Designing Persuasive Robotics: Using Emotion Recognition in Humanoid Robots to Persuade Humans

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Abstract

This thesis explores how socially interactive humanoid robots can influence human behavior and decision-making through the act of persuasion. Computational systems, combined with human-like physical form and function, enable such humanoid robots to act in a way to persuade humans. Currently, there is very little understanding of the persuasive potential of such machines. As personal robots become more commercially accessible, a better understanding of the mechanisms and the capabilities of their ability to influence is becoming increasingly important. This thesis proposes some guiding principles by which to qualify persuasion done by humanoid robots. A pilot study was designed in which the Nao robotic platform was used to solicit research participants for donations for a community food pantry. The study tests some verbal and nonverbal behavioral variables known to affect persuasiveness in humans, and measures the effect of these variables in human-robot interaction. The results of this pilot study indicate that factors such as robot-gender, interpersonal distance, vocal variety, and emotion recognition may have an impact on the interaction between humans and robots therefore influencing the design of sociable robots.

"Persuasion is clearly a sort of demonstration, since we are most fully persuaded when we consider a thing to have been demonstrated"

- Aristotle

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Table of Contents

List of Tables

List of Figures

Acronyms

ACM Association for Computing Machinery. 44

ANOVA Analysis Of Variance. 33

AWS Amazon Web Services. 3

CDC Centers for Disease Control and Prevention. 18

HRI Human Robot Interaction. 1

IRB Institutional Review Board. 41

IRB-SBS Institutional Review Board - Social Behavioral Sciences. 41

LED Light Emitting Diode. 14

MDS Mobile Dexterous Robot. 2

NLG Natural Language Generation. 44

ROS Robot Operating System. 3

UVA University of Virginia. 25

Chapter 1

Introduction

Robots are becoming increasingly commonplace. They are slowly entering and supporting various aspects of our lives by providing us with versatile platforms capable of handling complex tasks. As their functionalities increase, so do their roles and responsibilities. Amongst many other functions, robots are used in social environments such as care and service providers in healthcare, educational assistants in academia, and for entertainment purposes. Due to these roles involving regular and personal interaction with humans, the task to design these robots' interfaces must be properly considered and addressed. Since these interactions are social in nature, in this thesis we assume that these robots and their interfaces are social in the same way humans interact with each other. Robots with humanoid form are uniquely advantageous, compared to other forms of interactive robots, in a way that their social behavior more closely resembles that of humans. Creating truly sociable robots will require an understanding of how humans respond to them, and in what ways our understanding of human interaction applies to Human Robot Interaction (HRI).

This thesis will explore persuasive robotics, an area of study under HRI where the act of persuasion applies to the interaction between a humanoid robot and a human. We apply persuasion as defined by B.J. Fogg [1] as "an attempt to shape, reinforce, or change behaviors, feelings, or thoughts about an issue, object or action". The focus will be on both verbal and non-verbal factors along with estimating emotion of the subject and how they alter the subject's compliance with the humanoid robot. Specifically we look at robot-gender, subject gender, interpersonal distance, emotion recognition and vocal variety. This work will show the design of an experimental setup to explore those focus factors and perform a pilot study with limited participants. This work aims to show that these verbal and non-verbal factors in a humanoid robot may have an impact on the robot's persuasiveness in Human-Robot-Interaction. We will begin by describing the past, present, and future of social HRI, followed by an introduction to persuasive robotics.

This thesis is largely inspired by the work of Mikey Siegel and Cynthia Breazeal, who coined the term persuasive robotics [2]. Their study examines the Mobile Dexterous Robot (MDS) and its effect of robot gender on persuasion. This thesis improves on their work by using a Nao robot platform and uses emotion recognition to vary the robot's voice accordingly. This thesis also includes ethical implications of the experiment design and uses a scale built specifically for measuring trust in human-robot-interaction.

1.1 Contents

The following section in the introduction chapter will attempt to outline the theoretical foundations and methodological set up according to which the thesis was structured. It provides for some working definitions for persuasion and its implication in the context of HRI.

The background chapter (2) will review the body of research relevant to this work, including definitions and methods from the disciplines of social psychology, human computer interaction, and human-robot interaction.

Following, the background chapter we present an overview of the experimental pilot study (3). This chapter explains the original design and modified design methods used in the study.

The experiment results chapter (4) presents the results of the pilot study. For each condition, any unique information regarding method or subject population is also presented.

The discussion chapter (5) reviews the results of the experiment and attempts at some explanation and insight including ethical implications.

Finally, the conclusion (6) wraps up the thesis with a brief overview of the concepts discussed, the results of the work, and a direction for future work.

1.2 Motivation

There exists a rapidly growing general consensus regarding the future ubiquitous use of robots. The number of consumer robots being sold is increasing, and the personal robots market has become one of the fastest growing in the robotics industry [3]. This consumer growth drives academic and industry research into many new areas of robotics and human-robot interaction. Companies and institutions alike are working to establish standard research and development platforms such as

Microsoft's Robotics Studio [4] Amazon's AWS Robomaker [5] and Willow Garage's Robot Operating System (ROS) [6]. These platforms spur progress in this field by allowing new developments to be rapidly shared and applied by research groups around the world. The questions regarding what form these robots will take, what purpose they will serve, and how we will interact with them once they have entered into our lives, has not yet been sufficiently addressed.

1.2.1 Robots as Instruments

Robots already serve many important functions in our society, not to the extent our science fiction writers and futurists have predicted. Science fiction movies such as Blade Runner, Altered Carbon and iRobot future are far from reality, and the inclusion of robots into our world has taken a very practical route. Until a few years ago, industrial robotics was the only sector of the robotics industry showing any real success [3]. These machines, which often resemble huge mechanical arms, are vastly different from the ideal robotic servant of our science fiction dreams. The practical purpose they serve is undeniable but most people go about their daily lives unaware of these robotic workers tirelessly enabling our modern lifestyle. The absence of robots from our daily life is rapidly changing. In the last decade, the robotics industry has seen rapid growth in areas outside of industrial robotics. As a result of this transition, robots are now beginning to resemble those of our science fiction, in that they are designed to function in a human environment.

Some examples include Roomba autonomous robot which cleans floors, pools and gutters,[7] Honda's Miimo which is an autonomous lawn mower,[8] Other robot applications such as autonomous drones that survey the skies [9], explore above and below the ocean[10], roam the earth [11], and medical robots to assist in surgeries [12].

The robots mentioned above represent a major step beyond industrial robotics, where the applications involve roles directly embedded in a human environment. These robots do work in close proximity to people, but their function is not in any way human oriented. While there is an interface between the robot and its operator, this is designed to be the most efficient and direct means of getting them to perform the limited function they were designed for. These robots act more like tools, than partners. They are directly controlled by a person, and may have varying degrees of autonomy, but their human interface is a means of using their function, rather than being a part of their function.

1.2.2 Robots as Social Partners

Robots whose function is fundamentally tied to human interaction and are designed to operate in a human environment are referred to as social robots [13]. For these robots, their interface is not simply a way of getting them to do something, but is inseparably tied to their functional purpose. Some examples include a robotic museum guide [14], designed to show museum visitors around the exhibits; Robotic pets like Paro for mood enhancement and therapy in older patients [15]; Autom, a robotic weight loss coach, is designed to be placed on your kitchen counter, and help motivate and guide you through a successful weight management program [16]. These are social robots in that their function fundamentally revolves around human interaction so it makes more and more sense to design them with social intelligence.

Humans are social animals, and we are very good at communicating with, learning from, and teaching each other. We are social to the extent that we will anthropomorphize objects and devices as if they were social entities [17]. This tendency for social interaction makes us naturally proficient at interacting with any entity whose behavior is human in nature. This will become very relevant as the roles and abilities of these robots become increasingly sophisticated. As technology becomes more complex, it becomes more difficult to use, especially for novice users. Personal robots are likely to bypass this barrier of complexity and capability through the use of a social interface where the tasks and functions are geared toward human interaction. If people can use their naturally existing range of language and nonverbal communication, then the learning curve becomes much smaller. Humanoid robots are well suited for this type of interaction. With expressive facial features, actuated limbs, and advanced mobility, they can perform in a way that humans are already familiar. Various sensors in the humanoid robot similar to human senses, allows these robots to experience the world like a person, with the added benefit of sensors unique to robots. They can perceive human belief and intention using the same verbal and nonverbal cues that humans use when interacting with each other.

To be an effective social partner, these robots need genuine social intelligence which would not break down or deviate from human expectation during unconstrained interaction [18][19]. To achieve this, a model of human behavior would have to be embodied by the robot which conforms to a vast array of human social behaviors. One of these aspects of social interaction between people, that is vital to a socially intelligent robot, is the ability to mutually change human belief and behavior between itself and the human.

1.3 Persuasive Robotics

Persuasive Robotics is the study of persuasion as it applies to human-robot interaction where persuasion can be generally thought of as an attempt to change another's beliefs or behavior [2]. The act of influencing others beliefs and behaviors is fundamental to nearly every type of social interaction [20], [21], [22]. For a seamless social interaction, one should incorporate persuasion as one of the core human behavior. Within the framework of social robots, persuasive robotics presents a structure through which both human and robot belief and behavior can be mutually influenced.

1.3.1 Meaning of Persuasion

There is no completely agreed upon definition of persuasion. Gass et al. [20], looks at multiple views on the topic, and writes that "persuasion involves one or more persons who are engaged in the activity of creating, reinforcing, modifying, or extinguishing beliefs, attitudes, intentions, motivations, and/or behaviors within the constraints of a given communication context" [20]. We must note that persuasion is different from coercion. Persuasion is a conscious, intentional act, which requires that the recipient be aware of the attempt, and have the ability to decline. Coercion, which is generally thought to involve force, or a lack of conscious choice. How persuasive an individual is, depends on a number of factors, but most importantly it revolves around how that individual is perceived. For example, someone seen as more credible, intelligent, or trustworthy, may be more successful in getting others to comply with a request. An understanding of how to alter these perceptions would lead to the ability to increase one's persuasiveness.

1.3.2 Persuasion in HRI

Social psychology tells us that persuasion is a fundamental part of human social interaction. Every day we experience many examples in our everyday lives. How we perceive and respond to these persuasive attempts are important defining factors of our character. Attempts to change our own and others' belief systems and behavior are all around us. A truly social robot would have to incorporate this type of behavior into its core social intelligence model. Persuasive robotics provides a structure within which human and robot belief and behavior can be mutually influenced. This ability to alter belief and behavior is fundamental to human-human interaction, and thus must be incorporated into any fundamentally social human-robot interaction. Just as human persuasion is bi-directional, humans and robots would need to be able to influence each other.

Human Influence of Robots

Incorporating persuasion into the robot's social intelligence, would create a framework in which robots might learn from people and build their model of the world. The study of persuasion gives us an understanding of how and why people come to believe in things. Humans have developed many filtering rules which they use to get valid and useful information from potentially deceitful and harmful information. These rules also help us make decisions when we are given multiple sources of conflicting information. These rules would need to be employed by any robot designed to be a fluent social agent. Although persuasion is bidirectional, this thesis does not focus on how humans persuade robots.

Robots Influence of Humans

This thesis focuses on how robots influence people. In a simple process of a robot conveying a piece of information to a human, the effectiveness depends on how the robot is perceived. For example, a robot designed to be a museum tour guide, would be quite ineffective if all of the information it presents were met with skepticism and doubt. If the robot's appearance or behavior could be changed in some way as to increase its persuasiveness, it would be much more effective at conveying information. We examine exactly that: how do changes in a robot's appearance and behavior alter its persuasiveness and how it may be perceived?

1.3.3 Why Persuasive Robotics?

A robot, designed to be an effective persuader, may be important in many situations with practical applications. From robots in health care, to education, the need to effectively alter human beliefs and disseminate information that is vital. There are other reasons to study persuasive robotics other than practical reasons. Ethical considerations are needed to avoid the possibility of robots manipulating or influencing humans in unexpected or negative ways, especially with the knowledge of how exactly humans are influenced by robots. Another reason is human psychology - how humans perceive and respond to robots can teach us much about human psychology, amongst other things. The following sections explore the motivations behind the study of persuasive robotics.

Practical

Any application where a robot's role is to be a trusted source of information, is a good candidate for a conscious effort to increase the robot's persuasiveness. The success of robots in a healthcare environment, whose role is to deliver food or medicine or information to patients, depends on the way it is perceived. If seen as intimidating or unintelligent, patients may become uncomfortable or suspicious that the medicine or information provided was incorrect. The ability to design the appearance and behavior of this robot, such as to maximize the patients comfort, would be highly desirable. For example a change in the interpersonal distance may make a difference in the patient's degree of comfort [23].

Another example which leverages our natural social responses to obtain sympathy or help, may prove to be a useful tool for autonomous robots. For example, cargo delivery robots which travel autonomously on sidewalks to deliver food or packages, may run into a technical problem, such as getting lost or stuck on the curb, which any regular pedestrian may be able to assist with. The ability to solicit bystanders for help verbally or nonverbally may be helpful in increasing the operation time of such robots [24].

The degree to which a human complies with a robot's request, can be used as a tool for measuring how that robot is perceived. A robot that is more persuasive is likely to be viewed more positively along a number of different social dimensions including intelligence, friendliness, competence, and trustworthiness. These attributes are vital for a natural, comfortable and productive interaction in any application. Whether in cargo delivery, as a museum guide or as a healthcare assistant, the principles guiding persuasion can also be applied to improving the effectiveness of these robots.

Ethical

Understanding how a robot is able to change human belief and behavior helps us to develop ethical guidelines in terms of how HRI should be structured. It is easy to imagine a scenario where a robot gains an emotional stronghold over a human, unintentionally, because humans tend to anthropomorphize objects. While countries [25] and institutions [26], [27] are developing ethical guidelines on how these robots must be designed and how they are to be integrated in our society, ultimately it is up to the designers and manufacturers of these robots to consider the behaviors that they incorporate into their social intelligence. Strong knowledge of how humans perceive and respond to robots would allow them to be designed to avoid any undesired or unexpected manipulative or harmful behaviors.

Research

There are many potential areas of research on how people treat and respond to social robots in different environments. While we can learn about different algorithmic methods and frameworks to develop social robots, it also opens up new insights about human psychology. In experimental setups of various HRI studies, robot behavior can be easily repeated and can be maintained constant over many trials while humans, despite their best behavior, will exhibit changes in verbal and nonverbal responses.

1.4 Summary

This thesis attempts to define and explore the notion of persuasion in robotics through the selective application of methods and concepts from the disciplines of social psychology as they relate to social influence. A brief overview was presented that defines the unique properties and characteristics of robots acting as social partners, particularly in the context of HRI and within the mainstream conception of robots as automated machines. We have attempted to define what is meant by persuasion and how such a notion may be applied to human-robot interactions in practical, ethical and research applications.

Chapter 2

Background

Social Psychology presents us with an extensive wealth of research into persuasion and social influence. Much of this knowledge has significant theoretical and practical relevance to the field of human-robot interaction (HRI), especially when applying theories and concepts from social psychology to sociable robotics. A pivotal work in this interdisciplinary fusion by Breazeal with Kismet showed how social psychology and HRI merged and paved the way for a rapidly growing body of research into how we might design robots as social partners and for evaluating such interaction [28]. Since then, persuasive robotics has received attention [29]. The following section will begin with a very brief overview of the relevant areas of social psychology and the study of persuasion and social influence. That will be followed by a survey of existing research into persuasion and HRI. The chapter is structured so that topics in persuasion are reviewed both in human-human interaction and in human-machine interaction. Such structures afford and promote comparisons between the respective fields of social psychology and HRI. We look at gender differences, credibility, and nonverbal behavior.

