Summer 2010

Assessment of Society's Awareness, Acceptance, and Demand for Robotic Wait Staff in Restaurant Operations

Jeffrey Parrent
Regis University

Regis University
College for Professional Studies Graduate Programs
Final Project/Thesis

Disclaimer

ASSESSMENT OF SOCIETY'S AWARENESS, ACCEPTANCE, AND DEMAND FOR ROBOTIC WAIT STAFF IN RESTAURANT OPERATIONS

A THESIS

SUBMITTED ON JULY 17, 2010

TO THE DEPARTMENT OF COMPUTER INFORMATION TECHNOLOGY

OF THE SCHOOL OF COMPUTER AND INFORMATION SCIENCES

OF REGIS UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF MASTER OF SCIENCE IN COMPUTER INFORMATION TECHNOLOGY

BY

Jeffrey Parrent

APPROVALS

Shari Plantz-Masters, Thesis Advisor

Douglas Hart

Richard Blumenthal

Abstract

This research study consists of an assessment of participants' awareness of robotics in general and also their acceptance and consumer demand for mobile, humanoid robots in the role of robotic waiters in restaurants. The study also includes the awareness and consumer demand for Microsoft Surface Computers to be potentially used as restaurant tables capable of electronic order entry, payment, and entertainment. The social impacts of such high technology upon the human occupation of waiter or waitress were also examined relative to the resistance to automation from current human wait staff. The overall results of the study were luke-warm demand for robotic waiters, strong demand for Microsoft Surface Computers, and resistance to robotic waiters among most wait staff.

Table of Contents

List of Figures

List of Tables

Chapter 1 – Introduction

Inventors, engineers, and companies continue to advance the science in the field of robotics and artificial intelligence. When most people think about robots today, they tend to think of robots from science fiction movies, stationary robots that perform repetitive tasks on assembly lines, small robotic household appliances, or advanced military or space robots. In recent years, a new category of robotics has begun to emerge known as "personal and mobile robotics". This category of robotics consists of domestic robots for household automation and mobile robots in some workplaces such as materials management robots in warehouses. It does not include stationary robots on automotive assembly lines. The mobile robotics field is in its infancy today and is similar to personal computers of the early 1980s in terms of consumer awareness and acceptance. Within the personal robotics category there is a new sub-category of highly specialized robots known as humanoid, android, and geminoid robots. The development of such advanced machines was not only a major technological challenge, but also leads to major social implications such as the potential displacement of human workers in a number of different jobs spread across numerous industries. The focus of this study was to assess consumer and restaurant manager demand for humanoid robots to serve as waiters and waitresses in restaurants in the service sector. Another key goal of the study was to evaluate and interpret the reactions of waiters and waitresses to the concept of robotic waiters, especially when used in conjunction with Microsoft Surface Computers for order entry and payment.

Many consumers are aware of small robotic appliances such as the Roomba vacuum from iRobot Corporation. Of course, the Roomba and other small, mobile, robotic appliances do not fall into the humanoid category. However, a person's awareness of such small, robotic appliances can be used as a baseline for their overall level of awareness of mobile robotics in

general. Some people may have an adverse reaction to these humanoid and android robots, especially if their occupation may be affected by the widespread adoption of more advanced versions of these machines. Such professions could include restaurant wait staff, maids and housekeepers, some types of construction workers, and materials management personnel who move physical products in warehouses and grocery stores, etc.

The motivations for this study included understanding the answers to following research questions. How do customers, restaurant managers, and wait staff react to humanoid robotic waiters in restaurant settings? Are humanoid robots technologically ready to serve as waiters? Is society ready to socially accept robotic waiters? What is the general awareness level of mobile humanoid and android robots as of 2010? What is the demand for robotic waiters among consumers and restaurant managers? What will human wait staff do for employment if replaced by robotic waiters in the future? Do humans prefer to interact with humanoid, android, or geminoid robots? What is the general awareness level of Microsoft's new Surface Computer? What is the demand for Surface Computers in restaurant operations among all participants in the study?

While there was significant demand to increase the speed and efficiency of restaurant service via automation from consumers and lukewarm demand among restaurant managers, resistance to robotic waiters remained high among most human wait staff due to occupational displacement. However, there was strong demand for the Microsoft Surface Computer for order entry, payment, and entertainment among all types of participants: consumers, restaurant managers, and restaurant wait staff.

Chapter 2 – Review of Academic Literature

Three occupations have become highly automated and lost thousands of workers. These occupations are switchboard operators, company receptionists, and many types of automotive assembly workers. At one time, all of these occupations were extremely labor intensive, but technology advances have greatly reduced the number of workers in each of these types of jobs.

Elimination of Switchboard Operators and Receptionists

As late as the early 1970s, the occupation of switchboard operator was so labor intensive, that complex mathematical algorithms and computer programs were needed to optimize the scheduling of the operators (Segal, 1974). At the time, live operators were so common, that they were scheduled into shifts or tours and the goal of the scheduling software was to schedule the relief periods such that overall costs would be minimized.

The desire to automate live switchboard operators extends well back to the 1890s. Over one hundred years ago, Almon Strowger thought calls to his mortuary were being connected to his competitor by incompetent live operators ("No operator please", 2000). In the late 1880s and early 1890s, he built a prototype of an automatic switch and patented it in 1891. In 1892 he opened up the Strowger Automatic Telephone Exchange. He replaced the buttons on his automatic switch with a finger wheel dial, which was the precursor to the rotary dial telephone.

Today, just as sophisticated PBX equipment, interactive voice and dial response systems, and voicemail systems have largely replaced many company receptionists, voice over IP (VOIP) is quickly beginning to replace PBX systems. Mathews (2006) described the benefits of setting up a virtual assistant. Some of the benefits include: automated attendant or "digital receptionist", outbound voice or fax marketing, reminders or wake up calls via voice, "local" phone numbers

to almost any city in the world, and a unified inbox with faxes and voice mail delivered as email attachments, among other benefits.

Quain (2006) discussed twelve ways to boost businesses today, including VOIP systems and virtual PBX systems. The VOIP discussion described several VOIP providers for small businesses, of which Vonage is at the forefront with their Small Business Unlimited Premium package. In the category of free or almost free service, Skype is the leader. They also offer a business package called Skype for Business. Quain also discussed the benefits of a virtual PBX for small businesses, which can be managed via the Web. Quain compared three systems: VirtualPBX, Onebox's Receptionist, and Asterisk, the Linux-based, VOIP open source system. It is clear with all these technologies, that the days of the live receptionist are numbered and it is similar to what happened to switchboard operators.

Another technology that replaces human operators is TAPI. Young (1995) discussed a standard introduced in 1995 called TAPI (telephone applications programming interface) that allows personal computers to replace sophisticated switchboards and call processing systems. Microsoft's Windows 95 operating system lets a $2,000 computer act like a $25,000 call processing system for order entry for example. The other part of the equation is cheap semiconductors that bring powerful telephone switching and processing power to high-end personal computers. TAPI can bring features such as predictive dialers that automate junk telephone calls and systems which allow people to check their bank balances without talking to a human. At the time, Mediatrends sold a system for one hundred users for $4,000 with hardware add-ons for $1,600 compared to similar systems that sold for $25,000.

Reduction of Automotive Assembly Workers

Another occupation which has seen a tremendous amount of automation over the last several decades is that of the assembly worker, especially in the area of automotive assembly. At one time, in the early days of the automotive industry, the industry was so labor intensive that few workers, if any, could foresee that many of the jobs on the assembly line would one day be automated by machines called robots. There are numerous historical articles describing the impact of automation on factory workers.

Sheppard and Stern (1957) discussed the devastating impacts on laid-off workers at an automotive supplier firm after its client automated a stamping manufacturing process in the mid 1950s. In the specific example, prior to automation, 13,000 workers at a major company and 5,000 workers at one of its suppliers, produced stampings for 755,000 cars in 1947. The major company had completed its automation of the stamping process by 1955. The 5,000 workers at the supplier were laid off when their plant shut down. The remaining 13,000 workers at the major firm with the help of automation, produced stampings for 2,241,000 cars in 1955 for a 300% increase in productivity. Furthermore, the effects of the unemployment were hardest on older workers, female workers, and blacks in terms of length of time to find new jobs, reduced pay at the new jobs, and the percentage of laid-off workers that used up their unemployment benefits. These problems were due to general discrimination in the society at the time and not necessarily the automation itself. However, it is an historical example of the devastating effects of automation on employees, particularly for low and semi-skilled workers, whose jobs are the easiest to automate.

In another historical article on factory automation, Paul (1979) predicted in the late 1970s much of the automation to come in the 1980s. He described the state-of-the-art in industrial

robots in 1979. Most industrial robots at the time were limited to mechanical arms that could only move to precise Cartesian coordinates. If the parts to be worked on or assembled fell outside a desired range, the robot would fail. However, sensor-controlled robots and machine vision systems were starting to come into play in the late 1970s. However, in general the machines still lacked force feedback, that humans take for granted when using their own hands or when using power tools. Paul predicted that relatively low cost, mass produced industrial robots could free humans from the tedium of the assembly line in the 1980s. This is in fact, exactly what happened.

Boudette (2006) described the advantages Chrysler has gained at their Belvidere, Illinois plant by shifting to flexible assembly lines that can assemble more than one car model at the same plant. The plant used to produce only Neons, which were slow sellers. Now the plant produces two models, the Jeep Compass and Dodge Caliber, with a third model to be introduced later in 2006. The robotic body shop has only 180 workstations, about half as many as before. A single workstation that used to need five workers now uses only one worker and twenty robots to weld and glue parts for an eighty percent reduction in workers. The robotic process has cut the number of workers by ten percent, but overall employment at the plant is up by 1,000 workers for the second shift. An example of door production illustrates the efficiency of the new robots. A blue light illuminates, which means produce a Caliber door. A robot holds a reinforcing beam against a door panel held by a second robot, while a third robot welds the door in forty-two seconds. Now a yellow light comes on, which means produce a Compass door. Each robot changed tools on the end of the robot arm to ones designed to fit Compass doors and then welded the new door without any downtime for the assembly line.

Brown (2004) discussed Toyota's improvement to flexible manufacturing as described above by Boudette. Japanese companies were already ahead of Detroits' Big Three with flexible assembly lines, when Toyota took the next step to standardize its assembly lines around the world allowing it to produce numerous different car models on the same line. This process works both in countries like Vietnam with more low wage labor to high wage countries like the US or England, which use more robots. The previous system used three large pallets per vehicle to hold body pieces together while they were welded, creating a need for a large storage space to store pallets when not in use. The new global body line uses just one pallet per vehicle to hold parts in place during welding and then is quickly removed from the vehicle for reuse, which greatly reduces the number of pallets needed in the process. This frees up a large amount of space in the plant where more robots were added to further increase the efficiency of the entire process. Another secret to their success is to design numerous car models of similar sizes which can be accommodated by a single assembly line. This is in contrast to Chrysler's approach in which a size difference between the popular PT Cruiser and the Neon prevented Chrysler from easily expanding production of the Cruiser beyond its initial plant in Mexico.

Of course, Ford is no stranger to automation either. Glover (2005) discussed the boost in output achieved at a Ford Transit van plant. For the 2006 model year, twenty extra robots were added which boosted production by two vehicles per hour. Even as output volume increased, the plant was able to avoid adding much in the way of new labor workers, so their worker hours per unit time has actually decreased. Plant manager John Anderson recognizes that they will never be able to compete with the low cost labor in low wage countries, so the only way to stay competitive is to increase efficiency. The continued use of advanced robotics is one way to increase the efficiency.

James (2007) discussed the cutting edge in automotive robotic systems today which involves 3D vision systems. Traditionally, most automotive assembly robots have performed spot welding and painting by moving robotic arms repeatedly to fixed positions. Advances in 3D vision systems will allow additional uses of robots in automotive plants, including vehicle inspections currently performed by humans. According to the International Federation of Robotics, there were 850,000 industrial robots in operation around the globe in 2007. That is up a quarter million robots from ten years ago. Japan leads the way with 42%, followed by Europe at 33%, and the US trails at 14%. The automotive industry still accounts for over 55% of all robot use. Vehicle operations manager at Ford, Mark Diederich, said that almost everything they do in their body shop is done by robots. Ford is looking to go beyond automated painting and welding and use robots in their final assembly areas. Wong (2007) also noted that Japan had 356,500 industrial robots by the end of 2004 compared to only 122,000 industrial robots in the US at that time.

The use of robotics has been extended beyond the automotive assembly line to the purpose of testing cars. Romanchik (2004) described the benefits of using robots to test drive completed cars. Robots are increasingly being used for this purpose as they can perform more repeatable tests and thus fewer tests than human drivers. The Stahle SAP2000 robot sits in the driver's seat and connects to the car's accelerator and brake pedals, as well as the clutch and gearshift if the vehicle has a manual transmission. Another robot, the Anthony Best SR series is used for steering control only. There are also other robots that only perform braking. An example use of a braking robot involved a European auto company that needed to apply a force of 400 N to the brakes to stop from a speed of 160 kilometers per hour. Human drivers were able to meet

these requirements in only three of twenty-seven tests, while the robot performed the test successfully in five consecutive trials.

Artificial Intelligence Definitions

A thorough review of the current academic literature reveals the state-of-the-art in terms of mobile, personal and service robots, which is a relatively new field in robotics. However, before diving into the literature describing the world's most advanced mobile robots, some definitions of the terms are provided. Nishio, Ishiguro, and Hagita (2007) defined three types of human-like robots: humanoid, android, and geminoid. Humanoid robots resemble the appearance of humans with arms, legs, and heads, but still look very mechanical due to their metal and plastic construction. Android robots, in contrast, look exactly like humans with realistic hands and facial features. Geminoid robots are like androids, except that they mirror the appearance of a specific human. Ishiguro defined a number of other phrases that are important to understand when studying robotics (Coradeschi et al., 2006). Android science is a new interdisciplinary framework between engineering and cognitive science, which itself is the study of human reactions to android and geminoid robots. Another term, synergistic intelligence, refers to intelligent behaviors that emerge through interaction with the environment including humans. Cognitive development robotics is a methodology that comprises the design of self developing structures inside the robot's brain and environmental design. Lastly, Kara (2004) defined two emerging robotics markets: personal and service robots. Personal robots are robots purchased by individual buyers (consumers) which educate, entertain, or assist in the home. An example would be iRobot's Roomba robotic vacuum. Service robots are semi or fully autonomous mobile robots that assist humans, service equipment, and perform other autonomous functions. An example would be the da Vinci robotic surgery system.

Humanoids

Three of the most advanced humanoid robots that exist today are the Honda ASIMO, the Humanoid Robot Project (HRP) from Kawada Industries, and the HUBO robot from the Korean Advanced Institute of Science and Technology (KAIST). These robots illustrate some of the basic functionality that is needed in mobile robots, before one could be used as a robotic waiter. Following a brief description of humanoid and android robots is a discussion of human reactions and perceptions to some of these new machines.

ASIMO

ASIMO stands for Advanced Step in Innovative Mobility. ASIMOs are roughly four feet tall and 119 pounds. The machines can walk 1.6 kilometers per hour and can jog up to six kilometers per hour ("Smarter version of ASMIO robot", 2008). The ASIMO robot was invented by the Honda motor company, which has now programmed the robots to work together as a team for the first time. The ASIMOs can recognize moving objects coming toward them, follow a person as directed, and autonomously recharge their batteries. In addition, the new ASIMOs can respond in fifty different Japanese phrases. Honda's overall purpose is enhancing the cooperation, efficiency, and intelligence of these mobile, factory robots in a real world work environment.

Harris (2007) described the technology behind the ASIMO, which has been in research and development for twenty years at Honda. ASIMOs use supersonic waves to detect motion around them as well as two visual cameras, two infrared cameras, and an infrared laser beam to detect what is happening in their environment. Honda plans for ASIMOs of the future to assist the elderly and disabled. Honda projected it will take about ten years to produce a useful version of the ASIMO.

Humanoid Robot Project (HRP Series)

Kawada Industries manufactures the HRP series of robots also known as the Humanoid Robot Project. Their most famous models are the HRP-2, HRP-3, and HRP-4. The 5'1", roughly 130 pound HRP-2 is the first human-sized, humanoid robot that can stand up from a lying down position on its back or face down (Hirukawa, Kajita, Kanehiro, Kaneko, & Isozumi, 2005). It can also perform the reverse motion of starting in a standing position and then lie down. Prior to the HRP-2, only toy robots could perform similar motions. This motion is important for robots working in restaurants because robots need to stand up after falls and continue working and not remain on the ground helplessly. It is impossible to design the robot such that it is guaranteed to never fall down.

HUBO

The HUBO humanoid robot was developed by KAIST. The HUBO robot is another humanoid, bipedal walking robot that is similar in style and functionality to others in that product class such as the HRP-2 and ASIMO. The HUBO robot has forty-one degrees of freedom, weighs 125 pounds, and is 4'2" tall (Park, Kim, & Oh, 2006). It uses a 933 MHz Pentium III with Windows XP and a real time extension (RTX). HUBO can walk forward, backwards, sideways, and can turn around. Its maximum walking speed is 1.25 kilometers per hour.

Androids

Android robots represent the next step in making robots look very realistic and human-like in appearance. In fact, androids can be mistaken for humans for brief periods of two to ten seconds depending on the circumstances and micro-movements of the androids (Hornyak, 2006). Androids have been invented to see whether or not humans react better to them as opposed to the mechanical looking humanoid robots which consist of metal and plastic. According to Hornyak,

android robots begin to cross something known as the "uncanny valley", which is a negative reaction many humans may have to something that looks almost human, but actually is not human. The positive reaction only returns when androids and humans are nearly indistinguishable.

Ms. Saya

An example of an android robot is the robotic receptionist known as Ms. Saya. This android has already been at work serving as a receptionist in the Tokyo University of Science for the last few years (Hornyak, 2006). Ms. Saya is less sophisticated and has fewer sensors and more limited movement than some of the other geminoid robots described below. However, Ms. Saya has been programmed to generate very realistic facial expressions, thus simulating human emotions to an extent. Today's androids in general cannot walk and remain in seated or standing positions and Ms. Saya is no exception. Obviously, for androids to serve as waiters, they must overcome their inability to walk. Ms. Saya was developed by Hiroshi Kobayashi of the Tokyo University of Science.

Geminoids

Geminoid robots go one step beyond android robots in that they not only look human, but they in fact try to exactly mirror the appearance of a specific human being. This concept was recently portrayed in the 2009 science fiction film Surrogates starring Bruce Willis. Because they mirror a person exactly, geminoid robots are often used in a teleoperated mode in which a human operator is actually controlling the robot from some distance away. Part of the experiment with geminoid robots is to determine if they convey the same "human presence" as the original human they are modeled after. Like androids, today's geminoid robots also do not walk and are confined to a permanently seated or standing position.

Repliee Q1 Expo

The Repliee Q1 Expo geminoid robot is a copy of Ayako Fujii, a Japanese newscaster for NHK TV (Hornyak, 2006). The robot is almost indistinguishable from an ordinary Japanese woman in her 30s. Ishiguro does not believe that we will need empathy or emotional tests anytime in the near future to distinguish between geminoid robots and humans, as depicted in the science fiction cult classic Blade Runner, starring Harrison Ford. This is due to the fact that is so difficult to fool humans beyond about ten seconds when looking at today's geminoid robots.

