**	**5.67**

Table C.14: Player 13 Records Table

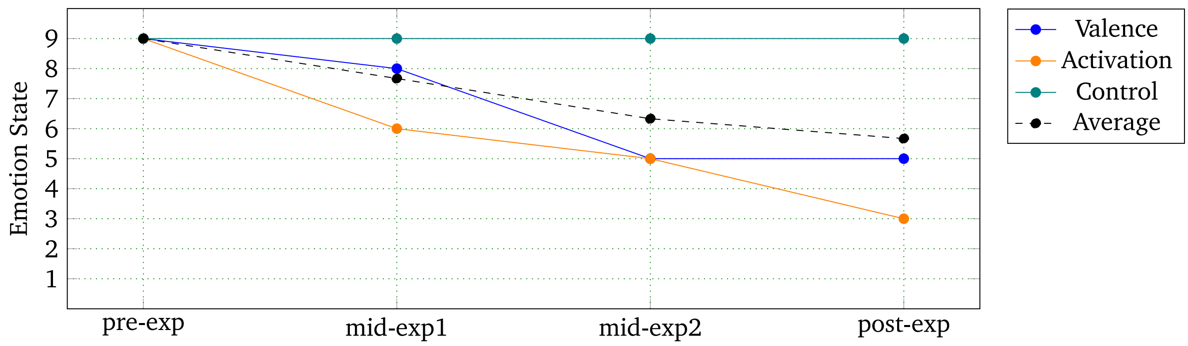


Figure C.12: Player 13 Data

Appendix D

Transcript of the Interview Sessions

The following appendix contains the transcript of the interview session of all the participants, whose data has been used for the study. Their general comments and the scores they acquired playing the game has also been added in the interview session.

Participant -1

General comments:

“The ball could be thrown a bit to the left.” “Pepper can’t pick up the ball?” Player was excited about ball handling. During the experiment, player and host got detected by pepper leading to minute distraction.

1. ***How frequently do you play Computer Games?***

Answer: The participant answered that they don’t play Computer Games that much.

2. ***What 3 games do you play the most on your computer/mobile phone?***

Answer: Wordle, Ludo and simple quiz games.

3. ***What kind of non-digital games do you play?***

Answer: Games like table tennis, sort of physical and board games combined.

4. ***What did you find enjoyable about playing with/against the robot?***

Answer: They found the experiment entertaining and said that checking the progress of gameplay was good. Regarding the individual aspects of collaboration and competition, they said that there was nothing specific about collaboration, but competition was quite good in nature, mentioning the tiebreaker rule of nomination.

5. ***What did you find difficult about playing with/against the robot?***

Answer: They said that in collaborative experiment, one player after another would have made more sense in terms of cooperation. They mentioned that they wanted to win it against the robot very much.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

Answer: They would have chosen the player themselves as they felt after the gameplay, they had more confidence in themselves. Also, the enthusiasm to win wanted them to go for competition as well.

7. ***Would you play with the robot again? Why or why not?***

Answer: They said that wouldn’t because even though the game was not too bad, the waiting made for the positioning made it hard for them to enjoy. More cooperation would be better by turn-wise gameplay was another key reason by them.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

Answer: They said competitive would be preferred for future because their feelings pushed them for competition mode.

9. ***How would the game be improved to make it more enjoyable?***

Answer: They mentioned the following points –

i. They said that if pepper could pick up a ball, they would love it.
ii. They mentioned that they really liked how pepper held the ball for throwing.
iii. The positioning needs to be improved and the time to be reduced.
iv. The knowledge of chocolate as reward could have increased the competitive nature in them.

<table>
<tr><td colspan="3">Cooperative</td><td rowspan="8">Cooperative 1st
and
Human 1st</td><td colspan="3">Competitive</td></tr>
<tr><td>Turn</td><td>H</td><td>R</td><td>Turn</td><td>H</td><td>R</td></tr>
<tr><td>1</td><td>X</td><td>X</td><td>1</td><td>X</td><td>X</td></tr>
<tr><td>2</td><td>✓</td><td>X</td><td>2</td><td>✓</td><td>✓</td></tr>
<tr><td>3</td><td>X</td><td>✓</td><td>3</td><td>✓</td><td>✓</td></tr>
<tr><td>4</td><td>X</td><td>X</td><td>4</td><td>✓</td><td>X</td></tr>
<tr><td>5</td><td>✓</td><td>✓</td><td>5</td><td>✓</td><td>X</td></tr>
<tr><td>Total</td><td>2</td><td>2</td><td>Total</td><td>4 (Winner)</td><td>2</td></tr>
</table>

Participant - 2

General comments:

"Way too simplistic", "Tried best to shoot the ball, so quite focused on the game", "interesting that there was competitive and cooperative mode". Prior experience with the humanoid robot made the player exhibit displeased behaviour the robot, leading to comment that they want to "beat the robot". They also commented on the questionnaire being too small to read and wanted larger text of questions.