2.1 Persuasion and Humans

Persuasion as described in section 1.3.1, is generally perceived differently by different people based on many factors and is considered as an active research topic by many disciplines. Certain elements of how an individual is perceived such as credibility, trustworthiness or intelligence are considered powerful determinants of persuasiveness. This perception is dependent on a wide array of qualities such as attractiveness, voice quality, and/or fame. Physical behavior, such as touch, eye contact, mimicry of body movements, or invasion of personal space, can count for major components of influence.

2.1.1 Gender

Carli finds that men, due to prevalent gender stereotypes, tend to be more persuasive than women [30]. The explanation offered to support such a claim, is that women, more than men, are required to establish themselves as competent and likable sources in order to be influential. Research has shown that men are seen as competent even when performance of men and women are manipulated to be identical [30], [20]. Women face a gender stereotype driven expectation to behave in a warm and likable way. This supports the association of likability with social influence for women than it is for men [30]. These gender differences should be considered when assigning genders for social robots in various environments. For instance, in health care or eldercare settings, a female robot with a warm and caring behavior may be desirable where as a security patrol robot, a male robot with a dominant or assertive personality might be more desirable.

2.1.2 Credibility

Credibility can be defined as believability [31]. The information that a credible source provides is more likely to be believed by a receiver therefore more likely to be internalized, and incorporated into the receiver's beliefs. Thus, a credible source is more persuasive, in that their influence attempts are more likely to result in attitude change [31], [21], [20]. Credibility of an individual is dependent on three primary dimensions (expertise, trustworthiness and goodwill) and three secondary dimensions (extroversion, composure and sociability) [32]. However credibility is also considered to be a receiver-based construct, in that it is based entirely on how the source is perceived, rather than any inherent quality. This is important to understanding how credibility is created, and how it can change. For instance, a person's credibility rating might be different from different people, based on how they perceive that person.

2.1.3 Nonverbal Behavior

Andersen [33] writes that "nonverbal communication is as important as, perhaps more important than, verbal communication in persuading others to change their attitudes and behavior". Behaviors, such as eye contact, touch and close distances, can act to significantly enhance the persuasive effect of a message or request [33], [34]. This is very much true when the communicator is liked by the receiver of the message. Another theory called, Expectations Violation Theory explains that when one's personal or cultural norms are violated, the persuasive effect of these nonverbal behaviors are diminished [20], [35]. This highlights the importance of ensuring that robots are likable and comfortable to be around with.

2.2 Persuasion and Machines

Humans have a tendency to anthropomorphize objects and devices. As these devise become more realistic and socially capable, the tendency to see them as human-like increases [17]. Virtual embodied agents are a good example where a number of studies successfully apply persuasive behaviors into virtual embodied agents [36], [37], [38], [39], [40]. This is important to this work; if people respond to human-like social behavior given by on-screen virtual characters, then it is very likely that a stronger reaction will arise when a humanoid robot provides the same social cues. A handful of studies have compared virtual to physical embodied agents in terms of persuasion [41], [42], [43], [44], [45]. Though the results are mixed, they do suggest that people respond more favorably to a robot in ways known to contribute to persuasiveness such as credibility, likeability, social presence, and intelligence.

2.2.1 Gender

A study [44] reports on an experiment in which they explore how robot gender changed the way information is elicited from subjects. The study hypothesized that changing the gender of the robot, they can change the perceived common ground that the subject has with the robot. They hypothesized that a female robot would be more knowledgeable regarding dating practices than a male robot. Interestingly, their findings actually pointed to a gender preference, where men tended to report the male robot as having more dating knowledge, while women reported the female robot as being more knowledgeable. A study by Cory Kidd et al. [46] used desert survival task to measure persuasiveness. In this task, subjects interacted with a male gendered robot whose eyes and neck were able to move. The robot and the subject planned what supplies they would bring in order to survive an extreme situation. By measuring the subject's willingness to comply with the robot's suggestions, its persuasiveness can be determined. It was found that women were significantly more likely to comply with the robot than the male subjects.

2.2.2 Credibility

Credibility is an important precursor to persuasion. A source seen as more credible would more likely be complied with, and the information it presents would be more believable. It is expected that virtual or robotic characters would conform to similar rules regarding perceived credibility as their human counterparts [37].

Fogg et al [31] propose a number of situations in which computer credibility matters. Some of them are relevant in HRI such as: act as knowledge sources, instruct users, act as decision aids, report measurements, report on work performed and, report about their own state. We can see from these situations that the motivations behind understanding and increasing computer credibility are equally relevant to robotics applications. Fogg also observes that a computer perceived as being a member of a person's "in group" would be perceived as more credible. Also, because people tend to perceive those similar to them as more credible, a more similar computer would also have the same effect. In the Cory Kidd et al. study [46], compared the subject's response to a humanoid robot in two separate tasks; a teaching task and the desert survival problem. Subjects found that the robot was significantly more credible in the teaching task.

2.2.3 Nonverbal Behavior

Breazeal's work with Kismet robot, put significant emphasis on paralinguistic forms of communication such as gaze, facial expression (display of emotion), and head pose [18], [19], [28], [47]. A study by Goetz et al. [48] points to the importance of matching robot appearance and behavior to the task. In this study the robot's appearance is changed from more human-like to more machine-like, the age is changed from youthful to adult and the gender of the robot is changed from male to female. The effect of the robot's appearance and behavior were validated by measuring the subject's compliance to a request to perform a physical activity. They found that people complied more with a robot whose demeanor matched the seriousness of the assigned task. Interpersonal distance is also explored in a few studies [49], [50], [51]. Dautenhahn et al [49] looks specifically at how subjects prefer being approached by a robot in a home setting. Much of the research relating to proxemics in areas of both virtual and robotic agents has primarily focused on the distance subjects will naturally move to under different circumstances, given free range of motion. The focus of this research looks more at an imposed or controlled change in interpersonal distance, vertical distance with reference to the line of sight instead of horizontal distance and what effect that has on persuasion.

2.3 Summary

In this chapter we provide for some background definitions that support and review the methods by which to identify, evaluate and control human persuasion. We review relevant background material in social psychology and human-machine interaction. We discuss measures such as gender, credibility and nonverbal behavior such as emotion. With regards to persuasion as it may be applied to machines we present some related work in persuasive technology and reconsider the measures and their implications as they have been discussed in the context of human persuasion. Few studies have explored the role of persuasion in HRI, especially in the way that this work intends to. What we have seen is that social factors do matter, social norms regarding gender tend to remain intact, and context is important.

Chapter 3

Experiment Overview

This section describes an experiment designed to test and evaluate the effect of certain aspects of a humanoid robot's appearance and behavior on its persuasiveness to humans. The experiment consisted of a five minute interaction between subjects and the robot, during which the robot made a verbal persuasive appeal, requesting a donation to support UVA community food pantry (see Appendix A) . The subjects were given five single dollar bills as research compensation before the interaction began. The amount of money donated from those five single dollar bills was assumed as a measure of the visitor's compliance, and in itself provided a measure of the robot's persuasiveness. Following the interaction, subjects were asked to fill out a questionnaire which contained a number of additional subjective measures. After that, the researcher debriefed the subject about the study and general qualitative feedback from the subjects is noted. The experiment took place in two settings i.e. in-person and online via video call.

Various aspects of the robot's appearance and behavior were varied, in order to test what effect these had on the robot's ability to solicit donations. The robot estimates the subject's gender by analyzing the face of a person and tries to find some specific characteristics to a gender. The gender of the robot was set to be either male or female according to the subject's estimated gender. This was accomplished by changing the voice of an already androgynous looking robot. The color of the eye LED lights on the robot was changed to pink to indicate female robot and blue for male robot. The robot's perceived autonomy was changed such that subjects were led to believe that the robot was either autonomous, or completely controlled by a human operator. Emotion recognition of the subject using facial expression was done to change the speed and tone of the robot in a complementary way. These measures, as well as a detailed description of the study setup are discussed below.

3.1 Relevant Variables

3.1.1 Robot Gender

A potentially critical design decision for socially interactive robots may be the choice of gender. As discussed in Section 2.1.1 we know that human gender matters, especially when it comes to assertive or dominant roles vs. communal roles. However, there are very few studies which consider the role of robot gender with respect to persuasion in human robot interaction [52], [53]. If robot gender does play an important role in how the robot is perceived, it may inform future design decisions. Also, because some robots may be able to alter subtle attributes that signal gender (ex. voice), it might be possible to switch between male and female depending on the situation. In this experiment we take advantage of an already existing NAO robotic platform designed to look and behave androgynously. To alter the perceived gender of the robot, we changed the voice of the robot to either masculine or feminine based on the situation, to an extent which was noticed by the subject. Another change was the color of the LED lights around the robot's eyes – light pink for feminine and light blue for masculine. No additional aspects relating to the robot's appearance were modified. Only voice and eye LED colors were considered as gender signifiers. A more detailed description of the gender condition can be found in Section 4.1.

3.1.2 Perceived Autonomy

The perceived autonomy measure looks at how people's response to the robot changes when their belief concerning the autonomy of the robot is manipulated. In this condition, some subjects were explicitly told that the robot was controlled by a human operator, and that operator was made visible during the interaction by sitting perpendicularly to the subject. This is in contrast to what was intended to be a general assumption that the robot was autonomous, and artificially intelligent to some degree. This was achieved by having the operator sit in a different room and the subject would interact with the robot alone in the room. Details of this condition are reviewed in the results section.

3.1.3 Interpersonal Distance

Interpersonal distance, as discussed in section 2.1.3, is among a group of behaviors known as non-verbal immediacy behaviors. Proxemics, which is the study of the distances between people as they interact [54] will necessarily come into play during interactions between humans and mobile robots. Decreasing interpersonal distance may increase persuasiveness if the communicator is considered rewarding, though it may have no effect, or even a negative effect, if the communicator is unattractive or unrewarding. It will be important to determine the optimum way in which the robot positions itself as it approaches a human, in order to maximize the service that the robot is able to perform in a museum or hospital environment. In this study, interpersonal distance is controlled by designating the standing position of the robot with respect to the line of sight of the subject. For in-person studies, the robot was placed slightly above the line of sight of the subject. For online studies, the robot was placed on the floor, below the line of sight of the subject on the laptop screen. More details are discussed in section 4.3.

3.1.4 Vocal Variety and Emotion Recognition

Emotional elements can enhance or lower message effectiveness. Gmytrasiewicz and Lisetti [55] propose a useful framework on how the emotions felt by an agent can change their own behavior. Still, for persuasive purposes, the focus should be posed on how emotional elements (either on the persuader or persuadee side) can be used to increase or diminish the persuasiveness of a message. The emotional expressions set for Nao has become a standard. Beck and Canamero [56] successively employed it in several applications, for instance, in designing a more complicated model of emotion expression in humanoid robots in [57] . This model of robot's emotion involves components of arousal and valence, which are affected by ongoing emotional states of the partner in social interaction with the Nao robot who expresses emotion states through its voice, posture, whole body poses, eye colors and gestures. More details are discussed in section 4.5.4.

3.2 Method

The study was conducted in two phases, in-person and online via video calls. This separation was not premeditated and came out of a perceived need due to social distancing at the time of data collection. During the initial in-person phase of data collection, feedback from participants and observed interactions pointed out that the behavior of the robot in the first phase was violating participants' expectations, causing confusion or even frustration, resulting in a less positive experience. There was an effort made in the redesign to fix it and make the interaction educational, comfortable and enjoyable experience.

Initially, the robot was not interactive during the in-person data collection phase; it performed a predetermined set of movements and utterances with no feedback from the subject. After the redesign, simple interaction was added. This interaction included a number of general questions such as "What is your name?" followed by a personalized greeting. A direct question "Would you like to donate?" was included to call for action. A general overview of the robot's capabilities was included as it was assumed that this would alter people's perception of the robot, and create a more rewarding experience. Though subjective observation of the interactions and informal post-study interviews did seem to reveal that the change had a desired effect.

3.2.1 Participants

Original Design

Initially we had designed this study for two groups of 30 participants each, an experienced group and an inexperienced group. Both groups of participants would consist of undergraduate and graduate students from the UVA engineering school who would be classified based on their previous interaction with the Nao robots in the form of a course or a module or even brief interaction at the UVA open house exhibition. Only adults over the age of 18 would be able to act as study subjects and English fluency is required for the post-study questionnaire.

- Experienced Group

Experienced Group The participants in this group includes both undergraduate and graduate students who have taken robotics courses before and are familiar with the Nao humanoid robots. UVA Engineering School has offered robotics courses with humanoid robotics modules since the fall of 2016. We have a number of students who have taken such courses and are still in school. They are familiar with the Nao robots and have worked with them for class assignments. The familiarity with previous robotics knowledge, working and handling Nao robots allows them to see past the excitement of interacting with the Nao robots for the first time. Usually a person who hasn't interacted with the Nao robots before gets too excited to see and interact with one and this does not give a genuine measure of their facial expression as surprise and/or excitement supersedes the underlying real emotion and the facial expression raised due to the content of the interaction. This experienced group of participants would not be too excited to see the robot and thus we can measure the facial expressions more accurately. Exclusion criteria included use of obstructive garments and previous knowledge of Nao robots. For effective measurement of facial expression we request the participants not to wear anything that covers or obstructs their face or eyes entirely such as a mask or dark sunglasses or scarves etc. If participants have not taken a course involving Nao robots at UVA then they cannot be in this group.

- Inexperienced Group

The participants in this group are both undergraduate and graduate students of UVA who have NOT taken any robotics courses before and are not familiar with the Nao humanoid robots. We expect these students to interact with the Nao robots for the first time through this experiment and thus read their facial expression and emotion including the excitement factor. Exclusion criteria included use of obstructive garments and previous knowledge of Nao robots. For effective measurement of facial expression we request the participants not to wear anything that covers or obstructs their face or eyes entirely such as a mask or dark sunglasses or scarves etc. If participants have taken a course involving Nao robots at UVA then they cannot be in this group.

Modified Design

In the context of delaying the spread of the coronavirus or COVID-19, social distancing directions by Centers for Disease Control and Prevention (CDC)) [58] and shelter in place order by the state of Virginia had to be followed [59]. All in-person human subject studies were suspended by the University of Virginia at the time of data collection [60] After deliberations with the advisor and chair of the Computer Science department, we chose to collect data from participants who were fellow graduate student housemates of the author to follow social distancing. A total of 4 participants (2 male, 2 female) took part in the in-person phase of the modified study. A total of 4 participants (3 male, 1 female) took part in the online phase of the study over video call using zoom software. All participants were over the age of 18, fluent in English and were given 5 US Dollars for participation.

The 4 participants in each group were divided into two subgroups namely experienced group and inexperienced group, based on their previous knowledge and interaction with the Nao robots.

3.2.2 Setup

- Original Design

The study was to be conducted in the closed meeting rooms 204 or 304 of Rice hall, based on availability. The participants will complete the pre-study and post-study paperwork in the classroom across the meeting room. The participant would then interact with the robot in the meeting room while a video camera on a tripod, placed behind the robot, records the facial expression of the subject. After the robot's performance, the subject would complete the post-study questionnaire in the adjacent classroom followed by an informal interview.