Geminoid HI-1

For his next project, Ighiguro set out to make a geminoid robot that was a copy of himself and he created the Geminoid HI-1 robot. Ishiguro believed that humans can more easily adjust to very realistic looking androids and geminoids than mechanical looking humanoid robots, since we should be already comfortable with something that looks like us (Harris, 2007). This is in contrast to Honda ASIMO project leader Stephen Keeney's view that robots need to look artificial like something out of science fiction movies for humans to accept them. Geminoid HI-1 is 5'9" tall, 220 pounds, and currently costs $300,000 (Gurchiek, 2007). The robot is usually seated because it does not walk. Professor Ishiguro teleoperated the robot via remote control and it sits in for him for lectures to students, in order to study the human presence of the robot. One of the challenges with android and geminoid robots is to synchronize the mouth movements of the robot to match what the robot is saying so that lip readers will get the same message as someone listening to the robot. The geminoid has Ishiguro's face, voice, hairstyle, glasses, and even a similar wardrobe. When the two are sitting side by side, it is difficult to tell them apart at first. Although the World Future Society projected in 2007 that a robotic workforce will change how bosses value employees, Ishiguro does not believe that robots will replace all human jobs.

He believed that we will automate the simpler, mundane jobs, leaving more challenging jobs to real humans.

Human Perceptions of Humanoid and Android Robots

Hinds, Roberts, and Jones (2004) performed one of the first ever large studies of human reactions to robotic coworkers when performing simple tasks. The study consisted of 292 participants of which fifty-nine percent were women. The study involved the simple, cooperative task of filling bins with parts placed in the room and setting the bins by the door. The researchers wanted to see if a human-looking robot made a difference in how human participants interacted with it versus machine-like robots. The robot was teleoperated by a hidden live operator to make the robot seem more autonomous than it really was. Although the human-looking robot was not very realistic (it looked more like a puppet than today's advanced humanoid or android robots), the researchers did find that humans felt less responsible for a collaborative task when working with a human-looking robot versus a machine-like robot. Thus, the participants felt that the human-like robot could accomplish more on its own than a machine-like robot.

In another study, researchers examined the effects of distance and robot approach direction upon human comfort levels (Walters, Dautenhahn, Woods, Koay, Boekhorst, & Lee, 2006). The first half of the study involved twenty-eight participants, evenly split between males and females. The researchers found that sixty percent of participants approached the robot to the limits of personal and social zones (.45 meters to 3.6 meters). Forty percent of respondents allowed the robot to approach up to the half meter safety limit. The second part of the study involved determining the preferred approach direction of the mechanical robot as it delivered a television remote control to fifty-three seated participants. The authors found that the preferred approach direction was from the right (fifty-nine percent), followed by the left (twenty-eight

percent), and lastly from the front (thirteen percent). When the robot approached directly from the front, the participants felt the most threatened.

Mutlu and colleagues studied the perceptions people have of the ASIMO robot (Mutlu, Osman, Forlizzi, Hodgins, & Kiesler, 2006). They recruited twenty-six undergraduate students consisting of sixteen females and ten males. The researchers designed an interactive, two-player video game in which participants would swipe a hand over green targets and avoid red targets on a screen. Participants played the game in either competitive or cooperative modes with the ASIMO. The researchers found that men thought that the ASIMO was less desirable for competitive tasks than for cooperative tasks. Women generally did not differ on their perceptions of the robot and usually had positive feelings and involvement in the two tasks studied.

Ishiguro (2007) discussed his development of androids and geminoids with a human-like appearance. He performed an experiment with twenty participants. The task was to identify the color of a cloth when it was revealed for two seconds from behind a curtain. At the same time, respondents were asked if the "person" they also saw behind the curtain was an android or a human. When the android performed micro-movements, similar to human involuntary movements, seventy percent of participants were not aware that they were seeing an android. In contrast, when the android was stationary with no micro-movements, seventy percent of volunteers were aware of the android. In terms of human perception of androids, this illustrates the importance of micro-movements in fooling humans into thinking that androids are human.

Takano and colleagues wanted to study the psychological effects of a geminoid robot bystander on human to human communication (Takano, E. et al., 2008). They chose a serious situation: patient and doctor meetings for patients with serious conditions so that the patients would already be a little nervous coming into the meeting. They then placed a Repliee Q2 Expo

robot dressed as a nurse or medical student in the background of the patient-doctor meeting without telling patients that the machine was really a geminoid robot. They came to some interesting conclusions. If the robot smiled and nodded in agreement with things the patient said, the patients felt comfortable with the android. However, if the robot smiled and nodded in agreement with things the doctor said, the effect on the patients was worse than having no android in the room.

Minato and colleagues studied the effects on human gaze behavior when participants were questioned by an android (Repliee Q1 Expo) versus a human questioner (Minato, Shimada, Itakura, Lee, & Ishiguro, 2006). Humans are known to break eye contact during conversation when speaking. The researchers teleoperated the robot in a "Wizard of Oz" approach. In this approach, participants thought the robot was asking questions autonomously, but really was remotely controlled and operated by a hidden human operator. The first experiment consisted of six men and six women volunteers with a human questioner and four men and four women with the android questioner. Respondents were asked ten questions which they should know the answers and ten questions that required some thinking. The researchers found that volunteers tended to avert their gaze downwards with the human questioner versus different directions with the android questioner. The direction of eye gaze aversion tended to vary by question type with the android questioner. Humans are also known to avert eye contact when trying to deceive a questioner. In the second half of the experiment, researchers recruited five men and six women for the human questioner and six men and ten women for the android questioner and asked them to intentionally lie on some answers. In this experiment, the authors found that respondents averted their gaze more with the human questioner, suggesting that perhaps they felt more

comfortable lying to the android and they may have felt the android was less likely to detect their lies.

This study seeks to extend upon these human reaction studies to understand human perceptions of robotic waiters in restaurant operations and add to the current body of scientific literature regarding human reaction studies to robots in the real world. Currently, there is a gap in the academic literature regarding human reactions among consumers, restaurant managers, and wait staff to the concept of robotic waiters.

Other Robot Developments

Takano, W. and Nakamura (2008) discussed the importance of speech recognition and natural language processing for today's modern robots. Suppose a customer drops his only fork on the floor and the robot sees it, the robot should promptly deliver a new fork to the customer without asking the customer. Other examples would be anticipating that a customer may want dessert after a meal or noticing an empty glass, in which case a customer may want a refill on his or her iced tea. Work is ongoing in the area of anticipation in humanoid to human interaction. Dominey and colleagues described the anticipation abilities of the small humanoid iCub robot (Dominey, Metta, Nori, & Natale, 2008). The robot is designed to approximate the size of a small child and has fifty-three degrees of freedom. The goal of the project was to see how well a robot could anticipate dialog, anticipate next actions, and initiate actions while assisting a human perform a task.

Many of the above articles in the academic literature demonstrate some of the fundamental capabilities a robotic waiter would need to have such as walking on two legs, navigating a room using vision systems, and listening and speaking with customers via speech recognition, voice synthesis, and natural language processing. However, researchers are also

working on replicating the more difficult sense of smell in machines. Robots are being programmed to recognize odors using electronic noses and this introduces the challenge of describing unfamiliar smells (Coradeschi et al., 2006). If this can be perfected, this capability would be very helpful to future robotic waiters who could perhaps smell if an order was stale, rotten, or otherwise smelled too bad to deliver to the customer.

Surface Computers

Microsoft released into the commercial market in 2007 a product known as a "Surface Computer" (Takahashi, 2007). The Surface Computer is basically an electronic table with an embedded computer that uses the same technology as rear projection televisions to project images onto its top, flat surface. At the same time, five infrared cameras embedded in the table detect the motions of users and objects on top of the table to create a highly interactive experience. The table also uses a Pentium 4 CPU and a very powerful graphics processing unit (GPU) as well as Windows Vista as the operating system for the computer. The unique design of the Surface Computer allows for interactions between the physical world and the virtual world. Current units are expensive at around $12,000 apiece. Some initial corporate customers include T-Mobile, Starwood Hotels and Resorts, and Harrah's Entertainment. Over three to five years, Microsoft hopes to reduce the cost in order to introduce the Surface Computer to the home market with different applications. There are many different uses for a Surface Computer. Sheraton Hotels use the computers as virtual concierges to allow customers to make plans for the evening. These electronic tables are quite durable. In fact, customers at Harrah's iBar in Las Vegas spill food and drinks on them all evening (Brandon, 2008).

Restaurant applications such as Resto Touch have been developed that allow users to order food and beverages from on screen menus. The menus present a scrollable list of product

descriptions, photos, and prices. Each user can select their items onto a virtual plate and submit their order. At the conclusion of the meal, the Surface Computer can replace the cashier by allowing customers to split the bill by simply dragging items to the proximity of individual credit cards placed on the computer's surface. It can even incorporate a tip amount on each credit card. Obviously, if such a computer was used in conjunction with a robotic waiter, it could be a very powerful combination. Surface Computers with restaurant applications could greatly simplify the chores of the robotic waiter by offloading order entry and payment to the Surface Computer. This is especially true if additional items such as beverage refills and desserts could be ordered on the Surface Computer. At that point, the robotic waiter need not be concerned about order entry or payment at all and simply focus on the physical tasks of delivering food and beverages and removing used dishes. Such a combination of technology could potentially speed up the introduction of robotic waiters, since the demands on the waiter would be much less, especially in the areas of order entry and payment, speech recognition, voice synthesis, and natural language processing.

Chapter 3 – Research Methodology

The previous chapter examined the current body of scientific literature regarding some of the most advanced humanoid, android, and geminoid robots built to date. Primary research was conducted to determine the consumer and manager demand for robotic waiters and Microsoft Surface computers in the restaurant industry, as well as to determine restaurant wait staff resistance to robotic waiters. The research methodology was an interview approach which consisted of one-on-one, one hour interviews with eleven participants. Five of these people were restaurant customers chosen randomly from among the author's friends and contacts. Three participants were current restaurant managers and the remaining three were active restaurant wait staff. Five of the six restaurant workers were career managers or wait staff. Restaurants of large national chains were initially approached for the study, but they either declined to participate or never responded to the inquiry, even after considerable follow up. Large corporations tended to be wary of the study for fear of having their name attached to a study concerning robotic waiters even though they were assured of confidentiality. Thus, two small, family-owned restaurants were ultimately chosen for the study: one was a French cafe and the other was an Asian restaurant.

There was an approximately even division among genders, with five male participants and six female participants to eliminate a gender bias in the study. Since there were three different groups of participants in the study, three different questionnaires were developed for the groups: customers, restaurant managers, and wait staff. There were several reasons to select these three groups of participants. One was to see the inherent contrast between restaurant managers and consumers who were expected to have demand for robotic waiters versus restaurant wait staff who were expected to resist automation to their occupation. Another reason was to

determine if all groups would be in favor of robotic waiters in the future assuming robots and human waiters could work together as part of a team.

Prior to conducting the study, each group was expected to have different views on the concepts of using robots as waiters as well as using Microsoft Surface Computers as sophisticated tables for order entry and payment. Many of the questions are the same across groups so that results could be compared and contrasted across groups. However, there were also some unique questions asked of each group. In all cases, permission for the interviews was obtained from restaurant managers and owners and all participants signed informed consent forms. Interviews were tape recorded on conventional audio tape and were later transcribed to text to interpret the results. A single controlled interview location could not be established, so interview locations varied and consisted of the author's work office, a Federal Express/Kinkos location, and one of the restaurants for convenience to their staff. All of the actual questions asked of each type of participant are listed in Appendix A along with all of their respective answers. However, some of the key questions for each participant type are listed here for reference. All participants also viewed on a laptop computer numerous still pictures and twenty-four short video clips of the relevant robots and Surface Computers during their interviews for educational purposes to allow them to form impressions. The questionnaires were all coded for interview location, respondent gender, and respondent type (consumer, manager, or wait staff). All answers were then analyzed and compared and contrasted across groups in a qualitative manner, except for the price demand curve among managers for the Surface Computers, which was quantified. The actual restaurant names and the names of all participants are confidential.

The following were some of the key questions asked of restaurant consumers. Do you think robots could be used as part of a team with human waiters? Would you like to see robots

used as waiters as part of a team or as a replacement for humans? Do you think using automated payment via a Surface Computer is a good way to protect against credit card fraud in restaurants? Would you trust handing your credit card to a robotic waiter if that was how payment occurred? What form factor of robot would you prefer: humanoid, android, or mixture of the two? Does the android form of robot make it feel more human or more creepy? How soon would you want to see robots and/or Surface Computers introduced in restaurants? Are you overall in favor of robotic waiters and/or Surface Computers?

Restaurant managers were asked many of the same questions along with the following questions. Depending on price, do you think you would ever buy robots to serve as wait staff? At what price? How soon? At what price for five or ten robots? Depending on price, do you think you would ever buy Microsoft Surface Computers to use as a restaurant tables? At what price? How soon? At what price would you buy five, ten, or twenty Surface Computers? Would you want to buy both robotic waiters and Surface Computers? Would you be interested in robotic chefs as well? How soon do you think consumers would like to see robotic waiters and/or Surface Computers?

Restaurant wait staff were asked many of the same questions as consumers plus the following questions. Depending on price, do you think your management would ever buy robotic waiters and/or Surface Computers for your restaurant? What would you do for a job if most restaurants replaced waiters in the future with robots and Surface Computers? Do you think humans would still give better customer service? Do you see the combination of a Surface Computer with a robotic waiter as a viable and fun way to speed up and automate restaurant service? Do you think customers would prefer four or five feet tall robots? Do you think robotic waiters and Surface Computers would be entertaining for kids?

Chapter 4 – Project Analysis and Results

For a comprehensive listing of all questions that were asked and the resulting answers during the research interviews, please see Appendix A. The following sections describe each interview and the respondents' answers to the key questions of the study. Chapter four focuses on these raw results. Chapter five provides more interpretations, conclusions, and areas for future research.

Participant One

A total of eleven volunteers were interviewed for the study. Those participants that were interviewed at Federal Express/Kinkos locations were all interviewed at the same FedEx office for consistency. Respondent one was a female restaurant consumer who was interviewed at a Federal Express/Kinkos location. She knew R2D2 by name from Star Wars when shown a picture, but did not recognize C3PO. However, she did know that Japan already has walking, humanoid robots. After seeing a picture of Repliee Q1 Expo, she felt that robot could move more or less like a human, even though the robot cannot, in fact, walk. Participant one would like to see Surface Computers used in restaurants. She felt that robotic waiters could be used as part of a team with humans because robots could automate tedious tasks such as bringing and fetching dishes, while humans could perform customer service and sales of items like desserts. Respondent one believed that sales is harder to automate.

She would like to see robotic waiters depending on the situation. She preferred to see robots for business lunches and at airports when you do not want to talk to anyone. But she preferred human waiters when going for a night out with friends. Respondent one felt that humans can give better customer service, but they are not always consistent. She has never had a problem with credit card fraud in restaurants, however, she did feel that using a Microsoft

Surface Computer could protect against fraud. She believed that robots could eliminate human error and give more reliable customer service. She also believed that the combination of Surface Computers and robots could speed up restaurant service. Volunteer one would trust handing her credit card over to a robotic waiter. She preferred a mixture of the humanoid and android form, because the pure android form is a little too creepy and looks like something in a wax museum. As far as height, she preferred the shorter robot such as the ASIMO. The android form of robot felt more creepy and disturbing to participant one and this was especially true if the human mimicry was not good enough. She would like to see robotic waiters in a couple of years and Surface Computers anytime. She also believed that robotic waiters and Surface Computers would be entertaining for kids. Lastly, she was overall in favor of robotic waiters, except for the androids. She was in favor of Surface Computers immediately and she also thought of other uses for the robots such as caretakers for the sick and elderly who may be too embarrassed to have human caretakers.

Participant Two

Participant two was a male waiter working part time for one or two years at an Asian restaurant. He was interviewed onsite at his restaurant during slow business hours. He knew both R2D2 and C3PO by name. Since these were two of the most popular science fiction robots of all time, this question was used as a baseline to test the participant's overall awareness of mobile robots. However, he felt that it will be at least twenty years, before we have C3PO-like robots in real life. When asked if his management would replace waiters with robots, he responded, "I would not want to lose my job to a humanoid robot. I prefer robotic appliances to do smaller tasks like mopping the floor. Economically, management would probably go for the robots, but humans are not easy to replace since they have been in the restaurant business for hundreds of

years." He felt that higher end restaurants would prefer the Surface Computers, especially if time was an issue. He did not think his restaurant would be as interested. He was then asked what he would do for a job if he lost the waiter job to automation. He replied, "I would not be ok with losing my job to a robot. People depend on the job of waiter. Waiters do not have practical training and if the restaurant industry is automated, all the industries below that would be assumed to be automated and there is really no place for you to go."

Respondent two felt that humans and robots could work together on a team, but he wondered why management would still need human waiters at that point. He asked, "Where should the line be drawn when dividing up tasks between humans and robots?" While he felt that humans would still give better customer service, he believed that robots might be more reliable because they can memorize things better. Volunteer two was then asked if the combination of a Surface Computer and robotic waiter could speed up restaurant service. He replied, "The combination would make for a fast dining experience, but would detract from the overall experience. It is ironic that a European firm developed restaurant software for the Surface Computer when the Europeans are known for slow restaurant service and taking more time to enjoy their meals." He felt that customers would trust robots with their credit cards more so than with human waiters. As far as the best form factor of robot, he preferred the pure android form and the shorter robot.

He was then asked if the android form felt more creepy. He responded, "I prefer the android robots because they are closer to being human. I would feel pretty ridiculous if I had to interact with the more mechanical robots." He felt that customers would like to see robotic waiters in twenty to thirty years, whereas they would like to see Surface Computers in ten years. He felt the machines would be more entertaining for kids than crayons that are used today.

Overall, he was opposed to robotic waiters, but in favor of Surface Computers, because they would make his job easier in terms of ordering a meal. His final question was, "Do you have a projected time frame when these advances might take place?"

Participant Three

Participant three was a male restaurant manager of a French cafe with one year of managerial experience. He was interviewed at a Federal Express/Kinkos location. He knew both R2D2 and C3PO by name and also knew that C3PO-like robots exist today. He would not buy robotic waiters at any price because they are not ready yet, but he did like the Surface Computer. For one Surface Computer, he would pay about $2,000 and for twenty units the price would need to be less than $2,000 per unit. He felt that Surface Computers could be purchased soon, but they were still more suited to high end restaurants and lounges. When asked if robots and humans could be used as a team, he replied, "It would not work out to have both human and robotic waiters due to price. It would not make sense or be a good business decision to have both. If the robots could do everything, I would use robots only. I would lean towards replacing human staff but might retain one or two human waiters." Based on experience, he felt that humans do not always give better customer service. He was also asked about the usefulness of robotic chefs and he responded, "Yes, I would be interested in robotic chefs way in the future, depending on price drops. The advantage of robots is that they can work eighty to one hundred or more hours per week without increases in pay."