1. ***How frequently do you play Computer Games?***

   Answer: The participant answered that they always play Computer Games very much.

2. ***What 3 games do you play the most on your computer/mobile phone?***

   Answer: The participant answered that the recent games they played were Final Fantasy XIV, Doom Eternal and Hades.

3. ***What kind of non-digital games do you play?***

   Answer: In terms of non-digital games, they said their choice of games would be on the physical side of sports like ping pong and volleyball, but they said they play board games as well. They also said that the choice would be more towards strategy games than physical sports or games.

4. ***What did you find enjoyable about playing with/against the robot?***

   Answer: They said that the rules, especially the tiebreaker section was to their liking. They believed that the game brought out highly competitive nature in them. They specified that they were happy to see the robot fail.

5. ***What did you find difficult about playing with/against the robot?***

   Answer: They said the game was too simple. It was too boring and slow. They said that even though the game was exciting initially, it quickly turned boring. They also specified that even during the collaborative session, they found themselves competing with the robot.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

   Answer: They said that they would choose themselves to take the tiebreaker shot because they have confidence in themselves.

7. ***Would you play with the robot again? Why or why not?***

   Answer: They said they wouldn't play the robot again because of the slow nature of game.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

   Answer: They said that even though generally they would have selected cooperative, at this stage, they would choose competitive because there was no excitement in the collaborative mode.

9. ***How would the game be improved to make it more enjoyable?***

   Answer: They said that positive reinforcement would be beneficial to the competitive mode. They also said that the game could be more interesting that just throwing balls. It would be better to play board games than this.

<table>
<tr><td colspan="3">Cooperative</td><td rowspan="8">Competitive 1st
and
Robot 1st</td><td colspan="3">Competitive</td></tr>
<tr><td>Turn</td><td>H</td><td>R</td><td>Turn</td><td>H</td><td>R</td></tr>
<tr><td>1</td><td>X</td><td>✓</td><td>1</td><td>X</td><td>✓</td></tr>
<tr><td>2</td><td>X</td><td>X</td><td>2</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>✓</td><td>X</td><td>3</td><td>✓</td><td>X</td></tr>
<tr><td>4</td><td>✓</td><td>✓</td><td>4</td><td>X</td><td>✓</td></tr>
<tr><td>5</td><td>✓</td><td>X</td><td>5</td><td>X</td><td>X</td></tr>
<tr><td>Total</td><td>3</td><td>2</td><td>Total</td><td>1</td><td>2 (Winner)</td></tr>
</table>

Participant - 3

General comments:

The player said the game was quite interesting and said they liked it. Between the games they said that they were a bit frustrated that they missed the throw. They looked impressed by pepper's throwing and scoring a shot ability. After the experiment, they pointed out that the questionnaire was a bit hard to fill because of the continuous straight lines, one after the other in questions.

1. ***How frequently do you play Computer Games?***

   Answer: The participant answered that they sometimes play computer games.

2. ***What 3 games do you play the most on your computer/mobile phone?***

   Answer: The participant answered that they played guitar hero online. Also, sometimes, they like to play card games on mobile phones.

3. ***What kind of non-digital games do you play?***

   Answer: In terms of non-digital games, they said they liked games like frisbee. They also mentioned that they played board games at times as well like chess and 4-in-a-row.

4. ***What did you find enjoyable about playing with/against the robot?***

   Answer: They said that they were excited about the robot throwing and how many hits it will make. They also mentioned that this excitement stayed throughout the game.

5. ***What did you find difficult about playing with/against the robot?***

   Answer: They didn't say much about any specific difficulty other than both the modes felt the same. Also, there were too many rules for the game and experiment in general.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

   Answer: They said that they would choose the robot to see how it would play in a tiebreaker situation.