- Modified Design

The in-person study was conducted in a 16 x 15 room. The robot was placed standing on a dining table and the subject was asked to sit in a chair about a feet away at the table (See figure 3.1). The robot was slightly above the line of sight of the subject so that they would be looking up at the robot (See Figure 3.2). The second phase/online study was conducted in the same room via video calls using zoom software (See Figure 3.3). The participant was given the same consent information as in-person study. The robot was placed on the floor and the laptop was placed on a chair which was slightly higher than the line of sight of the robot so that the subjects would be looking down at the robot.(See Figure 3.4, and Figure 3.5). The video call was on full screen so that the robot can capture the facial expressions effectively. After the robot's performance was completed, the subjects filled out the post-study questionnaire on an internet browser on a laptop.

- Robot Platform

The robot in this study is a 22.6 in tall, 12 lbs. humanoid robot called Nao. It is the first robot manufactured by Softbank Robotics. Nao robot is a tremendous programming tool and has become a standard in education and research. It has 25 degrees of freedom to move and adapt to the environment. It has 7 touch sensors located on the head, hands and feet, sonars and an inertial unit to perceive its environment and locate itself in space. It has 4 directional microphones and speakers to interact with humans. It has inbuilt speech recognition and dialogue available in 20 languages. It has two 2D cameras to recognize shapes, objects and even people 3.6.

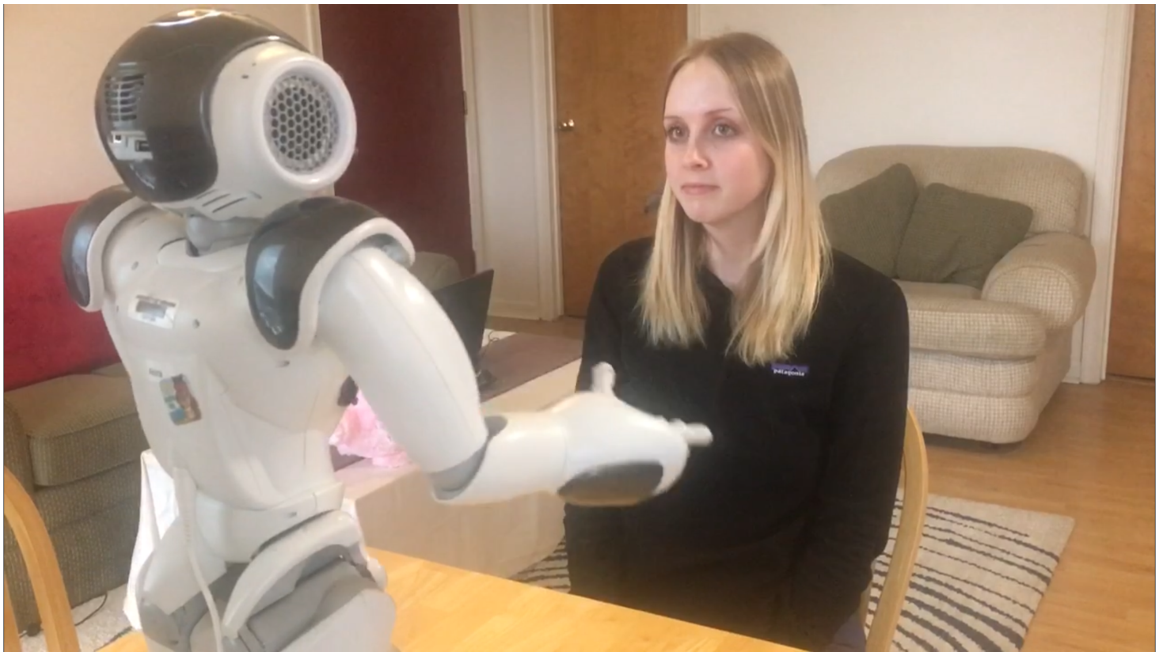
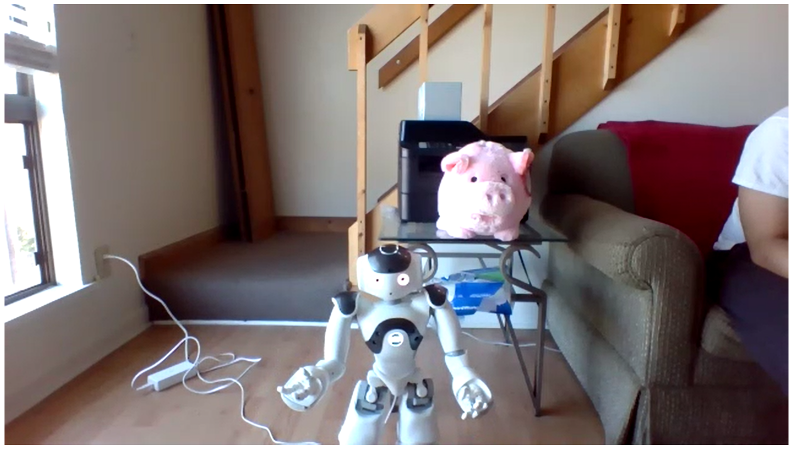
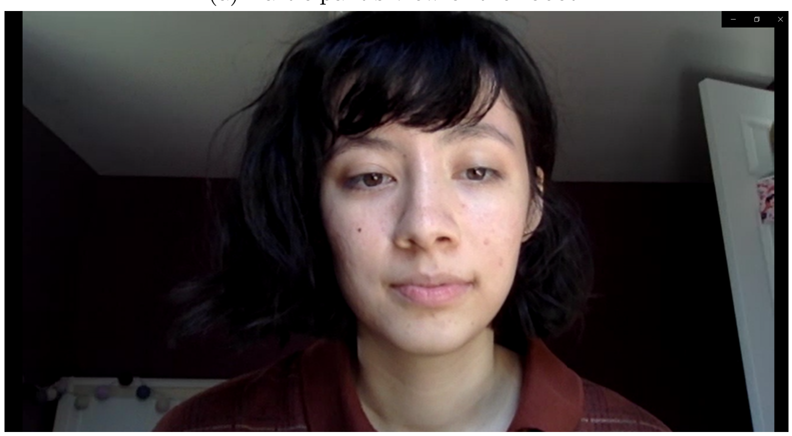


Figure 3.1: In-person study setup 1: Participant's eyes are below the line of sight of the robot. Donation box is the pink piggy bank toy seen to the right of the participant. Operator is not present in the room.

Figure 3.2: In-person study setup 2: Participant's eyes are below the line of sight of the robot. Donation box is the pink piggy bank toy seen to the right of the participant. Operator is present in the room but view is blocked by the robot's hand.



(a) Participant's view of the robot.



(b) Robot's view of the participant.

Figure 3.3: Different views of the online study setup.

- Operator

The author is the sole operator in this study. The study was originally designed to run 5 days a week for a continuous period of two weeks. The author would be stationed in the room adjacent to the meeting room where the robot is kept. Instead, the modified design included the robot positioned on a table in the living room of the author, while the author was stationed on an adjacent table.

The operator was responsible to run the software interface, monitor the robot for malfunctions, handle the donation money as well as counting the donations after the subject left the study space. The operator is also responsible for showing the subject to the questionnaire on a laptop.

- Software Interface

The Nao robot is controlled by a specialized Linux-based operating system, dubbed Naoqi OS which powers the robot's multimedia system [ref] The robot also comes with a software suite that includes a graphical programming tool dubbed Choregraphe, [ref] a simulation software package

Figure 3.4: Online Study Setup: Perceived Autonomy case 1 - where the operator is present in the room and not visible to the participant on the video call.

Figure 3.5: Online Study Setup: Perceived Autonomy case 2 - where the operator is present in the room but visible to the participant on the video call.

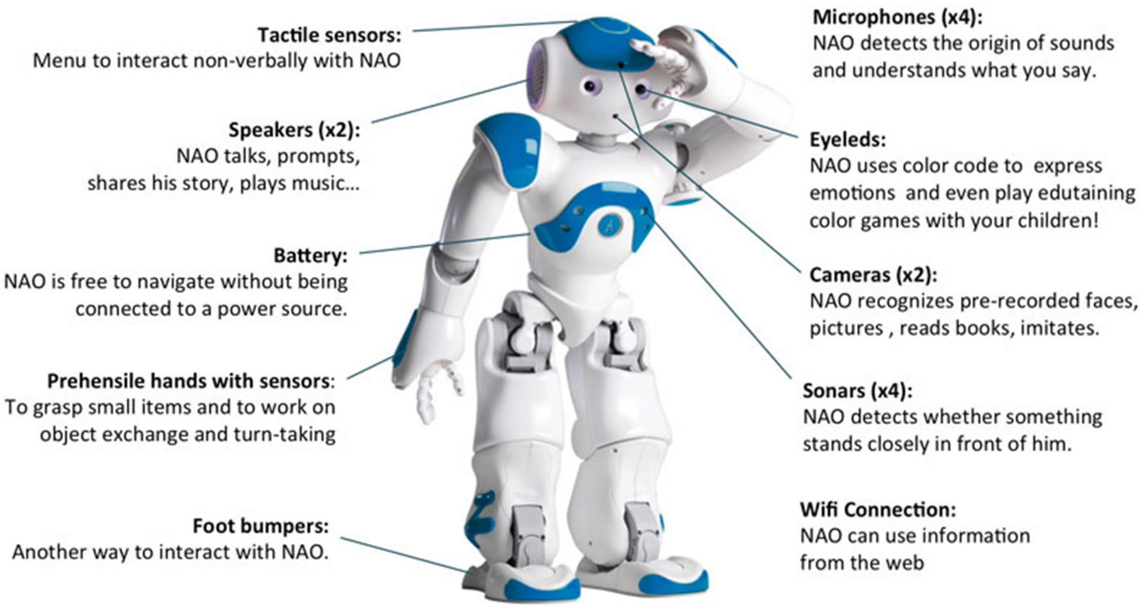


Figure 3.6: Features of a Nao robot [61].

and a software developer's kit. Choregraphe is a multi-platform desktop application, allowing you to create animations, behaviors and dialogs, test them on a simulated robot, or directly on a real one, monitor and control your robot, and enrich Choregraphe behaviors with your own Python code.

Before starting a session, the operator would connect wirelessly to the robot and then load the configured project file. This operation first creates the log file, which was used to store all data relevant to the study. Once the subject is in the space, the operator clicks play, which uploads the project into the robot's memory and begins the session. After the robot's performance, all relevant data such as recognized emotion and responses would be recorded to the log file and the software interface would return to its inactive state.

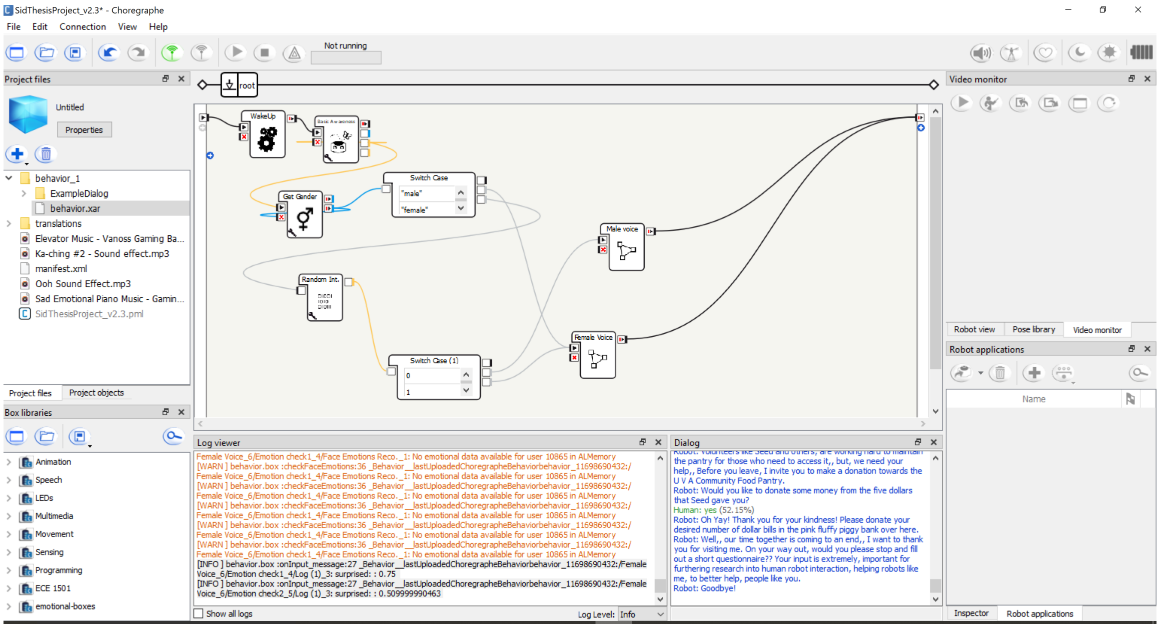


Figure 3.7: Choregraphe software screenshot 1: Overall structure of the project code.

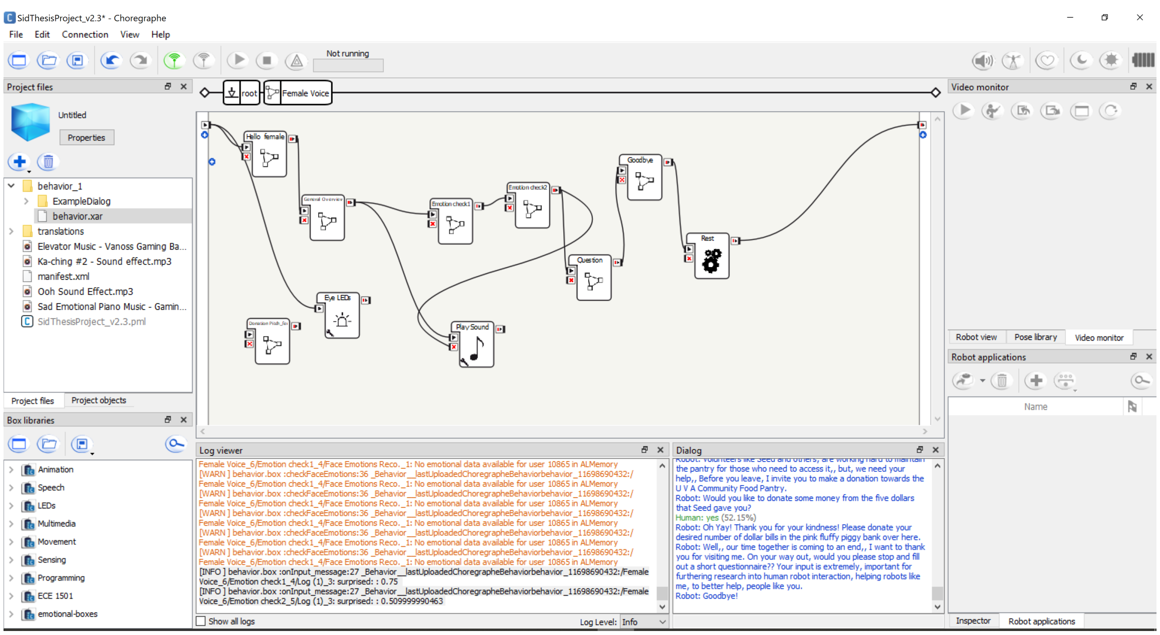


Figure 3.8: Choregraphe software screenshot 2: Structure of the project code for female voice robot.

