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A Sociable Humanoid Autonomous Robotic Platform (the SHARP Project): An evaluation of the G.E.N.E.S.I.S. robot as an interactive consumer robotic platform

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A SOCIABLE HUMANOID AUTONOMOUS ROBOTIC PLATFORM (THE SHARP PROJECT): AN EVALUATION OF THE G.E.N.E.S.I.S. ROBOT AS AN INTERACTIVE CONSUMER ROBOTIC PLATFORM

An Abstract of a Thesis

Submitted

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science

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ABSTRACT

The Social Humanoid Autonomous Robotic Platform (SHARP) project is an android project that was created with the intent of making learning about androids and robotics easier for the novice, diverse for the expert, educational in the classroom, and useful in the home or business. The project centers itself on its simplicity, low cost, and expandability. This paper illustrates how the SHARP Project has the potential to be an affordable fit in nearly every modern setting. The introduction of the SHARP project lays the groundwork for people of many ages, incomes, and educational levels to take advantage of robotics technology. The SHARP project features research based, in part, on a personal android project named "G.E.N.E.S.I.S." as an example of the SHARP project's features. The features of G.E.N.E.S.I.S. include voice recognition, speech synthesis, and responses to various sensor stimuli which help encourage human-robot interaction. This study uses survey results to examine the factors that make these robots desirable to consumers and identifies which factors make some robots more sociable than others. The study concludes with an evaluation of the G.E.N.E.S.I.S. robotic platform and suggests an appropriate market niche for this and other similar sociable humanoid robotic platforms.

Keywords: android, human-robot interaction (HRI), sociable robots, humanoid robots, GENESIS, G.E.N.E.S.I.S., SHARP Project

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Date	Dr. Hong (Jeff) Nie, Thesis Committee Member
Date	Dr. Michael J. Licari, Dean, Graduate College

DEDICATION

I would like to dedicate this work to my Grandmother M. Dorothy Rick, who has been there for me all of my life, through my hardest and roughest days and most discouraging moments, you were there to pick me up and keep me grounded. You gave me a place to live when I had nowhere else and you gave me food when I was hungry. You had complete confidence in my ability to succeed in my education, my career, and my life's work. You were my best friend and the inspiration for all of the work that follows. You are missed every day of my life and will live always in my heart. Thank you for being the candid, loving, caring, supportive, beautiful woman you have been since my earliest memories.

My Beloved Grandmother, until we meet on the other side may Heavenly Father keep you in his grace.

Rest in Peace

Margaret Dorothy Rick

3/2/1912 - 4/14/2008

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My family has been an amazing source of love, support, inspiration and encouragement through every step of my life especially my graduate work; my parents James and Barbara Rick, my grandmother Dorothy, my sister Julie, and my daughters Jordan, Kimberly, and Lisa, from the very bottom of my heart, Thank You!

Finally, I would also like to offer a very special Thank-You to my Lord and savior Jesus Christ who has blessed me and sustained me through the trials and tribulations of this work and in my life in general. Without the grace of the Holy Spirit, none of this work would be possible.

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CHAPTER 1

INTRODUCTION

Background

For the last 50 years, computers have played an increasingly integral role in the way people live their lives. With each new generation of computer technology, comes a newer, stronger, cleaner human-computer interface. As we add devices such as microphones, cameras, scanners, and other peripheral devices, we come a little closer to making our computers appear and behave more intelligent and act more human-like in nature. The addition of robotics in the computer field has added yet another dimension of interaction in which we can use to communicate with our computers.

In the field of human computer interaction (HCI), research by Reeves and Nass (1996) has shown that humans (whether computer experts, lay people, or computer critics) generally treat computers as they might treat other people. From their numerous studies, they argue that a social interface may be a truly universal interface (Breazeal, 2002; Reeves & Nass, 1996). The use of human-like features for social interaction with people can facilitate our social understanding. It is the explicit designing of anthropomorphic features, such as a head with eyes and a mouth that may facilitate social interaction (Duffy, 2003, p. 1).

Giving our computers a physical body (i.e., the body of a robot) allows us to physically interact with our computers as well as using the typical keyboard / mouse interface. The level of interaction between robots and humans is called sociability and these robots are described as "social robots." A social robot is a new type of robot whose major purpose is to interact with humans in socially meaningful ways (Breazeal, 2002; Fong, Nourbakhsh, & Dautenhahn, 2003; Lee, Jung, Kim, & Kim, 2006). These robots pose a dramatic and intriguing shift in the way one thinks about control of autonomous robots (Breazeal, 2002). So what makes a robot, or computer, sociable? This study focuses on the factors which make robots sociable and how these factors affect the overall interaction paradigm of the human-computer relationship.

> Social robots, such as those that operate in health care institutions and in museums, need to communicate with people in ways that are natural and easily understood, even by non-roboticists. We believe that one way to improve these interactions is to have robots display changing moods and emotions, just as humans do (Kirby, Forlizzi, & Simmons, 2007, p.1).

The human face is the dynamic icon of the human identity and is the primary input-output device of the human species. Thus, the humanlike robotic face could be one of the most promising new paradigms for computer interfaces (Hanson, 2007). This thesis focuses on the characteristics of the human face and head, when integrated into a robots appearance, and its effect on a robots sociability and desirability from a consumer stand-point.

Statement of the Problem

Robots in industry, education, and personal interests have become an outstanding part of our lives and are quickly immerging as a factor in the way we will live in our future. For this reason it is becoming increasingly important to make robotic products easier to interact with, easier to find, easier to understand, and easier to purchase. This study addresses the human-robot interface problem and proposes a solution through the development of a robotic platform designed specifically for human-robot interaction (HRI). Implementation of these robotic platforms in environments like schools, homes, and the work place will significantly reduce the learning curve needed to use robots efficiently and will make the overall end-user experience more enjoyable .

Purpose of the Study

The Social Humanoid Autonomous Robotics Platform (SHARP) project is an android project that was created with the intent of making learning about androids and robotics easier for the novice, diverse for the expert, educational in the classroom, and useful in the home or business. To achieve this, first we must discover what makes androids desirable for various applications and what factors make some robots more sociable than others. The project will be a comprehensive study of the factors that affect human robot interaction. In finding the relationships with these factors, we will be able to create and develop androids that are simplistic, interactive, low cost, and expandable. The introduction of the SHARP project lays the groundwork for people of many ages, incomes, and educational levels to take advantage of robotics technology. The project will feature a personal android project; a custom designed and built robotics system called "General Engineering Network of Electronically Simulated Intelligent Systems" (G.E.N.E.S.I.S.). G.E.N.E.S.I.S. will be used to test specific factors being investigated in this study as well as being used as an example of the SHARP project's features and functions and will also serve as a research tool for interaction between humans and robots. These interactions will be observed and studied in order to better understand the factors involved in the interaction between humans and robots. As these factors become more apparent, they will be used to create a more sociable android platform. With these targets in sight, the SHARP Project has the potential to be a logical and affordable fit in nearly every modern setting.

Need and Justification

This study attempts to expand on solutions proposed by Cynthia Breazeal and David Hanson in their research to the following questions, statements, and concerns.

> "As robots take on an increasingly ubiquitous role in society, they must be easy for the average citizen to use and interact with. They must also appeal to persons of different age, gender, income, education, and so forth. This raises the important question of how to properly interface untrained humans with these sophisticated technologies in a manner that is intuitive, efficient, and enjoyable to use. What might such an interface look like?"(Breazeal, 2002, p. 16).

As intelligent machines such as computers and robots advance, the interface used for communication between humans and computers becomes more important when considering the effectiveness and efficiency of communication between the two. The presumably ideal interface between man and machine is a machine that has human like features or qualities that can act and react as a human would with another human. This can be accomplished by exploring the human qualities used for communication and integrating them with computer communication methods.

Research Hypotheses Questions

The following research hypothesis questions are analyzed.

1. Which features do potential consumer groups most want in robotic systems.

2. Which factors encourage the sales of robotic systems?

3. In which environments are consumers comfortable interacting with robotic systems?

4. How appropriate is the G.E.N.E.S.I.S. robotic platform, as a product, for the consumer market?

Assumptions

The following criteria are assumed based on the research methodology.

1. People willingly participating in the survey or any evaluation and are being honest and attentive to the survey being issued to them.

2. The software used for modeling the results attained in this study is capable of completing the final models with the data provided within an acceptable range of error.

Limitations

1. This study will focus only on a set of initial variables. This leaves out some variables that may be realized later during the survey that would not be able to be studied as intently as the original variables without resetting the study.

2. Due to the budget of this study, the samples will be limited to the mid-west (Iowa) area; however, the target population is the global consumer population.

Definition of Terms

The following terms have been defined to clarify their use in the context of this study.

- Autonomous. (n.d.) Free from external control and constraint in e.g. action and judgment. (Wordnet, 2012)

- Humanoid. (n.d.) Android; an automaton that resembles a human being. (Wordnet, 2012)

- Interaction. (n.d.) A kind of action that occurs as two or more objects have an effect upon one another. The idea of a two-way effect is essential in the concept of interaction, as opposed to a one-way causal effect. (Wikipedia, 2012)

- Personality Simulating Device (PSD) Any device used by computer or robotic system to emulate or simulate a human emotion or behaviour.

- Platform. (n.d.) The combination of a particular computer and a particular operating system. (Wordnet, 2012)
- Robot. (n.d.) Automaton; a mechanism that can move automatically. (Wordnet, 2012)
- Robotics. (n.d.) The area of AI is concerned with the practical use of robots. (Wordnet, 2012)
- Sociable. (n.d.) Inclined to or conducive to companionship with others; "a sociable occasion"; "enjoyed a sociable chat"; "a sociable conversation"; "Americans are sociable and gregarious." (Wordnet, 2012)
- Uncanny-Valley. (n.d.) A hypothesis that when robots and other facsimiles of humans look and act almost like actual humans, it causes a response of revulsion among human observers. (Guizzo, 2010)

CHAPTER 2

REVIEW OF RELATED LITERATURE

Social Robotics Overview

The field of social robotics has been evolving into its own classification of the robotics field for the last fifty years. Researchers across the globe have recognized the need to study and improve these machines in hopes of eventually enhancing our daily lives in fields involving health care, day care, early childhood development, and elderly care. While the concept of a social robot can be defined as simply as: "a robot that participates in social interactions with people in order to satisfy some internal goal or motivation" (Kidd & Breazeal, 2005), the actual process involved in achieving this goal is a multi-layered process. This process consists of the design work involved in building the social robots physical body, understanding what society considers social behaviour and developing attributes of this behaviour which can be integrated into a robots software, observing the paradigm differences between human-human interaction and human-robot interaction when submerged in social situations, and making sociable robots act social while avoiding the "uncanny-valley" effect.

Social Hardware

A considerable amount of time and money are spent in the physical development of a social robot, long before the robot takes on any actual social behaviour. The robots physical appearance can set the mood for social interaction. In order for a social robot to be completely integrated into a human society, it must be able to understand and interpret human behaviour, speech, gestures, and body language as well as have an ability to reply to these gestures with its own form of social communication. Humans have been communicating with computers and robots by using keyboards, mice, and monitors as their primary interface to the machine world, however, this interface is becoming obsolete and unacceptable in light of voice recognition and other human-sensory devices, speech emulators, and robots with arms, legs, hands, and faces that are able to simulate human behaviour as a means of communication.

In Li, Rau, and Li's study, "A cross-cultural study: Effect of robot appearance and task", a robot's appearance verses its assigned task was measured. The study found positive correlations between a robot's appearance and its likability. This correlation also supports the statement that the more likable the robot is, the easier the robot is to interact with. The study also found that participants expected a robot's appearance to match its assigned task (Li, Rau, & Li, 2010).

Takacs and Hanak have developed an autonomous robot platform to be used for drug compliance and monitoring using facial recognition. It uses a monitor with a facial feedback display which allows in-home patients to feel personally connected and thus, more comfortable while interacting with the robot (Takacs & Hanak, 2008).

"Integration of a Low-Cost RGB-D Sensor in a Social Robot for Gesture Recognition" by Ramey et al., focuses on improving gesture recognition in social robots by integrating a low-cost commercial RGB-D (Red Green Blue - Depth) sensor in a social robot in order to enable it to recognize dynamic gestures in human behaviour. This is done by coding the temporal signature of the gestures detected by tracking a skeleton model of the subject in a Finite State Machine. Using these sensors allow robots to more accurately tract people and objects as well as recognize the gestures made by humans in every-day conversation (Ramey, Gonzalez-Pacheco, & Salichs, 2011).

Hirose and Ogawa discuss Honda's humanoid robot ASIMO in their article "Honda humanoid robots development." The article provides a summary of the robots physical and interactive functions. They also discuss the history and evolution of Honda's groundbreaking robot as well as Honda's goals for the future of ASIMO (Hirose & Ogawa, 2007).

Social Software

Software is the key to robot intelligence. While computers have had the ability to communicate with humans for decades, the actual level of communication, in regards to social interaction, has been very limited until recently. Various software models have been used to establish an acceptable version of a robotic-social paradigm. These strategies attack this problem from several different angles ranging from emotion detection and emulation to gesture and body language recognition that will allow robots to better understand its surrounding environment.

Cynthia Breazeal discusses the progress in social-robotic behaviour she has made with her research group, the Personal Robots Group at the MIT Media Lab. Her article "Role of expressive behaviour for robots that learn from people" is a review of over eight years of social-robotic research which focuses on four key challenges in developing robotic social interaction skills (Breazeal, 2009).

Michalowski et al. developed a social robot that plays "Social Tag," a task in which robots find and distinguish different humans by social gestures and behaviour. The research supports the idea that human social behaviour can be used to help robots achieve their assigned tasks (Michalowski et al., 2007).

The WE4-RII robot was designed to interpret and emulate human emotions by interacting with both human agents and with other robots that can emulate emotion and emotional behaviour. This study concludes that robots can be used to assess how factors like anthropomorphism affect neural responses stimulated by human actions (Chaminade et al., 2010).

Theories Involving Social Robots

Once a robot has its hardware and software, how do we know how it's going to act? This question seems simple enough, considering that a robot, or any computerized machine for that matter, will simply run its programming until its task has been completed, right? As simple as this may sound, the actual behaviour of the robot may become more unpredictable as its programming becomes more complex. When put into social situations where a robots environment is both dynamic and unpredictable, its behaviour, and the behaviour of the people interacting with it, start showing characteristics of their own unique social paradigm. These behaviour patterns are studied by several groups who attempt to understand more about social robotic behaviour by comparing human-robot interaction to human-human interaction.

Krach, et al. study the concept called "Theory of Mind" (ToM) which describes how humans perceive interaction with computers and robots on a neurological level. The study examines cortical activity and gauges responses to different stimulation offered by interaction with robots and computers. The study suggests there is a positive correlation between human-likeness in robots and the cortical activity caused as a result of interaction with human-like robots (Krach et al., 2008).

Waytz, Epley, and Cacioppo in their article "Social Cognition Unbound: Insights into Anthropomorphism and Dehumanization" summarize the characteristics of anthropomorphism into three main factors: elicited agent knowledge, sociality motivation, and "effectance motivation." They use these factors to discuss the humanization of non-human agents as well as the dehumanization of humans and their subsequent treatment as animals or objects (Waytz, Epley, & Cacioppo, 2010).

The study entitled "Computation of Emotions in Man and Machines," by Robinson and Kaliouby use techniques for studying emotions in humans, introduced by Charles Darwin in the nineteenth century, to observe and compare emotions emulated by intelligent machines. These techniques observe body language and facial expressions generated by both digital avatars and robots with facial expression capabilities. The results of this study are used to determine the minimum factors necessary in emotional expression in machines (Robinson & Kaliouby, 2009).

Coeckelbergh compares human-robot interaction to human-animal interaction in his paper titled: “Humans, Animals, and Robots: A Phenomenological Approach to Human-Robot Relations.” He attempts to clarify the similarities and differences in interaction styles by comparing and contrasting the relationships between humans and robots, humans and animals, and between animals and robots by illustrating how each is perceived by the other given different contexts and times. He raises the issue of a robot’s appearance verses its functional intent compared to a human’s or an animal’s appearance and perception. He suggests that a robots appearance and function should be closely related for easier human-robot interaction (Coeckelbergh, 2011).

Current Research with Social Robots

This study also considers current research in the social robotics field. Several trials have been conducted using social robots in specific situations to assess the robots ability to interact with its environment, as well how the robots environment interacts with the robot. Since social robots have potential uses that range from early childhood development, to taking care of elderly patients in retirement homes, various studies have been done to observe human-robot interaction in these fields.

Tanaka et al. immersed a social humanoid robot into a classroom filled with toddlers over the age of five months to observe the sociability of the robot and its relationship with the toddlers. Their article “Socialization between toddlers and robots at an early childhood education center” describes the behaviour exhibited by the toddlers and their reactions to changes in the robots programming as well as long term behaviour patterns in interaction between the children and robot over the course of the five month study. Their research results indicate that sociable robots, when allowed to interact with children in classroom environments, may encourage the developmental of social and behavioral skills (Tanaka, Cicourel, & Movellan, 2007).

Michalowski et al., discuss human-robot interaction in relation to human-robot team challenges where a robot must complete a task with the guidance of social gestures offered by human team mates. The social robot GRACE was used at the AAAI 2005 Mobile Robot Competition & Exhibition to play a game called "social tag." Their results suggest that their methods for social interaction allow people to help robots achieve their goals (Michalowski et al., 2007).

Glenda Shaw-Garlock compares the works of American robotic researcher Cynthia Breazeal at the Massachusetts Institute of Technology and her sociable robot project: Kismet and Japanese researcher Hiroshi Ishiguro at the Osaka University and his project: Repliée-Q2, in her article titled "Looking Forward to Sociable Robots." In this study, Shaw-Garlock examines the characteristics embodied and social intelligence, morphology and aesthetics, and moral equivalence of both robots in an attempt to understand the underlying concepts associated with each, which is connected to the societal preconditions of the robots (Shaw-Garlock, 2009).

Dautenhahn addresses the various dimensions of human-robot interaction and examines different paradigms regarding 'social relationships' between humans and robots. The paper entitled "Socially Intelligent Robots: Dimensions of Human-Robot Interaction" investigates the development of a cognitive companion and attempts to establish social rules for social-robotic behaviour. She discusses the possible educational and therapeutic benefits robots may provide in educational environments, especially those specific to children with autism (Dautenhahn, 2007).

Hancock et al. review datasets from twenty-nine empirical studies to determine the human-robot trust relationship correlation in the human-robot interaction scenario. Their findings indicate that human-robot trust is based mostly on the robots ability to accomplish its task as well as some notable environmental factors involved with the task being performed. The relationship was found to be influenced very slightly (if not at all) by human characteristics involved in the relationship (Hancock, Billings, & Schaefer, 2011).

Bemelmans et al. review current literature on the interaction between socially assistive robots and elderly patients in their article "The Potential of Socially Assistive Robotics in Care for Elderly, a Systematic Review." The article reviews research from eight different publication libraries as well as various internet sources found outside of the main libraries searched. They have concluded the use of robotic systems in health care seems generally accepted, based on their initial results; yet still require more in-depth research before robots can be seamlessly integrated into the healthcare profession for the purpose of actual interaction and health care provision (Bemelmans, Gelderblom, Jonker, & Witte, 2011).

Uncanny-Valley

What happens when robots look and act "too human" or even "not quite human enough?" In cases where people interacting with robots being used as human replicas look and act almost, but not perfectly, like actual human beings, can cause a response of repulsion. This is usually brought on by a robot moving, speaking, or behaving in anyway abnormally in comparison to its human counterpart. This phenomenon is referred to as the "Uncanny-Valley" effect and has been studied by researchers interested in dulling the line between human-human interaction and human-robot interaction.

Yamamoto et al. determined that children between the ages of two and three years acted negatively toward robots with non-human appearances in social situations. The study used computer images that resembled the human as well as non-human faces to determine what effect the paradigm of the human face has in regard to elementary human interaction. This study supports the "uncanny-valley" effect that robots create when they look human but do not react in human-like ways, or they act as a human would act, but without having a human-like appearance (Yamamoto, Tanaka, Kobayashi, Kozima, & Hashiya, 2009).

Dubal et al. find that humans read emotional responses from faces without regard to its origin. The study had participants examining pictures of emotional presentations from both human and robotic subjects. Their results concluded that humans react similarly with either stimulus (Dubal, Foucher, Jouvent, & Nadel, 2011). Figure 2.1 shows the uncanny-valley with respect to familiarity.