He thought the Surface Computer would protect against fraud, but the difference would be minimal due to the quality of his staff. He felt that robots could give faster and more reliable service in the future, but not right now. He also agreed the combination of Surface Computers and robots could speed up restaurant service. He felt that customers may not trust robots with

their credit cards, but may not trust the Surface Computer either. He preferred robots with the humanoid body and android head as the best form factor and five feet tall as the best height. He thought that the android form was not creepy for him, but may be for other people, which is why he leaned towards a mixture of the two. He felt that customers would like see both robotic waiters and Surface Computers right now. He thought the machines would be entertaining for kids, but that might be a problem because kids might want to play with the robots. Overall, he was not opposed to robotic waiters, but does not think it will happen any time soon because they are not ready yet. He was in favor of Surface Computers if the price comes down. Lastly, he thought the technology was exciting, but ambiance is also important at restaurants and sometimes faster service does not mean better service.

Participant Four

Participant four was a female restaurant customer who was interviewed at a Federal Express/Kinkos location. She knew both R2D2 and C3PO by name and also knew that C3PO-like robots already exist. She would like to see both Surface Computers and robots in restaurants, but admitted that humans can sometimes give better customer service. She wanted robots to be used as part of a team with humans, but it would depend on the situation. Respondent four preferred robots for fast food situations, but not for going out with friends for entertainment. Although robots could be used for heavy lifting, she thought she might miss the interaction with human waiters. However, she felt that humans do not necessarily always give better customer service. She has not had problems with credit card fraud in restaurants, but she believed that Surface Computers would protect against credit card fraud.

She thought that robots might give more reliable service if they were faster. She was then asked if the combination of machines could speed up restaurant service. She replied, "Yes, it

might be popular at first, but then people might miss human contact." She felt that she would trust robotic waiters with her credit card and that it might eliminate human errors. She preferred the pure android form factor and the taller, five feet tall robots. She felt the android form could be more creepy, but maybe not. She thought that different people will have different reactions. She would like to see robotic waiters in ten years and thinks it is already happening overseas. She would like to see Surface Computers in restaurants immediately and she felt that kids would love both technologies. She was asked if she was overall in favor of robots and Surface Computers. She replied, "Yes, if the robots are quicker. I still think it will take off at first and then you will either miss the human interaction or you will like not having human error. I am in favor of Surface Computers. It is really fascinating and technology keeps going faster and faster."

Participant Five

Participant five was a female waitress with thirty-two years of experience who was interviewed onsite at her Asian restaurant. She had seen R2D2 and C3PO in movies but could not recall their names. She felt it will be at least twenty years before we have C3PO-like robots in real life. She thought some of the robots she was shown had more functionality than they actually do. She believed that ASIMO could be a house assistant and can vacuum floors. She felt that the Repliee Q2 Expo robot could even be a girlfriend for a guy! (The robot does not have this capability and this is not the topic for this thesis.) She did not believe that her management would ever want to buy robotic waiters, but they may want to buy Surface Computers. She was then asked what she would do for employment if most restaurants eliminated waiters due to automation. She responded, "I would hope to be retired by then!" She agreed that robots could be

part of a team and they could do all the heavy work. When asked about customer service issues, she replied, "Yes, of course, humans give better customer service."

She felt that robots might be more reliable, but they cannot be perfect. She did not see the combination of Surface Computers and robots as a good way to speed up service because she felt that humans are faster at service. She agreed that customers would trust robots with their credit cards. She preferred the humanoid body with android head form factor and the taller, five feet tall robots. She felt that the pure android form was too scary and creepy because it is too real. She thought consumers would like to see robotic waiters in ten years and Surface Computers anytime. She also thought these machines might be entertaining for kids, but probably not. Overall, she was opposed to robotic waiters, but in favor of Surface Computers and believed the technology was very interesting.

Participant Six

Participant six was a male restaurant customer and former Microsoft executive who was interviewed at the researcher's office. He knew both R2D2 and C3PO by name, but thought it will be at least ten years before we have C3PO-like robots in real life. In a humorous answer, when asked what the Geminoid HI-1 robot could do, he replied, "This robot mostly just sits!" He would like to see Surface Computers in restaurants, but felt there were some caveats to the robots including their speed and accuracy. Given a choice, he preferred seeing robots used as part of team with humans. He thought humans are better at some aspects of customer service, but not as good in others. Respondent six did have a problem once with credit card fraud that he traced back to a restaurant. However, he was skeptical that the Surface Computer could provide enough security because it might be possible to hack its wireless signal. He also agreed that robots could give more reliable service.

He felt the combination of Surface Computers and robots could be extremely efficient. He would trust robots with his credit card eventually, but not in the short term. He was concerned about accuracy and whether or not today's robots would lose the card. He preferred the pure android form factor and the shorter, four feet tall robots. When asked if the android form was more creepy, he replied, "The android form feels more friendly and does not feel creepy to me." He would like to see Surface Computers in restaurants within twelve months and robotic waiters anytime as soon as their speed and reliability to serve food is near perfect. He thought these machines would be entertaining for kids, but that it might wear off over time. Overall, he was in favor of both robotic waiters and Surface Computers. Lastly, he had these final comments, "I am pleasantly surprised about the state of robotics today, because their capabilities are already beyond what I would have estimated. A small, robotic device to clean carpets is much less intimidating than a humanoid robot that has a certain visual intimidation factor to it. My feeling is that the interest, demand, and acceptance of realistic, human-looking robots will accelerate over time in service environments."

Participant Seven

Participant seven was a male restaurant manager with six years of experience at the French cafe who was interviewed at a Federal Express/Kinkos location. He knew both R2D2 and C3PO by name and also knew that C3PO-like robots already exist. Respondent seven would not buy robotic waiters yet, because he felt the robots need to be faster and more sophisticated in terms of taking orders. But he might purchase in about five years. He thought the robots were better for fast food, not high end restaurants. At fancy restaurants, he preferred more human interaction. However, he would buy Surface Computers at a price of $5,000 for one unit and $3,000 per unit for twenty units. Surface Computers could be purchased soon, but the robots

depend on future advancements. Respondent seven felt that robots could be used as part of a team because he could envision how the robots and humans could divide tasks. For right now, he believed that humans give better customer service because the robots need more skills. He would probably be interested in robotic chefs.

He agreed that the Surface Computer would protect against credit card fraud. He felt that robots could give faster service in the future, but not now. However, he did agree that the combination of Surface Computers and robots could speed up restaurant service. Volunteer seven believed that customers would trust robotic waiters with their credit cards. He preferred the humanoid body with android head as the best form factor and the taller, five feet tall robots. He was asked if the android form felt more creepy and replied, "The android form is ok. It does not feel creepy or scary, but I do not know how kids would feel." He felt customers would like to see robotic waiters in three to five years and Surface Computers anytime. He also thought the machines would be entertaining for kids. Overall, he was in favor of Surface Computers and robotic waiters, especially in the future. He made some final comments, "The robots need to work on customer service, especially with picky customers. There are many subtle details for being a waiter."

Participant Eight

Participant eight was a female restaurant manager with eight years of experience who was interviewed onsite at her Asian restaurant. She did not visually recognize either R2D2 or C3PO, but she was aware that we already have C3PO-like robots in real life. She felt based on a still picture of the Geminoid HI-1 robot, that it could replicate the functions of a human being. When looking at a picture of the human inventor next to the robot, she was the only respondent out of eleven respondents to incorrectly identify the robot as human and vice versa. She would

not buy robots at any price to serve food, because she felt that humans are better at customer service. However, she would be interested in buying Surface Computers at a price of $10,000 for one unit and $2,000 apiece for twenty units. She agreed with many other respondents that robotic waiters could be part of a team with humans because robots could do the busboy work of clearing dishes while the human waiters could take orders and serve food. If she were to use robotic waiters, she would use them as part of a team, but she felt that humans give better customer service. Even though she was opposed to robotic waiters, she was interested in robotic chefs in order to achieve consistency with the food products and the fact that chefs are not customer facing.

She believed that the Surface Computer would be a good way to protect against credit card fraud. Volunteer eight felt that robots could give more reliable service, because humans make mistakes and she also agreed that the combination of Surface Computers with robots could speed up restaurant service. She felt that customers would trust robots with their credit cards. She preferred the humanoid robot body with android head as the best form factor, although she did not feel that the android form was creepy or scary. She was then asked how soon customers would like to see robotic waiters and she replied, "I do not think customers will ever want a robotic waiter!", but she felt that customers would like the Surface Computers anytime. She believed that the machines would be entertaining for kids. She was overall opposed to robotic waiters but in favor of robotic chefs and Surface Computers.

Participant Nine

Participant nine was a female waitress with twenty years of experience. She worked at the French cafe but was interviewed at a Federal Express/Kinkos location. She knew R2D2 by name, but not C3PO. She thought it will be five or ten years before we have C3PO-like robots in

real life. She believed that the Repliee Q1 Expo robot was capable of any human task. She felt that her management might want to buy robotic waiters in the future because there would be no salary or sick time for the robots. She also felt that management would likely want to buy Surface Computers. If she lost her job in the future, she would probably do some kind of office work. She believed that robots could be used as part of a team, but that we would still need humans for hospitality and social interaction. Respondent nine felt that humans give better customer service most of the time, but robots could be more efficient and reliable.

She liked the combination of a Surface Computer with robots, especially in the role of a restaurant customer. She felt that she would trust robots with her credit cards, but the elderly might not. She preferred the humanoid form factor and the shorter, four feet tall robots. She found the android form to be more human, but that disturbed her because she wondered if she would be able to tell humans and robots apart in the future. She felt that customers would like to see robotic waiters now and Surface Computers immediately. She commented, "The Surface Computer would speed things up by allowing customers to order while I am in the back preparing drinks." She was then asked if these machines would be entertaining for kids and she replied, "Yes, it would be entertaining to attend restaurants with these machines with friends or children because it is something new. It would go over really well in Highlands Ranch. Even for nightlife or dates, the Surface Computer makes the meal more intimate with the other party, because the waiter is not interrupting as much." She was the only wait staff employee to be in favor of robotic waiters- as long as they were used as part of a team. She was also in favor of Surface Computers. She commented, "Why can't the androids walk yet and why is the United States not exploring these robots as much as the Asian nations?"

Participant Ten

Participant ten was a male restaurant customer who was interviewed at the researcher's office. He knew both R2D2 and C3PO by name, but felt that C3PO-like robots are ten to twenty years away. He felt that the Repliee Q1 Expo robot could mirror any human capability. He would like to see Surface Computers in restaurants and felt that robots could be used as part of a team with humans. He would like to see robotic waiters, but also felt that they were more of a novelty. He felt that humans would still give better customer service. Respondent ten has not had a problem with credit card fraud in restaurants, but did agree that the Surface Computer could protect against such fraud.

He felt the robots could give more reliable, but not necessarily faster service. He would trust robots with his credit card and in fact, suggested that the robots have a credit card slot in their hand or body so that payment could occur right at the table. Volunteer ten was the only one to suggest this innovation. He preferred the humanoid body with the android head as the best form factor and liked the shorter, four feet tall robots like the ASIMO. The pure android form felt more creepy to him, simply because of the fact that engineers and scientists are trying to mirror humans. He would like to see robotic waiters anytime and Surface Computers immediately. He felt the machines would be entertaining for kids and was overall in favor of both robots and Surface Computers. He commented, "The robots have come a long way since the last time I watched a documentary on them."

Participant Eleven

Participant eleven was a female restaurant customer and was the final respondent in the survey. She was interviewed at the researcher's office. She knew both R2D2 and C3PO by name, but felt that C3PO-like robots are five years away. She was also one of many respondents who

felt that the Geminoid HI-1 robot could replicate the functions of a human being. She would like to see Surface Computers in fast food restaurants, but not high end restaurants. She felt robots could work as part of a team, but she did not really want to see robotic waiters unless they could be faster. She felt that humans still give better customer service. She has not had a problem with credit card fraud in restaurants and felt that the Surface Computer might not be good at protecting against fraud.

She felt that robots could give more reliable service, but she was not sure that the combination of Surface Computers and robots could speed up service. She would trust robots with her credit card, but not at first. She preferred the android robots as the best form factor and she liked the taller, five feet tall robots. She believed the android form was more human and not creepy or scary. She was then asked how soon she would like to see robotic waiters and she replied, "I could see robotic waiters anytime, but not in high end restaurants where I want good service and personal interaction with the waiter." She would like to see Surface Computers anytime. She felt the machines would be entertaining for kids and was overall in favor of them given the caveats mentioned. She commented, "The robots need to be quicker. I do not think you can completely eliminate the human waiters. The robots would have to serve a business purpose by being more efficient and giving faster service."

Chapter 5 – Conclusion

While it is not possible to tie every conclusion to other findings in the academic literature, comparisons to results in the literature are discussed whenever possible. Some of the key conclusions for restaurant consumers are as follows. Among consumers, there was very little awareness of the small, mobile robotic appliances in terms of functionality, brand name, or manufacturer. The one exception was the Roomba vacuum from iRobot Corporation. None of the consumers in the study owned any of the robotic appliances.

Most of the consumers knew C3PO and R2D2 from Star Wars by name. The respondents felt that it would be anywhere from now up to twenty years from now before we have C3PO-like robots in real life. For the most part, there was very little awareness of the humanoid and android robots presented in the study, although a couple of the volunteers had seen one or two of the machines before. Three out of five consumers felt that some of the android and geminoid robots could do anything humans could do. This is in fact, far from reality considering that the android-like robots cannot even walk yet. However, it is supported in the literature by Hinds, Roberts, and Jones (2004) who found that the more human-looking the robot, the more humans assume that the machine has advanced capabilities. There was no awareness by brand name or manufacturer of the Microsoft Surface Computer.

Most consumers (four out of five) were in favor of robots being used as waiters and they preferred robots to be used as part of team with humans, rather than replace human waiters. Consumers wanted to see robotic waiters anytime from now up to ten years from now.
One participant preferred not to see robotic waiters in high end restaurants. Three out of five consumers felt that humans do not necessarily give better customer service than robots. Only one

consumer had trouble with credit card fraud at a restaurant, but two out of five customers felt the Microsoft Surface Computer might not be good at preventing credit card fraud in restaurants.

Four out of five consumers felt that robots might give more reliable service but not necessarily faster service than humans. Likewise, eighty percent of customers felt that the combination of a Surface Computer with robotic waiters might speed up restaurant service. Three out of five customers would trust robots with their credit cards, while two consumers were not as sure in the short term.

The preferred form factor for a robotic waiter was android (three people) versus a mixture of humanoid and android (two people). This is in agreement with Ishiguro's view in the literature that humans would relate better to androids than mechanical robots (Harris, 2007). Three out of five consumers preferred the shorter four feet tall robot in terms of height. However, two out of five customers felt that the android form of the robots was more disturbing or creepy. This is in agreement with Stephen Keeney's belief that humans are more accepting of mechanical-like robots (Harris, 2007).

Overall, consumers were in favor of robotic waiters given the caveats mentioned. Consumers were also in favor on Surface Computers being used anytime from now up to twelve months from now. One person did not wish to see Surface Computers used in high end restaurants, which is exactly the opposite of reality and the literature. Due to their high price, Surface Computers are already in use in many high end casinos in Las Vegas including Harrah's iBar (Brandon, 2008). Lastly, all consumers felt that robotic waiters and Surface Computers would be entertaining for their kids while they waited for their food.

Three career managers were interviewed at two different restaurants. Among managers, there was again little awareness of the robotic appliances by functionality, brand name, or

manufacturer, except for the floor cleaning robots. None of the managers owned any of the robotic appliances. Two out of three managers knew C3PO and R2D2 by name and all managers knew that we already have C3PO-like robots today in real life. There was again little to no awareness of the exact humanoids and androids presented, although one manager had seen a couple of the robots on television. One manager thought that the Geminoid HI-1 robot could do anything a human could do- a finding that is supported by Hinds, Roberts, and Jones (2004). This manager also incorrectly identified the Geminoid robot as human and thought the human in the picture was the robot! The managers had no brand name or manufacturer awareness of the Surface Computer.

One manager was opposed to robotic waiters entirely while the other two managers were not in favor of purchasing robotic waiters yet any price. They felt that current robots are not capable of serving as waiters. However, one manager might buy robotic waiters in five years. All the managers wanted to buy Microsoft Surface Computers anytime from now up to two years from now and a demand curve illustrating the prices they would pay for various numbers of units is shown below in Figure 1. None of the managers would buy both robotic waiters and Surface Computers.

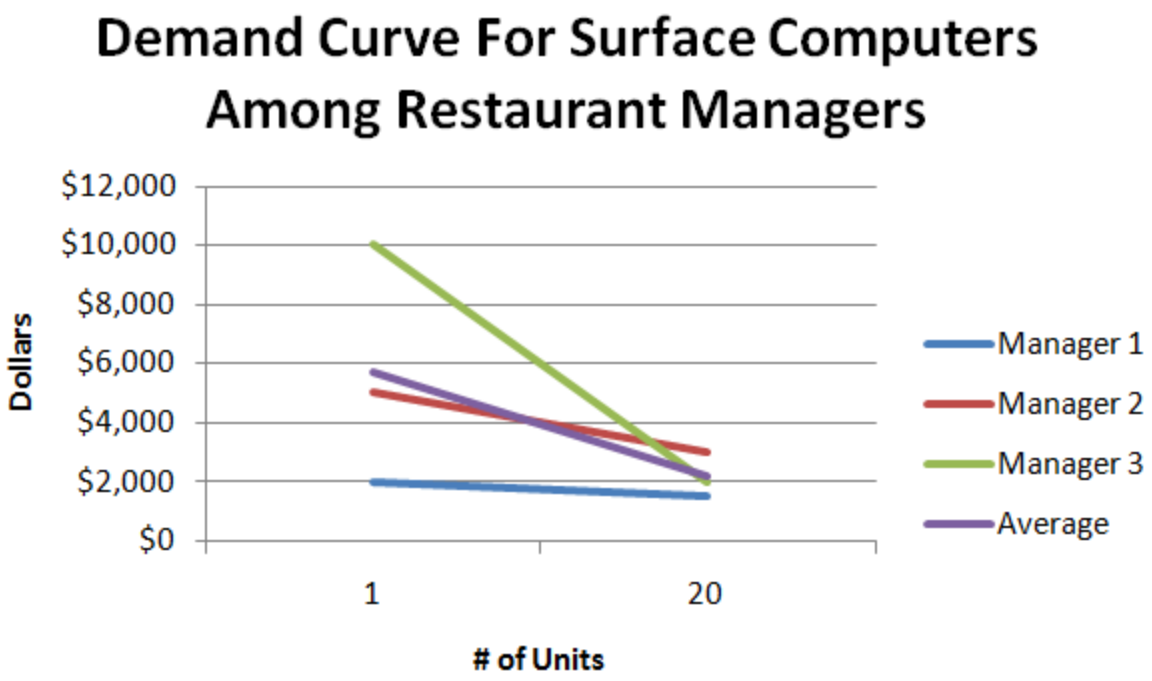

Figure 1 – Demand Curve for Surface Computers

Two out of three managers thought that robots could be used as part of a team with humans and would not replace human waiters even if they did buy robotic waiters. One manager felt this would not be a good business decision and leaned towards replacing human waiters if robots were purchased. This overall conclusion is in agreement with the literature that humans are more accepting of robots when working on cooperative tasks (Mutlu, Osman, Forlizzi, Hodgins, & Kiesler, 2006). Two out of three managers felt that humans still give better customer service over robots.