7. ***Would you play with the robot again? Why or why not?***

   Answer: They said they would play the robot again to see how the robot played the game in future.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

   Answer: They picked competitive mode because in cooperative mode, they said 7 is too high of a number to cross.

9. ***How would the game be improved to make it more enjoyable?***

   Answer: They mentioned the following points:

   i. They said the stability lines should be changed or removed as it is confusing.
   ii. They also said to use different tapes for marking the positions.

<table>
<tr><td colspan="3">Cooperative</td><td rowspan="8">Cooperation 1st
and
Robot 1st</td><td colspan="3">Competitive</td></tr>
<tr><td>Turn</td><td>H</td><td>R</td><td>Turn</td><td>H</td><td>R</td></tr>
<tr><td>1</td><td>X</td><td>X</td><td>1</td><td>✓</td><td>✓</td></tr>
<tr><td>2</td><td>X</td><td>✓</td><td>2</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>✓</td><td>X</td><td>3</td><td>X</td><td>X</td></tr>
<tr><td>4</td><td>✓</td><td>X</td><td>4</td><td>✓</td><td>X</td></tr>
<tr><td>5</td><td>X</td><td>X</td><td>5</td><td>X</td><td>X</td></tr>
<tr><td>Total</td><td>2</td><td>1</td><td>Total</td><td>2 (Winner)</td><td>1</td></tr>
</table>

Participant - 5

General comments:

They seemed impressed by the robots ability to complete a successful shot.

1. ***How frequently do you play Computer Games?***

   Answer: The participant answered that they did not quite play computer games.

2. ***What 3 games do you play the most on your computer/mobile phone?***

   Answer: The participant answered that the most games they played included League of Legends, HALO and GTA on pc.

3. ***What kind of non-digital games do you play?***

   Answer: In terms of non-digital games, they said they preferred playing board games. Catan and Kubbspill was their favourite games.

4. ***What did you find enjoyable about playing with/against the robot?***

   Answer: They said that they enjoyed seeing robot perform in the cooperative mode. For the competitive mode, they said that it was nice to see the robot fail.

5. ***What did you find difficult about playing with/against the robot?***

   Answer: They didn't say much about the gameplay sessions of either of the modes, but in general, the working of the robot was a little slow.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

   Answer: They said they would have picked the robot for the tiebreaker session, because the miss hits by robots could give them a winning factor.

7. ***Would you play with the robot again? Why or why not?***

   Answer: They said they would play the robot again because of its progress it will make in future.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

   Answer: They said that because they had never handled a robot before, they were insecure. They said they would prefer cooperative mode to play more with the robot and see its progress.

9. ***How would the game be improved to make it more enjoyable?***

   Answer: They mentioned the following points:

   i. They said the robot should be more encouraging, motivating, animated and life-like.

<table>
<tr><td colspan="3">Cooperative</td><td rowspan="8">Competitive 1st
and
Human 1st</td><td colspan="3">Competitive</td></tr>
<tr><td>Turn</td><td>H</td><td>R</td><td>Turn</td><td>H</td><td>R</td></tr>
<tr><td>1</td><td>X</td><td>X</td><td>1</td><td>X</td><td>X</td></tr>
<tr><td>2</td><td>✓</td><td>X</td><td>2</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>X</td><td>✓</td><td>3</td><td>X</td><td>X</td></tr>
<tr><td>4</td><td>✓</td><td>X</td><td>4</td><td>X</td><td>✓</td></tr>
<tr><td>5</td><td>X</td><td>X</td><td>5</td><td>X</td><td>X</td></tr>
<tr><td>Total</td><td>2</td><td>1</td><td>Total</td><td>0</td><td>1 (Winner)</td></tr>
</table>

Participant - 6

General comments:

1. ***How frequently do you play Computer Games?***

Answer: The participant answered that they don’t play computer games at all.

2. ***What 3 games do you play the most on your computer/mobile phone?***

Answer: The participant did not answer any games they play on computer/mobile phone.

3. ***What kind of non-digital games do you play?***

Answer: The participant said that they played more sports like volleyball and football.

4. ***What did you find enjoyable about playing with/against the robot?***

Answer: They said they were enjoying everything and that everything was okay.

5. ***What did you find difficult about playing with/against the robot?***

Answer: They said that the games were too slow, both cooperative and competitive modes.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

Answer: They said that they would choose the robot as they would like the robot to learn more.