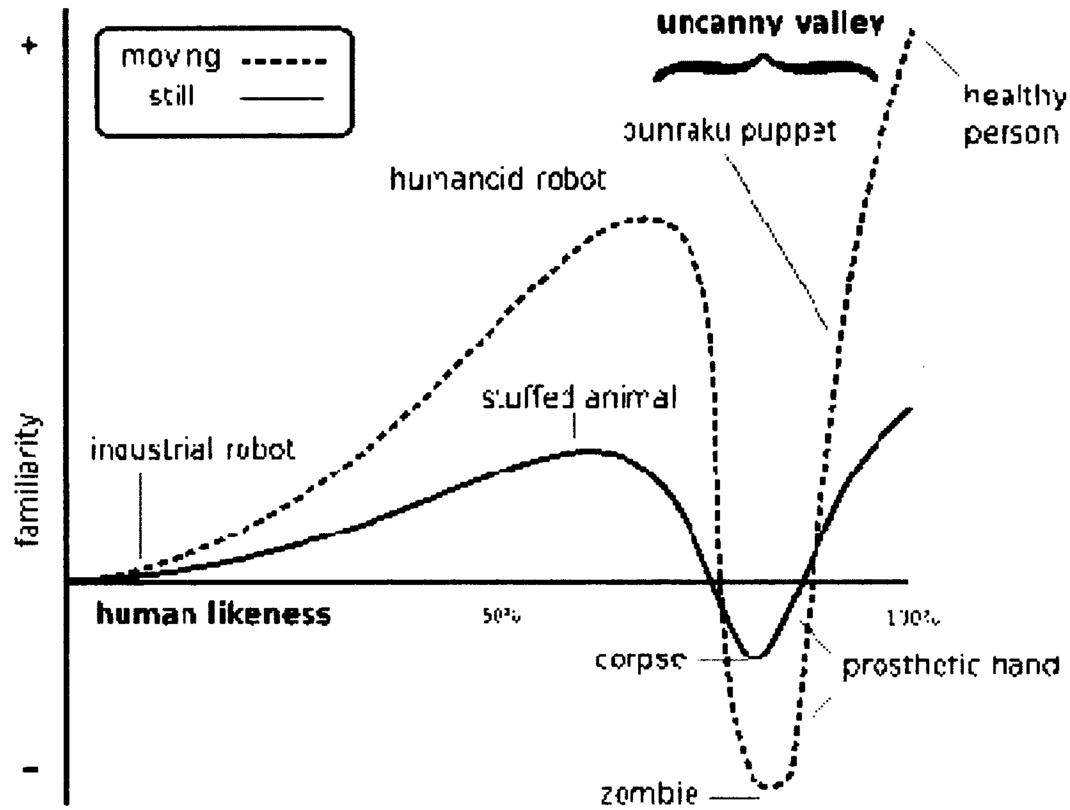

*Figure 2.1.*The Uncanny-Valley

Summary

Researchers are attacking the social robotics field from almost every angle in an attempt to make robots more sociable than ever before. Since there are so many potential applications for social robots in industry, healthcare, and education, it is difficult to propose a "one-size-fits-all" solution to every social human-robot environment. A particular team may present a robot that performs wonderfully in an elderly healthcare environment, but then may perform inadequately in an environment involving children, animals, or even other robots. It is the intent of this research to develop a robotic platform that will accommodate this "one-size-fits-all" situation and introduce a robot that can be used and/or modified to be used in almost every social situation with negligible added expenses or training.

CHAPTER 3

METHODOLOGY

Social Humanoid Autonomous Robotic Platform

The development of the Social Humanoid Autonomous Robotic Platform (SHARP) Project is presented in three tiers. The function of Tier One is to collect and evaluate information on currently existing social robots as well as consumer information regarding social robotics. This information will be used to assess what features and qualities are desirable to consumers as well as what qualities are useful, if not necessary, in developing a social robotic platform. The function of Tier Two is to design and build a simple social robotic platform that can be modified and tested to accommodate different variables used in human – robot interaction. Tier three will integrate and test variables on the platform to further evaluate the results collected during the first tier of the study. This will allow the SHARP Project to evolve by means of constantly upgrading the technology based on the most current information gathered from the variables being studied. The SHARP Project Overview in Figure 3.1 illustrates the three tier systems functionality.

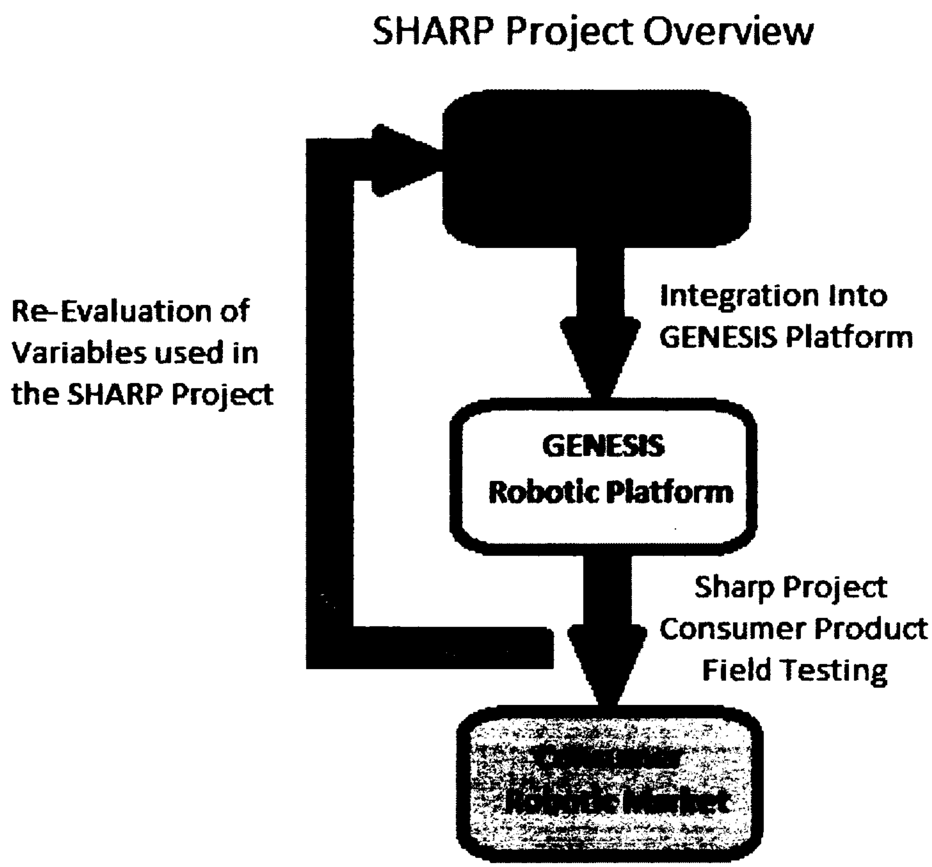

Figure 3.1. Functional Block diagram of the SHARP Project

The Survey

The survey used was designed to target the general consumer electronics market along with focusing on a high concentration of people in the educational field both as students and teachers. The main target market for the SHARP project is the educational field, so, with this in mind, the survey was designed and distributed in a manner that reaches a high concentration of consumers in the educational disciplines. These potential consumer groups will be targeted and asked which features they most want in robotic systems (Hobbyists, Educational Systems, Businesses, Health-Care, and General Household Applications). In developing the survey, the following procedure was considered:

1. Create a list of potential factors which may influence the way robots are perceived, distributed, and interacted with.
2. Develop a survey style questionnaire to distribute to the sample population.
3. Distribute survey to all samples through social networking media.
4. Collect and analyze the survey data.

The purpose of the first two questions of the survey was to categorize consumers into groups by age (0-15, 16-25, 26-39, 40- 49, 50 and over) and to categorize consumers into groups by occupation (student, educational, retail, health-care, food service, Other/Unemployed).

The next 21 questions polled respondents on their current technology usage and their opinions toward developing technology in the future. Of these questions, the first half discusses actual features that consumers either currently use or would be willing to use with their typical computer systems. These features focus mainly on voice recognition, speech reproduction, interactivity, and the computer's appearance itself. The last set of questions focuses on the environments in which the user feels it is appropriate for robots to be utilized. Environments such as health-care, day-care, school systems, and correctional facilities were suggested for respondents to express their approval.

Finally, the last two survey questions ask the respondent to leave a short answer regarding which features they feel are important and would like to see in up-and-coming technology. A complete copy of the survey can be found in APPENDIX B. Feature lists generated from respondents are expected to include (but not limited to) items regarding battery life, processor speed, range of motion, durability, interactivity, ease of usage, expandability, and customizability. Answers to the final question are expected to range from price, expandability, availability, size, appearance, customizability, product life, durability, warranty, manufacturer name/reputation, and other unknown, unlisted, or indescribable factors. Some respondents are expected to reply with answers similar to: "Don't want/don't like robots at all." The answers gathered from the survey will be used to answer the research questions:

- Which features do potential consumer groups most want in robotic systems?
- Which factors encourage the sales of robotic systems?

- In which environments are consumers comfortable interacting with robotic systems?

The answers to these three questions will then be used to speculate and determine a reasonable response to the research question posed:

- How appropriate is the G.E.N.E.S.I.S. robotic platform, as a product, for the consumer market?

Sample Collection

- Contact businesses, schools, and public social networking media to obtain samples from each group.

- Distribute surveys and questionnaires to be filed out by participants in order to obtain general information. The surveys will be distributed on line via www.facebook.com and other social media.

Sample Analysis

- Transfer answers from the surveys to Microsoft Excel and SPSS-PASW software to create a list of the most critical factors in human-robot interaction.
- Statistical analysis will be generated by the SPSS-PASW program to perform an ANOVA (analysis of variance) that will be used to determine the most effective factors in making a robot sociable and desirable to the consumer. Microsoft Excel will be implemented to show relationship tables and variable significance obtained from the study.
- Create a model for a social robot based on the findings
- Data that is not easily interpreted by the SPSS-PASW software will be discussed during the conclusions and recommendations section of the report and suggestions will be made as to incorporating them in a viable model.

The Interactive Face of G.E.N.E.S.I.S.

> As robots take on an increasingly ubiquitous role in society, they must be easy for the average citizen to use and interact with. They must also appeal to persons of different age, gender, income, education, and so forth. This raises the important question of how to properly interface untrained humans with these sophisticated technologies in a manner that is intuitive, efficient, and enjoyable to use. What might such an interface look like? (Breazeal, 2002, p. 16)

G.E.N.E.S.I.S. has 16 degrees of freedom (DOF) which are actuated by the sixteen servo motors in the cranial unit. Each servo controls movement of one specific part of the face and head. A servo placement map has been added to illustrate the position and function of each servo motor, as shown in Figure 3.2.

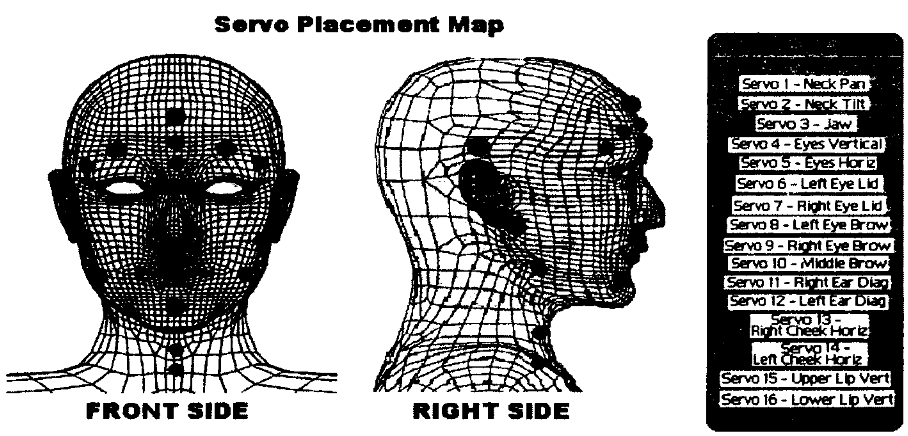

Figure 3.2. Servo Placement Map

While it is possible to emulate simple expressions with fewer than sixteen motors, sixteen motors placed strategically can effectively emulate almost every common human expression with a wide range of attitude for each expression such as an open-mouth smile or a wide-eyed wink. Figure 3.3 shows the G.E.N.E.S.I.S. prototype expressing various emotional expressions using facial servo motors which control mouth, eye, eye-lid, eye-brow, and head positioning.

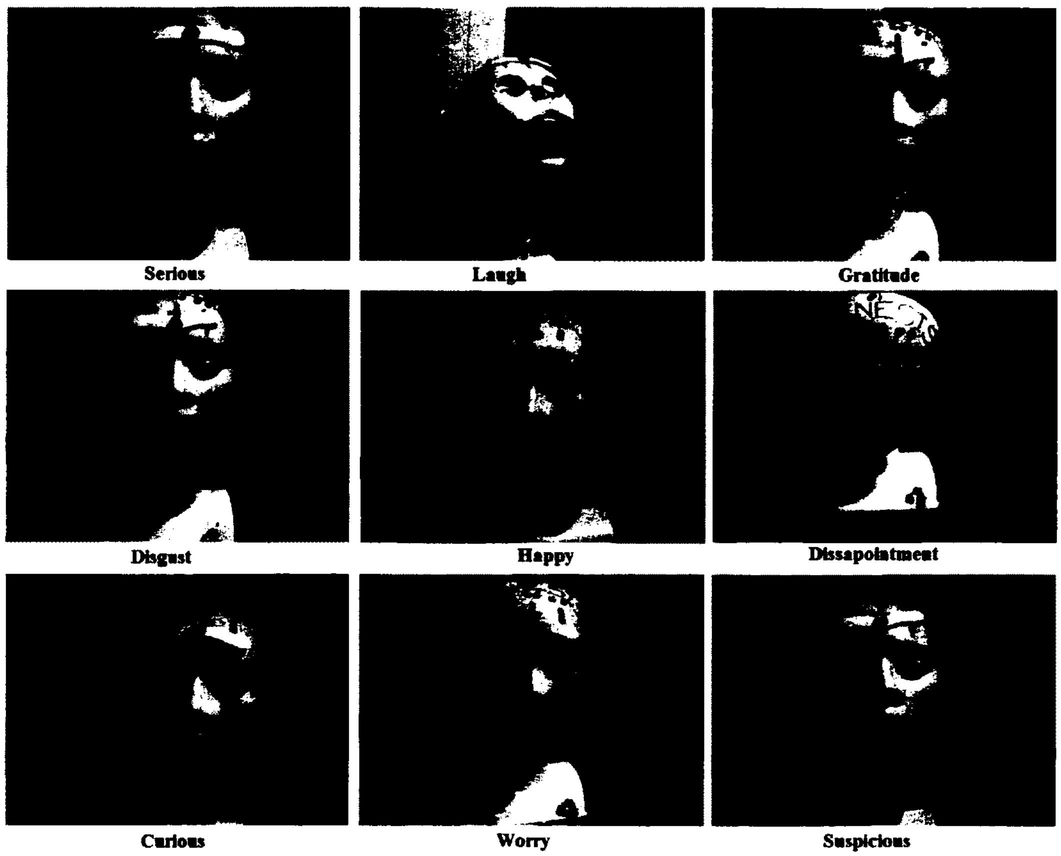

Figure 3.3. G.E.N.E.S.I.S. Emotional Expression Example

Some of these servos, such as the ones used for ear, cheek and lip movement, are under-utilized at this stage of development since certain parts of the face are under constant re-design and construction.

Speech and Vocabulary

To supplement a visually interactive face, G.E.N.E.S.I.S. uses a voice synthesizer to emulate a female voice. All of the vocal responses are pre-programmed words or statements that are used commonly in human interaction. The current response vocabulary is around one-hundred phrases but is updated and expanded periodically. The system used is a stand-alone EMIC Text-to-Speech module that has been used since the original creation of the project. This system will eventually be phased out and replaced with an integrated voice synthesizer that will draw words and phrases from its voice recognition vocabulary which is controlled by the Parallax Propeller chip. When this stage is implemented, it will have the ability to expand its vocabulary by simply interacting with its user. The extent of the vocabulary could potentially hold several thousand words however, at this point; the vocabulary is limited to around one hundred basic commands used for teaching and debugging purposes.

The Machine Intelligence Brain

The brain of G.E.N.E.S.I.S. is designed to emulate the human brain on a very rudimentary level. It contains several distinct modules that function in a similar fashion to their biological counterparts.

At the "stem" of the brain is the voice recognition system. This is controlled by four Parallax Propeller chips working in parallel to emulate the brains mass-parallel processing abilities. This receives input from two microphones which, together, indicate sound, direction, and balance for the system. The sound is stripped into segments, analyzed and stored in an on-board storage device. Currently a 16 GB flash drive is being used for this storage, but the system can handle over one TB of storage effectively which translates to a seemingly limitless vocabulary potential. The voice recognition system is buffered by External Random Access Memory (ERAM) since the on-board Propeller RAM is only 32 KB. Currently the system uses four ERAM boards totaling 16 MB of high-speed RAM. This additional memory decreases the bottle-neck between the system hearing a word and being able to find it in its vocabulary. The system handles its relatively large amount of storage space by searching only the section of storage where the relative information should held. For instance, if the word "test" is heard, it searches only the sector of storage where the voice recognition would build the synaptic pathways that may be associated with that word, thus eliminating the need to sift through the entire storage bank from start to finish every time it hears a new word. If there is no information in that sector of storage, a synaptic pathway is created and stored for later use.

Once the system hears a word or phrase, it checks to see if it has heard it before. The word does not need to be an exact match to something it has heard before since every sound is broken into segments. These segments are recorded in synapses in the storage area. When a word is recognized, the system outputs a set of characters to the output bus. If the word is not recognized, the system asks for a spelling of the word and creates another synaptic pathway to be stored in its storage bank.

The next part of the brain is the motor cortex. The motor cortex is a compilation of PIC AXE controllers that are used for motor control of the entire system. The brain is designed to accommodate an array of up to 64 controllers; however, controllers are only added when more motors are introduced to the system. The motor cortex can also be replaced by a standard three-pin servo controller if necessary, but precision, speed, and the number of motors decreases immensely if this is done. The current system uses a three-pin Parallax Servo Controller for the facial motors only.

The vision system is controlled by the cerebral cortex. This system utilizes two mini-cameras which determine color, pattern, and depth. These cameras are controlled by an array of four Vinculum II chips. This part of the system not only allows for vision processing, but also allows for rudimentary thought processes in the system. After being exposed to the same visual features repeatedly, the system will become familiar with its environment and will generate questions regarding changes in its environment.

The entire system is connected by a 12 pin General Purpose Parallel I/O (GPPIO) bus. The system will also take sensory input signals from other devices (to be integrated as the system develops) and process them in ways similar to the way it processes sound and vision. See Figure 3.4 for the general component layout.

This Machine Intelligence system is based greatly on system designs created by Dr. James O. Gouge, a military system design expert and computer science pioneer. They are being used and developed further with his guidance and permission on this project.