All of the managers were in favor of robotic chefs, including the one manager who was opposed to robotic waiters. This finding does make sense because restaurant managers want a consistent product as far as the food is concerned. All of the managers thought that the Surface Computers would protect against credit card fraud, but the difference would be minimal due to the high quality of their wait staffs. Two out of three managers felt that robots could not give

faster service, but one manager thought that robots could give more reliable service. All the managers felt that the combination of Surface Computers and robotic waiters could speed up restaurant service. Two-thirds of managers agreed that customers would trust robots with their credit cards.

Among managers, the preferred form factor for a robotic waiter was a humanoid body with android head and two out of three managers preferred the five feet tall robot. This form factor was somewhat surprising because it does not exist in nature and is not supported by the literature. None of the managers felt that the androids were creepy, supporting Ishiguro in the literature (Harris, 2007). Two-thirds of managers felt that customers would like to see robotic waiters anytime from now up to five years from now, while one manager thought that customers would never like to see robotic waiters. All managers felt that customers would like to see Surface Computers in restaurants immediately and they all agreed that the computers and robots would be entertaining for kids. One manager felt that kids might interfere and play with the robots. Overall, two-thirds of managers were not opposed to robotic waiters and all were in favor of the Microsoft Surface Computer. One manager really wanted robotic chefs because they are not customer facing.

Lastly, three wait staff employees were interviewed at two different restaurants. Two were career wait staff while one was part time. Among wait staff, there was again little awareness of the robotic appliances by functionality, brand name, or manufacturer. None of the wait staff owned any of the robotic appliances, but one waitress knew friends that owned a Roomba. For the most part, the respondents knew C3PO and R2D2 by name, but thought it would be five to twenty years before we have C3PO-like robots in real life. There was little to no awareness of the humanoid and android robots presented in the study. One waitress thought that

the Geminoid HI-1 robot could cook, clean house and entertain, when in fact the robot cannot even stand or walk. Another waitress thought that the Repliee Q2 Expo android could do anything a human can. These findings are again supported by Hinds, Roberts, and Jones (2004) in the literature. There was no awareness of brand name or manufacturer for the Surface Computer.

Two-thirds of wait staff thought their management may want to buy robotic waiters, when in fact they have nothing to worry about since their managers do not want to do this. Two out of three employees also felt that their management may like to buy Surface Computers. One employee felt that the Surface Computers were better suited to high end restaurants which is in fact happening in reality in Las Vegas and is supported by the literature (Brandon, 2008).

If automated out of a job by robotic waiters, one waitress would retire, one would do office work, and one waiter was not sure what to do since so many industries would be automated if the restaurant industry was automated. This was one of the key questions in the study and concerned the social implications of robotic waiters in the future. All wait staff agreed that robots could be part of a team with humans, which is supported in the literature (Hinds, Roberts, & Jones, 2004). For this reason, one waitress was not opposed to robotic waiters, while another waiter felt that human waiters may not be necessary if robotic waiters were available. All employees agreed that humans can give better customer service, but one waitress felt that robots might be more efficient.

The wait staff felt that robots could at least give more reliable, but not faster, service than humans. Two-thirds of employees felt that the combination of Surface Computers with robotic waiters would speed up restaurant service. All of the wait staff agreed that customers would trust robots with their credit cards. Among wait staff, there was not a preferred form factor for a

robotic waiter. One waiter preferred the android form, another waitress preferred the humanoid body with android head, while the last waitress preferred the pure humanoid form. Two out of three employees preferred the shorter four feet tall robot. Two-thirds of wait staff thought that androids were creepy and this supports Stephen Keeney in the literature that humans are more comfortable with humanoids (Harris, 2007).

The wait staff felt that customers would like to see robotic waiters anytime from now up to thirty years from now. Two-thirds of employees thought that customers would like to see Surface Computers immediately. All of them agreed that Surface Computers and robotic waiters would be entertaining for kids while they waited for their food. Two out of three wait staff employees were opposed to robotic waiters. One waitress was in favor of robotic waiters. Lastly, all of the wait staff were in favor of Surface Computers. One waiter asked the researcher what is the projected time frame to see robotic waiters.

The following summarizes some of the key results for entire group of respondents. Overall there was very little awareness of functionality, brand name, or manufacturer of the small, mobile robotic appliances, the Surface Computer, or the larger humanoid or android robots presented in this study. However, there were many good guesses on the functionality of these machines. None of the respondents owned any of the robotic appliances although one waitress knew some friends who own the Roomba robotic vacuum from iRobot corporation.

Most people recognized the C3PO and R2D2 robots from the Star Wars movies. However, some respondents felt that we will not have bipedal, walking, talking C3PO-like robots for twenty years. For the most part, restaurant managers were not opposed to robotic waiters. However, they were not ready to purchase robotic waiters either due to price and the limited functionality of today's robots. Customers expressed interest in robotic waiters anytime from

now up to ten years from now. The wait staff interviewed felt that customers would be ready for robotic waiters from now up to thirty years from now. Two-thirds of wait staff thought that their management may be interested in purchasing robotic waiters, even though none of the managers actually wanted to purchase the robots.

Ten out of eleven participants felt that robots could be used as part of a team with humans, while one manager felt this was unfeasible and not a good business decision. Three people did not want to see either robots or Surface Computers at high end restaurants. Approximately fifty percent of respondents preferred four feet tall robots and the other half preferred five feet tall robots. Four people felt that androids were creepy or scary and three of those respondents were female. This is supported in the literature by Stephen Keeney's view that humanoid robots are more acceptable (Harris, 2007). Everyone was in favor of the Surface Computers and wanted to see them in restaurants anytime from now up to twelve months from now. Managers were willing to pay from $2,000 up to $10,000 for one unit and around $2,000 per unit for twenty units.

Some of the most surprising findings are summarized as follows. Four out of eleven participants felt that humans do not necessarily give better customer service than robots. All managers were in favor of robotic chefs, including one manager who was opposed to robotic waiters. The reason was a desire for consistency among the food products produced and the fact that chefs are not customer facing. One waitress was not opposed to robotic waiters because she envisioned working with them as part of a team.

A majority of respondents (six) favored the form factor of a humanoid body with an android head for a robotic waiter, which is a combination not seen in nature. Nine out of eleven people would trust robotic waiters today with their credit cards for payment. Two out of eight

volunteers thought that Surface Computer might not be good for protecting against credit card fraud in restaurants. Lastly, the most surprising finding of all in the study was that four out of eleven respondents felt that the android robots could perform any human function simply because the androids looked so human. This is supported in the literature in the study by Hinds, Roberts, and Jones (2004) when they found that the more human-looking the robot, the more humans assume the robot has very advanced capabilities.

Will we ever see in the United States and around the world humanoid or android robots serving as restaurant waiters? Will Microsoft Surface Computers take off in the restaurant industry and be used as specialized tables for order entry, payment, and entertainment? Only time will tell. What is clear is that Surface Computers are already being used in high end restaurants and casinos, particularly in Las Vegas due to their high price of around $12,000 per unit. It is also very clear for that for the robots to be used as waiters, their cost needs to come way down from their current price tags of between $100,000 to $300,000 and their capabilities need to improve. Certainly, the androids need to overcome their inability to walk.

The conclusions of this small, preliminary, and exploratory study indicate that people are ready for robotic waiters if their capabilities do improve, except of course, for the waiters themselves. There was significant demand among consumers and lukewarm demand among restaurant managers for robotic waiters. Meanwhile, the demand for Microsoft Surface Computers was even higher and restaurant managers were even able to quantify their demand for the computers in terms of price. Certainly, the combination of Surface Computers and robotic waiters could potentially speed up the introduction of robotic waiters in restaurants because the robots need not be concerned with order entry and payment. The computational and processing

demands would then be less on the robots which would not need to use speech recognition, natural language processing, and voice synthesis to take customer orders.

Areas for Future Research

For those researchers wishing to expand upon this study, there are numerous areas to be explored for future work. The first one of these might be to greatly expand the number of recruited respondents for the study to see if the patterns found here hold with a larger sample size. One of the limitations of this study was the small sample size and thus the results cannot be extrapolated to the overall population. A future researcher may wish to greatly expand the sample size in order to fully address the larger question: is society socially ready to accept robotic waiters? Another area for future research would be to determine the response of major national restaurant chains to the concept of robotic waiters and Surface Computers, since this study involved only small, family owned restaurants. For an ambitious study with a large budget, a key experiment would be to test reactions of consumers, wait staff, and managers to the actual use of a Surface Computer combined with a humanoid robot such as the ASIMO to provide a dining experience.

Other areas for research include further study on the connection between science fiction movies and awareness of advanced robotic technology. Other researchers may want to study the effects of other science fiction films or robots such as Commander Data from Star Trek on the general public and how that translates to real knowledge about current real life robots. Another important question that needs further research is what will happen to college education in general if many students lose their part time jobs as waiters or waitresses due to robotic automation in the future? Many students now use such part time jobs to pay for their college educations. Obviously, mobile humanoid robots will transcend other industries in society beyond the

restaurant industry over time. Some researchers may want to investigate the implications of humanoid and android robots in other industries. Lastly, as android robots become increasingly intelligent, sophisticated, and lifelike, eventually humans may want such robots as companions and this opens the door to an entire new category of future studies. In any event, the 21st century promises to be very exciting to say the least if this study is any indication of what may be to come.

This study concludes with two interesting quotes, one of which was from a customer who said, "I am pleasantly surprised by the state-of-the-art in robotics today, because their abilities are already beyond what I would have estimated. I believe the interest, demand, and acceptance of realistic, human-looking robots will accelerate over time in service environments." The other quote was from a waitress who said, "The androids are more disturbing to me because I wonder if I will be able to tell androids and humans apart in the future. I like knowing the difference." Will androids ever become indistinguishable from humans? Only time will tell.

References

(2000, Jan/Feb). No operator please. *Technology Review*, 103(1), 104.

(2008, January 15). Smarter version of Asimo robot (Japan) (Advanced Step In Innovative Mobility). *Advanced Manufacturing Technology*, 29(1), 6-7.

Boudette, N. (2006, April 11). Shifting gears: Chrysler gains edge by giving new flexibility to its factories; Some can build one vehicle, then switch to another, a skill Japanese pioneered. *Wall Street Journal*, pp. A1.

Brandon, J. (2008, December 1). Microsoft research projects. *Network World*, 25(56), 27-34.

Brown, S. (2004). Toyota's global body shop. *Fortune*, 149(3), 120B-120F.

Coradeschi, S., Ishiguro, H., Asada, M., Shapiro, S. C., Thielscher, M., Breazeal, C., … Ishida, H. (2006, July). Human-inspired robots. *IEEE Intelligent Systems*, 74-85.

Dominey, P., Metta, G., Nori, F., & Natale, L. (2008, December 1-3). Anticipation and initiative in human-humanoid interaction. *The Eighth IEEE-RAS International Conference on Humanoid Robots 2008*, 693-699.

Glover, M. (2005, September). Robots lift transit output. *Automotive Engineer*, 30(8), 10-11.

Gurchiek, K. (2007, February). Robots take on roles in public, workforce. *HR Magazine*, 52(2), 26, 32.

Harris, D. (2007, February 15). To be almost human or not to be, that is the question. *Electronic Design*, 55(4), 37-40.

Hinds, P., Roberts T., & Jones, H. (2004). Whose job is it anyway? A study of human-robot interaction in a collaborative task. *Human-Computer Interaction*, 19(1/2), 151-181.

Hirukawa, H., Kajita, S., Kanehiro, F., Kaneko, K., & Isozumi, T. (2005, September). The human-size humanoid robot that can walk, lie down and get up. *The International Journal of Robotics Research*, 24(9), 755-770.

Hornyak, T. (2006). Android science. *Scientific American*, 294(5), 32-34.

Ishiguro, H. (2007, January). Scientific issues concerning androids. *The International Journal of Robotics Research*, 26(1), 105-118.

James, T. (2007, June/July). I see robot. *Control and Automation*, 18(3), 26-31.

Kara, D. (2004). Sizing and seizing the robotics opportunity, retrieved on 9-11-2007 from http://www.roboticsevents.com/robonexus2004/roboticsmarket.htm

Mathews, D. (2006, August 8). Your virtual assistant. *PC Magazine*, 25(13), 103-107.

Minato, T., Shimada, M., Itakura, S., Lee, K., & Ishiguro, H. (2006). Evaluating the human likeness of an android by comparing gaze behaviors elicited by the android and a person. *Advanced Robotics*, 20(10), 1147-1163.

Mutlu, B., Osman, S., Forlizzi, J., Hodgins, J., & Kiesler, S. (2006, March). Perceptions of Asimo: An exploration on co-operation and competition with humans and humanoid robots. *Proceedings of the First ACM SIGCHI/SIGART Conference on Human-Robot Interaction*, 351-352.

Nishio, S., Ishiguro, H., & Hagita, N. (2007, June). Geminoid: Teleoperated android of an existing person. In A. Filho (Eds.), *Humanoid robots: New developments* (pp. 343-352). Vienna, Austria: I-Tech Education and Publishing.

Park, I., Kim, J., & Oh, J. (2006). Online biped walking pattern generation for humanoid robot KHR-3 (KAIST humanoid robot-3: HUBO). *The Sixth IEEE-RAS Conference on Humanoid Robots 2006*, 398-403.

Paul, R. (1979, July). Robots, models, and automation. *Computer,* 19-27.

Quain, J. (2006, November 21). A dozen ways to boost your business. *PC Magazine*, 25(21), 91-102.

Romanchik, D. (2004, February). Robot drivers take the drudgery out of testing. *Test and Measurement World*, 24(1), A6-A8.

Segal, M. (1974, July/August). The operator-scheduling problem: A network-flow approach. *Operations Research*, 22(4), 808-823.

Sheppard, H. & Stern, J. (1957, October). Impact of automation on workers in supplier plants. *Labor Law Journal*, 8(10), 714-718.

Takahashi, D. (2007, July 16). Microsoft unveils surface computer. *Design News*, 62(10), 43-46.

Takano, E., Matsumoto, Y., Nakamura, Y., Ishiguro, H., & Sugamoto, K. (2008, December 1-3). Psychological effects of an android bystander on human-human communication. *The Eighth IEEE-RAS International Conference on Humanoid Robots 2008*, 635-639.

Takano, W. & Nakamura, Y. (2008, December 1-3). Integrating whole body motion primitives and natural language for humanoid robots. *The Eighth IEEE-RAS International Conference on Humanoid Robots 2008,* 708-713.

Walters, M., Dautenhahn, K., Woods, S., Koay, K., Te Boekhorst, R., & Lee, D. (2006). Exploratory studies on social spaces between humans and mechanical-looking robot. *Connection Science,* 18(4), 429-439.

Wong, B. (2007). Cognitive ability (iq), education quality, economic growth, human migration: Implications from a sociobiological paradigm of global economic inequality. *Mankind Quarterly,* 48(1), 3+.

Young, J. (1995). TAPI dancing. *Forbes*, 156(5), 114.

Appendix A – Interview Questions and Answers

The following sections list all of the interview questions that were asked for each type of study participant: restaurant consumers, restaurant managers, and restaurant wait staff. Listed after each questionnaire is a table of all of the exact answers of all participants grouped by participant type. In order to avoid significant redundancy in the answer tables, the questions are not repeated but are cross referenced by number instead.

Questions for Consumers

Background Questions:

1. How often per week do you dine out at sit down restaurants with wait staff, not fast food restaurants?

Robotic and Technology Awareness Questions:

1. Show a picture of the Robomow mower.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
2. Show a picture of the Verro pool cleaner.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?

3. Show a picture of the Looj rain gutter cleaner.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
4. Show a picture of the Scooba mop.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
5. Show a picture of the Roomba vacuum.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
6. Show a picture of C3PO and R2D2 from Star Wars.
    a. Can you name these two robots?
    b. How long do you think it will be in real life before we have real robots that can talk and walk on two legs?
7. Show a picture of ASIMO.

a. Are you familiar with this robot?

b. What is its name?

c. Who is the manufacturer or inventor?

d. What can the robot do?

8. Show pictures of HUBO.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What can the robot do?
9. Show pictures of HRP series of robots.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What can the robot do?
10. Show a picture of Ms. Saya.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What can the robot do?
11. Show pictures of Repliee Q1 and Q2 Expo.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?

d. What can the robot do?

12. Show pictures of Geminoid HI-1.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What can the robot do?
    e. Can you tell the difference between the robot and the human?
13. Show a picture of a Microsoft Surface Computer.
    a. Are you familiar with this type of computer?
    b. What is it called?
    c. Who is the manufacturer?
    d. What can it do?

Participants were then shown brief video clips of what some of these robots and a Surface Computer can do.

Occupational Questions:

1. Would you like to see Surface Computers used in restaurants for order entry, payment, and entertainment?
2. Do you think robots could be used in conjunction with human waiters on a team? For example, what if robots performed all the heavy lifting of food and dishes back and forth while human waiters still provided the customer service, sales, and order entry?
    a. Why or why not?
3. Would you like to see robots used as waiters?
    a. As part of a team with human waiters?

   b. As a replacement for human waiters?
4. Do you think human waiters would still give better customer service?
5. Have you ever had a problem with credit card fraud or identity theft that you traced to a waiter or waitress?

Technology Questions:

1. Do you think using automated payment via a Surface Computer is a good way to protect against credit card fraud and identity theft committed by some human waiters?
2. Do you think robots could give faster and more reliable customer service by never forgetting orders?
3. Do you see the combination of a Surface Computer with a robotic waiter as a viable and fun way to speed up and automate restaurant service?
4. Would you trust handing your credit card over to a robotic waiter if that was how payment occurred?
5. What do you think is the best form factor that you would prefer?
   a. Humanoid (mechanical) robot.
   b. Android (human-looking) robot.
   c. Mixture of two such as HRP-4 (humanoid body with android head).
6. As far as robot height, what are you more comfortable with?
   a. The 4 feet tall ASIMO.
   b. The 5 feet tall HRP series of robot.
7. Does the android form of robot make it feel more "human" and less mechanical or is the android form more creepy?
   a. Why?

8. How soon would you like to see these robots introduced in restaurants?
9. How soon would you like to see Surface Computers in restaurants?
10. Do you think robotic waiters and Surface Computers would be entertaining for your kids when they are waiting for their food?

General Questions:

1. Based on everything you have heard, are you overall in favor or opposed to these robots being used as waiters?
2. Are you overall in favor or opposed to Surface Computers in restaurants?
3. Do you have any other comments, questions, or concerns about these technologies?