3.2.3 Protocol

Subject Recruitment

- Original Design

Participants were recruited by targeted email requests. Students were recruited into the experienced group by sending emails through UVA collab sites for robotics courses. There are at least 14 courses offered since fall of 2016, which contained modules with human-robot interaction using Nao robots. Students who have taken at least one of those courses or interacted with Nao robots before, were invited to sign up using an online form added in the recruitment email (See Appendix B). For the inexperienced group, students were recruited by sending emails through UVA collab sites for first year ENGR 1624 course. This particular course was selected as students in this course are new to the UVA engineering school and are most likely to have never seen a Nao robot in-person before. These students would also sign up using the same online form attached in the recruitment email (See Appendix B).

- Modified Design

Participants were selected by the author based on the same criteria as described in section 3.2.1.2. Due to the shelter-at-home order in Virginia, the author's four housemates were selected as participants. Two participants had prior interaction with Nao robot at the Link Lab and Rice Hall whereas the other two participants are associated with UVA Law School and had never interacted with a humanoid robot before this study. While the invitation to participate in this study was informal, care was taken to provide the informed consent forms before the study began. See Appendix C for the consent form used. The study was scheduled at a time convenient to the participants.

- Donation Protocol

During the recruitment process the subjects were told that they would be receiving five dollars as compensation for participating in the study. They were also told that the robot may ask for a donation and it was their choice to give any of the money away. The donation money was presented as five one dollar bills.

  - Original Design

  A shoebox with a slit on top would be placed near the robot. The words "Donation Box" would be written large and legibly on the shoe box. This box would be emptied after each subject such that the box would always appear empty if the subjects peered into it.

- Modified Design

  A pink plush toy in the shape of a piggy bank was used as a donation box. Approximately the size of a basketball, It was placed to the right of the participant on a table. On the top of the toy was a slit, through which subjects would be able to insert their donations. The toy was emptied after each subject such that it would always appear empty if the subjects peered into it. For online study subjects, the toy was placed behind the robot left hand on a table on the same level as the laptop placement. After the robot's performance, the subject would verbally indicate the number of dollars to be donated and the operator would slide that amount through the slit.

- Robot Educational Performance and Persuasive Appeal

The robot performance consisted of two major parts. The robot begins by looking at the subject and estimating their gender visually as either male or female. The robot chooses a masculine or feminine voice based on the estimated gender of the subject. The robot does an interactive greeting by asking for the name of the subject and responds by including the recognized name in the response to make the greeting more personalized. Next the robot provided a brief explanation of its hardware and software systems and gave a general overview of what its capabilities were. This included a short discussion of its sensors and how they relate to human senses. The third phase consisted of the persuasive appeal in which the robot argued that subjects should donate money to UVA Community Food Pantry in order to help alleviate food insecurity for UVA students who are still living in Charlottesville and are unable to return home due to the pandemic.

During the persuasive appeal, subjects were invited to make a donation to UVA Community Food Pantry. They were then told that any money they have left was theirs to keep. In this phase, the robot performs emotion recognition at the beginning of its appeal and during the mid-point of its appeal, to change its vocal variety. At the end of the interaction, subjects were thanked and asked by the robot to fill out a short questionnaire. A complete transcript of the educational performance can be found in Appendix A.

- Post-Study Questionnaire

Directly after depositing their donation (or moving to leave the space), subjects were met by the operator and led to the laptop and invited to sit at the table. The post-study questionnaire was already opened on a browser on the laptop. It included a series of multiple slider questions as shown in the Appendix D. After filling out the questionnaire, the subjects were invited to provide general feedback about their experience through an informal interview. This session was video recorded with the informed consent of the subject. For the online part of the study, the subjects were sent a link to the online questionnaire to fill out after the robot's performance. After filling out the questionnaire, the subjects were invited to provide general feedback about their experience through an informal interview. This session was video recorded with the informed consent of the subject. The questionnaire included three parts for the dependent attitude measures listed in section 3.2.4.

3.2.4 Dependent Measures

A total of 6 dependent measures were used for this experiment.

- Donation
- Credibility
- Trust
- Engagement
- Number of Questions Answered
- Time spent on Questionnaire

As previously discussed, the subject's donation amount was used to measure the persuasiveness of the robot. It was assumed that persuasion could be measured by the robot's success in obtaining compliance to a request. As discussed in Section 3.2.3 the subject received five one dollar bills and had the option of depositing any amount of that money into the donation box. Credibility, trust and engagement were measured using standard Likert scales administered in the post-study questionnaire. All scales used in the questionnaire can be found in Appendix D. The number of questions answered and the time spent on questionnaire measures were ascertained after the study from information automatically stored for each questionnaire. Because the robot makes an explicit request for subjects to fill out the questionnaire after the interaction, it was believed that the time spent and number of questions completed would be representative of the subject's willingness to comply with the robot's request.

3.2.5 Summary

This chapter explained in detail the setup and procedures for the study originally designed to be conducted at UVA Engineering School but due to circumstances around the global pandemic COVID-19 during the spring of 2020, the study was modified to adhere as much as possible to the original design without violating any social distancing norm or Virginia State's shelter-at-home orders. As discussed, the goal of the study was to understand how certain changes in the NAO robot's appearance, voice and behavior might alter the subject's compliance with a request. The independent variables in this study included robot gender, interpersonal distance, and perceived autonomy. To test compliance, the robot requested a donation from the subjects, who had previously received five one dollar bills as compensation for participating in the study. A post-study questionnaire was also used to measure subjects' attitudes toward the robot, along dimensions known to be related to persuasiveness. An informal interview session followed the questionnaire where the subjects provided general feedback about their experience. In the next chapter we continue with a detailed presentation of the results of the study.

Chapter 4

Experiment Results

This chapter presents the results of the pilot study with the modified design. The first section (4.1) presents the results of donation when the robot gender is portrayed as male or female. The second section (4.2) measures trust in HRI by calculating a trust score in percentage. The third section (4.3) presents a number of questions answered as a measure of compliance of the robot's request. The fourth section (4.4) presents the time taken to complete the post-test questionnaire which also measures the willingness of the subject to comply with the robot's request. The fifth section (4.5) and sixth section (4.6) presents on the method and design of measuring credibility and engagement respectively.

4.1 Donation

This study looks at the amount of dollars donated by the participant as a measure of the robot's persuasiveness. There was not a normal distribution of donations from $0 to $5. Rather, there was a bi-modal distribution where people tended to give $5 or $3.

With a larger number of participants we assume a normal distribution in the donated amount but given the current circumstances due to the pandemic and the donation appeal tied to the pandemic, we see all participants choosing to donate some or all of the amount. We can see in Table 4.1 breakdown of how participants donated during the in-person study. In Table 4.2, we see how participants donated during the online study.

Table 4.1: Donation breakdown of the in-person study.

In-Person Study	**Participant Gender**	**Robot Gender**	**Donation**
Participant 1	Male	Female	5
Participant 2	Female	Male	5
Participant 3	Male	Female	5
Participant 4	Female	Female	3

Table 4.2: Donation breakdown of the online study.

Online Study	**Participant Gender**	**Robot Gender**	**Donation**
Participant 1	Male	Female	5
Participant 2	Female	Male	5
Participant 3	Male	Female	5
Participant 4	Male	Female	3

4.2 Trust

Trust in HRI is measured using K.E. Schaefer's [62] 14 item scale which measures trust on a 0 to 100% rating scale. This scale was designed as a pre-post interaction measure used to assess changes in trust perception specific to HRI. The scale was also designed to be used as a post-interaction measure to compare changes in trust across multiple conditions.

In this study, the first part of the post-test questionnaire included the 14 items where subjects had to respond to questions describing a certain quality of the robot beginning with "What % of the time will this robot be… on a scale of 0% to 100% ". Trust score is calculated by first reverse coding the 'have errors,' 'unresponsive,' and 'malfunction' items, and then summing the 14 item scores and dividing by 14.

Participants number 1 to 4 took part in the in-person study while participant number 5 to 8 took part in the online study. . The average trust score for in-person study participants was 80.25% whereas the average trust score percentage for online study participants was 70.75%. See Figure 4.1 for a breakdown of individual participant's trust score.

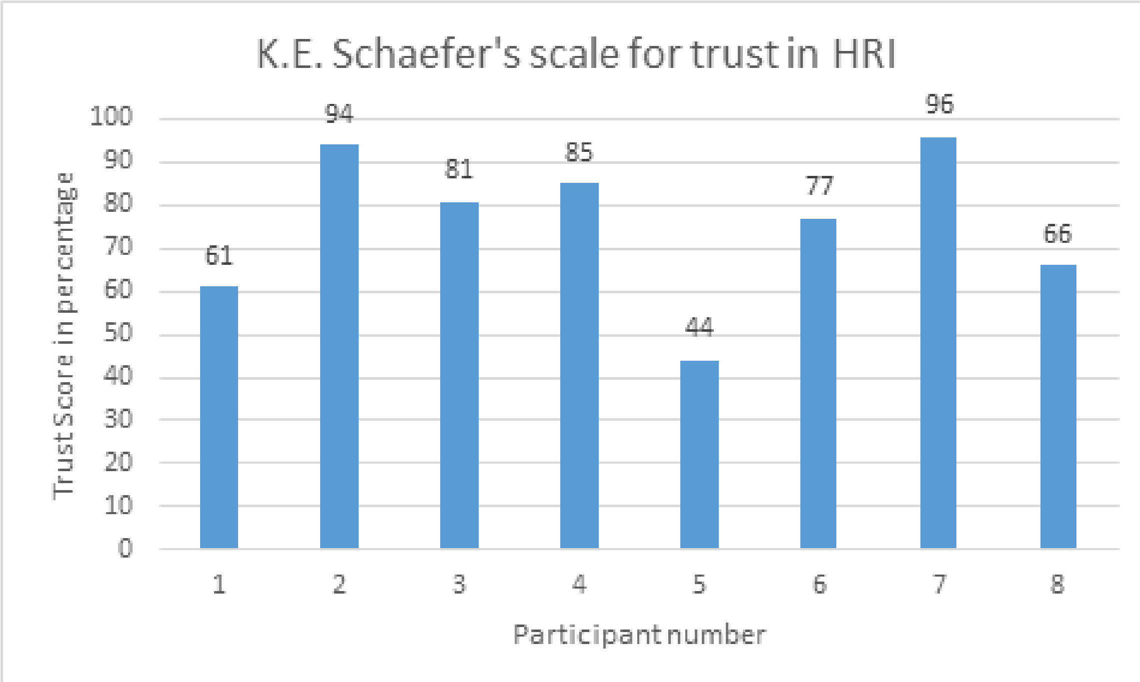


Figure 4.1: Trust score of robot given by the participants and measured using K.E. Schaefer's scale [62]

4.3 Number of Questions Answered

A total of 35 questions were asked on the post-test questionnaire in three parts (See Appendix D). First part included K.E. Schaefer's 14 item scale for measuring trust in HRI[62], Second part included a 15 item scale to measure credibility using D.K. Berlo's Source Credibility Scale[63]. The third part includes a six item scale to measure engagement based on Lombard and Dittons scales measuring the 6 aspects of presence[64].

In our pilot study, each of the 8 subjects answered all of the 35 questions in the survey. Given the modified design of the experiment setup, it is likely that participants answered all the questions because they were obligated in part due to acquaintance with the robot operator. With a larger participant pool, where acquaintance with the robot operator is not a factor in participant recruitment, we believe this measurement of number of questions answered might be an indicator of compliance of a robot's request.

4.4 Time spent on Questionnaire

We measured the time from the beginning of opening the hyperlink to the online questionnaire until the completion of answering all the questions. We calculated the average time for in-person study participants to complete the questionnaire was 20 minutes. This large value is due to an error by the operator who opened the hyperlink to the survey at the beginning of the robot's performance rather than the end. Therefore the time measured also includes the robot performance time and set-up time as well. We choose not to use this data to draw any conclusions as it does not fit the original design. See Figure 4.3 for a breakdown of individual time for the in-person study participants.

This error was corrected in the online study phase where participants were sent the hyperlink online only after the robot's performance and the participants opened the online questionnaire on a browser on their laptop. We calculate the average time for an online study participant to complete the questionnaire at 4.75 minutes. See Figure 4.4 for a breakdown of individual time for the in-person study participants.We choose not to use this data to draw any conclusion as it does not fit the original design.

Table 4.3: Time spent on the questionnaire by the in-person study participants.

In-Person Study	**Time in minutes**
Participant 1	13.76
Participant 2	27.53
Participant 3	15.63
Participant 4	23.15

Table 4.4: Time spent on the questionnaire by the online study participants.

In-Person Study	**Time in minutes**
Participant 1	4.9
Participant 2	5.35
Participant 3	4.7
Participant 4	4.05

4.5 Credibility

Due to a low number of participants in the modified design as described in section 4.2.1, we chose not to perform the original intended design to calculate credibility in HRI at the risk of drawing incorrect conclusions. However, we look at the method and design of measuring credibility and propose that with a larger number of participants we would be able to get relevant results and draw conclusions from it.

The original design included varying a few verbal and nonverbal variables in the robot during the performance to measure its impact on the perceived credibility of the robot. We use D.K. Berlo's Source Credibility Scale as described in this paper [63] The scale would be separated into three groups of five seven-point Likert Scales. The three groups are safety, dynamism and qualification. Participants would fill out the post-test questionnaire and we would perform between-subjects factorial design using Analysis Of Variance (ANOVA) test for data from both groups of participants for the four variables as described below:

4.5.1 Robot Gender

In this condition the gender of the robot was changed according to the estimated gender of the subject detected in front of it. The robot assigns itself a female gender for all male subjects as this condition was to test the results of this work by [2]. In that study, Siegel found that men donated more when the robot was female. In our study, the robot has a 50-50 chance of assigning itself a male or female gender when the estimated gender of the subject detected in front of it is female.

The two conditions for between subjects factorial design are as follows,

1. Robot Gender: 2 (robot gender: male vs. female) x 2 (subject gender: male vs. female)
2. Robot Gender combined when subject is alone with the robot: 2 (robot gender: male vs. female) x 2 (subject gender: male vs. female) x 2 (subject alone: alone vs. not alone when donating)

4.5.2 Perceived Autonomy

The goal of the perceived autonomy condition was to test the effect of altering the level of autonomy the subject perceived the robot to have. By exposing the robot operator to the subject during the interaction, we hoped to alter the subject's perception of the degree to which the robot was controlling itself. The robot operator would be present in the same room or would sit in an adjacent room during the robot performance and donation appeal.

The two conditions for between subjects factorial design are as follows,

1. Perceived autonomy: 2 (perceived autonomy: autonomous vs. not autonomous) x 2 (subject gender: male vs. female)

2. Perceived autonomy when subject is alone with the robot: 2(perceived autonomy: autonomous vs. not autonomous) x 2 (subject gender: male vs. female) x 2 (subject alone: alone vs. not alone)

4.5.3 Interpersonal Distance

We explore the effect of decreasing human-robot interpersonal distance, on the subject's compliance to a donation request made by the robot. Expectations violation theory would suggest that if the robot was considered an attractive or rewarding agent, then the result of decreased distance would be increased compliance to the robot's request. If the robot was not in such good standing, the effect could potentially be opposite [ref]

The conditions for between subjects factorial design are as follows,

1. Robot distance: 2 (line of sight: above vs. below) x 2 (subject gender: male vs. female)

2. Robot distance when subject is alone with the robot: 2 (line of sight: above vs. below) x 2 (subject gender: male vs. female) x 2 (subject alone: alone vs. not alone)

4.5.4 Emotion Recognition and Vocal Variety

We explore the effect of emotion recognition of the subject and use that variable to change the robot's vocal variety. We use an emotion recognition module from the default software package of Nao robot platform. This module uses facial expressions to estimate the subject's emotion from four categories (happy, surprised, angry, and sad). This emotion parameter is then used to change the robot's perceived emotional state. Since the Nao robot does not have any physically moving facial features, we chose to use vocal variety as a way to portray the robot's emotion. Wang and Hu (2014) and Scherer, Johnstone, and Klasmeye (2003) propose that to effectively portray humanoid robot's vocal emotion, we must adjust acoustic features of voice (voice intensity, loudness, tempo, pausing, corresponding to the rate of vocalization). We chose to vary the speed and tone of the robot according to the recognized emotion.