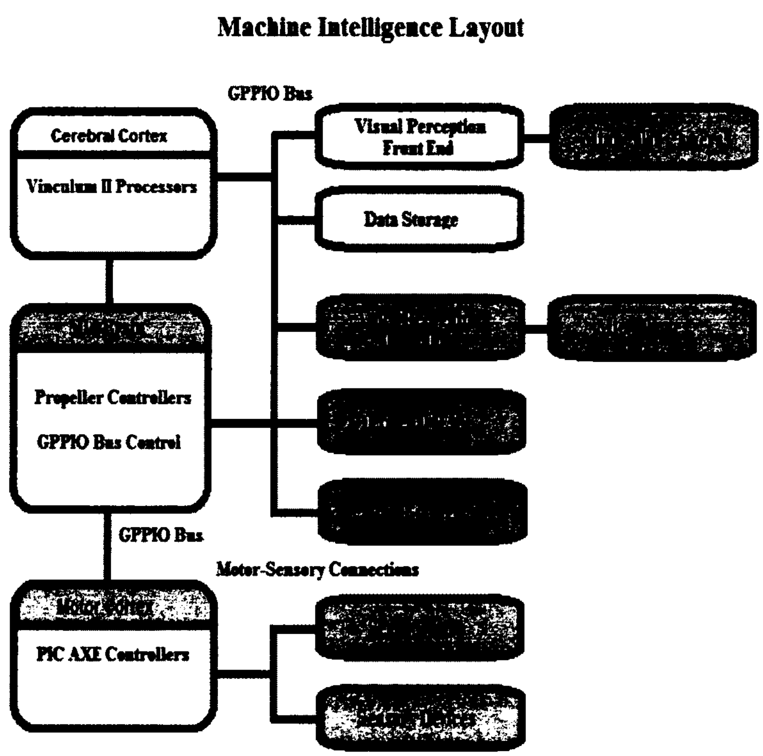

Figure 3.4. Machine Intelligence Root Component Layout

CHAPTER 4

ANALYSIS OF DATA

Statistical Overview

My original data set consists of a list of variables relating to communication methods commonly used in interacting with today's technology. The survey used to collect this data was issued publicly in March 2012 and ended in April 2012 with 101 respondents. It was distributed online, though Facebook and other similar online mediums and attracted respondents from both the United States and Europe. This data set contains 11 primary variables, not including respondent age or occupations, which represent methods of HRI. The variables being tested in this study are face, shape, voice, vision, speech, connectivity to other electronics, emotional response, trainability, user recognition, functionality and environment. I chose these variables because I suspected each one to be a significant factor in HRI. These variables were evaluated over a series of 23 multiple choice questions and two short answer questions. Survey participants were asked to complete the survey but had the option to skip any questions they did not wish to answer. The complete data set can be found in Appendix G.

General Respondent Information

Questions 1-4 of the survey involved information about the respondent's current situation regarding age, occupation, and whether or not their current technology uses voice recognition and/or speech reproduction. These questions were presented at the beginning of the survey to get a general idea of how familiar the survey respondent is with the technology they currently use. Question 24 asks: "What features do you feel are most important when interacting with your computer?" These questions also help to indicate the respondent's familiarity with their daily used computer technology.

Of the 101 survey respondents, 44 were between the ages of 16 and 25, 39 were between 26 and 39 years, seven were between 40 and 49, and 11 were over 50. No respondents were under the age of 16 years. Forty-eight claimed to be students, 14 were teachers or educational professionals, four were health-care professionals, six were retail/sales, 28 said other, and one stated they were unemployed. No respondents claimed to be involved in the food service industry. The "Other" category was merged with the "Unemployed" category for the purpose of running an Analysis of Variance (ANOVA) test, but was not changed during any other tests. Figures 4.1 and 4.2 below show the sample disbursement according to respondent age and occupation.

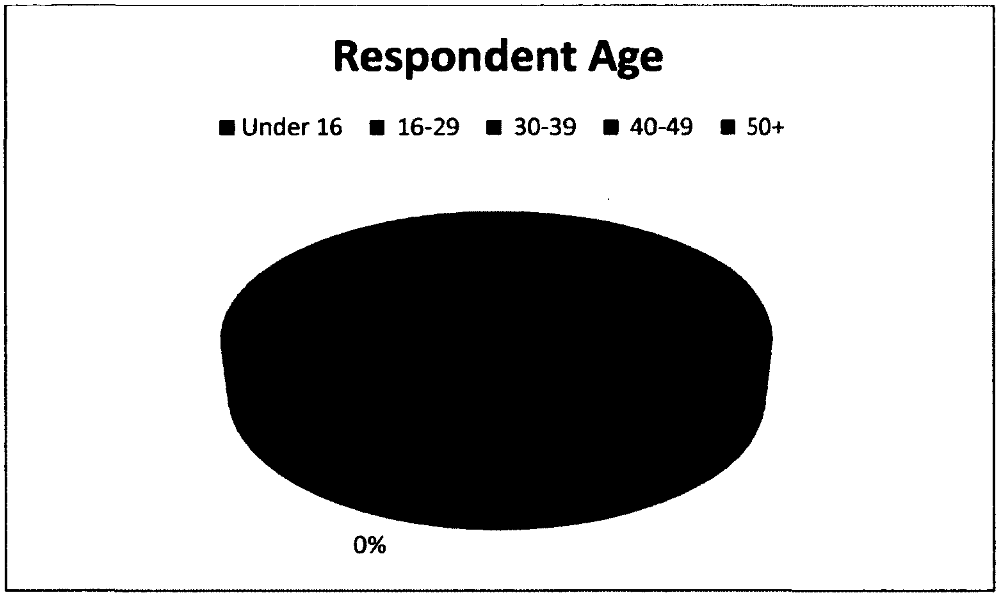

Figure 4.1. Respondent Age Chart

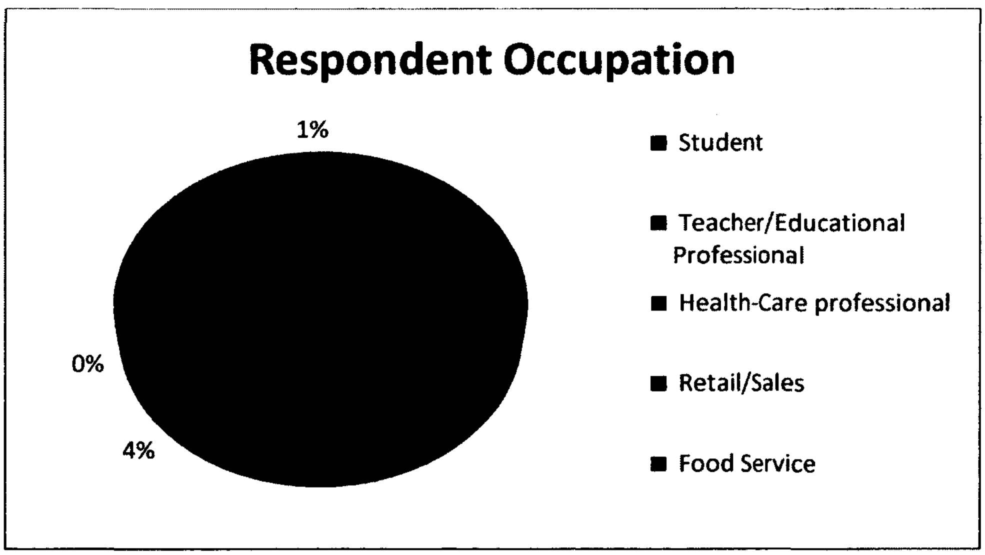

Figure 4.2. Respondent Occupation Chart

Interactive Features

The G.E.N.E.S.I.S. robotic platform's key interactive features are voice recognition, speech reproduction and its ability to express emulated emotional responses through its use of strategically placed motors in its head. While other interactive features such as vision, motion detection, and advanced pattern recognition will be available on advanced models, these first three features will be available on every model offered.

Survey questions 3 and 4 asked respondents about the interactive features their current computers use. Question 3 asked: "Does your computer have voice recognition?" and question 4 asked: "Does your computer have a voice?" These questions served two purposes; first, to obtain a general idea of how many respondents use voice recognition and speech software as part of their general technology interaction experience, and second, to discover how many users are actually aware of their computers interactive capabilities.

Windows users have actually had the ability to communicate with their computers with voice recognition and speech reproduction software since Windows XP was released in 2001. Mac OS users have had the option of voice recognition and speech reproduction as part of the general software package as early as 1993. Other voice recognition packages have been available much earlier than 1993; however, this study examines this question under the assumption that most survey participants are not actively seeking programs that are designed for voice recognition outside of the typical Windows or Mac OS environment and that most participants are using standard operating system packages.

The assumption regarding these questions would be that if users were fully aware of their computers interactive features, and were using operating systems released after 2001, than the vast majority would answer that their computers use at least one voice recognition program and their computers have a program for speech reproduction. Survey participants were not questioned on which operating systems they currently used, nor were they asked which programs they were using that used either voice recognition or speech reproduction. This study shows that most computer users, especially those in the age groups between 16 to 39 and those who described their occupation as "student" are unaware that their computer is probably able to both recognize voice and to produce a vocal response. Figure 4.3 shows responses concerning existing voice recognition systems by participants sorted by respondent age and Figure 4.4 shows responses sorted by respondent occupation. Only 30 % of the survey respondents claim their computers have voice recognition software.

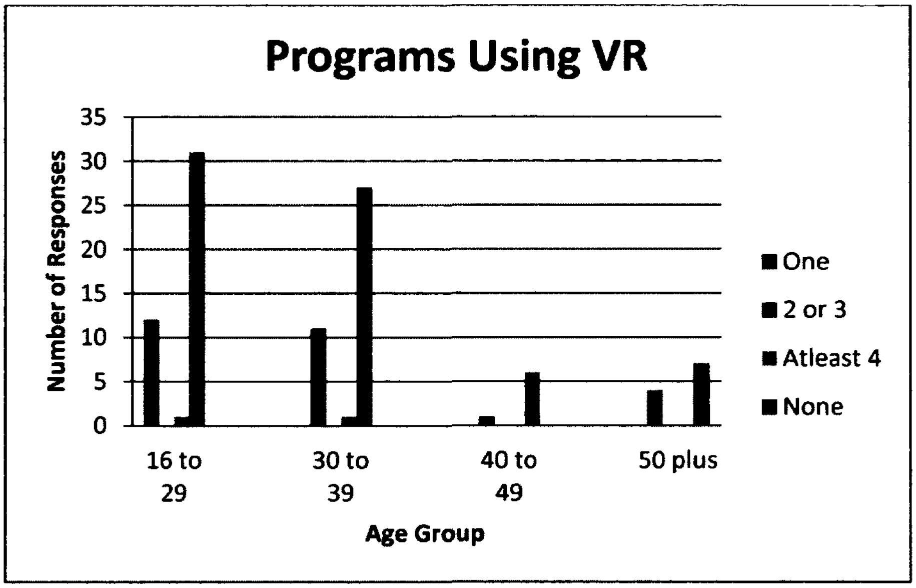

Figure 4.3. Programs Using Voice Recognition by Age

Figure 4.5 shows responses concerning existing speech reproduction systems by participants sorted by respondent age and Figure 4.6 shows responses sorted by respondent occupation. Only 34 % of the survey respondents claim their computers have speech reproduction software.

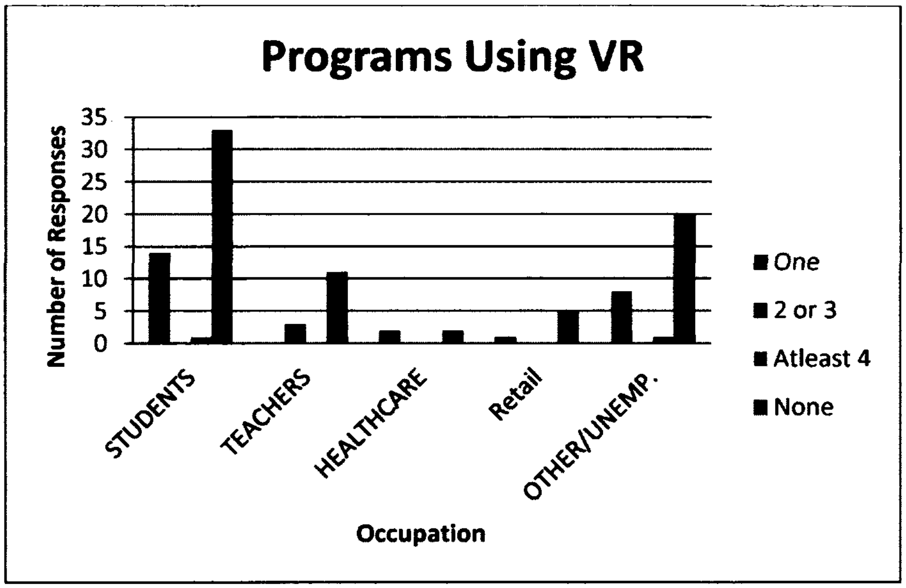

Figure 4.4. Programs Using Voice Recognition by Occupation

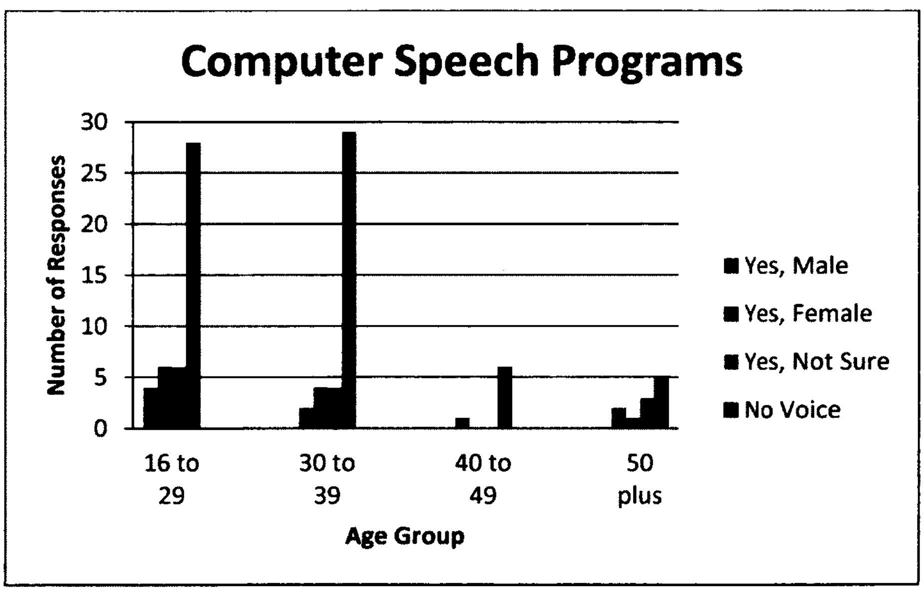

Figure 4.5. Programs Using Speech Programs by Age

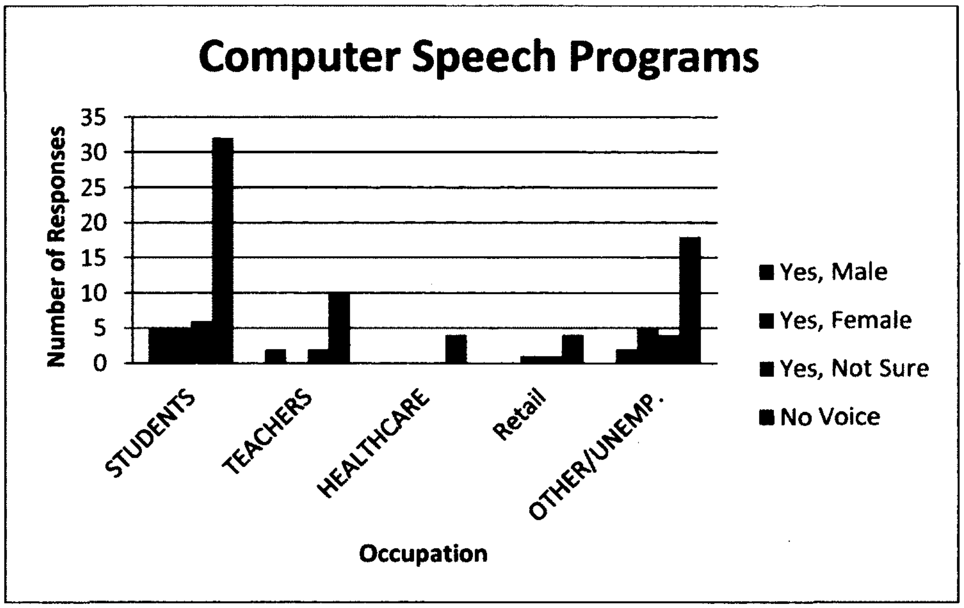

Figure 4.6. Programs Using Speech Programs by Occupation

Survey questions 5 through 15 polled participants on their willingness to upgrade or change existing features of their computer systems with features more conductive in HRI. Figure 4.7 shows respondents opinions regarding questions 5 and 7 through 15. Question 6 is discussed separately. Table 4.1 shows the relationship between the columns in Figure 4.7 and their corresponding questions on the survey. On questions 9 through 15, participants were asked to answer with "Yes," "No," or "Maybe." The "Maybe" option was given to encourage participants to answer the question even if they were undecided, rather than leaving the question unanswered entirely.

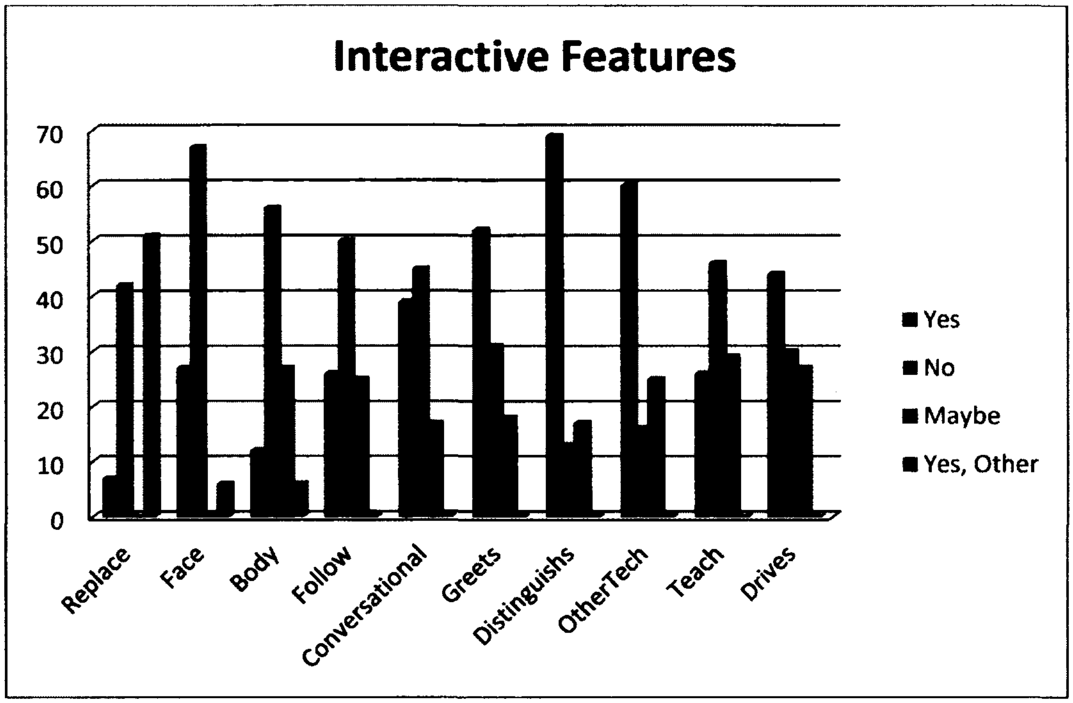

Figure 4.7. Interactive Features Chart

Questions 5 and 7 did not offer the "Maybe" option, but instead gave an additional choice. Question 5 gave the option: "I wouldn't completely replace my keyboard, but would like voice recognition as an option." This option helped to determine if the respondent was at least open to the option of having voice recognition software on their computer or if they would rather not have the option at all. Question 7 gave the option: "I would only consider buying a computer with a face that does NOT look human." In addition to the "Maybe" option, Question 8 had an extra choice as well. The extra option was presented as: "I would consider buying a computer that has a body like an animal or other living thing, but NOT human."

Table 4.1.

Interactive Features List

Column Name	Survey Question
Replace	Would you replace your keyboard with a voice recognition program?
Face	Would you buy a computer that had a human-like face?
Body	Would you buy a computer if it looked human (i.e. had a human-shaped body)?
Follow	Would you buy a computer that could follow you around your house?
Conversational	Would you buy a computer that initiates conversations with you?
Greets	Would you buy a computer that greets you when it sees you?
Distinguishes	Would you buy a computer that can distinguish you from other users by your face and voice?
Other Tech	Would you buy a computer that can operate other house-hold technology (microwaves, TVs, phones, stereos, etc.)?
Teach	Would you buy a computer that you had to teach (like a child or a pet) rather than program (by installing software)?
Drives	Would you buy a computer that could drive a car, mow your lawn or take out the trash?

It is reasonable to assume that some consumers would feel uncomfortable around an artificial personality of any kind, especially when its physical presentation is human in appearance. This theory supports the "Uncanny-Valley" effect which is often found when interacting with artificial personalities and machines that appear some-what human. The questions which listed choices other than Yes, No, and Maybe take into account the "Uncanny-Valley" effect and attempt to inspire survey participants to imagine interacting with an artificial personality in the shape of something non-human such as an animal, plant, or abstract object that may be more pleasing to the individual consumer.