Table 1 – Consumer Responses (Part 1)

Questions	Participant 1 (Female)	Participant 4 (Female)	Participant 6 (Male)
Background Questions			
1.	I eat out once a week.	I eat out once every other week.	I eat out twice a week.
Robotic Awareness Questions			
1a.	No.	No.	No.
1b.	I do not know.	I do not know.	I do not know.
1c.	I do not know.	I do not know.	I do not know.
1d.	Vacuum cleaner?	TV remote control?	I do not know.
1e.	No.	No.	No.
2a.	No.	No.	No.
2b.	I do not know.	I do not know.	I do not know.
2c.	I do not know.	I do not know.	I do not know.
2d.	I do not know.	Looks like an iron?	I do not know.
2e.	No.	No.	No.
3a.	No.	No.	No.
3b.	I do not know.	I do not know.	I do not know.
3c.	I do not know.	I do not know.	I do not know.
3d.	The robot has something to do with drainage or large pipes.	The robot is some kind of cleaner or duster.	I do not know.
3e.	No.	No.	No.
4a.	No.	Yes, looks like robovac.	No.

Table 1 – Consumer Responses (Part 1)

4b.	I do not know.	Zoomba.	I do not know.
4c.	I do not know.	I do not know.	I do not know.
4d.	Vacuum cleaner?	Floor cleaning robot.	Floor cleaning robot.
4e.	No.	No.	No.
5a.	No.	Yes.	No.
5b.	I do not know.	Zoomba.	I do not know.
5c.	I do not know.	I do not know.	I do not know.
5d.	Vacuum cleaner.	Vacuum cleaner.	Carpet cleaning robot.
5e.	No.	No.	No.
6a.	Volunteer knew R2D2 by name, but not C3PO.	Volunteer knew both R2D2 and C3PO by name.	Volunteer knew both R2D2 and C3PO by name.
6b.	They already have walking, humanoid robots in Japan.	C3PO-like robots already exist per the Scholastic News.	We will have C3PO-like robots within ten years.
7a.	No.	No.	No.
7b.	I do not know.	I do not know.	I do not know.
7c.	I do not know.	I do not know.	I do not know.
7d.	This robot is probably a walking prototype with arm movements.	I do not know.	This robot can lift heavy weights.
8a.	No.	No.	No.
8b.	I do not know.	I do not know.	I do not know.
8c.	I do not know.	I do not know.	I do not know.

Table 1 – Consumer Responses (Part 1)

8d.	This robot has more sophisticated arm movements and version with android head appears to have more cameras.	I do not know.	I do not know.
9a.	Volunteer recognized HRP-4, but not by name.	No.	No.
9b.	I do not know.	I do not know.	I do not know.
9c.	I do not know.	I do not know.	I do not know.
9d.	I saw HRP-4 demoed as a runway model- she has good human mimicry. She is very close to human movements, but not as good at carrying things. These robots can walk, but HRP-2 and HRP-3 look more practical.	This robot looks like a transformer. It can do security work and a lot more than you think.	HRP-2 and HRP-3 can perform movement, repetitive or dangerous tasks, and heavy lifting.
10a.	No.	No.	No.
10b.	I do not know.	I do not know.	I do not know.
10c.	I do not know.	I do not know.	I do not know.
10d.	This receptionist robot is better for human interaction.	This robot can do receptionist work.	This robot can do receptionist or executive administrative assistant work.
11a.	No.	No.	No.
11b.	I do not know.	I do not know.	I do not know.
11c.	I do not know.	I do not know.	I do not know.

Table 1 – Consumer Responses (Part 1)

11d.	This robot may showcase products at trade shows, but not as good at physical or dangerous tasks.	Version Q1 can be a news broadcaster and Q2 can be a flight attendant.	Q2 version can model clothes.
12a.	No.	No.	No.
12b.	I do not know.	I do not know.	I do not know.
12c.	I do not know.	I do not know.	I do not know.
12d.	It can move more or less like a human.	I do not know.	This robot mostly sits!
12e.	Volunteer could correctly identify the human versus the robot.	Volunteer could correctly identify the human versus the robot.	Volunteer could correctly identify the human versus the robot.
13a.	No.	No.	No.
13b.	I do not know.	I do not know.	I do not know.
13c.	I do not know.	IBM?	I do not know.
13d.	I do not know.	It looks like an automated fish tank or something at a museum. It can perform functions of a computer, TV, phone, and security system.	This computer can perform a variety of tasks, display and project images, and do computations.
Occupational Questions			
1.	Yes, definitely.	Yes, it would be very efficient.	Yes.
2.	Yes, robots could be part of a team.	Yes, robots could be part of a team.	Yes, absolutely.

Table 1 – Consumer Responses (Part 1)

2a.	Robots could automate tedious tasks of bringing and fetching dishes, while humans could perform customer service and sales of items like desserts. Sales is harder to automate due to human reactions to machines.	The one downside of robots is that humans often give better customer service.	Volunteer did not elaborate.
3.	Yes, I would like to see robots used as waiters.	It would depend on the setting. I would prefer robots for fast food, but not when out with friends for entertainment. I could see them being used for heavy lifting, but I might miss the human experience.	I would, but the caveats to the robots are speed and accuracy.
3a.	It depends on the restaurant type and purpose of the meal. For business lunches or airports when you do not want to talk to a person, I would prefer to see robotic waiters.	I would prefer to see robots as part of a team with humans.	I would rather see robots used as part of a team with humans, at least in the short term.
3b.	However, for a night out with friends, I would prefer human waiters.	No, I would not want to see robots replace humans waiters.	No, I would not want to see robots replace human waiters.
4.	They can, but they are not always consistent.	Not necessarily.	Humans are better in some respects, but not as good in others.
5.	No, I have not had fraud problems with restaurants.	No, I have not had fraud problems with restaurants.	Yes, I had a credit card fraud problem I traced back to a restaurant.

Table 1 – Consumer Responses (Part 1)

Technology Questions			
1.	Yes, the Surface Computer could protect against credit card fraud.	Yes, the Surface Computer could protect against credit card fraud.	I am not sure about the security of the Surface Computer. People could potentially hack the wireless signal.
2.	Yes, robots could eliminate human error.	Yes, if the robots were faster.	Yes, robots could give more reliable service.
3.	Yes, the combination of a Surface Computer and robotic waiter could speed up service.	Yes, it might be popular at first and then people might miss human contact.	Yes, I can see the combination of a Surface Computer and robotic waiter as being extremely efficient.
4.	Yes, I would trust the robotic waiter with my credit card.	It might eliminate human errors and I would not be afraid that the robotic waiter would lose the card.	I eventually would, but not in the short term. I would be concerned about accuracy and ensuring that my card got back to me and did not get lost.
5a.	Not applicable.	Not applicable.	Not applicable.
5b.	Not applicable.	I would prefer the android form factor.	I would prefer the android form factor as the most visually appealing.
5c.	I would prefer a form factor of a mixture of the two, because the pure android form is a little too creepy and scary and looks like something in a wax museum.	Not applicable.	Not applicable.

Table 1 – Consumer Responses (Part 1)

6a.	I would prefer the shorter ASIMO.	Not applicable.	I would prefer the four feet tall robot. The smaller is less intimidating and works better in a crowded restaurant.
6b.	Not applicable.	I would prefer the five feet tall robot.	Not applicable.
7.	The android form feels more creepy and disturbing.	I find the android form more intriguing.	The android form feels more friendly and does not feel creepy to me.
7a.	This is especially true if the human mimicry is not good enough. I get the same feeling when looking at women who have had Botox treatments because they look unnatural.	I can see where the androids can be creepy, but maybe not. Different people will have different reactions.	Volunteer did not elaborate.
8.	I would like to see robotic waiters in a couple of years.	I would like to see robotic waiters in ten years. I think it is happening already overseas.	I would be very accepting of robotic waiters anytime as soon as the speed and reliability to serve food is near perfection.
9.	I would like to see Surface Computers anytime.	I would like to see Surface Computers tomorrow.	Anytime within the next twelve months.
10.	Yes, this would definitely be entertaining for kids.	Yes, kids would love this.	Initially yes, but it might wear off as my kids are adults now.
General Questions			
1.	I am in favor of robotic waiters, except for the androids.	Yes, if the robots are quicker. I still think it will take off at first and then you will either miss the human interaction or you will like not having human error.	I am in favor of robotic waiters, because I am intrigued.

Table 1 – Consumer Responses (Part 1)

2.	I am in favor of Surface Computers.	I am in favor of Surface Computers.	I am in favor of Surface Computers.
3.	I like Surface Computers immediately. The robots could also be used as home health aides for the sick and elderly who may feel embarrassed to have human caretakers.	It is really fascinating and technology keeps going faster and faster.	I think I am pleasantly surprised about the state of robotics today, because their abilities are already beyond what I would have estimated. A small, robotic device to clean carpets is much less intimidating than a humanoid robot that has a certain visual intimidation factor to it. My feeling is that the interest, demand, and acceptance of realistic, human-like robots will accelerate over time in service environments.

Table 2 – Consumer Responses (Part 2)

Questions	**Participant 10 (Male)**	**Participant 11 (Female)**
Background Questions		
1.	I eat out once per week.	I eat out once a week.
Robotic Awareness Questions		
1a.	No.	Yes.
1b.	I do not know.	I do not know.
1c.	I do not know.	I do not know.
1d.	I do not know.	Vacuum cleaner?
1e.	No.	No.
2a.	No.	No.
2b.	I do not know.	I do not know.
2c.	I do not know.	I do not know.
2d.	I do not know.	This looks likes a sewing machine.
2e.	No.	No.
3a.	No.	No.
3b.	I do not know.	I do not know.
3c.	I do not know.	I do not know.
3d.	This robot is some kind of sweeper.	This robot is some kind of cleaner for vents or drilling.
3e.	No.	No.
4a.	Yes.	Yes.
4b.	Roomba.	I do not know.
4c.	I do not know.	I do not know.

Table 2 – Consumer Responses (Part 2)

4d.	This robot is a floor cleaner.	Vacuum cleaner.
4e.	No.	No.
5a.	Yes.	Yes.
5b.	Roomba.	I do not know.
5c.	I do not know.	I do not know.
5d.	Vacuum cleaner.	Vacuum cleaner.
5e.	No.	No.
6a.	Volunteer knew both R2D2 and C3PO by name.	Volunteer knew both R2D2 and C3PO by name.
6b.	We have walking machines now, but a true C3PO-like robot is ten to twenty years away.	It will be five years before we have C3PO-like robots.
7a.	Yes, I have seen this robot before.	No.
7b.	I do not know.	I do not know.
7c.	I do not know.	I do not know.
7d.	This is a humanoid that can walk on stairs, balance, pick things up, and use tools to a certain extent.	This is a space robot that can go to the moon.
8a.	I am not sure about Hubo. I have not seen the Albert Einstein one.	No.
8b.	I do not know.	I do not know.
8c.	I do not know.	I do not know.
8d.	It looks like an experimental robot, something that is not quite ready for the automotive assembly line.	I do not know.
9a.	No.	No.

Table 2 – Consumer Responses (Part 2)

9b.	I do not know.	I do not know.
9c.	I do not know.	I do not know.
9d.	This robot has the same capabilities as the ASIMO.	This looks like the Terminator robot. It is probably a Chinese robot that can walk and is experimental.
10a.	No.	No.
10b.	I do not know.	I do not know.
10c.	I do not know.	I do not know.
10d.	This robot might do the same things as the humanoid, probably typing and fine motor skills.	This robot can take reservations.
11a.	No.	No.
11b.	I do not know.	I do not know.
11c.	I do not know.	I do not know.
11d.	These robots can mirror any human capability! The Q2 version can talk.	I have no idea, but I would guess this robot can do customer service. Version Q2 can do something medical.
12a.	No.	No.
12b.	I do not know.	I do not know.
12c.	I do not know.	I do not know.
12d.	This robot is a human twin. I am not sure if it can walk, maybe.	This robot can replicate the functions of a human being!
12e.	Volunteer could correctly identify the human versus the robot, but was not totally sure.	Volunteer could correctly identify the human versus the robot.
13a.	No.	No.
13b.	I do not know.	I do not know.

Table 2 – Consumer Responses (Part 2)

13c.	I do not know.	I do not know.
13d.	This computer can do anything your laptop can do: popup menus, order a meal with the press of a button, and perform general computation.	I do not know.
Occupational Questions		
1.	Yes, I would definitely like to see Surface Computers in restaurants.	Yes, I would like Surface Computers in fast food restaurants, but not in high end restaurants.
2.	Yes, robots could be used as part of a team with humans.	Yes, I could see a combination of human and robotic waiters.
2a.	Volunteer did not elaborate.	Volunteer did not elaborate.
3.	I would like to see robots as waiters as a novelty, but I would probably resist it initially.	I do not really want to see robots used as waiters. Although I could see them taking orders, but humans still delivering the food unless the robots could be faster.
3a.	I would like to see robots as part of a team.	I would rather see robots as part of a team.
3b.	I would not like robots to replace human waiters.	I would not like robots to replace human waiters.
4.	Yes, humans would still give better customer service.	Yes, humans give better customer service.
5.	No, I have not had a credit fraud problem with restaurants.	No, I have not had a credit fraud problem with restaurants.
Technology Questions		
1.	Yes, the Surface Computer would protect against credit card fraud.	No, the Surface Computer could create more problems. People could see your card depending on how it is designed.
2.	Robots could give more reliable service, but I am not sure about faster service.	Yes, robots could probably give more reliable service.

Table 2 – Consumer Responses (Part 2)

3.	Yes, the combination of a Surface Computer and a robotic waiter could speed up service.	Maybe- it depends on the entire setup.
4.	Yes, I would trust the robot with my credit card. The robot could have a credit card slot in the robot body or hand, allowing you to pay right at the table.	I would probably trust robots with my credit card, but I would need to see it first.
5a.	Not applicable.	Not applicable.
5b.	Not applicable.	I would prefer the android form as the best form factor.
5c.	I would prefer the humanoid body with the android head as the best form factor.	Not applicable.
6a.	I would prefer the shorter ASIMO because it is less intrusive.	Not applicable.
6b.	Not applicable.	I would prefer the five feet tall robot.
7.	The pure android form feels more creepy.	The android form feels more human and is not creepy or scary.
7a.	This is simply due to the fact that they are even trying to mirror humans.	Volunteer did not elaborate.
8.	I would like to see robotic waiters anytime, but as a novelty.	I would like to see robotic waiters anytime, but not in high end restaurants where I want good service and personal interaction with the waiter.
9.	I would like to see Surface Computers immediately as they are very worthwhile.	I would like to see Surface Computers anytime.
10.	Yes, these machines would be entertaining for kids. You could put video games on the Surface Computer.	These machines would most definitely be entertaining for kids.

Table 2 – Consumer Responses (Part 2)

General Questions		
1.	I am in favor of robotic waiters.	I am in favor of robotic waiters.
2.	I am very in favor of Surface Computers.	I am in favor of Surface Computers.
3.	No. The robots have come a long way since the last time I watched documentaries on them.	No, not really. If these robots are put in restaurants, they need to be quicker. I do not think you can completely eliminate human waiters. The robots would have to serve a business purpose by being more efficient and giving faster service.

Questions for Restaurant Managers

Background Questions:

1. How long have you been a restaurant manager overall?
2. Do you consider yourself a career manager or are you only doing this job temporarily?

Robotic and Technology Awareness Questions:

1. Show a picture of the Robomow mower.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
2. Show a picture of the Verro pool cleaner.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
3. Show a picture of the Looj rain gutter cleaner.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?

4. Show a picture of the Scooba mop.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
5. Show a picture of the Roomba vacuum.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
6. Show a picture of C3PO and R2D2 from Star Wars.
    a. Can you name these two robots?
    b. How long do you think it will be in real life before we have real robots that can talk and walk on two legs?
7. Show a picture of ASIMO.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What can the robot do?
8. Show pictures of HUBO.
    a. Are you familiar with this robot?

   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?

9. Show pictures of HRP series of robots.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?
10. Show a picture of Ms. Saya.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?
11. Show pictures of Repliee Q1 and Q2 Expo.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?
12. Show pictures of Geminoid HI-1.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?

    e. Can you tell the difference between the robot and the human?

13. Show a picture of a Microsoft Surface computer.
    a. Are you familiar with this type of computer?
    b. What is it called?
    c. Who is the manufacturer?
    d. What can it do?

Participants were then shown brief video clips of what some of these robots and a Surface Computer can do.

Occupational Questions:

1. Depending on price, do you think you would ever buy robots to serve as waiters or waitresses?
    a. At what price?
    b. How soon?
    c. At what price would you buy five or ten robots?
2. Depending on price, do you think you would ever buy Microsoft Surface Computers to use as restaurant tables for order entry, payment, and entertainment?
    a. At what price?
    b. How soon?
    c. At what price would you buy five, ten, or twenty Surface Computers?
3. Would you want to buy both robotic waiters and Surface Computers?
4. Do you think robots could be used in conjunction with human waiters on a team? For example, what if robots performed all the heavy lifting of food and dishes back and forth while human waiters still provided the customer service, sales, and order entry?

   a. Why or why not?
5. If you bought robotic waiters, would you replace human wait staff or use them in conjunction with humans as part of a team?
6. Do you think human waiters would still give better customer service?
7. If these robots could be programmed to cook, would you be interested in robotic chefs as well?

Technology Questions:

1. Do you think using automated payment via a Surface Computer is a good way to protect against credit card fraud and identity theft committed by some human waiters?
2. Do you think robots could give faster and more reliable customer service by never forgetting orders?
3. Do you see the combination of a Surface Computer with a robotic waiter as a viable and fun way to speed up and automate restaurant service?
4. Do you think customers would trust handing their credit card over to a robotic waiter if that was how payment occurred?
5. What do you think is the best form factor that customers would prefer?
   a. Humanoid (mechanical) robot.
   b. Android (human-looking) robot.
   c. Mixture of two such as HRP-4 (humanoid body with android head).
6. As far as robot height, what do you think customers would be more comfortable with?
   a. The 4 feet tall ASIMO.
   b. The 5 feet tall HRP series of robot.

7. Does the android form of robot make it feel more "human" and less mechanical or is the android form more creepy?
    a. Why?
8. How soon do you think consumers would like to see these robots introduced in restaurants?
9. How soon do you think consumers would like to see Surface Computers in restaurants?
10. Do you think robotic waiters and Surface Computers would be entertaining for your customers' kids when they are waiting for their food?

General Questions:

1. Based on everything you have heard, are you overall in favor or opposed to these robots being used as waiters?
2. Are you overall in favor or opposed to Surface Computers in restaurants?
3. Do you have any other comments, questions, or concerns about these technologies?