7. ***Would you play with the robot again? Why or why not?***

Answer: They said they would play the robot again to see what changes have come up in its AI.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

Answer: They said that they would pick collaborative mode, just cause they felt like it.

9. ***How would the game be improved to make it more enjoyable?***

Answer: They said that the experiment and robot were quite interesting. They would have liked however for the robot to change the shoulder position while throwing the ball for better throw.

<table>
<tr><td colspan="3">Cooperative</td><td rowspan="7">Competitive 1st
and
Robot 1st</td><td colspan="3">Competitive</td></tr>
<tr><td>Turn</td><td>H</td><td>R</td><td>Turn</td><td>H</td><td>R</td></tr>
<tr><td>1</td><td>✓</td><td>✓</td><td>1</td><td>✓</td><td>X</td></tr>
<tr><td>2</td><td>X</td><td>X</td><td>2</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>X</td><td>X</td><td>3</td><td>X</td><td>X</td></tr>
<tr><td>4</td><td>✓</td><td>X</td><td>4</td><td>X</td><td>✓</td></tr>
<tr><td>5</td><td>X</td><td>X</td><td>5</td><td>✓</td><td>X</td></tr>
<tr><td>Total</td><td>2</td><td>1</td><td></td><td>Total</td><td>2 (Winner)</td><td>1</td></tr>
</table>

Participant - 7

General comments:
In the competitive aspect, the game went to a tiebreaker section, where the player accidentally selected themselves after suggesting they want to select the robot to throw. Overall, they seemed to be impressed with robots movements, speech and throwing. They also said that they were quite focused on playing the game and the expectations slowly grew.

1. ***How frequently do you play Computer Games?***

   Answer: The participant said that they rarely play computer games.

2. ***What 3 games do you play the most on your computer/mobile phone?***

   Answer: The participant answered that the most remembered games they have played include Sims, Hugo and Pacman in the digital format.

3. ***What kind of non-digital games do you play?***

   Answer: They answered that they don't play any non-digital games. However, they liked sports like tennis, volleyball, gymnastics and swimming.

4. ***What did you find enjoyable about playing with/against the robot?***

   Answer: They said that the speech interactions to cheer up the player was nice from the robot's side in cooperative mode. From the competitive side, it was interesting for them to see how the robot would move and play. They also added that it would be "cool" to do things together.

5. ***What did you find difficult about playing with/against the robot?***

   Answer: From the cooperation side, they said that since the robot went first and didn't score enough, the game was practically decided and there was no motivation to throw and score. For the competition side, they didn't have anything to say on the difficult front.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

   Answer: They wanted to choose the robot; however, they accidentally went for themselves. They stated that the reason for choosing robot was because they had low confidence in themselves. They also said they were "not in good throwing mood".

7. ***Would you play with the robot again? Why or why not?***

   Answer: They said that they would like to play with the robot because they were curious about the robot. They went into discussing the evolution of robots and how the communication will improve for the robotic systems.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

   Answer: They said that even though they liked the cooperation mode more, they would prefer to go for competitive games just to "prove to humanity that robots are not yet evolved".

9. ***How would the game be improved to make it more enjoyable?***

   Answer: They said that positive reinforcement would be beneficial to the competitive mode. They also said that the game could be more interesting that just throwing balls. It would be better to play board games than this.

<table>
<tr><th colspan="3">Cooperative</th><th rowspan="8">Competitive 1st
and
Robot 1st

Tie breaker session – Human missed, Robot Won</th><th colspan="3">Competitive</th></tr>
<tr><th>Turn</th><th>H</th><th>R</th><th>Turn</th><th>H</th><th>R</th></tr>
<tr><td>1</td><td>X</td><td>✓</td><td>1</td><td>X</td><td>X</td></tr>
<tr><td>2</td><td>X</td><td>X</td><td>2</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>✓</td><td>X</td><td>3</td><td>X</td><td>X</td></tr>
<tr><td>4</td><td>X</td><td>X</td><td>4</td><td>X</td><td>X</td></tr>
<tr><td>5</td><td>X</td><td>X</td><td>5</td><td>X</td><td>X</td></tr>
<tr><td>Total</td><td>1</td><td>1</td><td>Total</td><td>0</td><td>0</td></tr>
</table>

Participant - 8

General comments:

1. ***How frequently do you play Computer Games?***

Answer: The participant answered that they always play Computer Games once every two days, around three times a week.