Over half of the sample population indicated they would want some type of voice recognition feature in their computer system. When asked if they would replace their keyboard with a voice recognition system, 42 % said no, but 51 % said they would want it incorporated along with their existing keyboard. Seven percent said they would replace their keyboard completely with voice recognition if given the option.

As indicated by Figure 4.7, aside from the option of incorporating voice recognition, the most desirable interactive features are a computer's ability to greet you and distinguish you from other users. These options are also available, to some extent, with existing operating systems. These options usually take the form of the user entering their user-name and password, which then generates a greeting such as: "Hello User!" or something similar, then proceeds to load custom settings which the user has pre-programed on that particular system. While this option will most likely be a continued feature in any future computer operating system, this feature combined with two of the more popular features such as interacting with other technology and controlling vehicles, will help to strengthen the interactivity between humans and machines.

The ability to interact with other technology, or even the ability to drive a vehicle rated highly among the sample population. By incorporating all four of these features, a user could be completely interactive with their home and vehicle devices simply by being in proximity of the device they wish to control. To illustrate this, one may imagine the first hour of a consumers morning while taking advantage of some of these features. Consider the following scenario:

A student wakes up, about to begin his day at school. As soon as he gets out of bed, his computer senses a lot of movement and compares it with the time recognized on the alarm clock which is being monitored, among other household devices, by the computer system. Noticing that it is the typical time for the student to wake up, the computer turns on the room lights to a pre-set user level and calls the user by name as it asks if he wants a breakfast suggestion or perhaps make an online phone call to a restaurant on his normal path to school for an en-route breakfast order. As he proceeds through the house, lights go on and off automatically according to which room he is passing through. When he finally exits the house, his house door locks behind him and his car door unlocks. His car seat adjusts to his pre-set position and his typical route comes up on his GPS system with suggestions regarding traffic, road conditions, and of course, his stop for breakfast which was ordered automatically when he decided he'd rather not have to eat last night's left overs for breakfast today. On his way to school, the student receives a reminder through the stereo system in his car that he might want to stop at the grocery store on the way home because a sensor in his refrigerator indicates that his milk expires today.

In this scenario, the computer's ability to interact with other household devices is just as important as it ability to interact with the human itself. By taking advantage of Bluetooth, cellular, and other wireless technology, the G.E.N.E.S.I.S. platform has the ability to make this scenario a reality. The simple serial interface allows the G.E.N.E.S.I.S. platform to control, and interact with almost any piece of technology already on the consumer market.

The sample population indicated they were primarily opposed to their computer having a physical human body or face, however, 27 % of the sample said they would be interested in having a computer with a face and 12 % indicated they would buy a computer with a human shaped body. While this does not represent the majority of the population, it does indicate a market niche in which the G.E.N.E.S.I.S. platform would potentially be a popular product. This niche is also recognized in the feature responses of "Follow," "Conversational," and "Teach," which also are not the most popular options by the sample population, but yet all three choices, have over a quarter of the respondents expressing interest in these features.

Personality and Emotions

The G.E.N.E.S.I.S. platform will be available with specific gender assignment at the consumer's request. The prototype model has been assigned the gender of female, primarily because of the parts available at the time G.E.N.E.S.I.S. was designed, specifically; its voice synthesizer was only available in a female sounding voice, so the decision was made to continue with a female persona. Recent design changes are allowing for any gender-specific voice or even a non-gender specific, or neutral gender voice to be implemented with the G.E.N.E.S.I.S. platform. The concept of machines emulating emotions, while not new to the artificial intelligence world, has not been popular in the majority of robotic product design. While this feature is seen, to some degrees, in some toy products such as the Furby, released by Tiger Electronics in 1998, the consumer market has seen very few electronic devices that appear to express or emulate emotion. This could be due to the fact that in most electronic applications emotional emulation is neither needed, nor wanted. In other cases, the application of emotional emulation would simply be too costly and time consuming to design into the product. The G.E.N.E.S.I.S. platform is emotionally expressive through its facial muscles and through programming applications, will be able to emulate a wide array of expressive Behaviour.

Question 6 asked: "Would you want your computer to have its own personality? If so would it be: Male, Female, No gender (neutral), any gender would be acceptable, or No, I would NOT want my computer to have a personality." This question has been set aside since simply typing and clicking keys on a machine can be relatively impersonal, however, the act of becoming familiar with your own personal computer, getting to know its software, and customizing its settings such as desktop backgrounds, sounds, color schemes, and so on can become a much more intimate and unique experience. When considering the addition of an actual personality to your personal computer, more should be taken into account than just the machines speed, ease of use, or special applications available on that machine.

Once a gender has been assigned to a machine via appearance, sound, personality, or any combination of the above, the emotional level between the machine and its user is subject to change dynamically. In some cases, it would be predictable that a user could become emotionally connected to their machine as they would a pet or human acquaintance. By selecting a potential gender for their machines interactive experience, the user may also be indicating which gender they are interested in interacting with socially. By selecting the option "No gender (neutral)" or "No, I would NOT want my computer to have a personality" indicates that the user chooses to keep their interactive experience more impersonal and subjective. Figure 4.8 shows the respondent choices in response to Question 6. Only thirty-three respondents, roughly one third of the sample population, selected specifically a male or female personality, while 37 of the 101 respondents stated they would not want their computer to have a personality at all.

Within the age groups of 40 to 49 years and 50 years and older, the majority of the population indicated they were opposed to a computer having a personality at all.

While this seemed to be the general consensus of the entire sample population, the age group 16 to 29 also indicated that a female personality would be preferable to either a male personality, or not having a personality at all. The age group 30 to 39 indicated that if a personality was present, they would either want female personality rather than male, or they wouldn't care which gender their computer had. In every case, the female option was more popular than male, except in the over 50 age group, where one respondent each said male and female. These results can be observed in figure 4.9 which categorizes respondent's choices by age.

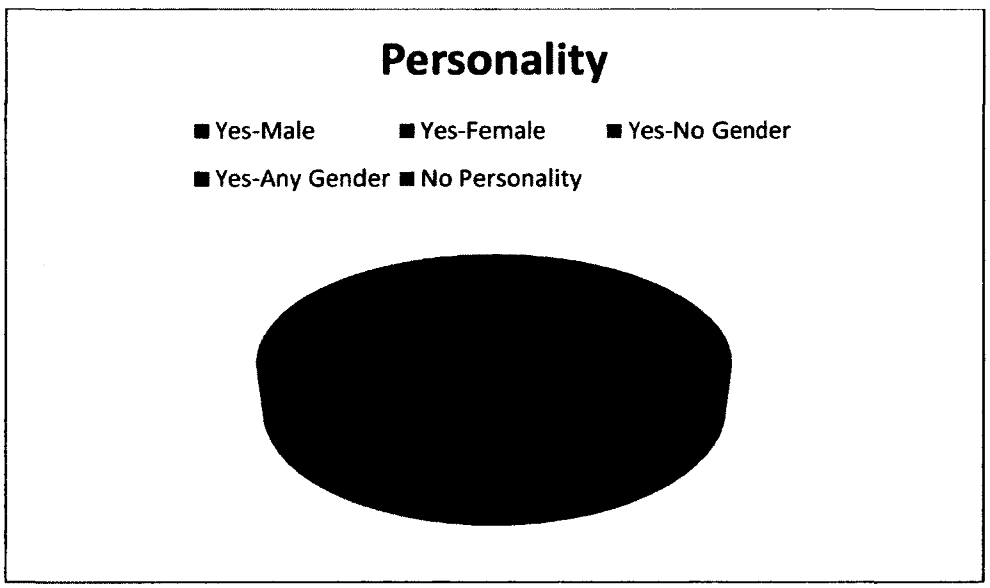

Figure 4.8. Artificial Personality Chart by Entire Sample Population

Figure 4.10 categorizes Question 6 responses by occupation. Observations from this graph indicate that in every profession a computer having no gender is preferable to any other choice. Respondents in the "Student" and "Other/Unemployed" occupations indicated that having a female personality is more than twice as favorable to having a male personality, yet still maintained that no personality was preferable. It should also be noted that no one in the health-care or retail occupations selected a female gender at all, but instead, said either male or no gender at all was preferable, second only to having no personality at all.

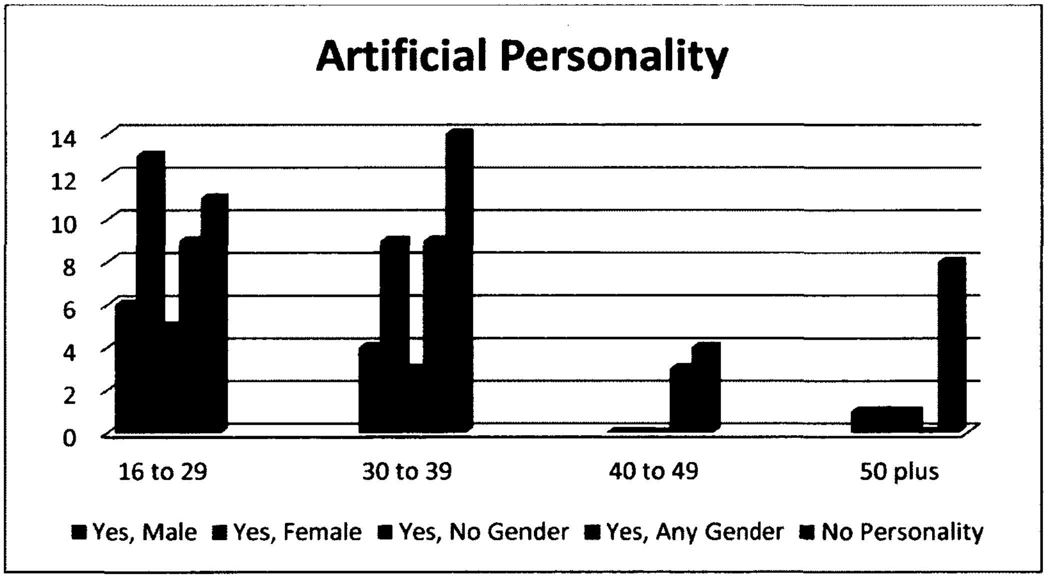

Figure 4.9. Artificial Personality Chart by Age

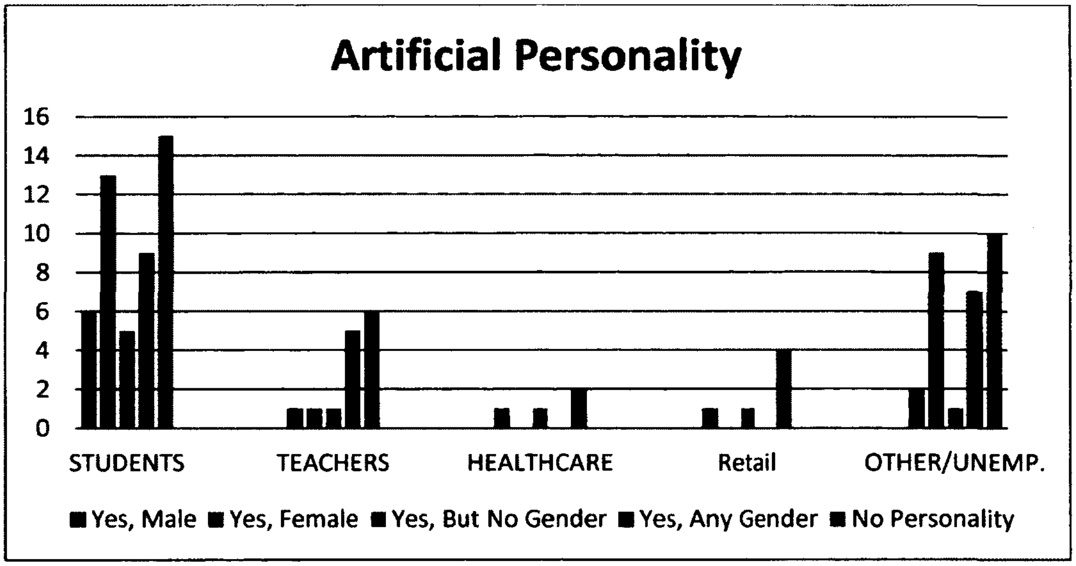

Figure 4.10. Artificial Personality Chart by Occupation

As we interact with other people, animals, even plants, and machines, humans, as a species, are naturally inclined to build emotional attachments. These attachments present themselves in many different ways, such as the feeling of excitement when you're shopping for a new car, the feeling of anticipation when you're waiting for a call from someone special, or the feeling of sadness when you finally have to get rid of your favorite pair of shoes. While there is currently no technology to make machines capable of actually having emotions, machines can most definitely cause an emotional response from its user; feelings of awe and amazement when you watch your new TV light up your living room with your favorite movie, frustration when your computer seems to take forever loading web pages, even betrayal when your trusty car refuses to wake up on a cold winter morning. Participants were asked to consider the idea of their computer expressing their own, simulated, emotional state.

Question 22 asked participants "would you like your computer to express emotional responses (happiness, curiosity, empathy)?" The choices given were: Yes, Yes, But ONLY if I can select which emotions it is able to express, No, and Maybe. Figure 4.11 shows an overview of respondent answers. Forty-seven percent of respondents say they would not chose to have their computer emulate any emotional response at all. Eighteen percent said "Yes" and 22 % of the sample population said they would let their computers emulate emotion if they could choose which emotions it was able to express.

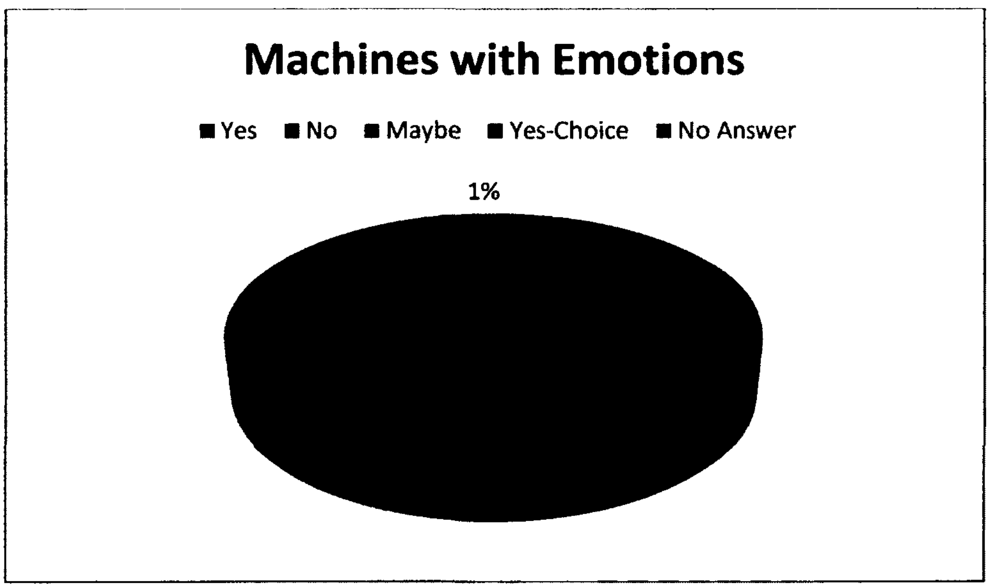

Figure 4.11. Machine Emotional Expression Chart by Entire Sample Population

The option to decline emotional emulation was popular in all age groups and all occupational groups as seen in Figure 4.12 and Figure 4.13. Respondents who said they would consider emotions for their computers, either by indicating "Yes" on the survey, were primarily by participants under 40 years of age and either in the occupation of "student," or "other/unemployed" category.

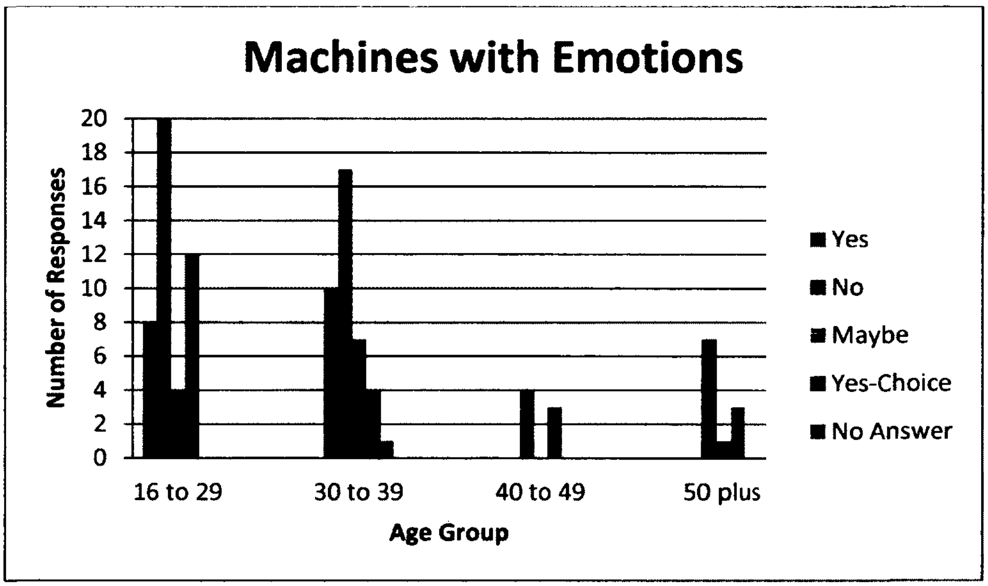

Figure 4.12. Machine Emotional Expression Chart by Age

The option to choose which emotions a computer can emulate, represented by the choice "Yes, But ONLY if I can select which emotions it is able to express," was most popular in the 16 to 29 age group and specifically by "students" and "other/unemployed" participants.

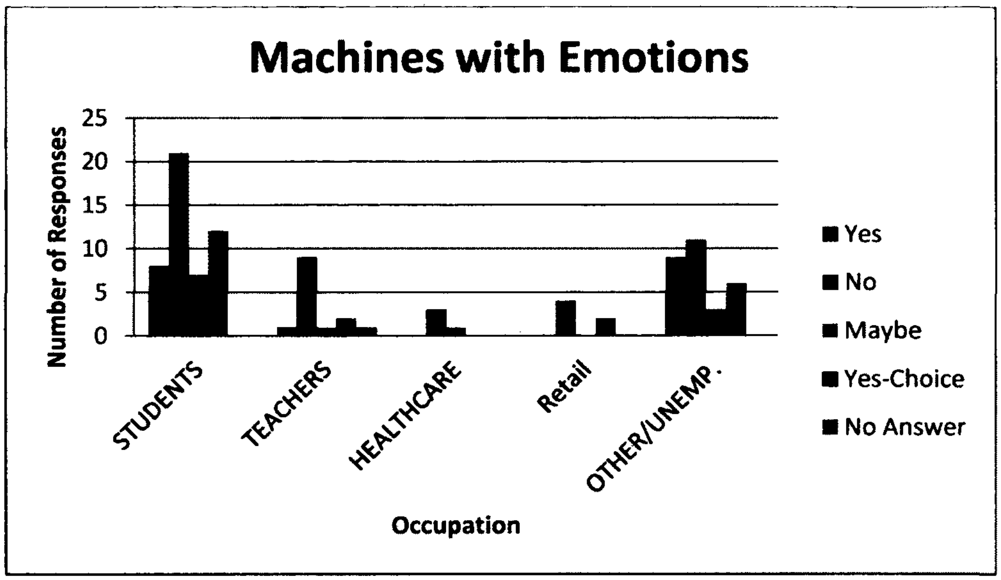

Figure 4.13. Machine Emotional Expression Chart by Occupation

Personality simulating devices (PSD's), for the purpose of this thesis, are considered any device that is used by the computer to emulate or simulate human emotions. The PSD's chosen for this survey were a simulated face generated by a computer screen, a separate artificial head which interacts with the user through its computer connection, and the complete replacement of the computer monitor with an artificial head that interacts with you in a human-like fashion.

The G.E.N.E.S.I.S. platform has the adaptability to either be an additional computer appendage or a stand-alone device. With this flexibility, a consumer of the G.E.N.E.S.I.S. platform could choose to use it as a peripheral device that interacts separately from a monitor for applications such as writing, voice dictation, video conversations, on line phone calls, or musical play back, games, and various other applications. A consumer could also choose to use the G.E.N.E.S.I.S. platform as a replacement for the computer monitor. In this application, the G.E.N.E.S.I.S. platform would be able to perform tasks such as reading on line information out loud, playing audio files, act as a voice recognition search engine that could use on line search engines simply by asking the G.E.N.E.S.I.S. platform a question, which would then reply, vocally, with popular search engine answers.