Table 3 – Restaurant Manager Responses

Questions	**Participant 3 (Male)**	**Participant 7 (Male)**	**Participant 8 (Female)**
Background Questions			
1.	I have been a manager for one year.	I have been a manager for six years.	I have been a manager for ten years.
2.	I am a career restaurant manager.	I am a career restaurant manager.	I am a career restaurant manager.
Robotic Awareness Questions			
1a.	No.	No.	No.
1b.	I do not know.	I do not know.	I do not know.
1c.	I do not know.	I do not know.	I do not know.
1d.	I do not know.	I do not know.	I do not know.
1e.	No.	No.	No.
2a.	No, it looks like an iron.	No.	No.
2b.	I do not know.	I do not know.	I do not know.
2c.	I do not know.	I do not know.	I do not know.
2d.	I do not know.	I do not know.	I do not know.
2e.	No.	No.	No.
3a.	No.	No.	No.
3b.	I do not know.	I do not know.	I do not know.
3c.	I do not know.	I do not know.	I do not know.
3d.	Some sort of cleaning device?	Some kind of cleaner?	This robot cleans carpets?
3e.	No.	No.	No.
4a.	Yes, I have seen it on TV.	No.	Yes, I saw this robot at Costco.
4b.	I do not know.	I do not know.	I do not know.

Table 3 – Restaurant Manager Responses

4c.	I do not know.	I do not know.	I do not know.
4d.	This robot cleans wood floors?	Vacuum cleaner?	Vacuum cleaner.
4e.	No.	No.	No.
5a.	No.	No.	No.
5b.	I do not know.	I do not know.	I do not know.
5c.	I do not know.	I do not know.	I do not know.
5d.	Vacuum cleaner for carpets.	Vacuum cleaner.	Vacuum cleaner.
5e.	No.	No.	No.
6a.	Volunteer knew both R2D2 and C3PO by name.	Volunteer knew both R2D2 and C3PO by name.	Volunteer was not familiar with these robots.
6b.	C3PO-like robots exist today.	We currently have C3PO-like robots.	We already have C3PO-like robots.
7a.	No.	Yes, I have seen this Japanese robot before.	Yes, I have seen it before.
7b.	I do not know.	I do not know.	I do not know.
7c.	I do not know.	I do not know.	I do not know.
7d.	This robot can walk and hold things or move things from place to place.	This robot can walk, hold things, lift trays, speak, and move head, arms, and legs.	I do not know.
8a.	No.	No.	I may have seen this robot before.
8b.	I do not know.	I do not know.	I do not know.
8c.	I do not know.	I do not know.	I do not know.
8d.	This robot can perform tasks for medical and chemical purposes.	This robot can walk, talk, hold things, and lift things.	I do not know.
9a.	No, they look like toys.	I saw HRP-4 before in a commercial three or four months ago.	No.

Table 3 – Restaurant Manager Responses

9b.	I do not know.	I do not know.	I do not know.
9c.	I do not know.	I do not know.	I do not know.
9d.	I do not know.	HRP-2 looks like a transformer. HRP-4 can change facial expressions.	I do not know.
10a.	No.	Yes, I saw this robot on TV.	No.
10b.	I do not know.	I do not know.	I do not know.
10c.	I do not know.	I do not know.	I do not know.
10d.	I do not know.	This robot can change facial expressions, talk, and give short answers.	This robot can teach or conduct meetings.
11a.	No.	No.	No.
11b.	I do not know.	I do not know.	I do not know.
11c.	I do not know.	I do not know.	I do not know.
11d.	I would guess customer care representative, especially Q2 version.	This robot is more flexible and can answer the phone and perform the role of a receptionist.	Version Q1 can talk. Q2 can talk also, especially on the phone.
12a.	No.	No.	No.
12b.	I do not know.	I do not know.	I do not know.
12c.	I do not know.	I do not know.	I do not know.
12d.	I do not know.	This robot can perform arm and hand movement, stand up, walk, and sit down.	This robot can do mechanical work or replicate the functions of a human being!

Table 3 – Restaurant Manager Responses

12e.	Volunteer could correctly identify the human versus the robot.	Volunteer could correctly identify the human versus the robot.	Volunteer was the only one out of eleven to incorrectly identify the robot as the human!
13a.	No.	No.	No.
13b.	I do not know.	I do not know.	I do not know.
13c.	I do not know.	I do not know.	I do not know.
13d.	This computer can run Windows, surf the internet, and use fingertips on a touch sensitive surface.	This is a bigger version of the iPad, a touch sensitive computer that can play music, videos, display pictures, surf the internet, serve as a Wi-Fi phone, and you can write your own programs for it.	I do not know.
Occupational Questions			
1.	I would probably not buy robotic waiters, but I like the Surface Computer.	I would not purchase robots yet, because they need to be faster and more sophisticated in terms of taking orders.	No, human waiters are better at serving food.
1a.	I doubt I would buy robots at any price because they are not ready yet.	Not yet.	I would not buy robots at any price.
1b.	Not yet.	I might purchase robots in five years.	Not applicable.
1c.	I would not buy five or ten robots.	It depends on the type of restaurant, these robots are better for fast food, not high end restaurants. I prefer human interaction for fancy restaurants.	I would not buy five or ten robots.

Table 3 – Restaurant Manager Responses

2.	Yes, I would buy Surface Computers depending on price.	Yes, I would buy Surface Computers.	Yes, I would buy Surface Computers.
2a.	I would buy one for $2,000.	I would buy one for $5,000.	I would buy one for $10,000.
2b.	This could be purchased very soon.	I would purchase in about two years.	This could be purchased anytime.
2c.	I would say these Surface Computers are more suited to high class restaurants and lounges. But for this many computers, the price would need to be less than $2,000.	I would buy twenty Surface Computers at $3,000 apiece.	I would buy twenty Surface Computers for $2,000 apiece.
3.	I would buy Surface Computers only.	The first purchase would be the Surface Computers, but the robots depend on future advancement and how functional they are in the future.	I would buy Surface Computers only.
4.	It would not work out to have both human and robotic waiters due to price.	Yes, robots could be part of a team with humans.	Yes, robots could be part of a team with humans.
4a.	It would not make sense or be a smart business decision to have both. If the robot could do everything, I would use robots only.	I can envision how the robots and human waiters could divide tasks.	The robots could do busboy work with dishes and the human waiters could take orders and serve food.
5.	I would lean towards replacing human staff, but might retain one or two human waiters.	I would use robots as part of the team with humans.	I would use robots as part of a team with humans.
6.	Human waiters do not necessarily give better customer service based on experience-not always.	Yes, for right now humans give better customer service. The robots need more skills.	Yes, humans still give better customer service.

Table 3 – Restaurant Manager Responses

7.	Yes, I would be interested in robotic chefs way in the future, depending on price drops. The advantage of robots is they can work eighty to one hundred or more hours per week without increases in pay.	Yes, I would probably be interested in robotic chefs.	Yes, I would want robotic chefs. I would like to automate the kitchen staff to have consistent food products. Unlike the waiters, the chefs are not customer facing.
Technology Questions			
1.	Yes, the Surface Computer would protect against fraud, but the difference would be minimal.	Yes, the Surface Computer would protect against fraud.	Yes, the Surface Computer would protect against fraud.
2.	Yes, in the future robots could give faster and more reliable service, but not right now.	Robots could give faster service in the future, but not right now.	Yes, robots could give more reliable service, because humans make mistakes.
3	Yes, the combination of Surface Computers and robots could speed up restaurant service.	Yes, the combination of Surface Computers and robots could speed up restaurant service.	Yes, the combination of Surface Computers and robots could speed up restaurant service.
4.	Customers may not trust robotic waiters with credit cards, they may not even trust the Surface Computer for payment either.	Yes, customers would trust robotic waiters with credit cards in the future.	Yes, customers would trust robotic waiters with credit cards.
5a.	Not applicable.	Not applicable.	Not applicable.
5b.	Not applicable.	Not applicable.	Not applicable.
5c.	I would prefer the humanoid body with the android head as the best form factor.	I would prefer the humanoid body with the android head as the best form factor.	I would prefer the humanoid body with the android head as the best form factor.
6a.	Not applicable.	Not applicable.	Whatever is eye level for most people.

Table 3 – Restaurant Manager Responses

6b.	I would prefer the five feet tall robot.	I would prefer the five feet tall robot.	See above.
7.	The android form is not creepy for me, but may be for other people. This is why I lean towards a mixture of the form factors.	The android form is ok. It does not feel creepy or scary, but I do not know how kids would feel.	The android form is not creepy or scary, but simply more human like.
7a.	Volunteer did not elaborate.	Volunteer did not elaborate.	Volunteer did not elaborate.
8.	Customers would like robotic waiters now.	Customers would like robotic waiters in three to five years.	I do not think customers ever want to see a robotic waiter.
9.	Customers would like Surface Computers right now.	Customers would like Surface Computers anytime.	Customers would like Surface Computers anytime.
10.	Yes, these machines would be entertaining for kids. But they may be a problem because the kids might want to play with the robots.	Yes, these machines would be entertaining for kids.	Yes, these machines would be entertaining for kids.
General Questions			
1.	I am not opposed to robotic waiters, but I do not think it will happen any time soon, because they are not ready yet.	I am in favor of robotic waiters in the future.	I do not like robots as waiters, but I do support robotic chefs. I would like to see less mistakes by chefs and see standardized products. Also, the chefs are not customer facing.
2.	I am in favor of Surface Computers as price comes down.	I am in favor of Surface Computers.	I am in favor of Surface Computers.

Table 3 – Restaurant Manager Responses

3.	I think it is exciting, but I do not think it will happen any time soon. Ambiance is important at restaurants. Sometimes faster service does not mean better service.	The robots need to work on customer service, especially with picky customers. There are many subtle details for being a waiter.	No.

Questions for Waiters and Waitresses

Background Questions:

1. How long have you been a waiter or waitress overall?
2. Do you consider yourself a career waiter or waitress or are you only doing this job temporarily?

Robotic and Technology Awareness Questions:

1. Show a picture of the Robomow mower.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
2. Show a picture of the Verro pool cleaner.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
3. Show a picture of the Looj rain gutter cleaner.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?

e. Do you own one?

4. Show a picture of the Scooba mop.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
5. Show a picture of the Roomba vacuum.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What does the robot do?
    e. Do you own one?
6. Show a picture of C3PO and R2D2 from Star Wars.
    a. Can you name these two robots?
    b. How long do you think it will be in real life before we have real robots that can talk and walk on two legs?
7. Show a picture of ASIMO.
    a. Are you familiar with this robot?
    b. What is its name?
    c. Who is the manufacturer or inventor?
    d. What can the robot do?
8. Show pictures of HUBO.

   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?

9. Show pictures of HRP series of robots.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?

10. Show a picture of Ms. Saya.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?

11. Show pictures of Repliee Q1 and Q2 Expo.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?
   d. What can the robot do?

12. Show pictures of Geminoid HI-1.
   a. Are you familiar with this robot?
   b. What is its name?
   c. Who is the manufacturer or inventor?

   d. What can the robot do?
   e. Can you tell the difference between the robot and the human?

13. Show a picture of a Microsoft Surface Computer.
   a. Are you familiar with this type of computer?
   b. What is it called?
   c. Who is the manufacturer?
   d. What can it do?

Participants were then shown brief video clips of what some of these robots and a Surface Computer can do.

Occupational Questions:

1. Depending on price, do you think your management would ever buy robots to serve as waiters or waitresses?
2. Depending on price, do you think your management would ever buy Microsoft Surface Computers to use as restaurant tables for order entry, payment, and entertainment?
3. What would you do for a job if most restaurants replaced waiters in the future with robots and Surface Computers?
4. Do you think robots could be used in conjunction with human waiters on a team? For example, what if robots performed all the heavy lifting of food and dishes back and forth while human waiters still provided the customer service, sales, and order entry?
   a. Why or why not?
5. Do you think humans would still give better customer service?

Technology Questions:

1. Do you think robots could give faster and more reliable customer service by never forgetting orders?
2. Do you see the combination of a Surface Computer with a robotic waiter as a viable and fun way to speed up and automate restaurant service?
3. Do you think customers would trust handing their credit card over to a robotic waiter if that was how payment occurred?
4. What do you think is the best form factor that customers would prefer?
    a. Humanoid (mechanical) robot.
    b. Android (human-looking) robot.
    c. Mixture of two such as HRP-4 (humanoid body with android head).
5. As far as robot height, what do you think customers would be more comfortable with?
    a. The 4 feet tall ASIMO.
    b. The 5 feet tall HRP series of robot.
6. Does the android form of robot make it feel more "human" and less mechanical or is the android form more creepy?
    a. Why?
7. How soon do you think consumers would like to see these robots introduced in restaurants?
8. How soon do you think consumers would like to see Surface Computers in restaurants?
9. Do you think robotic waiters and Surface Computers would be entertaining for your customers' kids when they are waiting for their food?

General Questions:

1. Based on everything you have heard, are you overall in favor or opposed to these robots being used as waiters?
2. Are you overall in favor or opposed to Surface Computers in restaurants?
3. Do you have any other comments, questions, or concerns about these technologies?

Table 4 – Restaurant Wait Staff Responses

Questions	**Participant 2 (Male)**	**Participant 5 (Female)**	**Participant 9 (Female)**
Background Questions			
1.	I have been a waiter and host for one or two years.	I have been a waitress for thirty two years.	I have been a waitress for twenty years.
2.	I am a part time waiter.	I am a career waitress.	I am career waitress.
Robotic Awareness Questions			
1a.	No.	No.	No.
1b.	I do not know.	I do not know.	I do not know.
1c.	I do not know.	I do not know.	I do not know.
1d.	I do not know.	I do not know.	Vacuum cleaner?
1e.	No.	No.	No.
2a.	No.	No.	No.
2b.	I do not know.	I do not know.	I do not know.
2c.	I do not know.	I do not know.	I do not know.
2d.	I do not know.	I do not know.	I do not know.
2e.	No.	No.	No.
3a.	No.	No.	No.
3b.	I do not know.	I do not know.	I do not know.
3c.	I do not know.	I do not know.	I do not know.
3d.	I do not know.	I do not know.	Some kind of yard tool?
3e.	No.	No.	No.
4a.	No.	Yes, I have seen it in a commercial.	Yes.

Table 4 – Restaurant Wait Staff Responses

4b.	I do not know.	I do not know.	I do not know, but it starts with "r".
4c.	I do not know.	I do not know.	I do not know.
4d.	Mops the floor?	This robot cleans floors.	Vacuum cleaner.
4e.	No.	No.	No.
5a.	No.	No.	No, but I know friends that have them.
5b.	I do not know.	I do not know.	I do not know.
5c.	I do not know.	I do not know.	I do not know.
5d.	Vacuum cleaner.	I do not know.	Vacuum cleaner.
5e.	No.	No.	No.
6a.	Volunteer knew both R2D2 and C3PO by name.	Volunteer has seen robots before in a movie, but does not recall their names.	Volunteer knew R2D2 by name, but not C3PO.
6b.	It will be twenty years before we have C3PO-like robots in real life.	It will be twenty years before we have C3PO-like robots in real life.	It will be five to ten years before we have C3PO-like robots in real life.
7a.	No.	No.	No.
7b.	I do not know.	I do not know.	I do not know.
7c.	I do not know.	I do not know.	I do not know.
7d.	I am not sure, maybe space travel.	This robot can open doors, be a house assistant, and vacuum floors.	This robot looks strong, has basic motor skills, and can grasp and hold things.
8a.	No.	No.	No.
8b.	I do not know.	I do not know.	I do not know.
8c.	I do not know.	I do not know.	I do not know.

Table 4 – Restaurant Wait Staff Responses

8d.	I do not know.	This robot can work in an office.	This robot looks a little more advanced with hands and wrists that have more dexterity, and it is more agile.
9a.	No.	No.	No.
9b.	I do not know.	I do not know.	I do not know.
9c.	I do not know.	I do not know.	I do not know.
9d.	This robot can do toxic or dangerous jobs. Maybe the shell of the robot could enclose a human for dangerous work.	This robot can use a computer.	These robots can work in dangerous situations or jobs that are tough for humans.
10a.	No.	No.	No.
10b.	I do not know.	I do not know.	I do not know.
10c.	I do not know.	I do not know.	I do not know.
10d.	This robot can do secretary or receptionist work.	This robot can type and act as a receptionist.	This robot can do office work.
11a.	No.	No.	No.
11b.	I do not know.	I do not know.	I do not know.
11c.	I do not know.	I do not know.	I do not know.
11d.	This robot can be used for entertainment.	This robot can talk and even be a girlfriend for a guy!	These robots are capable of any human task! Version Q2 looks like a pop or rock star.
12a.	No.	No.	No.
12b.	I do not know.	I do not know.	I do not know.
12c.	I do not know.	I do not know.	I do not know.

Table 4 – Restaurant Wait Staff Responses

12d.	I do not know.	This robot can clean house, cook, and entertain.	This robot looks like a mail man that can sort mail.
12e.	Volunteer could correctly identify the human versus the robot.	Volunteer could correctly identify the human versus the robot.	Volunteer could correctly identify the human versus the robot.
13a.	No.	No.	No.
13b.	I do not know.	I do not know.	I do not know.
13c.	I do not know.	I do not know.	I do not know.
13d.	This computer should have the same functionality as a desktop computer.	This computer can play games.	This computer has a touch screen, it can play games or videos, and might be used in the kitchen.
Occupational Questions			
1.	I would not want to lose my job to a humanoid robot. I prefer robotic appliances to do smaller tasks like mopping the floor. Economically, management would probably go for the robots, but humans are not easy to replace since they have been in the restaurant business for hundreds of years.	I do not think our management would ever want to buy robotic waiters.	It is possible our management would want to buy robotic waiters in the future because there would be no salary or sick time to pay to robots and no rescheduling.

Table 4 – Restaurant Wait Staff Responses

2.	I believe high end restaurants would prefer the Surface Computer, especially if time is a factor. However, this comes at a huge price of personal relationships with waiters and their familiarity with customers. This is especially true for neighborhood and family owned restaurants. Our restaurant probably would not be as interested.	Our managers may want to buy Surface Computers.	Our management would likely want to buy Surface Computers.
3.	I would not be ok with losing my job to a robot. People depend on the job of waiter. Waiters do not have practical training and if the restaurant industry is automated, all the industries below that would be assumed to be automated and there is really no place for you to go.	If robots automated the job of wait staff, I would hope to be retired by then!	If robots automated the job of wait staff, I would do some kind of office work.
4.	Yes, using robots as part of a team is a practical solution.	Yes, robots could be used as part of a team with humans.	Yes, robots could be used as part of a team with humans.
4a.	However, why would managers still need human waiters? Where do you draw the line when dividing up tasks between humans and robots?	Robots could do all the heavy work.	Robots could do the manual labor, but we still need humans for hospitality and social interaction. It would be excellent if robots were part of a team.

Table 4 – Restaurant Wait Staff Responses

5.	Yes, humans give better customer service.	Yes, of course, humans give better customer service.	Yes, humans give better customer service most of the time, but robots could be more efficient.
Technology Questions			
1.	I think robots could give more reliable service because they can memorize things better.	Robots might give faster or more reliable service, but robots cannot be perfect.	Yes, I believe robots could give faster and more reliable service.
2.	The combination of a Surface Computer and a robotic waiter would make for a fast dining experience, but would detract from the overall experience. It is ironic that a European firm developed software for the Surface Computer when Europeans are known for slow restaurant service and taking more time to enjoy their meals.	No, I do not see the combination of Surface Computers and robots as a good way to speed up service. Humans are faster at service.	Yes, as a customer I would want to go to restaurants that used a combination of Surface Computers and robots.
3.	Customers would trust robots with their credit cards more so than with human waiters.	Yes, customers would trust robots with their credit cards.	I would trust robots with my credit cards as a customer, but the elderly might not.
4a.	Not applicable.	Not applicable.	I prefer the humanoid form factor.
4b.	I would prefer the android form factor.	Not applicable.	Not applicable.
4c.	Not applicable.	I would prefer the humanoid body with the android head form factor.	Not applicable.