2. ***What 3 games do you play the most on your computer/mobile phone?***

Answer: The participant answered that the most remembered games on the digital platform were Factorial, Starcraft 2 and Zelda breath of the wild.

3. ***What kind of non-digital games do you play?***

Answer: In terms of non-digital games, they said their choice of games mainly included board games like Catan and chess, along with physical games like ping-pong.

4. ***What did you find enjoyable about playing with/against the robot?***

Answer: They said that they enjoying playing with the robot due to lack of pressure. For the competitive mode, they didn't find anything specific to say that they specially enjoyed. In general, they liked being able to give the ball to robot for throwing.

5. ***What did you find difficult about playing with/against the robot?***

Answer: They said pepper robot took too long to complete her part of the game. Also, that the game should have been atleast two rounds for better gameplay.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

Answer: They said that they would choose pepper robot because it just made one bucket and that gave them a better winning chance.

7. ***Would you play with the robot again? Why or why not?***

Answer: They said they would like to play with the robot again because it would be interesting to try new things.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

Answer: They said that they would like to try cooperative mode in the future because they like to play team games.

9. ***How would the game be improved to make it more enjoyable?***

Answer: They again stressed upon the fact that a second round to play would be fun. They suggested that more time to play would be better for the game as the robot took a lot of time just solo playing.

Cooperative				Competitive		
Turn	**H**	**R**		**Turn**	**H**	**R**
1	✓	X		**1**	X	✓
2	✓	X	**Competitive 1st**	**2**	X	X
3	✓	✓	**and**	**3**	✓	X
4	X	✓	**Human 1st**	**4**	X	✓
5	X	X		**5**	X	X
Total	**3**	**2**		**Total**	**1**	**2 (Winner)**

Participant - 9

General comments:

The participant was quite interested to interact with the robot.

1. ***How frequently do you play Computer Games?***

Answer: The participant answered that they play Computer Games quite frequently.

2. ***What 3 games do you play the most on your computer/mobile phone?***

Answer: The participant answered that the games they most play are Skyrim and Europa.

3. ***What kind of non-digital games do you play?***

Answer: In terms of non-digital games, they said their choice of games would include the Catan board game. They also mentioned that football is one of their favourite sport to play.

4. ***What did you find enjoyable about playing with/against the robot?***

Answer: They said that for the cooperative mode, they really enjoyed to see how the robot perform. It was quite interesting to see the robot in action. There was nothing quite mentioned about the competitive mode.

5. ***What did you find difficult about playing with/against the robot?***

Answer: They didn't have anything to say in terms of difficulty about playing with/against the robot.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

Answer: They said that they would choose the robot as it would be interesting to see how robot performs for the tiebreaker section.

7. ***Would you play with the robot again? Why or why not?***

Answer: They said they would like to play with the robot again, citing the same reason of finding the robot interesting.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

Answer: They said that their choice would cooperative mode because, again, it would be interesting to interact with the robot.

9. ***How would the game be improved to make it more enjoyable?***

Answer: They said that the game could be better if the robot was a bit more understanding.

Cooperative				Competitive		
Turn	**H**	**R**		**Turn**	**H**	**R**
1	X	✓	**Cooperative 1st and Human 1st**	**1**	X	X
2	✓	X		**2**	✓	✓
3	✓	X		**3**	✓	X
4	✓	X		**4**	✓	X
5	X	X		**5**	✓	X
Total	**3**	**1**		**Total**	**4 (Winner)**	**1**

Participant - 10

General comments:
The participant confessed during the end of questions that after the first successful shot by the robot, they got nervous and tried to sabotage the robots gameplay by handing the ball incorrectly.

1. ***How frequently do you play Computer Games?***

   Answer: The participant answered that they play Computer Games every day.

2. ***What 3 games do you play the most on your computer/mobile phone?***

   Answer: The participant answered that the recent games they played were Sekiro, Genshin Impact and Skyrim.

3. ***What kind of non-digital games do you play?***

   Answer: In terms of non-digital games, they said their choice of games would be on the physical side of sports like football and cricket.

4. ***What did you find enjoyable about playing with/against the robot?***

   Answer: They said that there was increased competitiveness in them when the gameplay was on. There was no specific remarks from the phase of participant playing with the robot. They however, said that the overall session was “fun to play”.