Question 23 asked participants "Would you rather have a computer that:

a. Has a computer screen and keyboard with no artificial personality?
b. Has a computer screen and keyboard with an interactive face?
c. Has a computer screen and keyboard only for general information (like displaying websites) as well as a separate, interactive human-like head that interacts with you as you use your computer)?"
d. Has only a human-like head that interacts with you and is the only interface between you and your computer (no screen or keyboard)?"

Forty-nine percent of respondents say they would chose to have personality simulating device, of some kind, as a feature for their computer. Of this 49 %, 28 % would chose to have a separate interactive head as part of their system, 24 % wanted the option of separate head along with their existing system while 4 % said they would completely replace their monitor with an interactive head if given the option. Twenty-one percent of respondents said they wanted the option of a computer generated face but no artificial head. The remaining 48 % of the population said they would not choose to have any PSD as a feature for their computer. Three percent of participants opted not to answer the question. Figure 4.14 shows the results of this question according with respect to the entire sample population.

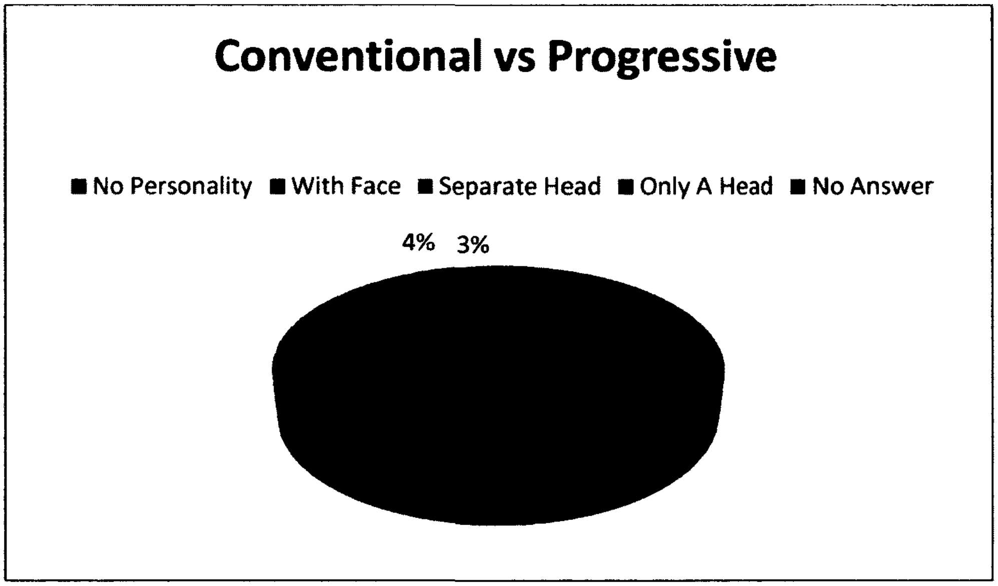

Figure 4.14. Computer Appearance Chart by Entire Sample Population

In all age groups, the option to have no PSD was more popular than any other choice available; however, the age groups who seemed most receptive of using a PSD as part of their computer systems were age groups 16 to 29 and 30 to 39. The 16 to 29 age group was more in favor of having a separate head as part of their system as oppose to having only a computer generated face. Thirty-four percent of this group chose the interactive head as an option the as opposed to the 13 % who opted only for the simulated face.

Age group 30 to 39 indicated that having the computer generated face was preferable to having the interactive head as an option, 30 % chose the simulated face option, where only 25 % opted for the interactive head.

Age group 40 to 49 indicated the least concern for any PSD option with 28 % of this age group selecting no personality, only a generated face, and a separate interactive head. The remaining respondent in this age group chose not to answer this question at all. Seventy-two percent of the 50 and over age group selected the no personality option making that choice the dominant choice for that group as well. Figure 4.15 shows respondent information for question 23 according to age group.

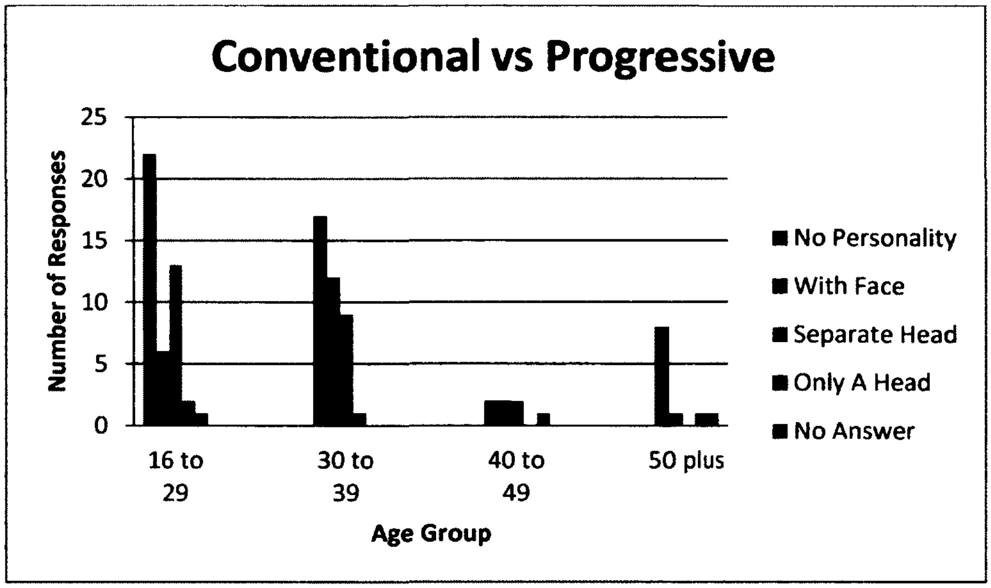

Figure 4.15. Computer Appearance Chart by Age

When responses were separated into occupational groups, the groups preferred not to use and PSD options except for the "Other/Unemployed" group who selected the option of a computer generated face above all other choices. Thirty-four percent of respondents in this group chose this option. Thirty-one percent chose using an interactive head as an option and another 31 % said they would rather have no PSD option at all. This occupational group appears to be the least decisive in this option. Figure 4.16 shows respondent information for question 23 according to occupational group.

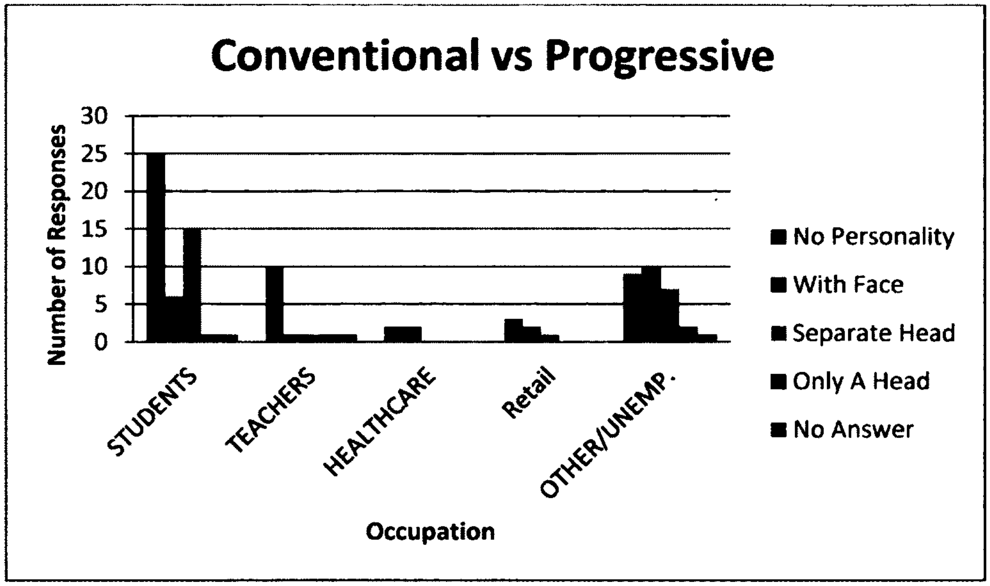

Figure 4.16. Computer Appearance Chart by Occupation

Fifty-two percent of the students surveyed claimed that would not want an artificial personality, however, 33 % say they would use an interactive head as a PSD. Another 12.5% respondents would use a computer generated face as an option. The Teachers occupational group shows strong opposition to PSD's with 77 % of respondents opting for no PSD options. Half of the respondents in the "retail" profession said they would not want a PSD option, while 33 % would choose to use a simulated face and the other 16 % would use an interactive head. Healthcare workers indicated they would not want an interactive head of any kind, but half of the respondents in this group said they would choose a simulated face as an option. The other half said they would not want any PSD option at all.

These results suggest that the interactive features of the G.E.N.E.S.I.S. platform, combined with its ability to either interface with personal computer systems or be used as a stand-alone robotics platform would be a viable consumer product if targeted towards consumers under the age of 40 or in educational and hobbyist fields.

Statistical Analysis of Personality, Emotions, and Conventional vs. Progressive

To get an overview of the characteristics regarding participant's opinions on PSDs in my data set, I ran two one-way ANOVA tests in SPSS- PASW. The independent variable for the first test was "Age" and for the second test was "Occupation." For the "Age" evaluation, the output from SPSS- PASW defines the data set as having an n = 101 with a Harmonic Mean Sample Size of 14.178 and a Subset for alpha = 0.05. For the "Occupation" evaluation, the output from SPSS- PASW defines the data set as having an n = 101 with a Harmonic Mean Sample Size of 9.201 and a Subset for alpha = 0.05. My confidence interval was therefore, 0.95, meaning any significant values found with an amount smaller than 0.05 will be outside of my confidence interval and consequently, observed more closely to see if a single factor can be determined to be influential in selecting successful interactive human-robot environment. The dependent variables used for both tests were "Personality," Emotions," and "Conventional vs. Progressive."

The ANOVA test using "Age" as the independent variable indicated that there is no significant difference between groups to warrant further investigation, however, the test using "Occupation" as the independent variable indicated there was a significant difference in the variable "Personality." The value of this variable fell below the 0.05

interval with a value of 0.027 as seen in Table 4.2. I then ran five Post Hoc ANOVA tests to identify the difference in occupational groups in relation to the "Personality" variable. The testing methods used were: Tukey HSD, Scheffe, LSD, Bonferroni, and Tukey B. Table 3 shows results of the least significant difference (LSD) method which was the only method used that successfully identified group differences below the interval of 0.05. Values below 0.05 have been highlighted. The complete multiple comparison output can be found in Appendix F.

For this test, my Null hypothesis: H_{01} is that there is no significant differences in Age groups when considering the PSD features Personality, Emotions, and Conventional vs. Progressive for interactive computers and robots.

The alternate hypothesis: H_{A1} that there are significant differences in Age groups when considering the PSD features Personality, Emotions, and Conventional vs. Progressive for interactive computers and robots.

For the second test on this variable, my Null hypothesis: H_{02} is that there are no significant differences in Occupational groups when considering the PSD features Personality, Emotions, and Conventional vs. Progressive for interactive computers and robots.

The alternate hypothesis: H_{A2} that there are significant differences in Occupational groups when considering the PSD features Personality, Emotions, and Conventional vs. Progressive for interactive computers and robots.

The LSD test revealed that respondents in age groups two compared to four as well as two compared to five had significant differences in their opinions on PSDs especially when considering personality as a factor. This means there is over a 95 % chance, and in the case of group two compared to group four, a 98.6 % chance and the case of group two compared to group five a 97 % chance, that consumers in the target population will have this difference in opinion within these age groups. This is an indication that the consumer age group containing people between the ages of 16 and 29 are an ideal target market when considering PSD features.

Based on these findings, this study fails to reject the Null hypothesis: H_{01} is that there are no significant differences in Age groups when considering the PSD features Personality, Emotions, and Conventional vs. Progressive for interactive computers and robots. Also, based on these findings, this study rejects the Null hypothesis: H_{02} is that there are significant differences in Occupational groups when considering the PSD features Personality, Emotions, and Conventional vs. Progressive for interactive computers and robots.

Table 4.2.

One-Way Personality ANOVA by Age

		F	Sig.
Personality	Between Groups	3.190	.027
	Within Groups		
	Total		
Emotions	Between Groups	1.909	.133
	Within Groups		
	Total		
ConventionalVsProgressive	Between Groups	.805	.494
	Within Groups		
	Total		

To get a complete overview of the PSD variables, I combined the mean sum of the dependent variables Personality, Emotions, and ConventionalVsProgressive to produce comprehensive variable. This variable was named "Consumer1" for the purpose of this evaluation. Consumer1 was then given a two way ANOVA evaluation in SPSS-PASW. The independent variable for the first test was "Age" and for the second test was "Occupation." The "Age" data set has an n = 101 with a Harmonic Mean Sample Size of 14.178 and a Subset for alpha = 0.05, The "Occupation" dataset has an n = 101 with a Harmonic Mean Sample Size of 9.201 and a Subset for alpha = 0.05 making my confidence interval 0.95.

Table 4.3.

Multiple Comparison Personality by Occupation

	(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	2	3	-.376	.310	.227	-.99	.24
		4	-1.435*	.573	.014	-2.57	-.30
		5	-1.045*	.475	.030	-1.99	-.10
	3	2	.376	.310	.227	-.24	.99
		4	-1.059	.578	.070	-2.21	.09
		5	-.669	.481	.167	-1.62	.28
	4	2	1.435*	.573	.014	.30	2.57
		3	1.059	.578	.070	-.09	2.21
		5	.390	.681	.568	-.96	1.74
	5	2	1.045*	.475	.030	.10	1.99
		3	.669	.481	.167	-.28	1.62
		4	-.390	.681	.568	-1.74	.96

For this test, my Null hypothesis: H_{03} is that there is no significant differences in Age groups when considering the mean sum of all PSD features for interactive computers and robots.

The alternate hypothesis: H_{A3} that there are significant differences in Age groups when considering the mean sum of all PSD features for interactive computers and robots.

For the second test on this variable, my Null hypothesis: H_{04} is that there are no significant differences in Occupational groups when considering the mean sum of all PSD features for interactive computers and robots.

The alternate hypothesis: H_{A4} that there are significant differences in Occupational groups when considering PSD features Personality, Emotions, and Conventional vs. Progressive for interactive computers and robots.

A one-way ANOVA test by "Occupation" determined there is no significant difference between groups. The ANOVA test by "Age" revealed a difference of 0.03 in significance which then generated a multiple comparison test to determine the difference between groups.

The methods used for this test were Tukey HSD, Scheffe, LSD, Bonferroni, and Tukey B. Each method used for this comparison identified age groups two and four being significantly different as well as groups and three and four. These differences have values as low as 0.001, meaning there is up to 99.9 % confidence that people in the target population in these age groups will respond to PSD's in a manner predictable by the results of the survey. Multiple comparison tables produced by SPSS-PASW can be found in Appendix F. Table 4 shows the result of the one-way ANOVA test on the variable "Consumer1."

Table 4.4.

One-Way Consumer1 ANOVA by Age

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.833	3	1.278	4.920	.003
Within Groups	25.190	97	.260		
Total	29.023	100			

Based on these findings, this study rejects the Null hypothesis: H_{03} is that there are no significant differences in Age groups when considering the mean sum of all PSD features for interactive computers and robots. Also, based on these findings, this study fails to reject the Null hypothesis: H_{04} is that there are significant differences in Occupational groups when considering the mean sum of all PSD features for interactive computers and robots.

The Human-Robot Environment

Survey Questions 16 through 21 polled participants on their overall acceptance of particular human-robot environments. The environments selected were day care facilities, elderly care facilities, health care facilities, correctional facilities, elementary schools (from grades kindergarten to sixth), and high school (from grades seven to twelve). Figure 4.17 shows respondents opinion regarding Questions 5 and 7 through 15. Table

4.5 shows the relationship between the columns in Figure 4.17 and their corresponding questions on the survey. Participants were asked to show their level of acceptance on a level of "zero to five" with zero indicating "strongly unsupportive" and five indicating "strongly supportive." A response of three would indicate impartiality or being undecided.

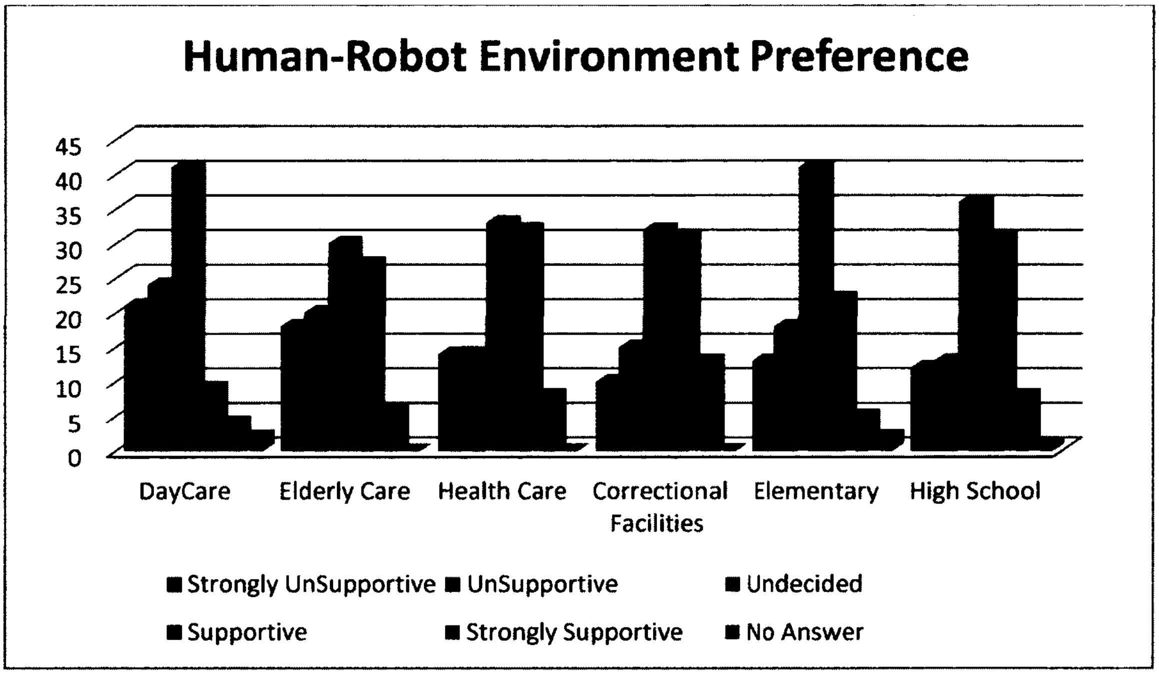

Figure 4.17. Human-Robot Environment Preference Chart

Table 4.5.

Human-Robot Environment List

Column Name	**Survey Question**
Day Care	How do you feel about robots being used in day-care and early childhood environments?
Elderly Care	How do you feel about robots being used in elderly-care facilities?
Health Care	How do you feel about robots being used in health-care facilities?
Correctional Facilities	How do you feel about robots being used in correctional facilities?
Elementary	How do you feel about robots being used in grade school / K-6 educational environments?
High School	How do you feel about robots being used in middle/high school / 7-12 educational environments?

To get an overview of the characteristics regarding environments for robot placement in my data set, I ran two one-way ANOVA tests in SPSS-PASW. The dependent variables used for both tests were "DayCare," "Elderly," "Health," "Correctional," "Elementary," and "High School." The independent variable for the first test was "Age" and for the second test was "Occupation." Values for n, Harmonic Mean Sample for "Age" and "Occupation" as well as the subset for alpha are the same as the values determined during the PSD variable evaluation. Both "Age" and "Occupation" have an n = 101 as well as a Subset for alpha = 0.05. The "Age" data set has a Harmonic Mean Sample Size of 14.178 and the "Occupation" dataset has a Harmonic Mean Sample Size of 9.201. My confidence interval was 0.95, meaning any significant values found with an amount smaller than 0.05 will be outside of my confidence interval and consequently, observed more closely to see if a single factor can be determined to be influential in selecting successful interactive human-robot environment.

Table 4.6.