Table 4 – Restaurant Wait Staff Responses

5a.	I would prefer the shorter ASIMO, but it does not really matter.	Not applicable.	I prefer the shorter ASIMO- it is more friendly.
5b.	Not applicable.	I prefer the five feet tall robot.	Not applicable.
6.	I prefer the android robots better because they are closer to being human.	The android form feels creepy and scary.	The android form is more human-like, but that disturbs me.
6a.	I would feel pretty ridiculous if I had to interact with the more mechanical robots.	This is because the android form is too real.	This is because I wonder if I will be able to tell androids and humans apart in the future. I like knowing the difference. But the technology and how far they have come is amazing.
7.	Customers would like to see these robots in restaurants in twenty to thirty years.	Customers would like to see robots in restaurants in ten years. Some people will still like a human waiter.	Customers would like to see robotic waiters now.
8.	Customers would like to see Surface Computers in ten years.	Customers would like to see Surface Computers anytime.	Customers would like see Surface Computers immediately. It would speed things up if they can order while I am in the back making drinks.

Table 4 – Restaurant Wait Staff Responses

9.	Yes, these machines would be entertaining for kids, more so than crayons, etc.	Surface computers and robotic waiters might be entertaining for kids, but probably not.	Yes, it would be entertaining to attend restaurants with these machines with friends or children because it is something new. It would go over really well in Highlands Ranch. Even for nightlife or dates, the Surface Computer makes the meal more intimate with the other party, because the waiter is not interrupting as much.
General Questions			
1.	I am actually going to say that I am opposed to robotic waiters.	I am opposed to robots being used as waiters.	(Volunteer was the only wait staff member to be in favor of robotic waiters!) I could work with robotic waiters as part of a team. Worst case, I could get another job.
2.	I am in favor of Surface Computers because it makes my job easier and it makes ordering a meal more convenient.	I am in favor of the Surface Computers.	Yes, I am in favor of Surface Computers.
3.	Do you have a projected time frame of when these advances might take place?	It is very interesting.	Why can't the androids walk yet? What is holding that up? Why is the United States not exploring this as much as the Asian nations?

Appendix B - Annotated Bibliography

(2000, Jan/Feb). No operator please. *Technology Review*, 103(1), 104.

The unnamed author of this article described the invention of what became the rotary dial phone. Over 100 years ago, Almon Strowger thought calls to his mortuary were being connected to his competitor by incompetent live operators. In the late 1880s and early 1890s, he built a prototype of an automatic switch and got it patented in 1891. In 1892 he opened up the Strowger Automatic Telephone Exchange. He replaced the buttons on his automatic switch with a finger wheel dial which was the precursor to the rotary dial telephone. When Strowger retired, he sold his patents for $1,800 and his stake in the company for $10,000 and then died in 1902. By 1916, Bell licensed his invention for $2.5 million. The brief article illustrates that the desire to eliminate live telephone operators extended back to the late 1800s.

(2008, January 15). Smarter version of Asimo robot (Japan) (Advanced Step In Innovative Mobility). *Advanced Manufacturing Technology*, 29(1), 6-7.

The anonymous author described that since introducing the ASIMO robot in the late 1990s, the Honda Motor company of Japan has continued to enhance that product line with increased intelligence features which allow multiple ASIMOs to work together as a team for the first time. ASIMOs are roughly four feet tall and 119 pounds and they can walk up to 1.6 km per hour. The ASIMOs can recognize moving objects coming toward them, follow a person as directed, and autonomously recharge their batteries. In addition, the new ASIMOs can respond in fifty different Japanese phrases. The author indicated that Honda's overall purpose is enhancing the cooperation, efficiency, and intelligence of these mobile factory robots in a real world work environment. Finally, the author described the real reason this is needed is due to the rapidly aging demographics of the Japanese population. By implication, this places the burden of heavier physical work on a fewer number of stronger young workers due to a growing number of aging Japanese retirees.

Boudette, N. (2006, April 11). Shifting gears: Chrysler gains edge by giving new flexibility to its factories; Some can build one vehicle, then switch to another, a skill Japanese pioneered. *Wall Street Journal*, pp. A1.

The author described the advantages Chrysler has gained at their Belvidere, Illinois plant by shifting to flexible assembly lines that can assemble more than one car model at the same plant. The plant used to produce only Neons, which were slow sellers. Now the plant produces two models, the Jeep Compass and Dodge Caliber, with a third model to be introduced later in the year. The robotic body shop has only 180 workstations, about half as many as before. A single workstation that used to need five workers now uses only one worker and twenty robots to weld and glue parts for an 80% reduction in workers. The robotic process has cut the number of workers by 10%, but overall employment at the plant is up by 1,000 workers for the second shift. An example of door production illustrates the efficiency of the new robots. A blue light illuminates, which

means produce a Caliber door. A robot holds a reinforcing beam against a door panel held by a second robot, while a third robot welds the door in forty-two seconds. Now a yellow light comes on, which means produce a Compass door. Each robot changed tools on the end of the robot arm to ones designed to fit Compass doors and then welded the new door without any downtime for the assembly line.

Brandon, J. (2008, December 1). Microsoft research projects. ***Network World,*** **25(56), 27-34.**

The author of this article described ten different research projects in progress at Microsoft. Some of these involve the Surface Computer or equivalent technologies. The Surface Computer also doubles as a table for eating and drinking and is quite durable. At Harrah's iBar in Las Vegas, people spill food and drinks on it all evening. Sheraton Hotels uses Surface Computers in their hotel lobbies as a virtual concierges or as conversation starters. AT&T also uses the Surface Computers to sell their phones. You can place cell phones on its surface and the computer will display lists of their features on the screen. The author also described other uses and forms of the Surface Computer such as for disaster recovery efforts and the new Touch Wall, a vertical version of a touch sensitive interface. Lastly, the author discussed a robotic receptionist project at Microsoft that may be deployed in 2009 at company headquarters to assist visitors find their way around the one hundred building Microsoft campus.

Brown, S. (2004). Toyota's global body shop. ***Fortune,*** **149(3), 120B-120F.**

The author discussed Toyota's improvement to flexible manufacturing as described by Boudette. Japanese companies were already ahead of Detroits' Big Three with flexible assembly lines, when Toyota took the next step to standardize its assembly lines around the world allowing it to produce numerous different car models on the same line. This process works both in countries like Vietnam with more low wage labor to high wage countries like the US or England which use more robots. The previous system used three large pallets per vehicle to hold body pieces together while they were welded, creating a need for a large storage space to store pallets when not in use. The new global body line uses just one pallet per vehicle to hold parts in place during welding and then is quickly removed from the vehicle for reuse, which greatly reduces the number of pallets needed in the process. This frees up a large amount of space in the plant where more robots were added to further increase the efficiency of the entire process. Another secret to their success is to design numerous car models of similar sizes which can be accommodated by a single assembly line. This is in contrast to Chrysler's approach in which a size difference between the popular PT Cruiser and the Neon prevented Chrysler from easily expanding production of the Cruiser beyond its initial plant in Mexico.

Coradeschi, S., Ishiguro, H., Asada, M., Shapiro, S. C., Thielscher, M., Breazeal, C., … Ishida, H. (2006, July). Human-inspired robots. ***IEEE Intelligent Systems,*** **74-85.**

This is a collection of articles by numerous authors on the various aspects of today's robots. Hiroshi defined a number of terms in describing his work with android and geminoid robots. The first is android science, which is a new interdisciplinary framework

between engineering and cognitive science. Another term, synergistic intelligence refers to intelligent behaviors that emerge through interaction with the environment including humans. Lastly, cognitive development robotics is a methodology that comprises the design of self developing structures inside the robot's brain and environmental design. Shapiro described the use of natural language as the best language to interface with robots and discusses the fact that current computer languages are a bottom-up attack on this problem. Breazeal discussed human-robot partnerships and sociable robots and has been a leading pioneer at MIT in such work. Ishida discussed efforts to train robots to smell odors by developing electronic noses and the difficulty of describing unfamiliar smells.

Dominey, P., Metta, G., Nori, F., & Natale, L. (2008, December 1-3). Anticipation and initiative in human-humanoid interaction. ***The Eighth IEEE-RAS International Conference on Humanoid Robots 2008*****, 693-699.**

The authors of this article described the ability of robots to anticipate actions and take initiative in human to humanoid interactions. They divided the article into five sections: introduction, our approach, system description, experimental results, and discussion. They described robot participation in terms of three levels of behavior: 1) anticipation of dialog, 2) anticipation of next actions, and 3) initiation of actions. For their study, they used the iCub robot, a small humanoid robot developed as part of the RoboCub project. It has been designed to approximate in size a child of 3.5 years and has fifty-three degrees of freedom. The task they used was that of assembling a table. For the task, the robot passed items to the user and held things while the user worked. The article is relevant for this topic of study because a good robotic waiter would need to anticipate such things as a customer possibly wanting dessert after a meal or needing a refill on their iced tea.

Glover, M. (2005, September). Robots lift transit output. ***Automotive Engineer*****, 30(8), 10-11.**

This author described the boost in output achieved at a Ford Transit van plant. For the 2006 model year, twenty extra robots were added which boosted production by two vehicles per hour. Even as output volume increased, the plant was able to avoid adding much in the way of new labor workers, so their worker hours per unit time has actually decreased. Plant manager John Anderson recognizes that they will never be able to compete with the low cost labor in low wage countries, so the only way to stay competitive is to increase efficiency. The continued use of advanced robotics is one way to increase the efficiency.

Gurchiek, K. (2007, February). Robots take on roles in public, workforce. ***HR Magazine*****, 52(2), 26, 32.**

This author discussed professor Hiroshi Ishiguro's creation, the Geminoid HI-1. Although the robot is usually seated since it does not walk, it is 5'9" tall, 220 pounds, and costs $300,000. Professor Ishiguro teleoperated the robot in a remote controlled fashion to sit in for him for lectures to students, in order study the human presence of the robot. The robot has Ishiguro's face, voice, hairstyle, glasses and even a similar wardrobe.

When the two are sitting side by side it is difficult to tell them apart at first. Although the World Future Society projected in 2007 that a robotic workforce will change how bosses value employees, professor Ishiguro does not believe that robots will replace all human jobs. He believes that we will automate the simpler, mundane jobs, leaving more challenging jobs to real humans. The author also covered a robot used by the Chicago police department and two hospital robots: MURDOC (Mobile Unit Robot Doctor) and ROHAS (Remote Operated Health Assessment System) which remotely monitor critically ill patients.

Harris, D. (2007, February 15). To be almost human or not to be, that is the question. *Electronic Design*, 55(4), 37-40.

The author discussed two different approaches to building human like robots based on the views of two different researchers. The first, Stephen Keeney of Honda's North American ASIMO project, believed that human like robots should look like mechanical humanoids for society to accept them. In contrast, the second researcher, Hiroshi Ishiguro of Osaka University believed that androids which look exactly like humans is a better form factor for people to get used to human like robots. ASIMO represents twenty years of research and development at Honda. ASIMOs use supersonic waves to detect motion around them as well as two visual cameras, two infrared cameras, and an infrared laser beam to detect what is happening in their environment. Honda plans for ASIMOs of the future to assist the elderly and disabled. Although they projected it will be forty to fifty years before an ASIMO can take over all tasks in the household, Honda expects to produce a useful version of ASIMO in about ten years. Meanwhile, Mr. Ishiguro is working on getting his android and geminoid robots, who look more like "Data" from Star Trek, to successfully cross the uncanny valley so that human beings are comfortable with them. His team of 50% engineers and 50% psychologists are beginning to achieve this with infants and young children, but still have a ways to go before adults are comfortable with androids.

Hinds, P., Roberts T., & Jones, H. (2004). Whose job is it anyway? A study of human-robot interaction in a collaborative task. *Human-Computer Interaction,* 19(1/2), 151-181.

The researchers discussed their findings of human reactions to robotic coworkers in an extensive study with 292 participants. The authors divided their paper into sections: introduction, theory and hypothesis, method, results, and discussion. They conducted a three by three experiment with the following variables: human likeness (human, human-looking robot, and machine-like robot) and worker status (subordinate, peer, and supervisor). The tasks of filling bins full of parts were divided between the human participant and the robotic coworker. The robot was teleoperated via remote control from a hidden live operator to make the robot seem more autonomous. One key hypothesis was that humans will feel less responsible for a task when working with a human-like robot as opposed to a machine-like robot. This hypothesis was supported by the research findings. They also found mixed support for a second hypothesis which was that humans would feel less responsible for a task when working with a robot partner who acted in the role of supervisor as opposed to subordinate or peer.

Hirukawa, H., Kajita, S., Kanehiro, F., Kaneko, K., & Isozumi, T. (2005, September). The human-size humanoid robot that can walk, lie down and get up. ***The International Journal of Robotics Research,*** **24(9), 755-770.**

The authors of this article described what led to the technical advances that allowed the HRP-2P robot to be the first life-sized, bipedal walking robot that can lie down on its back from a standing position. It can also perform the reverse motion of getting up to a standing position from lying down on its back or facing the floor in a push-up like position. The authors believe, to the best of their knowledge, that the 5'1", 132 pound HRP-2P robot is the first life-sized humanoid robot that can do this motion. Most robots that could do this until now were small toy robots such as Hanzou. The goal, of course, for HRP-2P was to create a robot that would be more effective in the workplace by continuing to work after falling down, as long as the fall did not severely damage the machine due to the implementation of a safe falling mechanism. This article is divided into five main sections: introduction, description of robot body, technical mathematics involved for the design, contact state graph of exact steps for standing (a finite state machine), and some overall conclusions. The relevance of this article for this topic of study is that if restaurants or other companies wanted to use more walking robots in the workplace, they would benefit from machines that could stand up after a fall and keep working, rather than lay on the ground helplessly.

Hornyak, T. (2006). Android science. ***Scientific American,*** **294(5), 32-34.**

This author discussed another of professor Hiroshi Ishiguro's creations, the geminoid robot Repliee Q1 Expo, which is a copy of Ayako Fujii, a Japanese newscaster for NHK TV. The author described how the robot at a 2005 World Expo fooled people into thinking it was human for a few seconds from several meters away. The robot is almost indistinguishable from an ordinary Japanese woman in her 30s. The 42 year old Ishiguro is the Director of Osaka University's Intelligent Robotics Laboratory. Professor Ishiguro studies android science and cognitive science, or the reactions humans have to his android and geminoid robots. He has found that when he programs his robots to have small micro movements, the equivalent of human subconscious movements, only 30% of humans that look at the robot behind a curtain for two seconds can determine that it is a robot. Even if his creations become bipedal in the future, he does not believe that a "Blade Runner" style empathy test will be needed in the future to distinguish androids from humans. Currently two to ten seconds of confusion is possible, but an entire day is not. The author also mentioned another less sophisticated android called Ms. Saya that is already at work functioning as a receptionist at the Tokyo University of Science for the last few years.

Ishiguro, H. (2007, January). Scientific issues concerning androids. ***The International Journal of Robotics Research,*** **26(1), 105-118.**

In this paper, Hiroshi Ishiguro described issues he encountered when building robots known as androids that are extremely realistic in terms of resembling humans' physical appearance and speech. In his paper, Hiroshi described his latest advances in building

android robots that reach what is known in the computer science field as the "uncanny valley" in which robots that resemble humans too closely, may make some people uncomfortable at some point. He divided the paper into four sections: introduction, development of androids, cognitive studies using androids, and conclusions. The first section covered android appearance and implications for cognitive science. The second section described his development of androids with a human-like appearance, where he described that one of the toughest areas to try to mimic human appearance is the eyes, since humans have "wet eyes" and robots do not. Androids also make use of pneumatic pumps using compressed air to give the androids a more realistic appearance for some of their gestures. He also used 3D motion capture technology to model the hand movements of real humans. Section three covered the cognitive aspects associated with androids and the possibility of performing a full Turing test someday, in which participants interact directly with the robot when asking questions. Such a test would be similar to a scene from the science fiction movie Blade Runner, in which actor Harrison Ford asks emotional questions to determine if the "person" he is interviewing is a real human or not. Finally, section four contained some concluding remarks and alluded to broader questions in social sciences and interpersonal relationships that humans and robots may have in the future. Such a robot could be used to provide information as a company receptionist/greeter to guests or act in a similar manner in libraries, museums, etc.

James, T. (2007, June/July). I see robot. *Control and Automation,* 18(3), 26-31.

The author described the cutting edge in automotive robotic systems today which involves 3D vision systems. Traditionally, most automotive assembly robots have performed spot welding and painting by moving robotic arms repeatedly to fixed positions. Advances in 3D vision systems will allow additional uses of robots in automotive plants, including vehicle inspections currently performed by humans. According to the International Federation of Robotics, there were 850,000 industrial robots in operation around the globe in 2007. That is up a quarter million robots from ten years ago. Not surprisingly, Japan leads the way with 42%, followed by Europe at 33%, and the US trails at 14%. The automotive industry still accounts for over 55% of all robot use. Mark Diederich, vehicle operations manager at Ford, said that almost everything they do in their body shop is done by robots. Ford is looking to go beyond automated painting and welding and use robots in their final assembly areas.

Kara, D. (2004). Sizing and seizing the robotics opportunity, retrieved on 9-11-2007 from http://www.roboticsevents.com/robonexus2004/roboticsmarket.htm

In this article published on the web, the author gave projections for the growing personal and service robotics sector of the economy. First he defined personal robotics as robots purchased by individual buyers (consumers) which educate, entertain, or assist in the home. An example would be iRobot's Roomba robotic vacuum. Secondly, he defined service robotics as semi or fully autonomous mobile robots that assist humans, service equipment, and perform other autonomous functions. An example would be the da Vinci robotic surgery system. The Japanese Robotic Association (JPA), the United Nations Economic Commission (UNEC), and the International Federation of Robotics (IFR)

projected that the service and personal robotics market will surpass the older industrial robotics market by the end of 2005. The JPA further projected that the service and personal robotics market will be twice the size of the industrial robotics market by 2010 and four times its size by 2025. At the time, the UNEC and IFR estimated that the personal and service robotics market would double from 2002 to 2005 to $5.2 billion in revenue in 2005. Likewise the JPA projected growth in the same market to expand from $600 million in 2002 to $5.4 billion in 2005. The article also included a graph which projected the overall robotics market to reach $66.4 billion in 2025, of which only $15 billion would be allocated to industrial robots.

Mathews, D. (2006, August 8). Your virtual assistant. *PC Magazine*, 25(13), 103-107.