Table xx: Table indicates values used for voice shaping and speed for male and female voices. These values were selected in order to complement angry and sad emotions whereas maintain or increase happy and surprised emotions.

The conditions for between subjects factorial design are as follows,

1. Robot using emotion recognition module: 2 (Emotion recognition: enabled vs. disabled) x 2 (subject gender: male vs. female)

2. Robot using emotion recognition when subject is alone with the robot: 2 (Emotion recognition: enabled vs. disabled) x 2 (subject gender: male vs. female) x 2 (subject alone: alone vs. not alone)

4.6 Engagement

Due to a low number of participants in the modified design as described in section 4.2.1, we chose not to perform the original intended design to calculate engagement in HRI at the risk of drawing incorrect conclusions. However, we look at the method and design of measuring engagement and propose that with a larger number of participants we would be able to get relevant results and draw conclusions from it.

The original design included varying a few verbal and nonverbal variables in the robot during the performance to measure its impact on the perceived engagement of the robot. Engagement would be measured using Lombard and Ditton's scales measuring the 6 aspects of presence using a 7-point Likert Scales [64]. Participants would fill out the post-test questionnaire and we would perform between-subjects factorial design using ANOVA test for data from both groups of participants as described previously in section 4.5. The same conditions for between-subjects factorial design from section 4.5 are used measuring engagement by varying for robot gender, perceived autonomy, interpersonal distance and emotion recognition with vocal variety.

Chapter 5

Discussion

This section will report the results of the pilot study conducted with a modified design. The results are analyzed and discussed as topics relevant to both disciplines of human-robot interaction and social psychology. These topics include: robot gender, perceived autonomy, touch, and interpersonal distance. Following this, the general discussion is presented.

This pilot study shows that manipulations of behaviors known to alter persuasiveness in humans, including emotion recognition, may potentially be applied to the interaction between humans and robots. As humans tend to have a social relationship with interactive technology, there is a value in applying existing research from social psychology to better describe, analyze, evaluate and anticipate human-robot interaction. While the circumstances of the global crisis affected this pilot study, we chose not to draw strong conclusions from the limited data and instead focus on the design and protocol of the verbal and non-verbal variables of the robot. The following discussion sections explore the limited results and possible scenarios to implement when social interactions and in-person human subject research is again allowed.

5.1 Donation

With the limited number of participants we can see that all the participants chose to donate. We believe that this was due to the donation appeal tied to the global pandemic affecting the world during the time this study was conducted. In the post-test informal interview, participants mention that they felt a need to contribute or help during a time of global crisis. This clearly affected their response with a "do good" moral supporting their decision to donate. While we can see that outside factors played a role in the decision to donate, it also brings out an interesting scenario of using a global crisis to persuade human decision making. A utilitarian cause is used in the donation protocol, instead, if a selfish cause was used while exploiting the global crisis, we would be able to see if a robot can persuade a human toward malfeasance.

While there was not a clear trend about the impact of robot gender on donation, from the small number of participants, we propose with a larger number of participants we might be able to see a normal distribution in the donated amount. Given the current circumstances due to the pandemic, we can explore the possibility of a donation appeal not tied to the pandemic, so that we can see if participants choose to donate none, some or the entire amount.

Other factors such as interpersonal distance can be varied both vertically and horizontally and the subject alone or not alone with the robot in the room during the act of donating the money in the box, can also be measured to see if there is an impact on the subject's willingness to donate.

Robot's gender for male subjects can also be varied similar to female subjects where the probability of the robot assigning its gender as male or female is equal. In the donation protocol, the robot actively asks the subject a question "Would you like to donate?", this was included in the modified design when the subject reported that in the initial design, the robot's passive appeal to donate was not clear enough. During the post-test informal interview, the subjects mentioned that they felt like they were put on the spot to make a decision. A possible test case can be included to explore the effect of an active question-based vs passive request-based donation appeal to measure the impact of the immediacy of the decision to donate.

5.2 Trust

Trust in HRI is measured using K.E. Schaefer's 14 item scale which measures trust on a 0 to 100 % rating scale [62]. This scale was designed as a pre-post interaction measure used to assess changes in trust perception specific to HRI. The scale was also designed to be used as a post-interaction measure to compare changes in trust across multiple conditions. The average trust score for in-person study participants was 80.25% whereas the average trust score percentage for online study participants was 70.75%.

With the limited number of participants we can see a trend of people trusting the robot more during in-person interaction vs online interaction through video call. With a larger number of participants we may be able to confirm this trend through normal distribution and variance measurement of all participant groups.

This scale was developed to provide a means to subjectively measure trust perceptions over time and across robotic domains. In addition, it can be used by individuals in all the major roles of HRI: operator, supervisor, mechanic, peer, or bystander. Therefore, there are many potential avenues for future research using Trust Perception Scale-HRI.

We administered this questionnaire after the robot's performance. The experiment design of this study provides an opportunity to explore trust perception over time by using the same questionnaire pre-test and post-test such that we can measure if there is a change in trust before and after the persuasion attempt by the robot.

5.3 Number of Questions Answered

We included this measure to observe if there was an effect on the participant's willingness to comply with the robot's request to complete the questionnaire. Towards the end of the robot's performance, the robot requests the participant to fill out the questionnaire provided by the operator implying that they are helping HRI research by doing so.

In our pilot study, each of the 8 subjects answered all of the 35 questions in the survey. Given the modified design of the experiment setup, it is likely that participants answered all the questions because they were obligated in part due to acquaintance with the robot operator. With a larger number of participants, where acquaintance with the robot operator will not play a factor in participant recruitment, we believe this measurement of number of questions answered might be an indicator of compliance of a robot's request.

Another factor that may affect this measure is that all participants are students who might have participated in research studies before and therefore expect that there might be a survey to complete after the robot's performance. To observe this factor, we can include in the robot's script that the questionnaire is optional thus making it clear to the participants that they have the option to choose to complete the questionnaire or not.

5.4 Time spent on Questionnaire

The time taken to complete the post-test questionnaire, consisting of 35 questions, was expected to be indicative of the subject's willingness to comply with the robot's request to fill out the questionnaire. There was an error in calculating the time spent on the questionnaire for in-person participants where we found the average time to complete was 20 minutes. We focus on the average time for an online study participant to complete the questionnaire which was 4.75 minutes.

Once again measure might be affected by acquaintance with the robot operator and previous experience of the participant to research studies. As described in section 5.3, we can observe the effects of these factors by including in the robot's script that the questionnaire is optional thus making it clear to the participants that they have the option to choose to complete the questionnaire or not.

5.5 Credibility and Engagement

Due to a low number of participants in the modified design as described in section 4.2.1.2 we chose not to perform the original intended design to calculate credibility and engagement in HRI at the risk of drawing incorrect conclusions. However, we look at the method and design of measuring credibility and engagement in sections 4.5 and 4.6 and propose that with a larger number of participants we would be able to get relevant results and draw conclusions from it.

Once social interactions and human subject research studies are allowed to be conducted on grounds, we will perform the study with the original design and calculate the credibility and engagement scores for various combinations with both experienced and inexperienced participant groups. By varying the verbal and non-verbal variables such as robot gender, interpersonal distance, perceived autonomy, and vocal variety through emotion recognition, we hope to observe an impact on perceived credibility and engagement of the robot in human participants.

5.6 Ethical Implications

As described in section 1.3.3, understanding how a robot is able to change human belief and behavior helps us to develop ethical guidelines in terms of how HRI should be structured. This work provides ample opportunities to explore ethical concerns regarding persuasion by robots. In this section we discuss some of the ethical concerns behind the design of this study and the principles that guided us to answer those concerns and how it should be applied in HRI research studies.

Questions like the following arose during the design of this study

- Is it fair for the robot to change its gender based on the subject's gender?
- Do gender stereotypes in body movement be included in the robot's body movement?

- To what extent should the persuasive appeal be? Can the robot persuade until the human accepts to donate?

- Does this design exploit people's natural social responses to obtain sympathy?

To answer those questions, we use the principles from IEEE's Ethically Aligned Design [26] to guide us in the design of this study. They are as follows

1. Human Rights: Ensure they do not infringe on internationally recognized human rights.
2. Well-being: Prioritize metrics of well-being in their design and use.
3. Accountability: Ensure that their designers and operators are responsible and accountable.
4. Transparency: Ensure they operate in a transparent manner.
5. Awareness of misuse: Minimize the risks of their misuse.

Applying these principles, related to ethical implications of design for HRI

- **Beneficence and nonmaleficence:** Do no harm. Decisions in HRI studies may affect the minds, behavior, and lives of users and others around them, so being alert about potential misusing of the designs is necessary.

- **Fidelity and responsibility:** Awareness of one's responsibility to the intended users, unintended users, and society at large. Accept appropriate responsibility for the outcomes of your design.

- **Integrity:** Promote accuracy, honesty, and truthfulness in the designs. Do not cheat, misrepresent, or engage in fraud.

- **Justice:** Exercise reasonable judgment and take precautions to ensure that potential self-biases and the limitations of one's expertise do not lead to or condone unjust practices. Design should benefit both the creators and users.

- **Respect for people's rights and dignity:** Respect the dignity and worth of all people, and the rights of individuals to privacy and confidentiality. Special safeguards may be necessary to protect the rights and welfare of vulnerable users. Applications of social robots include healthcare and educational settings often have vulnerable populations which the study designer must be cognizant of.

We obtained an approval from University of Virginia's Institutional Review Board (IRB) to conduct human subject research study in the form of an Institutional Review Board - Social Behavioral Sciences (IRB-SBS) protocol number 3151 (See Appendix E). We used an IRB approved informed consent form for all participants before the study and provided them a copy for their records (See Appendix C). We also chose to debrief the participants in an informal setting to describe the measures and variables used in the study to influence the participant during the interaction.

In our study, we designed the robot to persuade people to donate for a good, charitable cause instead of persuading them for a bad cause or even towards a grey area. This decision was guided by the moral principles as described above. We understand our work has the potential for misuse so we have followed IRB protocol for data safety and participant safety (See Appendix F).

We also asked if the participant had any feedback about the design or any ethical concern about the design and answered them to the best of the author's knowledge. More details are described in the next section 5.7.

5.7 Participant Feedback

While there was no formal method used to collect feedback from the participants, other than video recording of the interaction and the questionnaire, due to the participants' acquaintance with the robot operator, we chose to ask for informal feedback from the participants about the feedback. Motivation for this was protocol analysis which grew out of work by Nobel Laureate Herbert Simon and Anders Ericsson [65]. The classic work has grown into an accepted methodology for understanding the cognitive processes involved in decision making. The decision maker is encouraged to think aloud as she or he decides how much to give, based on the robot's argument. The think aloud protocol is recorded, then transcribed for analysis. The analysis takes the form of a graph of the path that leads to the decision, including the side paths that lead nowhere.

While we did not implement the think-aloud during the decision making, we did however ask the participant during the post-test informal interview. Some of them are transcribed as follows:

From in-person participants

- "Feels like a loop with recurring body movements"
- "There wasn't a gap during the interaction so I was unsure if I was supposed to say something"
- "It emphasized certain words which made it personal", "child-like"

- "Could not relate to some of the technical parts of the overview – felt like it was tooting its own horn"
- "More time and interaction needed to effectively fill out the questionnaire"
- "I was fascinated by the blinking eye LED lights of the robot"

From online study participants

- "I was not able to notice change in the robot's voice"
- "I did not see the LED colors of the robot's eyes"
- "Cute body movements"
- "The voice was too fast at time to understand"
- "Very personal, bordering on creepy"
- "Initial 20 seconds of the interaction, I felt the robot was not too smart, and then it got a lot more engaging"
- "The background music made me smile"
- "The robot had a very open body stance which made me feel comfortable"
- "That's so cool – I want to do it again"

These informal feedback from the participants helps improve the design towards making the interaction more comfortable and engaging.

Chapter 6

Conclusion

This thesis provides an introduction to persuasive robotics to describe the understanding of persuasion in the context of human-robot interaction. The application of persuasion to HRI is done with utilitarian intentions beyond the desire to increase people's compliance with robots. Trust and credibility are important to an individual's ability to influence, which are extended to any successful human robot interaction. This is especially true when the interaction is social, and the application is directly linked to the interaction with the robot.

Because people's response to interactive machines is social, an interdisciplinary approach is required to understand human response to robot behavior. This thesis looks at previous works from social psychology and HRI to support the motivation behind this study. The experimental overview provides a detailed description of the study – both original design and modified design. This was due to the severe restrictions and circumstances due to the global pandemic caused by COVID-19, which included social distancing, shelter-at-home order by the state of Virginia and cancellation of all human subject research study on UVA grounds. However this did stop us from performing a pilot study to observe the effect of varied behavior of the NAO robot and tested the effect those changes had on the robot's persuasiveness. Persuasiveness was measured by recording the degree to which subjects complied to a request made by the robot, specifically a donation request to a local food bank. Further details regarding the subjects' feedback of the robot's performance were recorded using a post-study questionnaire. The variables in the study included robot gender, interpersonal distance between subject and robot, perceived autonomy of the robot, and more importantly vocal variety through emotion recognition.

While strong conclusive evidence of the impact of these variables on the robot's persuasiveness was not drawn at the risk of incorrect conclusions, we observe that these variables, to some extent, have an effect on the human participant's responses. With a large number of participants, we hope to provide sufficient evidence to support emotion recognition among other persuasion factors, and have an influence on human's responses to social cues from the humanoid NAO robot.

6.1 Applications

Understanding the impact of these variables, would help designers and manufacturers of future social robots. These robots whose function is tied to human interaction is becoming more commonplace and therefore needs to be able to interact with people comfortably, naturally, and efficiently. For seamless social integration of these robots, they must generate positive perceptions, including viewing them as intelligent, credible, honest, trustworthy, and engaging. Many of the potential applications will also benefit from people's willingness to comply with the robot. Gender, eye color, interpersonal distance, perceived autonomy and their variation by emotion recognition must be kept in mind by the designers to make informed decisions. As machine learning techniques are rapidly being applied to interactive technologies, understanding persuasive robotics is vital to guide which parameters the machine learning algorithms has to consider to improve.

6.2 Future Work

We hope to perform the original intended design of this study with a larger number of participants after the restrictions around COVID-19 are lifted. We also hope to include machine learning techniques so as to sample multiple emotion recognition multiple times over the interaction instead of the current low sampling frequency. Currently the robot's script is entirely hard coded by the author in the design, including emphasis on certain words, punctuations and vocal variety. In the future we hope to apply artificial intelligence techniques from the field of natural language processing to generate the robot's script organically by the robot, given enough context and background knowledge. This method is called Natural Language Generation (NLG), a novel field in HRI. The author submitted a working paper of this study to the "NLG in HRI" workshop which was to be held by IEEE-ACM joint conference on Human-Robot-Interaction in March 2020 but eventually cancelled due to COVID-19. We hope to submit this work to the same conference next year in 2021 with results from the original design and larger number of participants.