One-Way Environment ANOVA by Age

		Sum of Squares	df	Mean Square	F	Sig.
DayCare	Between Groups	4.672	3	1.557	1.257	.293
	Within Groups	120.160	97	1.239		
	Total	124.832	100			
Elderly	Between Groups	9.690	3	3.230	2.332	.079
	Within Groups	134.350	97	1.385		
	Total	144.040	100			
Health	Between Groups	5.684	3	1.895	1.436	.237
	Within Groups	127.960	97	1.319		
	Total	133.644	100			
Correctional	Between Groups	.856	3	.285	.213	.887
	Within Groups	129.778	97	1.338		
	Total	130.634	100			
k-6	Between Groups	2.659	3	.886	.692	.559
	Within Groups	124.133	97	1.280		
	Total	126.792	100			
mid-high_sch	Between Groups	6.513	3	2.171	1.671	.178
	Within Groups	126.002	97	1.299		
	Total	132.515	100			

Table 4.7.

One-Way Environment ANOVA by Occupation

		Sum of Squares	df	Mean Square	F	Sig.
DayCare	Between Groups	2.762	4	.690	.543	.705
	Within Groups	122.070	96	1.272		
	Total	124.832	100			
Elderly	Between Groups	14.751	4	3.688	2.738	.033
	Within Groups	129.289	96	1.347		
	Total	144.040	100			
Health	Between Groups	4.235	4	1.059	.785	.537
	Within Groups	129.409	96	1.348		
	Total	133.644	100			
Correctional	Between Groups	3.311	4	.828	.624	.646
	Within Groups	127.322	96	1.326		
	Total	130.634	100			
k-6	Between Groups	1.197	4	.299	.229	.922
	Within Groups	125.595	96	1.308		
	Total	126.792	100			
mid-high_sch	Between Groups	3.856	4	.964	.719	.581
	Within Groups	128.659	96	1.340		
	Total	132.515	100			

For this test, my Null hypothesis: H_{05} is that there are no significant differences in Age groups when considering the ideal human-robot social environment.

The alternate hypothesis: H_{A5} that there are significant differences in Age groups when considering the ideal human-robot social environment.

Also, my Null hypothesis: H_{06} is that there are no significant differences in Occupational groups when considering the ideal human-robot social environment.

The alternate hypothesis: H_{A6} that there are significant differences in Occupational groups when considering the ideal human-robot social environment.

Table 4.6 shows the ANOVA test using "Age" as the independent variable and Table 4.7 shows the ANOVA test using "Occupation" as the independent variable. My ANOVA Post Hoc tests were done in two sets: Scheffe and Tukey B, these tests were followed by five additional Post Hoc tests which used the methods: Tukey, HSD, Scheffe, LSD, Bonferroni, and Tukey B. I ran the additional tests only on the variable "Occupation" to further evaluate the dependent variable "Elderly." This variable was chosen because in the original ANOVA test, it was the only one with significance under a value of 0.05; in this case, its value was 0.033 which brought it outside my confidence interval. With the occupations separated, the LSD method revealed that occupational groups four (Retail/Sales) and five (Other/Unemployed) had significance values of 0.012 and 0.021 respectively. Table 4.8 shows a section of the SPSS-PASW output where the values described can be seen and are highlighted. This section shows the LSD Post Hoc test. The complete multiple comparison output can be found in Appendix F.

Table 4.8.

Multiple Comparison LSD Environment by Occupation

		(I) Occup		(J) Occup	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
								Lower Bound	Upper Bound
LSD		1	dimension3	2	.482	.352	.175	-.22	1.18
				3	-.125	.604	.836	-1.32	1.07
				4	1.292*	.503	.012	.29	2.29
				5	.642*	.273	.021	.10	1.18
		2	dimension3	1	-.482	.352	.175	-1.18	.22
				3	-.607	.658	.358	-1.91	.70
				4	.810	.566	.156	-.31	1.93
				5	.160	.378	.673	-.59	.91
	dimension2	3	dimension3	1	.125	.604	.836	-1.07	1.32
				2	.607	.658	.358	-.70	1.91
				4	1.417	.749	.062	-.07	2.90
				5	.767	.619	.218	-.46	2.00
		4	dimension3	1	-1.292*	.503	.012	-2.29	-.29
				2	-.810	.566	.156	-1.93	.31
				3	-1.417	.749	.062	-2.90	.07
				5	-.649	.520	.215	-1.68	.38
		5	dimension3	1	-.642*	.273	.021	-1.18	-.10
				2	-.160	.378	.673	-.91	.59
				3	-.767	.619	.218	-2.00	.46
				4	.649	.520	.215	-.38	1.68

Based on these findings, this study fails to reject the Null hypothesis: H_{05} is that there are no significant differences in Age groups when considering the ideal human-robot social environment. Also, based on these findings, this study rejects the Null hypothesis: H_{06} is that there are significant differences in Occupational groups when considering the ideal human-robot social environment.

To get a complete overview of the Environmental variables, I combined the mean sum of the dependent variables Day Care, Elderly, Health Care, Correctional, Elementary, and High School to produce comprehensive variable. This variable was named “Consumer2” for the purpose of this evaluation. Consumer2 was then given a two way ANOVA evaluation in SPSS-PASW. The independent variable for the first test was “Age” and for the second test was “Occupation.” The “Age” data set has an n = 101 with a Harmonic Mean Sample Size of 14.178 and a Subset for alpha = 0.05, The “Occupation” dataset has an n = 101 with a Harmonic Mean Sample Size of 9.201 and a Subset for alpha = 0.05 making my confidence interval 0.95.

For this test, my Null hypothesis: H_{07} is that there are no significant differences in Age groups when considering robot placement in any human-robot social environment.

The alternate hypothesis: H_{A7} that there are significant differences in Age groups when considering robot placement in any human-robot social environment.

Also, my Null hypothesis: H_{08} is that there are no significant differences in Occupational groups when considering ideal human-robot social environment.

The alternate hypothesis: H_{A8} that there are significant differences in Occupational groups when considering robot placement in any human-robot social environment.

Neither the one-way ANOVA test by "Occupation" nor the one-way ANOVA test by "Age" determined there is a significant difference between groups in the Environmental variables. No further tests were run on the variable "Consumer2."

Based on these findings, this study fails to reject the Null hypothesis: H_{07} is that there are no significant differences in Age groups when considering robot placement in any human-robot social environment. Also, based on these findings, this study fails to reject the Null hypothesis: H_{08} is that there are no significant differences in Occupational groups when considering robot placement in any human-robot social environment

User Defined Features

Questions 24 and 25 of the survey were short-answer questions. Respondents were given the opportunity to mention features they felt were important to them in their typical interaction with their computers. Since the survey focused on only a few of the interactive features a household computer could potentially accommodate, these two questions allow for the user to mention any features that might have been left out during the survey. Feedback from these questions will also inspire future revisions of the survey and perhaps, the G.E.N.E.S.I.S. robotic platform itself to include different interactive features that can be evaluated in the pursuit of an ideal socially interactive robot model.

Question 24 asks "What features do you feel are most important when interacting with your computer?" Only 66 out of the 101 survey respondents chose to answer this question. Out of those 66 respondents, 24 said that a computers ease of use is of greatest importance. Respondents were not given specific instructions as to the length of their answer, so some listed several features they felt were important while some gave no answer at all. The answers have been generalized and sorted into popular categories which emerged from the survey. For instance, 12 respondents said that speed was important, eight said its reliability was a big factor , seven said typical peripheral devices such as keyboard, monitor and mouse are important, and four respondents said that a computer's ability to learn and use new programs is important as well as its overall interactive capabilities such as voice recognition. Other answers observed ranged from security features, expandability and compatibility with other machines to explanations regarding why computers should not emulate any emotional stimulation at all.

Question 25 asks "What is one task you would like your computer to do that it does not already do? (EXAMPLES: walking your dog, washing dishes, alert you when you have visitors at your home.)" The examples were initially given to inspire respondents to be creative and think of typical household tasks that might be able to be done by a computer or machine of some sort. While some answers were indeed thoughtful and creative, many answered with the replication of one or more of the suggestions. Nine of the 73 of respondents who chose to answer this question mentioned security and 10 of the 73 mentioned reminders or alerts when something unusual has happened. Fifteen of the 73 respondents mentioned they would like their computer to cook, wash dishes, or participate in some sort of house work.

Three of the 73 respondents suggested their technology should be interactive with other technology and four of the 73 said they would like their computer to be more interactive in general. This reinforces the concept that consumers consider connectivity to their surrounding environment relatively important and would enjoy the ability to control devices such as televisions, stereos, and house hold appliances such as lights and microwaves from their computers. Perhaps a feedback device communicating with a computer that indicated when someone hasn't completely shut the refrigerator door, or has left a light on after leaving the bathroom would serve as a handy consumer feature in a new computer or robot.

Results and Discussion

Based on the findings of this thesis, the following research questions, which were presented at the beginning of this thesis, can now be answered.

- "Which features do potential consumer groups most want in robotic systems?"

Voice recognition as well as the ability to distinguish one user from another are the two features that have the most support from the survey participants in this study. While voice recognition is already being used in devices ranging from computers, phones, and games, it is still seemingly very un-utilized by the general technology using population. Most computers have had the ability to recognize vocal commands for over twenty years, but a lot of users either are uncomfortable using it in their computer systems, or simply don't realize it is there at all. This option should be made more easily accessible and easier to understand for users who may be intimidated by technology especially when it involves the use of features that don't require simple peripheral devices like a keyboard and mouse.

Currently, most computer systems distinguish users from each other only when the initial user logs on to their computers user profile. From this point, anyone with access to the keyboard or mouse can manipulate information on the computer as freely as the initial user itself. Some users choose to lock individual files on their computers, but this only make accessing that information by other users more difficult. A feature that constantly samples user identities would allow a computer to tell its users apart from each other and improve information security as well as help separate users on the same computer to interact with the computer simultaneously without having to continuously switch user profiles and re-enter passwords. Users also indicated that they would like their computers to greet them when recognized. This simple gesture can be performed by almost every computer on the market today, but most users either don't use this feature, or don't recognize that the feature is even there to begin with. The use of devices such as webcams with pattern recognition software, fingerprint sensors and voice analysis could help exploit this feature and make it easier for computers to recognize individual as well as multiple users more dynamically than with just password protection. The addition of these features to computer systems could also help users feel more personally attached to their computer.

Participants also strongly indicated that a computer's ability to interact with other technology is an important interactive feature. Currently, most new computer are Bluetooth capable and can interact with other devices such as phones, iPods, and other computers, but not other typical household items such as televisions, refrigerators, microwaves, stereo systems, or automobiles. A simple interface designed for a computer to communicate with other household appliances may also prove to be a very marketable niche.

To supplement these two major factors, the features of a voice simulator and PSDs also show promise in users between the ages of 16 and 39 and also with students. While these options weren't universally desired within all age and occupational groups, the high percentage of participants that indicated these features would be desirable proves a market niche as well.

The option to be able to teach your computer simply by interacting with it, also called "machine learning" was also presented to survey participants; however, this option was not generally popular enough among the sample population to justify a market niche, but should be studied further to discover what methods of machine learning can be implemented to make the users interactive experience more productive and enjoyable.

- "Which factors encourage the sales of robotic systems?"

The factors that seem most influential to the sales of robotic systems, as indicated by this study, are voice recognition and a computers ease of use. While voice recognition has been an integral topic of this study and is very specific in its function, the term "ease of use" is much more general. As discussed earlier, modern computers have several interactive features that are greatly unutilized by computer users. It is easy enough to turn on a computer and log onto the internet for a little social networking, but accessing simple features like accessing calendars, setting appointment reminders, and voice recognition can be a challenging task to the common user either because of its location in the menu, or simply because the user doesn't know that it exists. Over a third of the survey participants indicated they would like features for their computer that are already common features that just need to be made more user-friendly. By making a computers features easier to see, understand, and use right "out-of-the-box" may help users feel more comfortable with their technology, and having this benefit may make a particular computer more marketable regardless of age or occupation.

- "In which environments are consumers comfortable interacting with robotic systems?"

The environments, in which most survey participants said they felt were most suitable for human-robot interaction, were Health-Care, Correctional Facilities, and High-School, all of which had more than a third of the participants' definite approval over disapproval. The environments that were least approved by participants were Day-Care, Elderly-Care, and Elementary. All of these had more participants' disapproval rather than approval. It should be also noted, when considering the approval rating of these environments that most participants do not typically find themselves immersed in all of these fields on a regular basis so these results could hold a particular bias in regard to preferred environment verses actual occupation.

This study also discovered a market niche in the category in the occupational group of students. This group was more supportive of HRI in every potential environment including "Elderly-Care which had the biggest difference in opinion between occupational groups.

- "How appropriate is the G.E.N.E.S.I.S. robotic platform, as a product, for the consumer market?"

Based on the findings from the analysis of the survey, as well as the information describing the features of the G.E.N.E.S.I.S. robotic platform itself, the G.E.N.E.S.I.S. robotic platform may be considered an appropriate product for several niches in the consumer market.

The features of voice recognition and voice reproduction appear to appeal to every group studied and appear likely to draw sales of a product which has these features readily available. The additional features included with the G.E.N.E.S.I.S. robotic platform such as facial expressions and the actual appearance of the head-shaped design itself force the G.E.N.E.S.I.S. robotic platform away from the total consumer market and make it more desirable in specific consumer niches instead.

These niches are students as well as general consumers between the ages of sixteen to thirty-nine years old. The "Other" and "Unemployed" occupational groups may also be included in this niche, however, since the term "Other" isn't descriptive of an actual occupational group other than to say that it is not one of the specific groups selected for the survey; it is hard to determine who actually fits into this group. The same could be said about the term "Unemployed," since the participants in this group may actually be representing a featured group in which they are not currently a part of or part of the "Other" group but are unemployed at the time the survey was taken by the participant.

Another possible niche in which the G.E.N.E.S.I.S. robotic platform could be marketed is the RC (Remote-Control) and robotic hobbyist market. This group was not featured in this study, however, since the G.E.N.E.S.I.S. robotic platform is primarily a robotics oriented product, so because of that, this niche was assumed for the sake of this study. It is further recommended that this particular market niche be researched in more detail to determine how much of the RC (Remote-Control) and robotic hobbyist market the G.E.N.E.S.I.S. robotic platform is suitable for.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Chapter 1 discussed the history of Human-Robot-Interaction (HRI) and acknowledged the problem of making robotic products easier to interact with, easier to find, easier to understand, and easier to purchase. This study addressed the human-robot interface problem and proposed a solution through the development of a robotic platform designed specifically for human-robot interaction (HRI). The solution proposed was introduced as the SHARP project, an interactive robotics platform that has been designed to be a simple, interactive, robust, and low cost android platform. The personal android project named G.E.N.E.S.I.S. was used to demonstrate the features of the SHARP project and was subjected to evaluation in this thesis. Chapter 1 also defined terms commonly used in this thesis along with the assumptions and limitations of the work contained in the study itself.

Chapter 2 discussed the related literature in the field of Human-Robot-Interaction starting with a technology overview which covered interactive technology in the rapidly immerging field of social robotics. Chapter 2 went on to discuss HRI in several facets of the technology field including social hardware, social software, theories involving social robots, current research with social robots, and an introduction to the, Uncanny-Valley followed by a summary of the literature.

Chapter 3 described the methodology used in this study to answer the research questions:

- Which features do potential consumer groups most want in robotic systems?
- Which factors encourage the sales of robotic systems?
- In which environments are consumers comfortable interacting with robotic systems?

These questions were presented to answer the final research question:

- How appropriate is the G.E.N.E.S.I.S. robotic platform, as a product, for the consumer market?

The survey used was discussed as well as methods for deploying the survey and analyzing the data collected. This chapter also discussed, in detail, the G.E.N.E.S.I.S. robotic platform and the machine intelligence brain that controls it with special attention paid to the speech and vocabulary of the interactive robot.

Chapter 4 analyzed the data collected from the survey. The initial data set was categorized and discussed in each category. The chapter begins with a statistical overview followed by a discussion of the general respondent information. Excel and SPSS-PASW were used to test and describe the data in their respective categories. The categories tested were in interactive features, personality and emotions, statistical analysis of personality, emotions, conventional verses progressive the human-robot environment, and user defined features. Analysis of Variance (ANOVA) tests were ran on data regarding Personality Simulating Device (PSD) features including Personality, Emotions, and Conventional vs. Progressive as well as on data regarding the human-robot environment. This chapter closed with a discussion of the results collected for analyzing the data and answered the research questions laid out in Chapter 3.

Hypothesis Findings

The purpose of the hypothesis was to prove that the G.E.N.E.S.I.S. robotic platform is appropriate for the consumer market.

Based on the findings of this study, I believe that the features of the G.E.N.E.S.I.S. robotic platform are viable and marketable features when considering a robotics kit in the consumer market. The primary target consumer market niche is determined to consist of students between the ages of 16 to 29; however, this study also indicated that consumers of various occupations between the ages of 30 and 39 may also be considered in this particular market niche as well as the general Radio Control and robotics hobbyist market.

Conclusions

The SHARP project presents a solution to the problems discussed in this thesis by offering a simple, low cost, interactive robotic platform. The features of the G.E.N.E.S.I.S. robotic platform which include voice recognition, speech reproduction, and the ability to make facial expressions were evaluated and found to be an acceptable product to fill the market niche containing 16 to 39 year olds as well as students, educators, and robotic hobbyists and enthusiasts. It's low cost and diverse base allow a variety of consumers to use the platform at any level of education as well as provides a means to continually expand and advance the sophistication of the platform to any level the consumer desires. Its voice recognition and speech reproduction features were found to be the most desirable features of the platform as well as the optional feature to interface with other electronic technology.

While only a small percentage of survey respondents said they would purchase a human-shaped head as an interactive device linked directly to their computer, there were enough to prove a market niche at 0.05 alpha levels. The PSD features evaluated also show a potential market niche consisting of students and people between the ages of 16 and 39 years old. The study also revealed that other popular features for an interactive platform were user distinction and recognition, the ability to interact with other technology, and applications involving calendars, alerts, and reminders. This study also determined that fully interactive robots could be used in environments such as health-care, correctional facilities, and high-schools.

The G.E.N.E.S.I.S. robotic platform has the ability to fill these market niches by providing an affordable approach to introducing robotics and autonomous mobile devices into modern homes and educational facilities to enhance the everyday living and learning experiences of individuals and institutions of any income level. As this technology progresses and becomes more available on the open market, the SHARP project will be a pioneering product leading the way for a wide range of educational and practical android-based products.

The survey used for this study also helps to guide the development of the G.E.N.E.S.I.S. robotic platform by indicating which features should be considered higher priority in their development according to consumer demand. The platform, when considered as only a dis-embodied head unit, should be developed on at least three different levels according to feedback indicated by the survey.

The first level should be a simple do-it-yourself robotics kit. The purpose of this kit would be for the user to assemble the kit as a learning experience and to gain knowledge of robotics. A kit like this would include features in which the user could chose to either purchase or disregard as part of the kit depending on factors like user preference and cost. These features would include voice recognition, speech reproduction, motor control, a variety of sensors including touch sensors and cameras, as well as a choice of controllers to be used as the brain of the system. Simple motor control could be managed by a single board controller such as the motor cortex section of the Machine Intelligence brain or an off-the-shelf microcontroller, depending on user preference, or could be as complex as a multi-board system that incorporated several intelligence features such as speech, vision, motor control, and sensor management all in one complex system. Depending on the users experience level and budget, the platform could be purchased at a variety of price levels. However, since the Machine Intelligence brain is one of the more costly and complex features, this option would be suggested for advanced robotic enthusiasts. For the beginner to intermediate levels a less complex and less costly controller could be developed for the system that is still capable of handling voice recognition and speech reproduction as well as motor control on a less advanced level. This option encourages the development of not only the machine Intelligence brain, but also a less complex and less costly controller package to encourage the use of the G.E.N.E.S.I.S. robotic platform in a wider variety of consumer budgets.

The second level, as indicated by the survey, should be a completed android head that requires little to no assembly and can be either plugged into a personal computer for use as a peripheral device or could be used as a stand-alone platform that can be programmed for specific tasks through a PC. These stand-alone tasks could range from greeting customers when they walk into a store, to echoing everything it hears back to you, to simply telling you the time when you ask for it. To accomplish the step, in interface would have to be developed to make the G.E.N.E.S.I.S. robotic platform communicate effectively with the computer it is connected to. This could be done through a serial connection such as a USB port. This level would satisfy the consumers need to have an interactive head as a peripheral device. The platform could then be used for such tasks as voice dictation, e-book reading, on-line conversations that require webcams and microphones, and interactive games that could also be developed for use on the platform. This option encourages the development of a PC interface for the G.E.N.E.S.I.S. robotic platform and also PC software development for programs such as interactive games and activities to be used with the platform.