This author described the benefits of installing a VOIP PBX system for your small office and provided a series of steps in the installation process. Some of the benefits include: automated attendant or "digital receptionist", outbound voice or fax marketing, reminders or wake up calls via voice, "local" phone numbers to almost any city in the world, and a unified inbox with faxes and voice mail delivered as email attachments, among other benefits. The following summarizes the installation steps: First find a suitable PC with sufficient power. Second, decide whether you wish to use POTS lines or use an IP connection. Third, choose a version of Asterisk and burn it to a CD-R. Fourth, boot the CD and follow the on-screen prompts for setup. Fifth, open a few holes in the firewall. Sixth, change the default passwords for managing the system. Seventh, log onto your web browser to establish the web-based configuration of your system. Eighth, create numeric SIP extensions for your PC or hardware clients. Ninth, create trunk lines for your calls. Tenth, install a SIP-compliant phone on your laptop or PDA. Lastly, after you have attached two computers to your Asterisk server, place a call between those two extensions.

Minato, T., Shimada, M., Itakura, S., Lee, K., & Ishiguro, H. (2006). Evaluating the human likeness of an android by comparing gaze behaviors elicited by the android and a person. *Advanced Robotics*, 20(10), 1147-1163.

In this study, the researchers divided their paper into four sections: introduction, research map, evaluation of human likeness of the android, and conclusion. The goal of the research was to study human gaze behavior when questioned by a very realistic, human-looking android versus a human questioner. The authors noted that in human to human communication, volunteers tend to break eye contact when they are thinking. The researchers found that this is also true in to human to android communication, except that the gaze behavior of human volunteers is different. They used a wizard of Oz approach in which a live operator triggered the questions from the android. The first experiment included six men and six women volunteers with a human questioner and four men and four women volunteers with an android questioner (Repliee Q1 Expo). The questioner asked ten questions the volunteers should know and ten questions where the volunteers had to think. Volunteers tended to avert their gaze by looking downwards with the human questioner, whereas with the android questioner, volunteers' gaze directions changed with question type but they did tend to look around more during think questions. In the

second experiment, volunteers were instructed to intentionally deceive the questioner by lying about some answers. Volunteers are expected to break eye contact when trying to deceive the questioner. Volunteers looked around more frequently with human questioners than with the android, suggesting they may have felt it easier to deceive the android and felt less nervous about lying to the android.

Mutlu, B., Osman, S., Forlizzi, J., Hodgins, J., & Kiesler, S. (2006, March). Perceptions of Asimo: An exploration on co-operation and competition with humans and humanoid robots. *Proceedings of the First ACM SIGCHI/SIGART Conference on Human-Robot Interaction*, 351-352.

In this article, the authors designed and tested an experiment that made use of ASIMOs in an interactive videogame. Essentially, they are just testing how consumers will interact with them once they are massively launched into the marketplace. They conducted experiments with ASIMOs working in either cooperative or competitive modes. The experiments involved an interactive experience and a videogame between a person and an ASIMO. The article briefly described the experiment setup, results, discussion, and conclusions. Men found the ASIMO less desirable in the competitive task than in the cooperative task. Women generally did not differ on their perceptions of the robot and usually had positive feelings and involvement in the two tasks studied. The intent of the article was get to the perceptions people have of the ASIMO robot. The authors also speculate that in the future, ASIMOs may be used to handle household chores such as washing dishes or clothes and caring for the elderly either at home or in institutions.

Nishio, S., Ishiguro, H., & Hagita, N. (2007, June). Geminoid: Teleoperated android of an existing person. In A. Filho (Eds.), *Humanoid robots: New developments* (pp. 343-352). Vienna, Austria: I-Tech Education and Publishing.

The authors of this article described in significant detail some of the social aspects of advanced androids that very closely resemble humans in terms of appearance, some gestures, and speech. The authors defined three different categories of human-like robots: humanoids which resemble humans but still look mechanical, androids that look very human, and geminoids that mirror the appearance of a specific human. This article is divided into four main sections: introduction, android science, geminoids, and summary and conclusions. The authors of this study are interested in learning how well such advanced androids may be accepted socially in various work settings. The researchers have found that observers initially do not know that the geminoid is a robot, but become nervous once they realize it is a robot. Once the robot starts speaking and interacting with them, the observers then become more comfortable with the robot. Researchers also measured the cognitive aspects in terms of response time for humans to realize that what they are looking at in the case of a geminoid is a robot and not a human. The time frame for most people to recognize that Geminoid is a robot is on the order of up to ten seconds. The researchers are particularly interested in whether or not robots like Geminoid can not only speak prerecorded messages, but also if they can be programmed to give the sense of the real human person that is controlling them remotely. Teleoperation is achieved by programming the robot's mouth movements to match up to its actual speech such that lip

readers and people hearing the robot speak will both get the same message. The article is relevant to this topic of study because an important social question for introducing robotic waiters and waitresses into US society would be whether or not a humanoid form factor like ASIMO or a more realistic human-looking form factor such as Geminoid would be more socially acceptable. The technical problem to be solved is that geminoids and androids are generally not advanced enough to walk yet due to limitations with their compressed air pumps and external air compressors, etc.

Park, I., Kim, J., & Oh, J. (2006). Online biped walking pattern generation for humanoid robot KHR-3 (KAIST humanoid robot-3: HUBO). ***The Sixth IEEE-RAS Conference on Humanoid Robots 2006*****, 398-403.**

The authors of this article described the development of the original HUBO robot from KAIST (Korea Advanced Institute of Science and Technology). They divided the article into seven sections: introduction, technical overview of the KHR-3 platform, walking pattern generation, experimental results, conclusion, and a section for future work. The article covered some very advanced mathematics including trigonometric and differential and matrix equations and described the goals of the project regarding making the robot easy to use and operate, despite the fact that the programming is quite complex technically. The HUBO robot is another humanoid, bipedal walking robot that is similar in style and functionality to others in that product class such as the HRP-2P and ASIMO. The HUBO robot has forty-one degrees of freedom, weighs 125 pounds, and is 4'2" tall. It uses a 933 MHz Pentium III with Windows XP and a real time extension (RTX). HUBO can walk forward, backwards, sideways, and can turn around. Its maximum walking speed is 1.25 km/hour. The authors described three different approaches for bipedal walking: offline pattern generation, offline pattern generation with online feedback, and online pattern generation with online feedback. The authors used the third approach for their paper.

Paul, R. (1979, July). Robots, models, and automation. ***Computer*****, 19-27.**

The author described the state-of-the-art in industrial robots in 1979. Most industrial robots at the time were limited to mechanical arms that could only move to precise Cartesian coordinates. If the parts to be worked on or assembled fall outside a desired range, the robot would fail. However, sensor-controlled robots and machine vision systems were starting to come into play in the late 1970s. However, in general the machines still lacked force feedback, that humans take for granted when using their own hands or when using power tools. The article included some mathematical analysis as well as a computer algorithm for a machine to successfully drive a screw. The author predicted that relatively low cost, mass produced industrial robots could free humans from the tedium of the assembly line within the next decade. This is in fact, exactly what happened. This article is relevant for this paper, because it is an historical example of how machine automation led to loss of jobs and reduced employment for humans.

Quain, J. (2006, November 21). A dozen ways to boost your business. *PC Magazine*, 25(21), 91-102.

This author discussed twelve ways to boost small businesses, including VOIP, virtual PBXs, Wi-Fi phones, virtual meetings, business blogs, in-house copy shop, wikis, online file sharing and backup, web-based CRM, online databases and applications, online recruiting, and online payroll. The VOIP discussion describes several VOIP providers for small businesses, of which Vonage is at the forefront with their $49.99 Small Business Unlimited Premium package. In the category of free or almost free service, Skype is the leader. They also offer a business package called Skype for Business. The author then discussed the benefits of a virtual PBX for small businesses, which can be managed via the Web. The author compared three systems: VirtualPBX, Onebox's Receptionist, and Asterisk, the Linux-based, VOIP open source system. It is clear with all these technologies, that the days of the live receptionist are numbered and is similar to what happened to switchboard operators.

Romanchik, D. (2004, February). Robot drivers take the drudgery out of testing. *Test and Measurement World*, 24(1), A6-A8.

While many of the articles in this bibliography examine the impact of robotic automation on workers in automotive assembly plants, the author of this article described the benefits of using robots to test drive completed cars. Robots are increasingly being used for this purpose as they can perform more repeatable tests and thus fewer tests than human drivers. The Stahle SAP2000 robot sits in the driver's seat and connects to the car's accelerator and brake pedals, as well as the clutch and gearshift if the vehicle has a manual transmission. Another robot, the Anthony Best SR series is used for steering control only. There are also other robots that only perform braking. An example use of a braking robot involved a European auto company that needed to apply a force of 400 N to the brakes to stop from a speed of 160 kph. Human drivers were able to meet these requirements in only three of twenty-seven tests, while the robot performed the test successfully in five consecutive trials.

Segal, M. (1974, July/August). The operator-scheduling problem: A network-flow approach. *Operations Research*, 22(4), 808-823.

Today, live operators at switchboards are so rare that callers often have difficulty reaching a live operator and instead must traverse a maze of voicemail and automated phone systems. The author of this article described the reverse problem back in the early 1970s, when switchboard operators were so common that scheduling them into shifts was sufficiently complex that it warranted highly mathematical algorithms that were implemented on a computer. The author divided the article into seven sections: the problem statement, an integer-programming formulation, assignment of operators to tours: a network-flow model, incremental demands for breaks and relief periods, the algorithm, determining trick assignments, and concluding remarks. At the time, so many switchboard operators were needed that they were scheduled into tours or shifts and the

goal of the scheduling software was to schedule the tricks or relief periods so as to minimize the costs.

Sheppard, H. & Stern, J. (1957, October). Impact of automation on workers in supplier plants. *Labor Law Journal*, 8(10), 714-718.

This is an excellent historical article in which the authors discussed the impacts on laid-off workers at an automotive supplier firm after its client automated a stamping manufacturing process in the mid 1950s. In the specific example, prior to automation, 13,000 workers at a major company and 5,000 workers at one of its suppliers, produced stampings for 755,000 cars in 1947. The major company had completed its automation of the stamping process by 1955. The 5,000 workers at the supplier were laid off when their plant shut down. The remaining 13,000 workers at the major firm with the help of automation, produced stampings for 2,241,000 cars in 1955 for a 300% increase in productivity. Furthermore, the effects of the unemployment were hardest on older workers, female workers, and blacks in terms of length of time to find new jobs, reduced pay at the new jobs, and the percentage of laid-off workers that used up their unemployment benefits. These problems were due to general discrimination in the society at the time and not necessarily the automation itself. However, this article is relevant to this topic of study since it is an historical example of the devastating effects of automation on employees, particularly for low and semi-skilled workers, whose jobs are the easiest to automate.

Takahashi, D. (2007, July 16). Microsoft unveils surface computer. *Design News*, 62(10), 43-46.

In October 2001, Stevie Bathiche and Andy Wilson at Microsoft came up with an idea for "Surface Computing" and they were way ahead of their time. This initiated an extensive, multi-year research and development effort until the product was released into the commercial market in 2007. The Surface Computer is basically an electronic table that uses the same technology as rear projection televisions to project images onto its top surface. At the same time, five cameras embedded in the table detect the motions of users and objects on top of the table to create a highly interactive experience. The table also uses a Pentium 4 CPU and a very powerful graphics processing unit (GPU) as well as Windows Vista as the OS for the computer. The unique design of the Surface Computer allows for interactions between the physical world and the virtual world. For example, the computer can detect Microsoft's Zune music player and transfer music between Zunes by "dragging" song titles across with your fingers. Current units are expensive at $5,000 to $12,000 apiece. Initial corporate customers include T-Mobile, Starwood Hotels and Resorts, and Harrah's Entertainment. Over three to five years, Microsoft hopes to reduce the cost in order to introduce the Surface Computer to the home market.

Takano, E., Matsumoto, Y., Nakamura, Y., Ishiguro, H., & Sugamoto, K. (2008, December 1-3). Psychological effects of an android bystander on human-human communication. ***The Eighth IEEE-RAS International Conference on Humanoid Robots 2008,*** **635-639.**

This is a very interesting article in which the authors studied the psychological reaction of human volunteers when an android bystander is present during serious human to human communication. One of the authors, Hiroshi Ishiguro, is one of the inventors of android and geminoid robots. The article is divided into six sections: introduction, android in trilateral communication, the chameleon effect, preliminary experiment with human bystander, clinical experiment with an android, and conclusion. For the experiment, the authors used a Repliee Q2 female android robot posing as a medical student or nurse. The robot is 5'0" tall and the upper body has forty-two degrees of freedom, while the lower body is stationary. The authors chose patient to doctor interaction for patients with serious health conditions, so that the patients would already be nervous. The intent of the experiment was to determine if an android bystander that was not involved in the communication, would be soothing to the patients or cause more nervousness. The result of the study was that if the android and nodded in agreement with things the patient said, patients appreciated the presence of the android. Conversely, if the android smiled and nodded in agreement with the doctor, the effect was worse than having no android in the room.

Takano, W. & Nakamura, Y. (2008, December 1-3). Integrating whole body motion primitives and natural language for humanoid robots. ***The Eighth IEEE-RAS International Conference on Humanoid Robots 2008,*** **708-713.**

The two authors discussed the importance of language for humanoid robots to communicate with humans. They divided the article into six sections plus an appendix: introduction, motion language model, natural language model, generation of sentences, experimental result, and conclusion. The motion language model represents the stochastic association of morpheme words with proto symbols via latent states. The natural language model represents the dynamics of word classes by Hidden Markov Models. The motion language model corresponds to semantics and the natural language model corresponds to syntax. This article is relevant since a robotic waiter needs to understand and convey language to be truly effective as waiter. It must interpret customer requests as well as be able to speak back to the customer.

Walters, M., Dautenhahn, K., Woods, S., Koay, K., Te Boekhorst, R., & Lee, D. (2006). Exploratory studies on social spaces between humans and mechanical-looking robot. ***Connection Science,*** **18(4), 429-439.**

In this study, the researchers examined the effects of distance and approach direction of a mechanical robot on human comfort levels. In the first part of the study, the authors measured the minimum distance that humans would allow when either approaching the robot or allowing the robot to approach them. The study involved twenty-eight participants evenly split between males and females. For sixty percent of participants, the

comfortable distance was within the human and social zones (.45 meters to 3.6 meters). However, forty percent of respondents allowed the robot to approach within the half meter safety limit. The second half of the study involved discovering the preferred approach direction when the robot delivered a television remote control to the seated participants. This study involved fifty-three participants. The researchers found that the preferred approach direction was from the right (fifty-nine percent), followed by the left (twenty-eight percent), and lastly the front (thirteen percent). Participants found the robot the most threatening when it approached them directly from the front.

Wong, B. (2007). Cognitive ability (iq), education quality, economic growth, human migration: Implications from a sociobiological paradigm of global economic inequality. *Mankind Quarterly*, 48(1), 3+.

The author focused most of this article on economic issues and not on robotics. However, the author did agree with many other articles that the Japanese and South Koreans prefer to innovate with high technology and robotics, rather than import millions of people from other countries who are willing to work for sub minimum wages. He also agreed that in Japan, robots are seen as a way to deal with the rapidly aging population and to make up for a coming labor shortage and also robots will be used in the future to take care of the elderly. The author noted that Japan had 356,500 industrial robots by the end of 2004 compared to only 122,000 industrial robots in the US at that time. The goal of the Honda researchers who are working on the ASIMO robot is to eventually produce a domestic machine that is as versatile as a human, but works twenty-four hours per day and performs all household chores. Japan's personal robot market could grow to $8 billion by 2010. Planned uses for the humanoid robots include health care roles, receptionists, and automotive assembly work. South Korea is not far behind and has set a goal of having all households have domestic robots by 2020.

Young, J. (1995). TAPI dancing. *Forbes*, 156(5), 114.

The author described a standard introduced in 1995 called TAPI (telephone applications programming interface) that allows personal computers to replace sophisticated switchboards and call processing systems. Microsoft's Windows 95 operating system lets a $2,000 computer act like a $25,000 call processing system for order entry for example. The other part of the equation is cheap semiconductors that bring powerful telephone switching and processing powers to high-end personal computers. TAPI can bring features such as predictive dialers that automate junk telephone calls and systems which allow people to check their bank balances without talking to a human. At the time, Mediatrends sold a system for one hundred users for $4,000 with hardware add-ons for $1,600 compared to similar systems that sold for $25,000. According to Charles Fitzgerald, Microsoft's marketing manager for computer telephony, "The personal computer is going to crush the telephony world."

Glossary

Android – A very lifelike robot with artificial skin and very realistic facial features that closely resembles a human being. An example would be the robot Ms. Saya.

Android Science - A new interdisciplinary framework between engineering and cognitive science.

ASIMO – A mechanical, humanoid robot from Honda that can walk and has advanced collision avoidance technologies.

Blade Runner – A 1982 cult classic science fiction film starring Harrison Ford in which Harrison must track down non-human replicants who are nearly indistinguishable from humans.

Cognitive Development Robotics – A methodology that comprises the design of self developing structures inside the robot's brain and incorporates environmental design.

Cognitive Science – The study of human reactions to android and geminoid robots.

Commander Data – An android like robot made famous in the Star Trek movies and television series.

C3PO – A golden,walking, talking, bipedal robot made popular by the science fiction movie Star Wars, originally released in 1977.

Doppelganger – A ghostly counterpart of a living person. Geminoid robots are also referred to as doppelgangers.

Geminoid – An android that is made to exactly mirror a specific human being. Examples would be Repliee Q1 Expo and Geminoid HI-1.

Geminoid HI-1 – A geminoid robot that looks exactly like its inventor Hiroshi Ishiguro.

HUBO – A mechanical, humanoid robot from the Korean Advanced Institute for Science and Technology (KAIST).

Humanoid – A robot that has a human form with a body, arms, legs, and a head but is still very mechanical looking due to its metal and plastic construction.

HRP – A humanoid robot project from Kawada Industries that can walk, lie down, and stand up.

Ms. Saya – A realistic android robot that can mimic many human facial expressions.

Personal Robots – Robots purchased by individual buyers (consumers) which educate, entertain, or assist in the home. An example would be iRobot's Roomba robotic vacuum.

Repliee Q1 Expo – A lifelike, geminoid robot modeled after Japanese newscaster Ayako Fujii.

Roomba – A round, rolling, autonomous robotic vacuum. One of iRobot's most popular robots with over five million units sold.

R2D2 – A cylindrical, rolling and beeping robot that was a companion to C3PO in Star Wars.

Service Robots - Semi or fully autonomous mobile robots that assist humans, service equipment, and perform other autonomous functions. An example would be the da Vinci robotic surgery system.

Surface Computer – A new kind of touch-sensitive computer hardware device released by Microsoft in 2007 that consists of a Vista-enabled computer embedded in a table that also uses cameras to detect hand motions on the computer's surface.

Surrogates – A 2009 science fiction film starring Bruce Willis in which humans interact with the outside world using surrogate robots.

Synergistic Intelligence - Intelligent behaviors that emerge through interaction with the environment including humans.

Uncanny Valley – The point at which a non-human object's resemblance to humans becomes so real that it frightens people or makes them uncomfortable.