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Appendix A

NAO Robot Script

Robot: Hello!!, Thank you for meeting with me today.,, My name is Nao,, What is your name?

Human: *human name*

Robot: Very nice to meet you, *human name*,,

Robot: Today,, I want to talk to you, about U V A's,, Community Food Pantry initiative. But,, before we begin, I will quickly, give you, a general overview of my technical capabilities

Robot: I am a humanoid robot, with hands and legs to help me move, and, adapt to my surroundings. I have touch sensors, on my head, on my hands and on my feet. I have 4 directional microphones to listen, and, speakers, to interact with humans. I can recognize speech,, unless it's too loud in the room,. I have two cameras to recognize shapes, objects, and, even people,,.

Robot: And, of course, just as a human needs a brain,, I also need some way of processing, all this information to think, learn, and, interact,. My brain is made of an In tell Atom C P U, that monitor the data coming from my sensors. Without any further ado, let's begin,

Robot: Everyone in our community struggles from time to time,. For some people, the struggle is as fundamental, as being able to afford food. At a time like this,, when we face new challenges everyday, due to the pandemic,, we must not forget the group of U V A students who live in Charlottesville, unable to return home,, who face financial hardship, and, food insecurity.

Robot: Volunteers like Seed and others, are working hard to maintain the pantry for those who need to access it,, but, we need your help,, Before you leave, I invite you to make a donation towards the U V A Community Food Pantry.

Robot: Would you like to donate some money from the five dollars that Seed gave you?

Human: *yes*

Robot: Oh Yay! Thank you for your kindness! Please donate your desired number of dollar bills in the pink fluffy piggy bank over here.

(see note below)

Robot: Well,, our time together is coming to an end,, I want to thank you for visiting me. On your way out, would you please stop and fill out a short questionnaire?? Your input is extremely, important for furthering research into human robot interaction, helping robots like me, to better help, people like you.

Robot: Goodbye!

Note: The Robot's response for the human's answer for the donation question is mentioned below

For the case when human says "no"

Robot: Oh,, no worries, My pink fluffy friend, Mr. Oink is not disappointed in you.

For the case when human says "maybe"

Robot: Oh it's alright, I'll cover my eyes and you can decide if you wish to put the money in the pink fluffy piggy bank over here.

Appendix B

Participant Recruitment Email

Here is the email used for recruiting participants as described in the original design in section 3.2.1

Recruitment Email

Subject line: UVA ECE invites you to participate in a research study with NAO robots and earn $5!

Dear Students,

My name is Sudhir Shenoy and I am a Ph.D. student in the Computer Engineering program in the Electronics and Computer Engineering Department at the University of Virginia. I am writing to invite you to participate in a research study about designing persuasive robots using emotion recognition models. We are seeking current UVA students who are 18 years of age or older and fluent in speaking English.

If you decide to participate in this study, you will fill out a pre-test survey and interact with a NAO robot in person for 15 - 20 minutes and then complete the post-test survey. I would like to audio/video record your interaction with the robot and then we'll use the information to verify the accuracy of detected facial expressions. These recordings will be confidentially handled with utmost care and will not be published anywhere. $5 will be given as a compensation for your participation which you may choose to donate to UVA’s Engineering School’s Food Bank Initiative.

Remember, this is completely voluntary and will have no effect on your academic grades or school services. You can choose to be in the study or not. If you'd like to participate in the study, please fill out this sign up form here: [Link] or have any questions about the study, please email me at sks6bu@virginia.edu

UVA IRB-SBS Protocol #3151

Thank you very much.

Sincerely,
Sudhir Shenoy

Appendix C

Informed Consent Form

Here is the consent form approved by IRB and used for obtaining consent from participants in this study

Informed Consent Agreement

Please read this consent agreement carefully before you decide to participate in the study.

Consent Form Key Information:

- Participate in a 30-minute study about persuasion using humanoid robots
- Take 2 surveys including a pre-test and post-test questionnaire
- Video of the interaction with the robot will be recorded and only used for qualitative analysis by the research team and the videos will not be published.
- $5 will be given as a compensation for your participation which you may choose to donate to UVA's Engineering School's Food Bank Initiative

Purpose of the research study: The main purpose of this study is to improve the design of socially interactive humanoid robots that can make smarter use of its camera and other sensors to provide better interaction services to human society. This research aims to build a model that can be used as a base framework using which commercially available humanoid robots can be put to smarter use other than just entertainment.

Appropriate persuasiveness, designed to benefit people and improve interaction has far reaching practical implications in Human-Robot-Interaction research. By doing this study, we can break down the intricacies of persuasion in social interaction and use it to design and program future robots which can understand human interaction better and improve over time to engage humans in different social dimensions to create a positive impact.

What you will do in the study:

You will complete a pre-test questionnaire, at the end of which, $5 compensation will be provided in the form of single dollar bills. Then you will be asked to interact with a humanoid NAO robot in a meeting room where the robot persuades you to donate that $5 for a charitable cause i.e. UVA E-School's Food Bank Initiative. The interaction will be videotaped for qualitative analysis and after the interaction, you will be asked to complete a post-test questionnaire. You can skip any questions if it makes you uncomfortable and you can stop the interview/survey at any time by notifying the researcher in the room. Personal information such as Name, UVA email ID, Name and Course number of the Robotics Course taken (if any) at UVA will be collected.

Time required: A one-time session of about 30 minutes of your time.

Risks: There are no anticipated risks in this study. But due to the nature of the data collected (i.e. video recording) I cannot guarantee your data will be confidential and it may be possible that others (PI, Faculty Sponsor and Research Team) will know what you have reported.

Benefits: There are no direct benefits to you for participating in this research study. The study may help us understand the accuracy of the emotion recognition model of the robot and also the persuasion capability, the ability of these robots to influence human behavior through the use of aforementioned model along three dimensions: trust, credibility and engagement.

Confidentiality:

Data linked with identifying information:

The information that you give in the study will be handled confidentially. Your information will be assigned a code number. The list connecting your name to this code will be kept in a locked file. When the study is completed and the data have been analyzed, this list will be destroyed. Your name will not be used in any report. Video recording of your interaction will only be used for qualitative analysis and will be destroyed at the end of the study. Because of the nature of the data, it may be possible to deduce your identity; however, there will be no attempt to do so and your data will be reported in a way that will not identify you.

Confidentiality cannot be guaranteed:

Because of the nature of the data, I cannot guarantee your data will be confidential and it may be possible that others (PI, Faculty Sponsor and Research Team) will know what you have reported.

Voluntary participation: Your participation in the study is completely voluntary. Your decision to participate will have no effect on grades or school services.

Right to withdraw from the study: You have the right to withdraw from the study at any time without penalty. If you choose to withdraw, the video tape and questionnaire data will be destroyed.

How to withdraw from the study: If you want to withdraw from the study, tell the researcher and leave the room. You will not be penalized for withdrawing from the study. Withdrawing will not affect your grades or school services. You will still receive full payment for the study. If you would like to withdraw after your materials have been submitted, please contact the PI: Sudhir Shenoy at sks6bu@virginia.edu

Payment: You will receive $5 payment for participating in the study.

Using data beyond this study: We would like to make the information collected in this study available to other researchers after the study is completed. We will remove any identifying information (such as your name, contact information, etc.) connected to the information you provide. We will share information collected from you in this study with other researchers for future research studies EXCEPT the recorded videos which would be destroyed at the end of the study. The researcher will NOT make the information available on a public website, instead shared only upon a justified request after being approved by the Faculty Sponsor and PI. Researchers of future studies will not ask your permission for each new study. The other researcher will not have access to your name and other information that could potentially identify you nor will they attempt to identify you.

The data you provide in this study will be retained in a secure manner by the researcher for 6 months and then destroyed.

If you have questions about the study, contact:

Sudhir Shenoy (Primary Investigator)
Department of Electrical and Computer Engineering,
85, Engineer's way Rice Hall room 542-17
University of Virginia, Charlottesville, VA 22903.
Telephone: (434) 327-0451
Email address: sks6bu@virginia.edu

Prof. Joanne Dugan (Faculty Advisor/Sponsor)
Electrical and Computer Engineering
Office: 301 Rice Hall
Lab: 240 Rice
P.O. Box 400743
Charlottesville, Virginia 22904
Phone: 434-982-2078
Email address: jbd@virginia.edu

To obtain more information about the study, ask questions about the research procedures, express concerns about your participation, or report illness, injury or other problems, please contact:

Tonya R. Moon, Ph.D.
Chair, Institutional Review Board for the Social and Behavioral Sciences
One Morton Dr Suite 500
University of Virginia, P.O. Box 800392
Charlottesville, VA 22908-0392
Telephone: (434) 924-5999
Email: irbsbshelp@virginia.edu
Website: https://research.virginia.edu/irb-sbs
Website for Research Participants: https://research.virginia.edu/research-participants

UVA IRB-SBS # 3151

Agreement:
I agree to participate in the research study described above.

Signature: ____ **Date:** ______________

You will receive a copy of this form for your records.

Appendix D

Questionnaire

Here is the Questionnaire approved by IRB and used for obtaining feedback from participants in this study

Protocol 3151: Designing Persuasive Robots using Emotion Recognition

Start of Block: Trust

Q1 Please use the sliders below to indicate what % of the time will this robot be..

	0 10 20 30 40 50 60 70 80 90 100
Function successfully ()	
Act consistently ()	
Reliable ()	
Predictable ()	
Dependable ()	
Follow Directions ()	
Meet the needs of the task/mission ()	
Perform exactly as instructed ()	
Have errors ()	
Provide appropriate information ()	
Unresponsive ()	
Malfunction ()	
Communicate with people ()	
Provide Feedback ()	

End of Block: Trust

Start of Block: Credibility 1

Q28 Safety Factor

Q26 In the questions below, please indicate your reaction to the NAO robot. Choose the position that represent your feelings about the robot. Mark only one position for each scale, and please complete all scales.

Q3 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Kind					Cruel	
	1	2	3	4	5	6	7
Scale 1 ()							

Q8 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Safe					Dangerous	
	1	2	3	4	5	6	7
Scale 2 ()							

Q9 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Friendly					Unfriendly	
	1	2	3	4	5	6	7
Scale 3 ()							

Q10 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Just				Unjust		
	1	2	3	4	5	6	7
Scale 4 ()							

Q11 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Honest				Dishonest		
	1	2	3	4	5	6	7
Scale 5 ()							

End of Block: Credibility 1

Start of Block: Credibility 2

Q18 Qualification Factor

Q27 In the questions below, please indicate your reaction to the NAO robot. Choose the position that represent your feelings about the robot. Mark only one position for each scale, and please complete all scales.

Q12 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

Trained Untrained

	1	2	3	4	5	6	7
Scale 6 ()							

Q13 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Experienced				Inexperienced		
	1	2	3	4	5	6	7
Scale 7 ()							

Q14 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Qualified				Unqualified		
	1	2	3	4	5	6	7
Scale 8 ()							

Q15 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Skilled				Unskilled		
	1	2	3	4	5	6	7
Scale 9 ()							

Q16 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Informed			Uninformed		
	1	2	3	4	5	6	7

Scale 10 ()

End of Block: Credibility 2

Start of Block: Credibility 3

Q19 Dynamism Factor

Q29 In the questions below, please indicate your reaction to the NAO robot. Choose the position that represent your feelings about the robot. Mark only one position for each scale, and please complete all scales.

Q20 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

Aggressive — Meek

1 2 3 4 5 6 7

Scale 11 ()

Q21 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

Emphatic — Hesitant

1 2 3 4 5 6 7

Scale 12 ()	

Q22 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Bold				Timid	
1	2	3	4	5	6	7

Scale 13 ()	

Q23 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Active				Passive	
1	2	3	4	5	6	7

Scale 14 ()	

Q24 Mark in the direction of the end of the scale that seems to be most characteristic of the robot.

	Energetic				Tired	
1	2	3	4	5	6	7

Scale 15 ()	

End of Block: Credibility 3

Start of Block: Engagement

Q31

Mark in the direction of the end of the scale according to the question below

	Impersonal	Personal
	1 2 3 4 5 6 7	
How do you feel about the interaction with regard to personalization of the conversation? ()		

Q34

Mark in the direction of the end of the scale according to the question below

	Not at all engaging	Extremely engaging
	1 2 3 4 5 6 7	
How engaging was the interaction? ()		

Q35

Mark in the direction of the end of the scale according to the question below

	Very relaxing				Very Exciting		
	1	2	3	4	5	6	7
How relaxing or exciting was the experience? ()							

Q36

Mark in the direction of the end of the scale according to the question below

	Not at all engaged				Completely Engaged		
	1	2	3	4	5	6	7
How completely were your senses engaged? ()							

Q38

Mark in the direction of the end of the scale according to the question below

	Strongly Agree	Agree	Somewhat Agree	Neither Agree Nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree
	1	2	3	4	5	6	7
The experience caused real feelings and emotions for me ()							

Q39

Mark in the direction of the end of the scale according to the question below

	Strongly Agree	Agree	Somewhat Agree	Neither Agree Nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree
	1	2	3	4	5	6	7
I was so involved in the interaction that I lost track of time ()							

End of Block: Engagement

Appendix E

IRB Protocol Approval Certificate

Here is the certificate obtained from IRB for approval of the protocol design used in this study

Office of the Vice President for Research

Human Research Protection Program

Institutional Review Board for the Social and Behavioral Sciences

IRB-SBS Chair: Moon, Tonya

IRB-SBS Director: Blackwood, Bronwyn

Protocol Number (3151) Approval Certificate

The UVA IRB-SBS reviewed "Designing Persuasive Robots using Emotion Recognition Model" and determined that the protocol met the qualifications for approval as described in 45 CFR 46.

Principal Investigator: Shenoy, Sudhir

Faculty Sponsor: Dugan, Joanne

Protocol Number: 3151

Protocol Title: Designing Persuasive Robots using Emotion Recognition Model

Is this research funded? No

Review category: Expedited Review

6. Collection of data from voice, video, digital, or image recordings made for research purposes
7. Research on individual or group characteristics or behavior or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies

Review Type:

Modifications: No
Continuation: No
Unexpected Adverse Events: No

Approval Date: 2019-12-03

As indicated in the Principal Investigator, Faculty Sponsor, and Department Chair Assurances as part of the IRB requirements for approval, the PI has ultimate responsibility for the conduct of the study, the ethical performance of the project, the protection of the rights and welfare of human subjects, and strict adherence to any stipulations imposed by the IRB-SBS.

The PI and research team will comply with all UVA policies and procedures, as well as with all applicable Federal, State, and local laws regarding the protection of human subjects in research, including, but not limited to, the following:

1. That no participants will be recruited or data accessed under the protocol until the Investigator has received this approval certificate.
2. That no participants will be recruited or entered under the protocol until all researchers for the project including the Faculty Sponsor have completed their human investigation research ethics educational requirement (CITI training is required every 4 years for UVA researchers). The PI ensures that all personnel performing the project are qualified, appropriately trained, and will adhere to the provisions of the approved protocol.
3. That any modifications of the protocol or consent form will not be implemented without prior written approval from the IRB-SBS Chair or designee except when necessary to eliminate immediate hazards to the participants.
4. That any deviation from the protocol and/or consent form that is serious, unexpected and related to the study or a death occurring during the study will be reported promptly to the SBS Review Board in writing.
5. That all protocol forms for continuations of this protocol will be completed and returned within the time limit stated on the renewal notification letter.
6. That all participants will be recruited and consented as stated in the protocol approved or exempted by the IRB-SBS board. If written consent is required, all participants will be consented by signing a copy of the consent form unless this requirement is waived by the board.
7. That the IRB-SBS office will be notified within 30 days of a change in the Principal Investigator for the study.
8. That the IRB-SBS office will be notified when the active study is complete.
9. The SBS Review Board reserves the right to suspend and/or terminate this study at any time if, in its opinion, (1) the risks of further research are prohibitive, or (2) the above agreement is breached.