The third level, as indicated by the survey, should be to make the G.E.N.E.S.I.S. robotic platform as expandable as possible by developing and offering options to make the G.E.N.E.S.I.S. robotic platform a mobile platform. The addition of arms, legs, or wheels connected to the platform would allow for tasks such as simple house work like mowing the lawn, taking out the trash, vacuuming the carpet and walking the family pet. This option encourages the development robotic accessories such as robotic arms, mobile platforms, and other peripheral devices that can be ultimately controlled by the G.E.N.E.S.I.S. robotic platform or, in some cases, be their own stand-alone devices.

The option should also be available to switch the G.E.N.E.S.I.S. robotic platform from one user mode to another. For instance, if a consumer purchased a do-it-yourself kit and assembled it to specifications for use as a stand-alone device, then it should also have the ability to interface with a personal computer, assuming the user has also chosen to purchase the PC interface option. The survey has also helped to point out features such as interfacing with other technology, being able to remind you of calendar events and alerts, and being able to distinguish one user from another that should be developed for the G.E.N.E.S.I.S. robotic platform on all levels discussed in this study.

The ultimate goal of the SHARP Project is to develop an android platform that can undertake nearly any human task. The process of developing the G.E.N.E.S.I.S. robotic platform past the point of a simple robotic head must be done to accomplish this goal, by using the feedback from the survey; popular features like household chores and operating other machinery can be focused on to make G.E.N.E.S.I.S. more attractive to the consumer market.

Recommendations for Future Work

The main objective of the SHARP project is to fill the void in the robotics market for an affordable, expandable, educational, and fully functional general purpose android. During this ongoing development process, G.E.N.E.S.I.S. has already been used as an educational aid including a recruitment tool for potential robotics and electronics students, a sensor and servo test platform, and a visually stimulating source of entertainment for a wide range of individuals. These are what would be considered the baby steps in the SHARP projects development, or as proof of concept that this type of product has a place in today's market on several levels. A brief list of potential uses for an android platform such as the one presented in the SHARP project is:

- Hobbyists looking to expand their knowledge of robotics
- Teachers using robots as interaction tools for students ranging from children with Autism to graduate level robotics students.
- S.T.E.M. educational courses and curriculums.

- Educators teaching electronics/robotics classes
- Store owners looking for unique, interactive displays for their stores
- Theatric based events using interactive animatronic devices.

It is recommended that all of these particular niches be investigated to more accurately determine the full marketability dynamics of the G.E.N.E.S.I.S. robotic platform. It is also recommended that other such platforms be evaluated and compared to the G.E.N.E.S.I.S. robotic platform to establish a marketability level for this and similar platforms attempting to fill this market niche.

A follow up or amended survey should be distributed to include questions that further pin-point the market niche such as:

- Which operating system do you use? (Windows XP? Windows 7, 8? Linux? Mac OS?)
- Are you a robotics enthusiast/hobbyist?
- Have you ever used a robot at school/work/home?
- Do you use any robotic systems in your current occupation?
- Do you use voice recognition on your phone or hand-held computer?
- Do you believe robots are a benefit or a threat to the work force?

Lastly, it is recommended that all of a small number of G.E.N.E.S.I.S. robotic platforms be constructed and deployed to beta-testing groups as well as various social groups in the environments being studied to observe actual interaction with the G.E.N.E.S.I.S. robotic platform. These sessions will help to evaluate real-world interaction with this platform and help to reveal inconsistencies as well as PSD feature effectiveness. The information gathered from these sessions can then be used to further develop the G.E.N.E.S.I.S. robotic platform to make it an even better fit for the market niches discovered by this study.

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APPENDIX A

HUMAN PARTICIPANTS REVIEW FORM

Office of Sponsored Programs University of Northern Iowa

Human Participants Review Committee
UNI Institutional Review Board (IRB)
213 East Bartlett Hall

Jeffrey Rick
2909 East Bremer Avenue, Lot 7
Waverly, IA 40677

Re: IRB 11-0201

Dear Mr. Rick:

Your study, **Interactive Technology Survey**, has been approved by the UNI IRB effective **3/8/12**, following an Expedited review of your application performed by **IRB member Helen Harton, Ph.D.** You may begin enrolling participants in your study.

Problems and Adverse Events: If during the study you observe any problems or events pertaining to participation in your study that are *serious* and *unexpected* (e.g., you did not include them in your IRB materials as a potential risk), you must report this to the IRB within 10 days. Examples include unexpected injury or emotional stress, missteps in the consent documentation, or breaches of confidentiality. You may send this information to me by mail or email.

Expiration Date: Your study **approval will expire on 3/8/13**. Beyond that, you may not recruit participants or collect data without continuing approval. We will email you an Annual Renewal/Update form about 4-6 weeks before your expiration date, or you can download it from our website. You are responsible for seeking continuing approval before your expiration date *whether you receive a reminder or not.* If your approval lapses, you will need to submit a new application for review.

Closure: If you complete your project before the expiration date, or it ends for other reasons, please download and submit the IRB Project Renewal/Closure form and submit in order to close our your protocol file. It is especially important to do this if you are a student and planning to leave campus at the end of the academic year. Advisors are encouraged to monitor that this occurs.

Forms: Information and all IRB forms are available online at http://www.uni.edu/osp/irb-forms.

If you have any questions about Human Participants Review policies or procedures, please contact me at 319.273.6148 or anita.gordon@uni.edu. Best wishes for your project success.

Sincerely,

Anita M. Gordon

Anita M. Gordon, MSW
IRB Administrator

cc: Recayi Pecen, Faculty Advisor

sent 4-2-12

213 East Bartlett Hall • Cedar Falls, Iowa 50614-0394 • Phone: 319-273-3217 • Fax: 319-273-2634 • E-mail: osp@uni.edu • Web: www.uni.edu/osp

APPENDIX B

INTRACTIVE TECHNOLOGY SURVEY

1. How old are you?
    a. 0-15
    b. 16-25
    c. 26-39
    d. 40-49
    e. 50+
2. What is your profession?
    a. Student
    b. Teacher / Educational Professional
    c. Healthcare Professional
    d. Retail/ Sales
    e. Food Service Professional
    f. Other
    g. Unemployed/ no profession
3. Does your computer have voice recognition?
    a. Yes, at least one program on my computer uses voice recognition
    b. Yes, two or three programs on my computer use voice recognition
    c. Yes, at least four programs on my computer use voice recognition.
    d. No, my computer does not have voice recognition.
4. Does your computer have a voice?
    a. Yes, a male voice
    b. Yes, a female voice
    c. Yes, but I'm not sure if it is male or female
    d. No
5. Would you replace your keyboard with a voice recognition program?
    a. Yes
    b. No
    c. I wouldn't completely replace my keyboard, but would like voice recognition as an option.
6. Would you want your computer to have its own personality? If so would it be:
    a. Male
    b. Female
    c. No gender (neutral)
    d. Any gender would be acceptable
    e. No, I would NOT want my computer to have a personality

7. Would you buy a computer that had a human-like face?
    a. Yes
    b. No
    c. I would only consider buying a computer with a face that does NOT look human
8. Would you buy a computer if it looked human (i.e. had a human-shaped body)?
    a. Yes
    b. No
    c. Maybe
    d. I would consider buying a computer that has a body like an animal or other living thing, but NOT human.
9. Would you buy a computer that could follow you around your house?
    a. Yes
    b. No
    c. Maybe
10. Would you buy a computer that initiates conversations with you?
    a. Yes
    b. No
    c. Maybe
11. Would you buy a computer that greets you when it sees you?
    a. Yes
    b. No
    c. Maybe
12. Would you buy a computer that can distinguish you from other users by your face and voice?
    a. Yes
    b. No
    c. Maybe
13. Would you buy a computer that can operate other house-hold technology (microwaves, TVs, phones, stereos, etc.)?
    a. Yes
    b. No
    c. Maybe
14. Would you buy a computer that you had to teach (like a child or a pet) rather than program (by installing software)?
    a. Yes
    b. No
    c. Maybe
15. Would you buy a computer that could drive a car, mow your lawn or take out the trash?
    a. Yes
    b. No
    c. Maybe

16. How do you feel about robots being used in day-care and early childhood environments?
Not supportive at all 0 1 2 3 4 5 Very supportive

17. How do you feel about robots being used in elderly-care facilities?
Not supportive at all 0 1 2 3 4 5 Very supportive

18. How do you feel about robots being used in health-care facilities?
Not supportive at all 0 1 2 3 4 5 Very supportive

19. How do you feel about robots being used in correctional facilities?
Not supportive at all 0 1 2 3 4 5 Very supportive

20. How do you feel about robots being used in grade school / K-6 educational environments?
Not supportive at all 0 1 2 3 4 5 Very supportive

21. How do you feel about robots being used in middle/high school / 7-12 educational environments?
Not supportive at all 0 1 2 3 4 5 Very supportive

22. Would you like your computer to express emotional responses (happiness, curiosity, empathy)?
    a. Yes
    b. Yes, But ONLY if I can select which emotions it is able to express
    c. No
    d. Maybe
23. Would you rather have a computer that:
    a. Has a computer screen and keyboard with no artificial personality
    b. Has a computer screen and keyboard with an interactive face
    c. Has a computer screen and keyboard only for general information (like displaying websites) as well as a separate, interactive human-like head that interacts with you as you use your computer)
    d. Has only a human-like head that interacts with you and is the only interface between you and your computer (no screen or keyboard)

24. What features do you feel are most important when interacting with your computer?

25. What is one task you would like your computer to do that it does not already do? (EXAMPLES: walking your dog, washing dishes, alert you when you have visitors at your home.)

APPENDIX C

INTRACTIVE TECHNOLOGY SURVEY COVER LETTER

The technology we use every day is constantly becoming smarter and faster. This makes our technology easier for us to use and makes the technology more useful than ever before! A study of this technology is being conducted by researchers at the University of Northern Iowa to help assess the features that consumers find valuable in their technology.

This survey is a quick reflection of what YOU as a valued technology consumer believe are important in technology features. By participating in the survey, you be helping to choose which options may be available in new products.

Completion of this survey is COMPLETELY VOLUNTARY. You may choose to stop taking the survey at any time and may choose NOT to answer any questions on the survey. All answers are confidential and NO identifying information is collected. Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties.

The survey will take 10 to 15 minutes to complete. All your responses will be kept confidential within reasonable limits. Only people directly involved with this project will have access to the surveys. There is no follow-up planned for participants in this survey and all survey questions pose MINIMAL to NO risk to its participants.

Questions about this study can be directed to me or to my supervising professor, Dr. Pecen, Department of Industrial Technology, UNI, Cedar Falls, IA. 50613.

Phone (319) 273-2598.

Thank you for taking the time to assist us in this research.

Jeffrey J. Rick

(319) 939-6252

rickj@uni.edu

For questions regarding research participant's rights or the Internal Review Board policies at the University of Northern Iowa, please contact Anita Gordon, UNI IRB Administrator, 319-273-6148, anita.gordon@uni.edu.

APPENDIX D

FACEBOOK SURVEY INVITATION

Facebook friends!!! Please take a few minutes to take my online "Interactive Technology Survey." It takes about 10 – 15 minutes to complete the 25 questions. It is COMPLETELY VOLUNTARY and you may skip any questions you like. NO identifying information is collected and you will not be contacted for further information regarding the survey or the research it supports. This survey poses MINIMAL to NO risk to participations and will help contribute to the technology research being conducted by myself and collogues at the University of Northern Iowa. Please follow this link to the survey site: http://www.eSurveysPro.com/Survey.aspx?id=75e6678b-5294-4e43-84ed-4ab0753e6166&cid=adb1fb03-1ccc-4f18-8031-650f6d8b192d Thank you!!!!

APPENDIX E

VARIABLES RESEARCHED:

1. Face
2. Shape
3. Voice
4. Vision
5. Speech
6. Connectivity to other electronics
7. Emotional response
8. Trainability
9. User recognition
10. Functionality
11. Environment

APPENDIX F

SPSS-PASW MULTIPLE COMPARISON OUTPUT:

Dependent Variable:**Elderly**

	(I) Occup		(J) Occup	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD	1	di	2	.482	.352	.650	-.50	1.46
		me nsi	3	-.125	.604	1.000	-1.80	1.55
		on 3	4	1.292	.503	.084	-.11	2.69
			5	.642	.273	.138	-.12	1.40
	2	di	1	-.482	.352	.650	-1.46	.50
		me nsi	3	-.607	.658	.887	-2.44	1.22
		on 3	4	.810	.566	.610	-.76	2.38
	di m		5	.160	.378	.993	-.89	1.21
	en 3	di	1	.125	.604	1.000	-1.55	1.80
	si on	me nsi	2	.607	.658	.887	-1.22	2.44
	2	on 3	4	1.417	.749	.329	-.67	3.50
			5	.767	.619	.728	-.95	2.49
	4	di	1	-1.292	.503	.084	-2.69	.11
		me nsi	2	-.810	.566	.610	-2.38	.76
		on 3	3	-1.417	.749	.329	-3.50	.67
			5	-.649	.520	.723	-2.10	.80
	5	di	1	-.642	.273	.138	-1.40	.12
		me nsi	2	-.160	.378	.993	-1.21	.89

	on 3	3	-.767	.619	.728	-2.49	.95
		4	.649	.520	.723	-.80	2.10
Scheffe	1 dimension3	2	.482	.352	.759	-.63	1.59
		3	-.125	.604	1.000	-2.02	1.77
		4	1.292	.503	.168	-.29	2.87
		5	.642	.273	.245	-.22	1.50
	2 dimension3	1	-.482	.352	.759	-1.59	.63
		3	-.607	.658	.931	-2.67	1.46
		4	.810	.566	.728	-.97	2.59
		5	.160	.378	.996	-1.03	1.35
dimension2	3 dimension3	1	.125	.604	1.000	-1.77	2.02
		2	.607	.658	.931	-1.46	2.67
		4	1.417	.749	.471	-.94	3.77
		5	.767	.619	.820	-1.18	2.71
	4 dimension3	1	-1.292	.503	.168	-2.87	.29
		2	-.810	.566	.728	-2.59	.97
		3	-1.417	.749	.471	-3.77	.94
		5	-.649	.520	.816	-2.28	.99
	5 dimension3	1	-.642	.273	.245	-1.50	.22
		2	-.160	.378	.996	-1.35	1.03
		3	-.767	.619	.820	-2.71	1.18
		4	.649	.520	.816	-.99	2.28
LSD dimen	1 dimensi	2	.482	.352	.175	-.22	1.18
		3	-.125	.604	.836	-1.32	1.07

	sion2		on3	4	1.292*	.503	.012	.29	2.29
				5	.642*	.273	.021	.10	1.18
		2	dimension3	1	-.482	.352	.175	-1.18	.22
				3	-.607	.658	.358	-1.91	.70
				4	.810	.566	.156	-.31	1.93
				5	.160	.378	.673	-.59	.91
		3	dimension3	1	.125	.604	.836	-1.07	1.32
				2	.607	.658	.358	-.70	1.91
				4	1.417	.749	.062	-.07	2.90
				5	.767	.619	.218	-.46	2.00
		4	dimension3	1	-1.292*	.503	.012	-2.29	-.29
				2	-.810	.566	.156	-1.93	.31
				3	-1.417	.749	.062	-2.90	.07
				5	-.649	.520	.215	-1.68	.38
		5	dimension3	1	-.642*	.273	.021	-1.18	-.10
				2	-.160	.378	.673	-.91	.59
				3	-.767	.619	.218	-2.00	.46
				4	.649	.520	.215	-.38	1.68
Bonferroni	dimension2	1	dimension3	2	.482	.352	1.000	-.53	1.49
				3	-.125	.604	1.000	-1.86	1.61
				4	1.292	.503	.117	-.15	2.74
				5	.642	.273	.207	-.14	1.43
		2	dimensi	1	-.482	.352	1.000	-1.49	.53
				3	-.607	.658	1.000	-2.50	1.28

(I) Age		(J) Age	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
	on	4	.810	.566	1.000	-.82	2.44
	3						
		5	.160	.378	1.000	-.93	1.25
3		1	.125	.604	1.000	-1.61	1.86
	di						
	me	2	.607	.658	1.000	-1.28	2.50
	nsi						
	on	4	1.417	.749	.616	-.74	3.57
	3						
		5	.767	.619	1.000	-1.01	2.55
4		1	-1.292	.503	.117	-2.74	.15
	di						
	me	2	-.810	.566	1.000	-2.44	.82
	nsi						
	on	3	-1.417	.749	.616	-3.57	.74
	3						
		5	-.649	.520	1.000	-2.14	.85
5		1	-.642	.273	.207	-1.43	.14
	di						
	me	2	-.160	.378	1.000	-1.25	.93
	nsi						
	on	3	-.767	.619	1.000	-2.55	1.01
	3						
		4	.649	.520	1.000	-.85	2.14

Dependent Variable:**Personality**

	(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scheffe	(2	d 3	-.376	.310	.688	-1.26	.50
	i	i					
	ı	n 4	-1.435	.573	.106	-3.07	.19

	ension3	5	-1.045	.475	.190	-2.40	.30
3	dimension3	2	.376	.310	.688	-.50	1.26
		4	-1.059	.578	.346	-2.70	.59
		5	-.669	.481	.587	-2.04	.70
4	dimension3	2	1.435	.573	.106	-.19	3.07
		3	1.059	.578	.346	-.59	2.70
		5	.390	.681	.955	-1.55	2.33
5	din	2	1.045	.475	.190	-.30	2.40
		3	.669	.481	.587	-.70	2.04

		dimension3 4	-.390	.681	.955	-2.33	1.55
LSD	2	dimension3 3	-.376	.310	.227	-.99	.24
		4	-1.435*	.573	.014	-2.57	-.30
		5	-1.045*	.475	.030	-1.99	-.10
	3	dimension3 2	.376	.310	.227	-.24	.99
		4	-1.059	.578	.070	-2.21	.09
		5	-.669	.481	.167	-1.62	.28
	4	din 2	1.435*	.573	.014	.30	2.57
		3	1.059	.578	.070	-.09	2.21

		ension3	5	.390	.681	.568	-.96	1.74
	5	dimension3	2	1.045*	.475	.030	.10	1.99
			3	.669	.481	.167	-.28	1.62
			4	-.390	.681	.568	-1.74	.96
Bonferroni	2	dimension3	3	-.376	.310	1.000	-1.21	.46
			4	-1.435	.573	.083	-2.98	.11
			5	-1.045	.475	.180	-2.32	.23
	3	din	2	.376	.310	1.000	-.46	1.21
			4	-1.059	.578	.420	-2.62	.50

	ension3	5	-.669	.481	1.000	-1.96	.63
4	dimension3	2	1.435	.573	.083	-.11	2.98
		3	1.059	.578	.420	-.50	2.62
		5	.390	.681	1.000	-1.44	2.22
5	dimension3	2	1.045	.475	.180	-.23	2.32
		3	.669	.481	1.000	-.63	1.96
		4	-.390	.681	1.000	-2.22	1.44

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Consumer1	Between Groups	.423	4	.106	.355	.840
	Within Groups	28.600	96	.298		
	Total	29.023	100			

Consumer2	Between Groups	2.713	4	.678	.877	.481
	Within Groups	74.291	96	.774		
	Total	77.004	100			

		Sum of Squares	df	Mean Square	F	Sig.
Consumer1	Between Groups	3.833	3	1.278	4.920	.003
	Within Groups	25.190	97	.260		
	Total	29.023	100			
Consumer2	Between Groups	2.857	3	.952	1.246	.297
	Within Groups	74.147	97	.764		
	Total	77.004	100			

Consumer1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.833	3	1.278	4.920	.003
Within Groups	25.190	97	.260		
Total	29.023	100			