5. ***What did you find difficult about playing with/against the robot?***

   Answer: For the difficulty portion, the participant answered by saying that due to the gameplay being human first and them missing out on a specific number of hits, they didn’t feel focused enough for the rest of cooperation mode. For the competition mode, they didn’t have any specific thing to say. They however, pointed out that the fact that ball had to be picked up after each thing, made it difficult to enjoy the gameplay, along with the sensitivity of the robot.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

   Answer: They said, they would have nominated themselves to take the shot. Initially being nervous about robot getting many shots, made them nervous but they started gaining confidence with each successive misses by the robot.

7. ***Would you play with the robot again? Why or why not?***

   Answer: They said they would like to play with the robot again mainly to see if there is a different experience.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

   Answer: They spoke about picking competition for future possibilities because it gives a sense of accomplishment and sets a goal of playing against the robot.

9. ***How would the game be improved to make it more enjoyable?***

   Answer: They mentioned the following points:

   i. They said that the cooperative mode would be better if it was human and robot against another human or robot.

   ii. They said that sensitivity issue was a big thing for them. They wanted to move and talk freely during the experiment.

   iii. They also wanted the robot to be more flexible while moving around.

Cooperative				Competitive		
Turn	**H**	**R**		**Turn**	**H**	**R**
1	✓	X	**Cooperative 1st and Human 1st**	**1**	✓	✓
2	X	X		**2**	✓	X
3	X	X		**3**	X	X
4	X	X		**4**	X	X
5	X	X		**5**	✓	X
Total	**1**	**0**		**Total**	**3 (Winner)**	**1**

Participant - 11

General comments:

They did comment in the middle “the robot is not perfect” and were smiling during the whole experiment trying to observe how the robot moves and throws.

1. ***How frequently do you play Computer Games?***

Answer: The participant answered that they frequently play Computer Games, almost one hour everyday.

2. ***What 3 games do you play the most on your computer/mobile phone?***

Answer: The participant answered that the usual games they play comprise of Candy Crush, car race games and PUBG.

3. ***What kind of non-digital games do you play?***

Answer: They said that they don’t play any non-digital games.

4. ***What did you find enjoyable about playing with/against the robot?***

Answer: They said that during the cooperation mode, they were praying for more scoring and for the competition mode, they were praying for robots failure.

5. ***What did you find difficult about playing with/against the robot?***

Answer: They did not find anything in the difficult area about playing with/against the robot.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

Answer: They said that they would have selected themselves because their confidence was growing after seeing the robot perform.

7. ***Would you play with the robot again? Why or why not?***

Answer: They said they would like to play with the robot again in the future, because they liked it and enjoyed the experience.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

Answer: They said that they would choose cooperative mode to play in the future because it didn’t feel nice to lose to the robot.

9. ***How would the game be improved to make it more enjoyable?***

Answer: They said that the robot was not understanding much and was a big problem on their part. They wanted more communication between the robot and themselves.

<table>
<tr><th colspan="3">Cooperative</th><td rowspan="8">Cooperation 1st
and
Robot 1st</td><th colspan="3">Competitive</th></tr>
<tr><th>Turn</th><th>H</th><th>R</th><th>Turn</th><th>H</th><th>R</th></tr>
<tr><td>1</td><td>✓</td><td>✓</td><td>1</td><td>X</td><td>✓</td></tr>
<tr><td>2</td><td>X</td><td>X</td><td>2</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>X</td><td>✓</td><td>3</td><td>X</td><td>X</td></tr>
<tr><td>4</td><td>✓</td><td>X</td><td>4</td><td>X</td><td>X</td></tr>
<tr><td>5</td><td>X</td><td>X</td><td>5</td><td>X</td><td>X</td></tr>
<tr><td>Total</td><td>2</td><td>2</td><td>Total</td><td>0</td><td>1 (Winner)</td></tr>
</table>

Participant - 12

General comments:
The participant was observed saying "the experience was fun"

1. ***How frequently do you play Computer Games?***

Answer: The participant answered that they don't play Computer games at all.

2. ***What 3 games do you play the most on your computer/mobile phone?***

Answer: The participant answered that the game they can think, at that moment, playing on these platforms was super mario. They also stressed on that fact that they loved watching gameplays, than actually playing them.

3. ***What kind of non-digital games do you play?***

Answer: In terms of non-digital games, they said their choice of games would be on the physical side like football, cricket and basketball. They said physical sports were fun and engaging. They also spoke about their recent experience of trying to be more social in social events, participating in games like sac-race and potato-race.