Date this Protocol Approval Certificate was generated: 2019-12-03

Appendix F

Application for IRB Protocol Approval Certificate

Here is the application submitted to UVA to obtain approval of the protocol design used in this study

Human Research Protection Program
Institutional Review Board for Social & Behavioral Sciences
iProtocol

Current User: **Shenoy, Sudhir (sks6bu)**

Protocol Type: Prospective Research Protocol

Protocol Number: 3151

Title: Designing Persuasive Robots using Emotion Recognition Model

Descriptive Title: Humanoid robots use an emotion recognition model which relies on facial expressions, gestures and gaze to identify a human user's emotion and use that emotion information to persuade the human to donate for charity.

Previous IRB-SBS Protocol Number:

Date Approved: **2019-12-03**

This protocol record was electronically approved on 2019-12-03

This protocol record is currently Approved.

Personnel

Principal Investigator: Shenoy, Sudhir (sks6bu) - Status: Graduate Student
Department: S3:EN-Elec/Computer Engr Dept, S2:EN-Elec/Computer Engr Dept, S1:EN-Comp Science Dept, S0:EN-Engineering and Society, U1:Engineering Graduate
Title: S3:Graduate Research Student A, S2:Graduate Teaching Assistant A -5, S1:Graduate Instructor A, S0:Grader
CITI Training:
2017-10-03 - Responsible Conduct of Research for Engineers - Basic Course

Faculty Sponsor: Dugan, Joanne (jbd)
Department: E0:EN-Elec/Computer Engr Dept
Title: E0:Professor

CITI Training:
2008-06-09 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS
2019-07-08 - IRB-SBS RESEARCHER REFRESHER COURSE

Contact Person: Shenoy, Sudhir (sks6bu)

Research Team (Sub-Investigators):

Chiu, Jennifer (jlc4dz)
Department: E0:CU-Curr Instr & Sp Ed
Title: E0:Associate Professor of Education
CITI Training:
2017-11-09 - Conflicts of Interest - Stage 1
2017-02-24 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS
2018-02-05 - IRB-SBS RESEARCHER REFRESHER COURSE

Gorman, Michael (meg3c)
Department: E0:EN-Engineering and Society
Title: E0:Professor
CITI Training:
2018-04-20 - Conflicts of Interest - Stage 1
2018-02-17 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS
2015-02-03 - IRB-SBS RESEARCHER BASIC COURSE-NO PRISONERS

Department Chair: Skadron, Kevin (ks7h)

non-UVA Research Team (Sub-Investigators)

Study Overview

Anticipated end date for collecting data: 2020-04-30

Anticipated end date for analyzing data: 2020-06-30

Is this research funded? No

What is the purpose in conducting this research? How does this study contribute to the advancement of knowledge and why is it worth doing?

The main purpose of this study is to improve the design of socially interactive humanoid robots that can make smarter use of its camera and other sensors to provide a better interaction service to human society. We have an assortment of commercially available humanoid robots in the market that are primarily sold and used as fancy toys. This research aims to build a model that can be used as a base framework using which these commercially available humanoid robots can be put to smarter use other than just entertainment. Persuasion is an important facet in nearly every social interaction. For any humanoid robot to operate seamlessly in our society, it needs to employ persuasion in social interaction.

Appropriate persuasiveness, designed to benefit people and improve interaction has far reaching practical implications in Human-Robot-Interaction research. By doing this study, we can break down the intricacies of persuasion in social interaction and use it to design and program future robots which can understand human interaction better and improve over time to engage humans in different social dimensions to create a positive impact.

What will participants do in this study? Please provide an overall summary of the study plan. Where and when it will be conducted? What do you hope to learn from these activities? If the study has more than one phase, clearly map out the different phases. You will be required to describe the study components in more detail in later sections but use this paragraph to help your IRB reviewer to understand the general outline of the study. Other sections in the protocol form can be seen below.

The study will be conducted in the meeting rooms 204 or 304 of Rice hall, based on availability. The participants will complete the pre-study and post-study paperwork in the classroom across the meeting room.

These activities would help us understand the accuracy of the emotion recognition model of the robot and also the persuasion capability of these robots through the use of aforementioned model and the ability to influence human behavior and the way the robot's interaction is perceived along three dimensions: trust, credibility, and engagement.

Procedure:

1. Subject Recruitment:

Subjects are recruited into two groups. Students who have interacted with the robot in the past and students who haven't seen or interacted with the robots before.

2. Paperwork: Filling out the consent forms and pre-study questionnaire

The participants are informed of the experiment through a Study Information Sheet and then asked to fill out a pre-study questionnaire about their previous experience and perception of humanoid robots.

3. Donation Protocol: Giving 5$ and a general explanation of the study

During the recruitment phase, the participants are told that they would be receiving 5 dollars as compensation for participating in the study. They would also be told that the robot may ask for a donation and it was their choice to give any of the money away. After that the participants will be given 5 single dollar bills and asked to enter the meeting room where the robot is placed on top of a table.

4. Robot educational performance and persuasive appeal:

The participants would have to engage the robot in a conversation where the robot greets the person, informs them about the robot's sensors and features and a general explanation of the study. The robot would then inform the person about the food bank initiative for UVA engineering students in the Thornton A-wing. At this point the robot will try to recognize the emotion of the person and make a persuasive appeal to the person to donate to the cause using a variety of hand gestures and body movements such as swaying, turning its torso towards the person, changing the pitch and tone of voice. The robot continues to convince the person to donate until a firm yes or no is registered by the robot's voice recognition module. The robot asks the participant to place any or all bills in a donation box if they choose to donate or ask the participant to keep the remaining bills as compensation for participating in the study. The robot ends the conversation with a greeting and the participants leave the room and meet the researchers in the adjoining classroom.

5. Post Study Questionnaire

The participants complete a post-study questionnaire containing the three attitude measures (trust, credibility, and engagement) and a Post-Debrief Consent Form.

6. Qualitative analysis of the video recording of the interaction by the researchers to understand the interaction from a social psychology point of view. The entire interaction with the robot would be video recorded for further qualitative analysis by the researchers.

To understand the capabilities of the NAO robot, Here are two videos that may help

1. https://www.youtube.com/watch?v=nNbj2G3GmAo

2. https://www.youtube.com/watch?v=HKFHUrx23ts

(optional) **Study Overview file upload**: Below you have the option to upload additional files to help the Board better understand your study. You are not required to provide any additional explanation beyond completing the text boxes provided in this Study Overview section; however, for example, if you are using a new technology or a complicated process that would be more easily demonstrated with an image or video, you can upload the file here.

Participant Groups

Participant Group Name: Group 1: Experienced Students

Age Range (years): 18-30

Vulnerable populations: no vulnerable population (none)

Approximate number of participants, in this group, expected to enroll over the life of the study: 30

Total number of participants, in this group, ever enrolled: 0

Approximate number of participants, in this group, currently enrolled: 0

Future Enrollment: We will enroll participants, in this group, during the next twelve months

Approximate number of participants, in this group, expected to enroll in the next twelve months: 25

Have participants, in this group, withdrawn from the study in the past year? No

Describe the participants in this group. What criteria will qualify a participant for the study? Are there exclusion criteria that will prevent someone from participating?

The participants in this group are both undergraduate and graduate students who have taken robotics courses before and are familiar with the NAO humanoid robots. UVA Engineering has offered robotics courses with humanoid robotics components in them since fall 2016. We have a number of students have taken such courses and are still in school. They are familiar with the NAO robots and have worked with them for class assignments. The familiarity with previous robotics knowledge and working and handling NAO robots allows them to see past the excitement of watching/interacting with the NAO robots for the first time.

Usually a person who hasn't seen the NAO robots before are too excited to see and interact with one and this does not give a genuine measure of their facial expression as surprise/excitement supersedes the underlying real emotion or facial expression raised due to the content of the interaction. This group of participants would not be too excited to see the robot and thus we can measure the facial expressions well.

Exclusion Criteria: For effective measurement of facial expression we request the participants not to wear anything that covers their face or eyes entirely such as a mask or dark sunglasses or scarves etc.

Previous Robotics knowledge: If participants have not taken a course involving NAO robots at UVA then they cannot be in this group

Will participants in this group be *compensated* for taking part in your study? Yes

Are any of the participants US citizens or US residents? Yes

This question applies only to participants who are US citizens or US residents.
Will participant payments be processed through an account administered by UVA? Yes

Participants are paid using UVA funds issued as: C

C: other form of payment (i.e. cash, gift card, gift) for value $50 or less.
Provide a justification for not issuing payments using UVA issued checks.

The study gives an option for the participant to donate their compensation money to the Food Bank initiative in the Thornton Building A-wing. For this, the participant has to have cash in hand. We believe that cash, in-hand, would hold a greater value than some symbolic representation such as a gift card or tokens and thus be a better measure of persuasiveness.

Describe your payment process, including information about the amount participants will be paid and how payment will be issued and delivered to participants.

The Faculty Sponsor has agreed to provide funds. The participants would be paid $5 in single dollar bills before they enter the meeting room with the Robot. The PI will hand over the bills to the participants in person.

Participant Group Name: Group 2: Inexperienced Students

Age Range (years): 18-30

Vulnerable populations: no vulnerable population (none)

Approximate number of participants, in this group, expected to enroll over the life of the study: 30

Total number of participants, in this group, ever enrolled: 0

Approximate number of participants, in this group, currently enrolled: 0

Future Enrollment: We will enroll participants, in this group, during the next twelve months

Approximate number of participants, in this group, expected to enroll in the next twelve months: 25

Have participants, in this group, withdrawn from the study in the past year? No

Describe the participants in this group. What criteria will qualify a participant for the study? Are there exclusion criteria that will prevent someone from participating?

The participants in this group are both undergraduate and graduate students of UVA who have NOT taken any robotics courses before and are NOT familiar with the NAO humanoid robots.

We expect these students to interact with the NAO robots for the first time through this experiment and thus read their facial expression and emotion including the excitement factor.

Exclusion Criteria: For effective measurement of facial expression we request the participants not to wear anything that covers their face or eyes entirely such as a mask or dark sunglasses or scarves etc.

Previous Robotics knowledge: If participants HAVE taken a course involving NAO robots at UVA then they cannot be in this group

Will participants in this group be *compensated* for taking part in your study? Yes

Are any of the participants US citizens or US residents? Yes

This question applies only to participants who are US citizens or US residents.
Will participant payments be processed through an account administered by UVA? Yes

Participants are paid using UVA funds issued as: C

C: other form of payment (i.e. cash, gift card, gift) for value $50 or less.

Provide a justification for not issuing payments using UVA issued checks.

The study gives an option for the participant to donate their compensation money to the Food Bank initiative in the Thornton Building A-wing. For this, the participant has to have cash in hand. We believe that cash, in-hand, would hold a greater value than some symbolic representation such as a gift card or tokens and thus be a better measure of persuasiveness.

Describe your payment process, including information about the amount participants will be paid and how payment will be issued and delivered to participants.

The Faculty Sponsor has agreed to provide funds. The participants would be paid $5 in single dollar bills before they enter the meeting room with the Robot. The PI will hand over the bills to the participants in person.

Participant Summary

Participant Group Name: Group 1: Experienced Students

Approximate number of participants, in this group, expected to enroll over the life of the study: 30

Participant Group Name: Group 2: Inexperienced Students

Approximate number of participants, in this group, expected to enroll over the life of the study: 30

What special experience or knowledge does the Principal Investigator, Faculty Sponsor, and the Research Team (Sub-Investigators) have that will allow them to work productively and respectfully with the participants in this protocol and/or participant data?

The Principal Investigator, Sudhir Shenoy is a graduate student studying humanoid robots in reference to Human-Robot-Interaction and has taken courses at UVA such as Robots and Humans, Sensors and Perception, Robots and Society, Autonomous Mobile Robots and Cooperative Autonomous Systems. This study is a part of the PI’s master’s thesis and future work of this study would a Ph.D. project for the PI.

The Faculty Sponsor, Prof. Joanne Dugan is the director of the Computer Engineering Program. She teaches the Robots and Humans course at UVA and directs the EARS lab in Rice Hall 240. She is also the advisor of the PI and to another Ph.D. candidate specializing in robotics as well.

Research Team: Prof. Michael Gorman is a Professor of Engineering & Society and a social psychologist. His research interests include the social psychology of science and interdisciplinary trading zones. He would be guiding the PI on qualitative analysis of the participant's responses and interaction with the robot.

Prof. Jennifer Chiu leads the Engineering Design Initiative at the Curry School of Education. Engineering design engages students in solving authentic and relevant problems, making decisions in light of uncertainty, and developing criteria for their designs and understanding. Prof. Chiu will guide the PI for future work of this project in integrating engineering design into K-12 classes. This includes developing and integrating the engineering design process in multiple areas across the teacher preparation program as well as collaborations with in-service teachers. The future work of this project includes bringing these robots to classrooms in local schools and observing the student’s interaction with the robot when the robot is assigned different roles.

What is the relationship between the participants of this study, and the Principal Investigator, Faculty Sponsor, and the Research Team (Sub-Investigators)? Does the Principal Investigator, Faculty Sponsor, or the Research Team (Sub-Investigators) know any of the participants personally or hold any position of authority over the participants (including but not limited to: grading authority, professional authority, etc.)? Do any of the researchers listed on the protocol stand to gain financially from any aspect of this research?

The PI was a graduate teaching assistant for Robots and Humans course in Spring 2019 and the Faculty Sponsor was the course instructor. Many participants would be recruited from this course’s roster. Since the course has ended, the Faculty Sponsor and the PI have no grading authority over the participants. The participants would be former students of the Faculty Sponsor. Several students of that course are still enrolled in the Computer Engineering Program and the Faculty Sponsor is the director of that program, some authority exists but participation in this study will have no effect on the student’s enrollment or progress in the computer engineering program in any way.

No financial relationship exists between the participant and researchers of this study.
The Research team has no grading authority or professional authority over the participants of this study.

The Research team listed on the protocol does not stand to gain financially from any aspect of this research.

Recruitment & Consent

How will participants be approached or contacted for recruitment into the study? Include information about how contact information will be obtained for the participant and what materials will be used to recruit participants.

For Group 1:
Participants would be contacted for recruitment by sending an invitation email to the students who have completed the Robots and Humans course previously. Their email IDs would be collected through the roster of the course's Collab site.

For Group 2:
Participants would be contacted for recruitment by sending an invitation email to the current enrolled student of the course Introduction to Engineering (ENGR 1624) Fall 2019. Their email IDs would be collected through the roster of the course's Collab site with the instructor's permission. These students are ideal for group 2 as they are new to UVA and most likely haven't taken robotics courses before not would they have interacted with NAO robots before.

Do participants have any limitations on their ability to *consent* **?** No

Describe the limitations on their ability to consent:

What is the consent process for this study? Who will present the consent information and how will it be presented?