Post Hoc Tests

Multiple Comparisons

Dependent Variable:**Consumer1**

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound

Scheffe	2	dimension3	3	.02137	.11208	.998	-.2975	.3402
			4	-.69048*	.20737	.014	-1.2805	-.1005
			5	-.30303	.17179	.380	-.7918	.1857
	3	dimension3	2	-.02137	.11208	.998	-.3402	.2975
			4	-.71184*	.20918	.012	-1.3070	-.1167
			5	-.32440	.17398	.329	-.8194	.1706
	4	dimension3	2	.69048*	.20737	.014	.1005	1.2805
			3	.71184*	.20918	.012	.1167	1.3070
			5	.38745	.24639	.484	-.3136	1.0885
	5	din	2	.30303	.17179	.380	-.1857	.7918
			3	.32440	.17398	.329	-.1706	.8194

		ension3	4	-.38745	.24639	.484	-1.0885	.3136
LSD	2	dimension3	3	.02137	.11208	.849	-.2011	.2438
			4	-.69048*	.20737	.001	-1.1020	-.2789
			5	-.30303	.17179	.081	-.6440	.0379
	3	dimension3	2	-.02137	.11208	.849	-.2438	.2011
			4	-.71184*	.20918	.001	-1.1270	-.2967
			5	-.32440	.17398	.065	-.6697	.0209
	4	din	2	.69048*	.20737	.001	.2789	1.1020
			3	.71184*	.20918	.001	.2967	1.1270

		dimension3 5	.38745	.24639	.119	-.1016	.8765
	5	dimension3 2	.30303	.17179	.081	-.0379	.6440
		3	.32440	.17398	.065	-.0209	.6697
		4	-.38745	.24639	.119	-.8765	.1016
Bonferroni	2	dimension3 3	.02137	.11208	1.000	-.2805	.3232
	dimension2	4	-.69048*	.20737	.007	-1.2490	-.1319
		5	-.30303	.17179	.485	-.7657	.1597
	3	dimension3 2	-.02137	.11208	1.000	-.3232	.2805
		4	-.71184*	.20918	.006	-1.2753	-.1484

	ension3	5	-.32440	.17398	.392	-.7930	.1442
4	dinension3	2	.69048*	.20737	.007	.1319	1.2490
		3	.71184*	.20918	.006	.1484	1.2753
		5	.38745	.24639	.715	-.2762	1.0511
5	dinension3	2	.30303	.17179	.485	-.1597	.7657
		3	.32440	.17398	.392	-.1442	.7930
		4	-.38745	.24639	.715	-1.0511	.2762

Homogeneous Subsets

Consumer1

Age	N	Subset for alpha = 0.05	
		1	2

Tukey B[a,b]	3	39	2.4786	
	2	44	2.5000	
	5	11	2.8030	2.8030
	4	7		3.1905
Scheffe[a,b]	3	39	2.4786	
	2	44	2.5000	
	5	11	2.8030	2.8030
	4	7		3.1905
	Sig.		.416	.258

Dependent Variable:**Consumer1**

	(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scheffe	2	d 3	.02137	.11208	.998	-.2975	.3402
		i n 4	-.69048*	.20737	.014	-1.2805	-.1005
		e n 5	-.30303	.17179	.380	-.7918	.1857
		s i o n 3					
	3	d 2	-.02137	.11208	.998	-.3402	.2975
		i n 4	-.71184*	.20918	.012	-1.3070	-.1167

		dimension3	5	-.32440	.17398	.329	-.8194	.1706
	4	dimension3	2	.69048*	.20737	.014	.1005	1.2805
			3	.71184*	.20918	.012	.1167	1.3070
			5	.38745	.24639	.484	-.3136	1.0885
	5	dimension3	2	.30303	.17179	.380	-.1857	.7918
			3	.32440	.17398	.329	-.1706	.8194
			4	-.38745	.24639	.484	-1.0885	.3136
LSD	2	din	3	.02137	.11208	.849	-.2011	.2438
			4	-.69048*	.20737	.001	-1.1020	-.2789

	ension3	5	-.30303	.17179	.081	-.6440	.0379
3	dimension3	2	-.02137	.11208	.849	-.2438	.2011
		4	-.71184*	.20918	.001	-1.1270	-.2967
		5	-.32440	.17398	.065	-.6697	.0209
4	dimension3	2	.69048*	.20737	.001	.2789	1.1020
		3	.71184*	.20918	.001	.2967	1.1270
		5	.38745	.24639	.119	-.1016	.8765
5	din	2	.30303	.17179	.081	-.0379	.6440
		3	.32440	.17398	.065	-.0209	.6697

		dimension3 4	-.38745	.24639	.119	-.8765	.1016
Bonferroni	2	dimension3 3	.02137	.11208	1.000	-.2805	.3232
		4	-.69048*	.20737	.007	-1.2490	-.1319
		5	-.30303	.17179	.485	-.7657	.1597
	3	dimension3 2	-.02137	.11208	1.000	-.3232	.2805
		4	-.71184*	.20918	.006	-1.2753	-.1484
		5	-.32440	.17398	.392	-.7930	.1442
	4	din 2	.69048*	.20737	.007	.1319	1.2490
		3	.71184*	.20918	.006	.1484	1.2753

	ension3	5	.38745	.24639	.715	-.2762	1.0511
5	dinension3	2	.30303	.17179	.485	-.1597	.7657
		3	.32440	.17398	.392	-.1442	.7930
		4	-.38745	.24639	.715	-1.0511	.2762

*. The mean difference is significant at the 0.05 level.

APPENDIX G

INTRACTIVE TECHNOLOGY SURVEY DATASET:

Age (A-	Occupa	Has VR	Has VO	Replace	Person	Want Fa	Want Be	Follow	Starts C	Greets	Disting	Use Oth	Teach F	Drive/ I	Day Ca	Elderly	Health c	Correc	Elemen	Middle	Emotion	Conven	FEATU	TASKS
B	B	D	D	O	E	N	N	M	M	M	Y	Y	M	N	B	B	B	B	B	B	N	A	NA	SORT LAUNDRY
C	B	D	D	X	B	N	N	M	M	Y	Y	M	M	M	B	C	C	D	C	D	Y	A	NA-	DICTATION
C	F	D	D	O	D	N	M	M	Y	Y	Y	Y	Y	Y	B	B	D	D	C	D	Y	C	SPEED	MAPPING
C	A	D	D	N	E	N	N	N	N	Y	Y	Y	N	M	B	B	B	A	B	B	N	A	EASE O	VISITOR / SECURITY
D	A	D	D	O	E	O	N	N	N	Y	Y	Y	M	Y	C	B	B	D	D	D	O	C	EASE O	VISITOR / SECURITY
B	A	D	B	O	B	Y	Y	M	Y	Y	Y	Y	N	Y	E	E	E	C	C	C	O	C	INTERE	DO ALL MY WORK
B	A	D	D	N	B	Y	M	M	Y	Y	Y	Y	M	Y	D	D	E	D	D	D	Y	C	SCREE	COMPANIONSHIP
B	A	D	C	O	C	N	N	Y	Y	Y	Y	M	Y	M	D	D	E	C	D	D	Y	C	X	SMART SEARCHING / I
C	F	D	B	O	C	Y	M	Y	Y	Y	Y	Y	M	Y	C	C	C	B	C	C	O	B	EASE O	HOUSE WORK
B	A	D	D	O	A	X	M	N	Y	Y	Y	N	N	Y	A	D	B	B	C	C	N	C	X	GARDENING
C	F	D	D	N	B	N	N	N	N	Y	Y	M	N	N	C	D	D	B	D	D	Y	C	KEYBO	COOKING
E	C	D	D	N	E	N	N	N	N	M	M	M	N	M	C	D	D	D	D	D	N	A	SPEED	FINANCES
C	F	D	D	Y	D	Y	N	N	Y	N	Y	N	N	N	A	A	A	A	A	A	O	D	COOKI	COMPANIONSHIP
D	D	D	D	O	E	N	N	N	Y	M	Y	M	N	M	A	A	C	D	C	C	N	B	SPEED	SECURITY FEATURES
B	A	D	D	O	B	Y	M	M	Y	Y	Y	Y	M	Y	A	A	C	D	B	B	O	C	ACTUA	HOUSE WORK
B	A	D	D	O	D	N	N	M	N	Y	Y	N	Y	Y	B	B	B	B	B	B	O	A	INTER.	X
C	F	D	D	O	B	Y	M	M	M	Y	Y	Y	M	M	C	C	D	D	X	C	O	B	X	X
C	B	D	D	O	D	N	N	M	N	Y	Y	Y	N	M	C	C	D	D	O	D	N	A	EASE O	LIGHTING CONTROL
B	A	D	C	N	B	N	M	M	Y	Y	Y	N	M	M	C	D	D	D	C	D	Y	C	EASE O	INTERACTIVE
B	A	D	D	O	C	N	N	N	N	N	N	M	N	N	C	C	C	D	C	C	N	A	RELIAB	REMINDERS/ ALERTS
B	A	D	D	O	A	O	Y	N	Y	Y	Y	Y	N	Y	B	E	D	B	C	D	O	B	EASE O	WASH DISHES
C	O	D	D	N	E	N	N	N	N	N	N	N	N	N	B	B	B	B	B	B	N	A	X	X
E	F	A	A	Y	B	Y	O	Y	N	Y	Y	M	N	N	C	A	A	E	A	A	O	B	PERSO	VISITOR / SECURITY
C	A	A	D	N	E	N	N	N	N	N	N	N	N	N	A	A	A	A	A	A	N	A	RELIAB	NO NEW FEATURES
B	D	D	B	Y	C	Y	M	Y	Y	M	M	M	N	M	C	B	B	C	B	B	N	B	X	X
C	D	D	D	N	E	N	N	N	N	N	M	N	N	N	B	C	C	D	C	C	N	A	EASE O	NO NEW FEATURES
C	B	D	D	N	C	N	N	N	N	N	Y	Y	N	N	A	A	A	A	A	A	N	A	EASE O	REMINDERS/ ALERTS
D	C	D	D	N	E	N	N	N	N	N	M	N	N	N	B	C	B	B	B	B	N	A	X	AUTOMATICALLY PRI
B	A	D	D	O	D	O	O	Y	Y	Y	Y	Y	M	Y	C	C	C	D	D	D	O	B	KEYBO	KEYS FOR MATH CHAR
B	A	D	D	N	E	N	N	N	M	M	N	M	M	N	A	B	B	B	B	B	N	A	SPEED	INTERACTS WITH OTH
B	A	D	D	O	E	N	N	N	M	N	Y	N	N	N	A	A	A	A	A	A	N	A	X	X
B	A	D	D	O	A	N	N	N	N	M	Y	M	N	M	C	C	C	C	C	C	N	A	X	X
C	F	D	D	O	A	Y	N	N	N	Y	Y	M	N	M	A	A	A	A	B	B	M	B	SPEED	SECURITY FEATURES
B	A	D	D	O	B	N	M	M	Y	Y	Y	Y	Y	Y	C	C	D	C	C	C	O	B	EASE O	COOKING
B	A	A	B	N	B	N	N	N	M	M	Y	Y	Y	Y	B	B	A	D	E	E	Y	A	KEYBO	HOME WORK
B	A	D	D	O	C	N	O	M	Y	Y	Y	Y	Y	M	B	D	C	C	C	C	N	C	MONIT	VOICE RECOGNITION
C	F	D	D	O	B	Y	Y	Y	Y	Y	Y	Y	Y	Y	B	B	D	D	B	B	Y	C	X	INDEPENDENT THOUG
B	F	D	D	O	B	N	N	N	N	N	X	N	N	N	A	A	A	C	C	C	O	A	KEYBO	COOKING
B	A	D	D	O	E	O	O	M	N	N	M	M	N	M	C	C	D	B	C	C	N	A	X	X
B	A	A	C	N	E	N	N	N	N	M	Y	Y	N	N	C	C	A	E	C	C	N	A	X	X
C	C	A	D	Y	A	N	N	N	N	M	Y	Y	Y	N	C	C	D	A	E	E	N	B	X	X
B	A	A	B	N	D	N	N	Y	N	N	Y	N	Y	Y	D	D	B	E	X	D	N	X	SAFETY	COOKING
C	F	A	B	O	B	Y	Y	Y	Y	Y	Y	Y	Y	Y	C	D	D	E	B	D	Y	B	FUNCT	HOUSE WORK
D	F	D	D	N	E	N	N	N	N	N	N	Y	N	N	A	A	A	E	A	A	N	A	X	X
B	A	D	D	O	A	N	N	M	Y	Y	Y	Y	Y	Y	C	D	D	D	D	D	O	B	X	REMINDERS/ ALERTS
B	A	A	D	O	D	Y	M	Y	Y	M	Y	Y	N	Y	C	C	C	C	C	C	M	C	X	HOUSE WORK/ INTERA
C	F	D	D	O	B	Y	Y	Y	Y	Y	Y	Y	Y	Y	D	D	E	E	D	D	Y	C	X	X
C	F	D	D	O	D	Y	M	Y	Y	Y	Y	Y	M	Y	C	C	C	C	C	C	Y	C	EASE O	VISITOR / SECURITY
C	F	A	C	Y	B	Y	Y	Y	Y	Y	Y	Y	Y	Y	C	C	C	C	C	C	Y	B	X	X
C	F	A	C	N	E	N	N	N	N	N	N	N	N	N	A	A	C	C	C	C	N	B	X	X
C	F	A	B	N	D	Y	M	Y	Y	Y	Y	Y	Y	Y	X	E	D	D	D	D	Y	C	EASE O	TEACHABILITY / PERS
B	A	D	D	N	E	N	O	N	N	N	M	Y	N	M	C	C	D	C	C	C	N	A	EASE O	REMINDERS/ ALERTS
C	B	D	D	O	D	Y	M	M	M	Y	Y	Y	Y	Y	C	C	D	D	D	D	M	B	INTUIT	CLIMATE CONTROL
B	A	A	B	N	D	Y	M	M	Y	Y	Y	Y	M	Y	C	D	D	E	C	C	Y	C	X	VIRUS SCAN / PROTEC
B	A	D	D	O	A	N	M	Y	Y	Y	Y	Y	Y	Y	C	E	E	E	D	E	Y	C	TEACH	ANYTHING I WANT
B	A	D	D	N	E	N	N	M	N	N	M	Y	N	N	C	C	C	C	C	C	N	A	X	X
B	A	D	D	O	B	Y	M	Y	Y	Y	Y	Y	Y	Y	E	E	E	E	E	E	Y	C	EASE O	INTERACTS WITH OTH
B	A	D	D	N	E	N	N	N	N	N	N	M	N	Y	C	C	D	C	D	D	N	A	SPEED	MANUAL LABOR
D	F	D	D	N	D	N	N	N	Y	Y	Y	Y	Y	Y	E	D	E	C	E	E	O	B	X	X
B	A	D	D	N	B	N	N	N	N	Y	Y	Y	N	N	B	B	C	C	C	C	N	A	KEYBO	INTERACTS WITH OTH
E	B	D	D	N	E	N	N	N	N	N	N	Y	N	N	B	B	B	B	B	B	N	A	X	X
B	A	D	D	O	D	N	N	N	N	N	N	Y	N	N	C	C	D	D	C	C	N	A	X	X
B	A	A	A	N	E	N	N	M	N	N	Y	Y	N	Y	B	C	C	C	C	C	N	A	X	X
D	B	A	A	Y	D	Y	M	Y	Y	Y	Y	Y	Y	M	C	B	B	C	C	D	O	C	SPEED	X
E	B	A	C	N	E	N	N	N	N	N	X	M	M	M	C	D	D	C	D	C	N	A	SPEED	APPLIANCE MONITORI
E	A	A	C	O	C	N	N	M	M	M	Y	M	M	M	A	A	C	D	C	C	M	A	SPEED	WASH DISHES
D	B	D	D	N	D	N	M	M	M	M	M	M	N	M	C	C	C	C	C	C	N	X	X	COOKING
C	F	D	C	O	E	N	N	N	N	N	Y	N	N	N	A	A	A	A	A	A	N	A	NOT E	SECURITY FEATURES
B	A	C	A	O	D	N	M	Y	Y	Y	Y	Y	M	Y	A	D	D	A	A	E	M	A	RELIAB	TASKS
E	B	D	D	N	E	N	N	N	N	N	N	M	N	N	A	A	A	A	A	A	N	A	EASE O	SHOVELING THE DRIVE
B	A	A	A	O	B	N	M	Y	M	Y	Y	Y	M	M	D	B	D	B	B	C	O	B	ACTUA	SELF REPAIR
E	B	A	C	N	E	N	M	N	M	N	N	M	M	Y	B	D	D	C	C	D	N	A	SECUR	SATELLITE APP
E	B	D	A	O	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	D	D	D	D	D	D	O	D	SPEED	REMINDERS/ ALERTS
C	B	D	D	N	D	N	N	N	N	N	Y	Y	Y	Y	C	D	C	D	C	C	X	A	X	TAKING CARE OF PETS
C	A	D	D	N	E	N	N	N	N	N	N	N	N	Y	A	D	C	D	A	B	N	A	X	X
C	A	D	D	O	D	N	M	M	M	M	Y	Y	M	M	X	D	D	D	C	C	M	A	X	X
E	D	D	D	O	E	N	N	N	N	Y	Y	Y	N	N	A	A	A	D	A	A	O	A	SPEED	VISITOR / SECURITY
B	A	D	D	N	E	N	N	N	M	N	M	M	M	M	B	C	C	C	B	C	M	A	X	X
B	F	D	D	O	A	Y	M	Y	Y	Y	Y	Y	Y	Y	B	C	C	C	C	C	Y	D	INFORM	INTERACTIVE
B	A	D	D	O	B	O	N	N	Y	Y	Y	N	Y	N	B	B	B	B	B	D	O	C	X	X
C	F	D	D	O	D	Y	Y	Y	Y	Y	Y	Y	M	Y	C	C	C	C	D	D	M	C	EASE O	TAKING CARE OF PETS
C	F	D	D	O	B	Y	Y	Y	Y	Y	Y	Y	M	Y	A	A	C	D	B	D	N	B	EASE O	COOKING
E	F	D	D	N	E	N	N	N	N	N	M	N	N	N	A	A	A	C	C	C	N	X	X	X
C	F	A	D	N	E	N	N	N	N	N	M	Y	N	Y	A	A	C	B	C	D	N	A	USER F	WASH DISHES
B	F	A	C	N	E	N	N	N	N	N	Y	M	M	M	C	D	D	C	D	D	N	A	SPEED	X
B	A	A	C	N	C	N	N	N	M	Y	M	M	N	M	B	B	B	B	B	B	M	C	EFFICI	TAXES
C	A	D	D	N	E	N	N	N	N	N	N	Y	N	N	D	D	D	E	B	A	N	A	KEYBO	REMINDERS/ ALERTS
C	A	A	A	N	E	N	N	N	M	M	M	M	M	Y	D	D	D	D	C	C	M	A	X	X
C	A	D	D	O	B	N	M	N	N	Y	Y	Y	N	Y	C	D	D	D	D	D	N	B	OBEDI	MAKING COFFEE
C	B	D	D	O	E	N	N	M	N	M	M	M	N	N	A	A	C	C	A	A	N	A	EASE O	DICTATION
E	F	D	B	O	E	N	N	M	M	M	Y	M	N	M	C	B	C	D	D	D	N	A	X	VISITOR / SECURITY
B	A	D	D	N	B	Y	Y	Y	Y	Y	Y	Y	Y	Y	E	E	E	E	E	E	O	D	X	X
C	A	A	B	N	A	Y	Y	Y	Y	Y	Y	Y	Y	Y	C	C	C	C	C	D	Y	C	RELIAB	ADAPTIBILITY / INTUI
C	C	A	D	O	C	O	O	M	N	Y	M	Y	Y	Y	A	C	C	D	A	A	M	B	X	X
B	A	A	A	O	D	N	M	N	N	Y	Y	Y	M	M	B	B	C	C	C	C	N	A	X	X
C	D	D	D	N	E	N	N	M	N	M	M	M	M	M	C	C	C	C	C	C	N	A	X	WASH DISHES
B	A	A	C	O	B	N	N	N	Y	Y	Y	Y	M	M	B	C	C	C	D	D	O	A	X	X
C	F	C	A	O	B	N	N	N	N	N	Y	Y	N	N	C	C	D	C	C	X	M	B	NATUR	24 HR BATTERY
B	F	A	B	O	D	N	N	N	Y	Y	Y	Y	M	N	C	D	D	E	D	E	N	A	RELIAB	INTERACTIVE
C	F	D	D	N	E	N	M	Y	M	M	M	Y	M	Y	D	D	D	D	D	D	N	A	NOT EA	ORGANIZATION / PHYS
C	D	A	C	Y	Y	Y	Y	Y	Y	Y	Y	Y	M	Y	C	A	C	D	C	C	O	C	VOICE	REMINDERS/ ALERTS