4. ***What did you find enjoyable about playing with/against the robot?***

Answer: They said the fact that the robot scored more than them in the cooperation mode, made it fun to look at the robots play. For the competition mode, they felt that the sense of competition was high during the session.

5. ***What did you find difficult about playing with/against the robot?***

Answer: They said the game took some time to play. It would have been fun to watch the sessions and see the robot play & score instead. No particular thing was said for the individual mode in terms of being difficult.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

Answer: They said that they would choose the robot because it would be fun to watch what it does and how it performs. However, they also mentioned that if there was multiple sessions for the tiebreaker, they would have chosen themselves.

7. ***Would you play with the robot again? Why or why not?***

Answer: They said they would play with the robot again because the interaction was fun and quite engaging.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

Answer: They said they would prefer the cooperative mode because then they would be able to focus on fun. Competition however, created more pressure in their mind.

9. ***How would the game be improved to make it more enjoyable?***

Answer: They mentioned the following points:

i. They said that they would have liked multiple rounds of gameplay, just to see the robot more in action.

ii. They said that the questionnaire could have been more interactive.

Cooperative **(Winner)**				Competitive		
Turn	**H**	**R**		**Turn**	**H**	**R**
1	✓	✓	**Cooperative 1st and Robot 1st**	**1**	✓	X
2	✓	X		**2**	✓	X
3	X	✓		**3**	✓	X
4	X	✓		**4**	X	✓
5	✓	✓		**5**	✓	X
Total	**3**	**4**		**Total**	**4 (Winner)**	**1**

Participant - 13

General comments:

The prior knowledge of peppers activities made the participant a bit frustrated with the robot, at times even uttering the word “it is dumb” and “I hate you”. The player also spoke about robot having tons of issues in itself and ending their interview with the sentiment of “throwing it out of the window”.

1. ***How frequently do you play Computer Games?***

Answer: The participant answered that they never play Computer Games.

2. ***What 3 games do you play the most on your computer/mobile phone?***

Answer: The participant answered that the most remembered games for them could be like super mario, tarzan, sandwich game, lava floor game and car racing games.

3. ***What kind of non-digital games do you play?***

Answer: In terms of non-digital games, they said their choice of games would be on the physical side like bouldering and frisbee.

4. ***What did you find enjoyable about playing with/against the robot?***

Answer: They said that both the modes felt the same. They also stated that the competition mode made them stressed and eager to win.

5. ***What did you find difficult about playing with/against the robot?***

Answer: They mentioned that if the robot was a human, they would have had enjoyed the cooperative mode more. They also pointed out that there was a distinct difference in the playing level.

6. ***If the game went into tiebreaker, who would they have had chosen to compete and why?***

Answer: They said that they would choose themselves to take the tiebreaker shot because they have confidence in themselves.

7. ***Would you play with the robot again? Why or why not?***

Answer: They said they wouldn’t play the robot again because of past experience in interacting and playing with the robot.

8. ***For gameplay, which aspect (cooperative or competitive) would you prefer? And why?***

Answer: They said that they would go for the cooperative mode in the future because of the difference in experience level.

9. ***How would the game be improved to make it more enjoyable?***

Answer: They mentioned the following points:

i. They said that the robot spent a lot of time while its turn, so perhaps recognition techniques for programming might help reduce the time.

ii. They also said that the robot talked a bit fast, so it would be good if it talked a little slow for people to understand.

<table>
<tr><td colspan="3">Cooperative</td><td rowspan="7">Competitive 1st
and
Human 1st</td><td colspan="3">Competitive</td></tr>
<tr><td>Turn</td><td>H</td><td>R</td><td>Turn</td><td>H</td><td>R</td></tr>
<tr><td>1</td><td>✓</td><td>X</td><td>1</td><td>X</td><td>X</td></tr>
<tr><td>2</td><td>X</td><td>X</td><td>2</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>X</td><td>X</td><td>3</td><td>✓</td><td>X</td></tr>
<tr><td>4</td><td>X</td><td>X</td><td>4</td><td>✓</td><td>X</td></tr>
<tr><td>5</td><td>X</td><td>X</td><td>5</td><td>X</td><td>X</td></tr>
<tr><td>Total</td><td>1</td><td>0</td><td></td><td>Total</td><td>2 (Winner)</td><td>0</td></tr>
</table>