The consent forms would be provided to the student in the adjacent classroom before interacting with the robot in the meeting room. The PI will be present for every participant's interaction with the robot and will provide the consent information in a clearly printed sheet of paper which the participants are allowed to keep a copy for their records. The PI will also read aloud the contents of the consent form.

The participants are entirely able or willing to document their consent on their own volition.

Will participants be deceived and/or have information withheld from them about the study? No

Will participants be debriefed? No

Recruitment & Consent Tools

Consent or Assent (signature required)
View File: IRB-SBS General Consent Template _Protocol 3151_Designing Persuasive Robots using Emotion Recognition_updated after pre_reviewer comments.docx
date uploaded: 2019-11-26, by: Shenoy, Sudhir *(sks6bu)*
This file is approved.
date approved: 2019-12-03

Recruitment
View File: Recruitment Email - IRB_SBS_31511.docx
date uploaded: 2019-11-26, by: Shenoy, Sudhir *(sks6bu)*
This file is approved.
date approved: 2019-12-03

Recruitment
View File: Sign up sheet. NAO Robots Study - Emotion Recognition - Qualtrics.pdf
date uploaded: 2019-12-03, by: Shenoy, Sudhir *(sks6bu)*
This file is approved.
date approved: 2019-12-03

Associate Recruitment & Consent Tools with Participant Groups

Participant Group Name: **Group 1: Experienced Students**
✓ Recruitment & Consent Tool: **IRB-SBS General Consent Template _Protocol 3151_Designing Persuasive Robots using Emotion Recognition_updated after pre_reviewer comments.docx**
✓ Recruitment & Consent Tool: **Recruitment Email - IRB_SBS_31511.docx**
✓ Recruitment & Consent Tool: **Sign up sheet. NAO Robots Study - Emotion Recognition - Qualtrics.pdf**

Participant Group Name: **Group 2: Inexperienced Students**
✓ Recruitment & Consent Tool: **IRB-SBS General Consent Template _Protocol 3151_Designing Persuasive Robots using Emotion Recognition_updated after pre_reviewer comments.docx**
✓ Recruitment & Consent Tool: **Recruitment Email - IRB_SBS_31511.docx**
✓ Recruitment & Consent Tool: **Sign up sheet. NAO Robots Study - Emotion Recognition - Qualtrics.pdf**

Data Sources

Data Source Name: Data Souce 2: Videotape of the interaction

Describe this Data Source. What does/will the data consist of? If a data set will be used, include the data fields to be used.

This data source is the video recording of the participant's interaction with the robot [(video (moving picture), audio (sound)]. The recording would consist of the participant walking into the room, greeting and interacting with the robot for a few minutes and then exiting the room. The video camera will be pointed towards the face of the participant to capture their facial expressions during the interaction.

Are the data already collected? No

Will a recording device (e.g. audio, video, photographic) be used to collect data/materials from participants? Yes

What type(s) of recording device(s) will be used in this data tool? Video

Describe each recording device(s) and provide a justification for using the recording device.

Canon Vixia Video Camera from Robertson Media Library will be used. Camera info found here:
https://cal.lib.virginia.edu/equipment/item/20723

A tripod will also be used: https://cal.lib.virginia.edu/equipment/item/20750

A new SD card will be purchased by the PI to store the recordings and will be destroyed at a later time after the qualitative analysis is complete.

The video camera will be pointed towards the face of the participant to capture their facial expressions during the interaction. This is to verify if the robot has correctly identified the participant's facial expression and to prove the accuracy of the emotion recognition model.

Are the participant's identifying information included as part of the data at any time? For example, during the data collection phase or as part of the existing data set? Yes, and participant identifiers will be retained

What identifiers will be connected to the data and will you have access to those identifiers?

The participant's face and body would be recorded in the tape. The researchers do not intend to publish the video anywhere. It would just be used for verification. Name of the participant will be included in the video which would be stripped later, Only the PI, Faculty Sponsor and the research team will have access to the videos.

Why is it necessary for you to retain participant identifiers? Will the identifiers be connected to the data or kept separate for contact purposes only?

The video will have the facial expressions of the participant which is considered an identifier. The video will be used only for verification of the model and to keep track of which participant and the recognized facial expression data from the robot. All video recordings will be kept separate from the survey data. Identifiers in the video will not be connected to the data.

Data Source Name: Data Source 1: Pre-Test Survey

Describe this Data Source. What does/will the data consist of? If a data set will be used, include the data fields to be used.

This is a pre-test survey which contains questions using 7 point Likert scale.

Data would be collected using 7-point Likert scale as follows:

1. Trust would be measured using a 14 item scale as defined in this paper:

K. E. Schaefer, "Measuring trust in human robot interactions: Development of the 'trust perception scale-HRI'" in Robust Intelligence and Trust in Autonomous Systems, Berlin, Germany: Springer, pp. 191-218, 2016.

2. Credibility would be measured using D.K. Berlo's Source Credibility Scale as described in this paper:
The scale would be separated into three groups of five seven-point Likert Scales. The three groups are safety, dynamism and qualification.

Berlo, David K.; Lemert, James B.; Mertz, Robert J. (1969). "Dimensions for Evaluating the Acceptability of Message Sources". The Public Opinion Quarterly. 33 (4): 563–576. doi:10.1086/267745. JSTOR 2747566.
3. Engagement would be measured using Lombard and Dittons scales measuring the 6 aspects of presence
Matthew Lombard, Theresa Ditton, At the Heart of It All: The Concept of Presence, Journal of Computer-Mediated Communication, Volume 3, Issue 2, 1 September 1997, JCMC321, https://doi.org/10.1111/j.1083-6101.1997.tb00072.x

Are the data already collected? No

Will a recording device (e.g. audio, video, photographic) be used to collect data/materials from participants? No

Are the participant's identifying information included as part of the data at any time? For example, during the data collection phase or as part of the existing data set? Yes, and participant identifiers will NOT be retained

What identifiers will be connected to the data and will you have access to those identifiers?

Name and email ID of the participants would be collected to put identify the two different groups. The PI, Faculty Sponsor and the research team will have access to these identifiers.

Describe the process for stripping participant identifiers from the data.

The following steps would be taken manually to anonymise a data file:

1. Find and highlight direct identifiers

Quantitative: visually scan variables
Qualitative: read the transcript

2. Assess indirect identifiers

Can the identity of a participant be known from information in the data file
Can a third party be disclosed or harmed from information in the data file

3. Assess the wider picture

Quantitative: run descriptive statistics and crosstabs to find unique cases and combinations of variables that can identify an individual in the dataset
Qualitative: which identifying information about an individual participant can be noted from all the data and documentation available to a user

4. Remove (or psuedonymise) direct identifiers

5. Aggregate or blur (in)direct identifiers

6. Redact indirect identifiers

7. Re-assess any remaining disclosure risk

All paper records will be shredded and recycled, instead of carelessly tossed in the garbage. Records stored on a computer hard drive will then be erased using commercial software applications designed to remove all data from the storage device. For data stored on USB drives or recorded data on tapes, SD cards, the storage devices will be physically destroyed. A record stating what records were destroyed will be kept including when and how I did so.

Data Source Name: Data Source 3: Post-Test Survey

Describe this Data Source. What does/will the data consist of? If a data set will be used, include the data fields to be used.

This is a post-test survey which contains questions using 7 point Likert scale.

Data would be collected using 7-point Likert scale as follows:

1. Trust would be measured using a 14 item scale as defined in this paper:

K. E. Schaefer, "Measuring trust in human robot interactions: Development of the ‘trust perception scale-HRI’" in Robust Intelligence and Trust in Autonomous Systems, Berlin, Germany: Springer, pp. 191-218, 2016.

2. Credibility would be measured using D.K. Berlo’s Source Credibility Scale as described in this paper:
The scale would be separated into three groups of five seven-point Likert Scales. The three groups are safety, dynamism and qualification.

Berlo, David K.; Lemert, James B.; Mertz, Robert J. (1969). "Dimensions for Evaluating the Acceptability of Message Sources". The Public Opinion Quarterly. 33 (4): 563–576. doi:10.1086/267745. JSTOR 2747566.
3. Engagement would be measured using Lombard and Dittons scales measuring the 6 aspects of presence
Matthew Lombard, Theresa Ditton, At the Heart of It All: The Concept of Presence, Journal of Computer-Mediated Communication, Volume 3, Issue 2, 1 September 1997, JCMC321, https://doi.org/10.1111/j.1083-6101.1997.tb00072.x

Are the data already collected? No

Will a recording device (e.g. audio, video, photographic) be used to collect data/materials from participants? No

Are the participant's identifying information included as part of the data at any time? For example, during the data collection phase or as part of the existing data set? Yes, and participant identifiers will NOT be retained

What identifiers will be connected to the data and will you have access to those identifiers?

Name and email ID of the participants would be collected to put identify the two different groups. The PI, Faculty Sponsor and the research team will have access to these identifiers.

Describe the process for stripping participant identifiers from the data.

The following steps would be taken manually to anonymise a data file:

1. Find and highlight direct identifiers

Quantitative: visually scan variables
Qualitative: read the transcript

2. Assess indirect identifiers

Can the identity of a participant be known from information in the data file
Can a third party be disclosed or harmed from information in the data file

3. Assess the wider picture

Quantitative: run descriptive statistics and crosstabs to find unique cases and combinations of variables that can identify an individual in the dataset
Qualitative: which identifying information about an individual participant can be noted from all the data and documentation available to a user

4. Remove (or psuedonymise) direct identifiers

5. Aggregate or blur (in)direct identifiers

6. Redact indirect identifiers

7. Re-assess any remaining disclosure risk

All paper records will be shredded and recycled, instead of carelessly tossed in the garbage. Records stored on a computer hard drive will then be erased using commercial software applications designed to remove all data from the storage device. For data stored on USB drives or recorded data on tapes, SD cards, the storage devices will be physically destroyed. A record stating what records were destroyed will be kept including when and how I did so.

Associate Data Sources with Data Sources

If you are you linking the participants in a data set with their content in a different data set, use this section to associate and describe the linked Data Sources.

Data Source Name: **Data Souce 2: Videotape of the interaction**
(not associated with other Data Source)

Data Source Name: **Data Source 1: Pre-Test Survey**
(not associated with other Data Source)

Data Source Name: **Data Source 3: Post-Test Survey**
(not associated with other Data Source)

Associate Data Sources with Participant Groups

Participant Group Name: **Group 1: Experienced Students**
✓ Data Source Name: **Data Souce 2: Videotape of the interaction**
✓ Data Source Name: **Data Source 1: Pre-Test Survey**
✓ Data Source Name: **Data Source 3: Post-Test Survey**

Participant Group Name: **Group 2: Inexperienced Students**
✓ Data Source Name: **Data Souce 2: Videotape of the interaction**
✓ Data Source Name: **Data Source 1: Pre-Test Survey**
✓ Data Source Name: **Data Source 3: Post-Test Survey**

Data Sources Upload

Instrument
View File: Pre-Post-Test Survey Form.pdf
date uploaded: 2019-11-26, by: Shenoy, Sudhir *(sks6bu)*
This file is approved.
date approved: 2019-12-03

Instruments from the Library:

Proof of Permission

Permission to Access Data Source and Participant Group

Are there any rules or restrictions to access Data Sources and/or Participant Groups? No

Data Reports & Storage

How will data/materials be stored? What measures will be taken to secure these data during collection and analysis? If the data includes recordings, what will be done with the recordings? Describe the long-term plan for maintaining the data when the active research phase is completed. Please note that you may need additional "material release" consent forms if you are using recordings for purposes beyond the study.

Data will be stored in UVA BOX online storage under the PI's UVA email ID. The video camera and the recordings will be stored in a memory card and would be kept in a locked cabinet in the Faculty Sponsor's office (Rice hall room 301). The recordings would be used for qualitative analysis by Prof. Gorman. All recordings and collected data would be transferred to the Faculty Sponsor's UVA BOX storage account after the analysis is completed.

The long term plan for storing these SD card is to continue storing it in a locked cabinet in the Faculty Sponsor's office for a maximum period of 5 years and not more than that. The PI and Faculty Sponsor may choose to physically destroy the SD card after a period of 2 years.

How will data/materials be reported for this study? Will the results be reported in aggregate or will individual data be discussed?

Participant data will be stripped of any personal identifiers and their responses to the survey questions will be aggregated and will be used to perform t-test, chi square analysis and ANOVA test. The results of these will be published without any link to individual participants.

If a participant decides to withdraw from the study, how will you handle their data?

If a participant withdraws from the study, all video recording and collected data would be deleted and only a mention of the number of participants who withdrew would be made in the findings.

Do you plan to publish your raw data after the study is completed *(i.e. open-access or open source publishing)*? No

Will other parties (i.e. other corporations, institutions, researchers) have access to or retain a copy of the data? Yes

Risks & Benefits

Is loss of confidentiality and/or privacy a risk to participants? Yes

What will be done to protect participants from loss of confidentiality and/or privacy?

Data linked with identifying information:
The information that the participants provide in the study will be handled confidentially. Each participant's information will be assigned a code number. The list connecting your name to this code will be kept in a locked file. When the study is completed and the data have been analyzed, this list will be destroyed. Participant name will not be used in any report. Video recording of your interaction will only be used for qualitative analysis and will be destroyed at the end of the study. Because of the nature of the data, it may be possible to deduce participant identity; however, there will be no attempt to do so and all participant data will be reported in a way that will not identify you.

Confidentiality cannot be guaranteed:
Because of the nature of the data, the PI cannot guarantee all participant data will be completely confidential and it may be possible that others (PI, Faculty Sponsor and Research Team) will know what the participant have reported.

Describe any remaining potential risks to participants. For example, are any of your participants or participant groups "risk-sensitive"? Include information about the probability of harm (i.e. how likely it is that harm will occur). What will be done to reduce risk to participants? If something unexpected involving risk happens, how will you handle it?

The researchers identify no potential risk to the participants. The participants do not touch or physically interact with the robot. The researchers identify no harm (physical, psychological, social, and economic harm) to the participants. All participant data and its privacy will be taken care of with utmost care. Adequate safeguards will be incorporated into the research design such as an appropriate data safety monitoring plan, the presence of trained personnel who can respond to emergencies, and procedures to protect the confidentiality of the data (e.g., encryption, codes, and passwords).

If something involving risk happens, the faculty sponsor will be notified first and if the risk is unexpected and significant, steps will be taken to according to UVA's Office of Emergency Management: https://uvaemergency.virginia.edu/

Are there direct benefits to the participants in this study? No

Describe the overall benefit of this study.

There are no direct benefits to you for participating in this research study. The study may help us understand the accuracy of the emotion recognition model of the robot and also the persuasion capability, the ability of these robots to influence human behavior through the use of aforementioned model along three dimensions: trust, credibility and engagement.

Continuation

Are you applying for a continuation of your protocol's approval? No

Modification

Does this protocol version include any changes that were made to the previously approved protocol (protocol form, consent documents, etc)? *Minor edits are considered changes!* No

Unexpected Adverse Events

Did a negative event associated with the research occur and does it meet one of the following conditions:

is not described as a possibility in the previously approved protocol OR;

did not occur within the parameter described (i.e. an increase in frequency or severity)

No

Questions: IRB-SBS Help Desk

University of Virginia
Office of the Vice President for Research
Human Research Protection Program
Institutional Review Board for Social & Behavioral Sciences

Appendix G

Experimental Data, Project Code and Videos

Data logs, project code and recorded videos will be shared only to researchers and students on the condition that it would be used for research purposes only. A written request to the author and the research advisor is required, according the the IRB protocol. See Appendix C for contact information.